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Embryology

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Embryology Definition

1- Embryology is the study of the origin and development of an organism

2- Embryology is the study of an animal's development from the fertilized egg to the formation of all major organ systems. But in its broadest sense it deals with the complex changes which an individual organism undergoes in its life cycle from fertilization to death.

Almost all higher animals start their lives from a single cell, the fertilized ovum (*zygote*). The zygote has a dual origin from two gametes- a spermatozoon from the male parent and an ovum from the female parent. The time of fertilization represents the starting point in the life history, or *ontogeny,* of the individual. In its broadest sense, ontogeny refers to the individual's entire life span.

The development of many animals is divided by the incident of the birth or hatching into - prenatal period and postnatal periods.

Historical of Embryology

Embryology as a branch of biology was initiated by the famous Greek philosopher Aristotle (384-322 B.C). He was the first embryologist to describe the development and reproduction of many kinds of organisms in his book entitled "*Degeneratione Animalium".*

Theories of embryology

1-Preformation Theory

Biologists of the seventeenth and eighteenth centuries believed in preformation, the concept that gametes contain miniaturized versions of all of the elements present in the adult. Some biologists thought that the ovum contained miniature of the adult, which was in some way stimulated to growth by the seminal fluid. Some other biologist believed that preformed miniature organism presented in the head of the sperm.

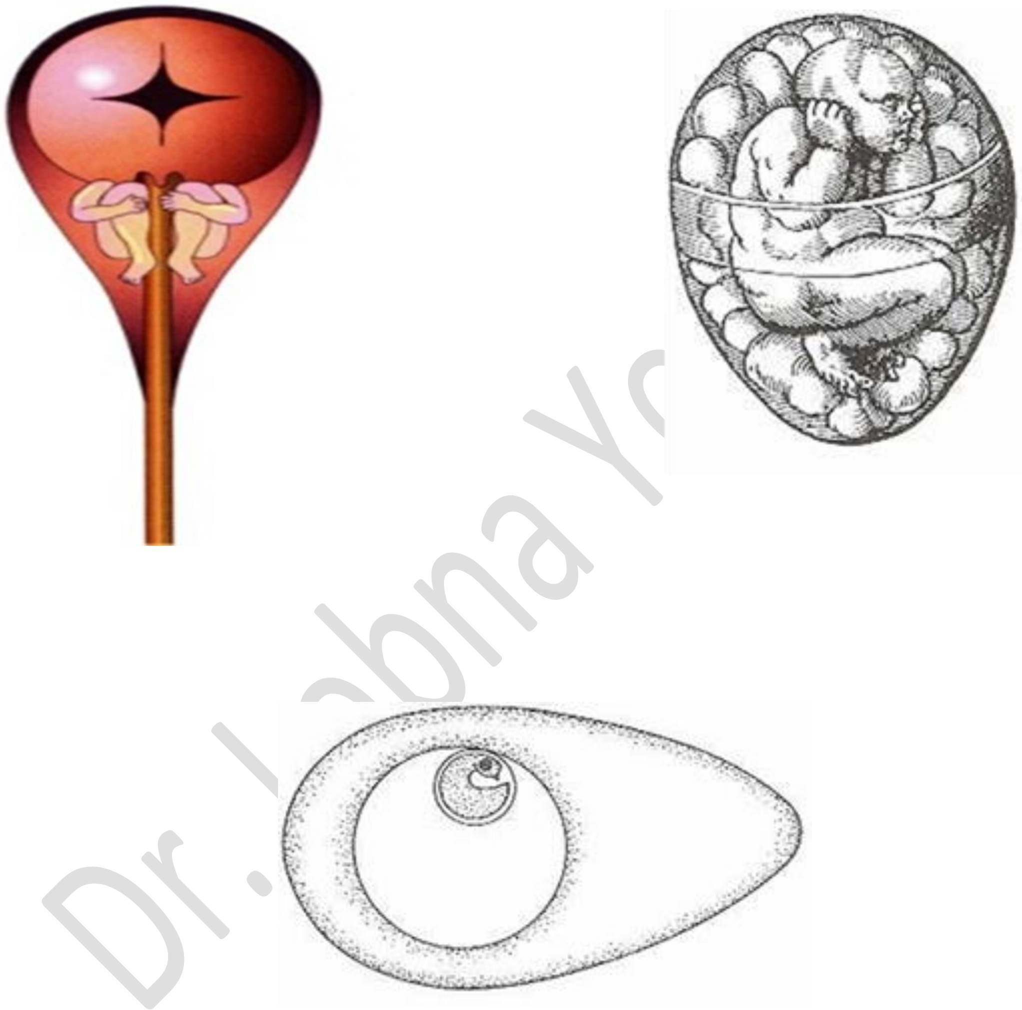


Figure 1: preformation theory

3-Epigenesis Theory

In the mid-eighteenth century, the theory of epigenesis maintained that the egg contains the material from which the embryo is gradually built. This theory assumes that embryonic development and differentiation originate in a homogeneous mass of living matter in which there is no preformed materials, neither tissue nor organs.

3- Recapitulation Theory:

This theory was postulated by *Ernst Haeckel* (1868) and *Muller* (1864). It is based on the contribution of evolutionary theory. This theory states that higher animals in their development passes through stages which are similar to the adult stages of lower animals which were their ancestors. That is the *ontogeny* briefly repeats or recapitulates the *phylogeny*. In other words the ancestral characters reappear in the developmental stages of an individual. Thus the recapitulation theory states that the embryonic stages of a higher animal resemble the adult stages of its ancestor.

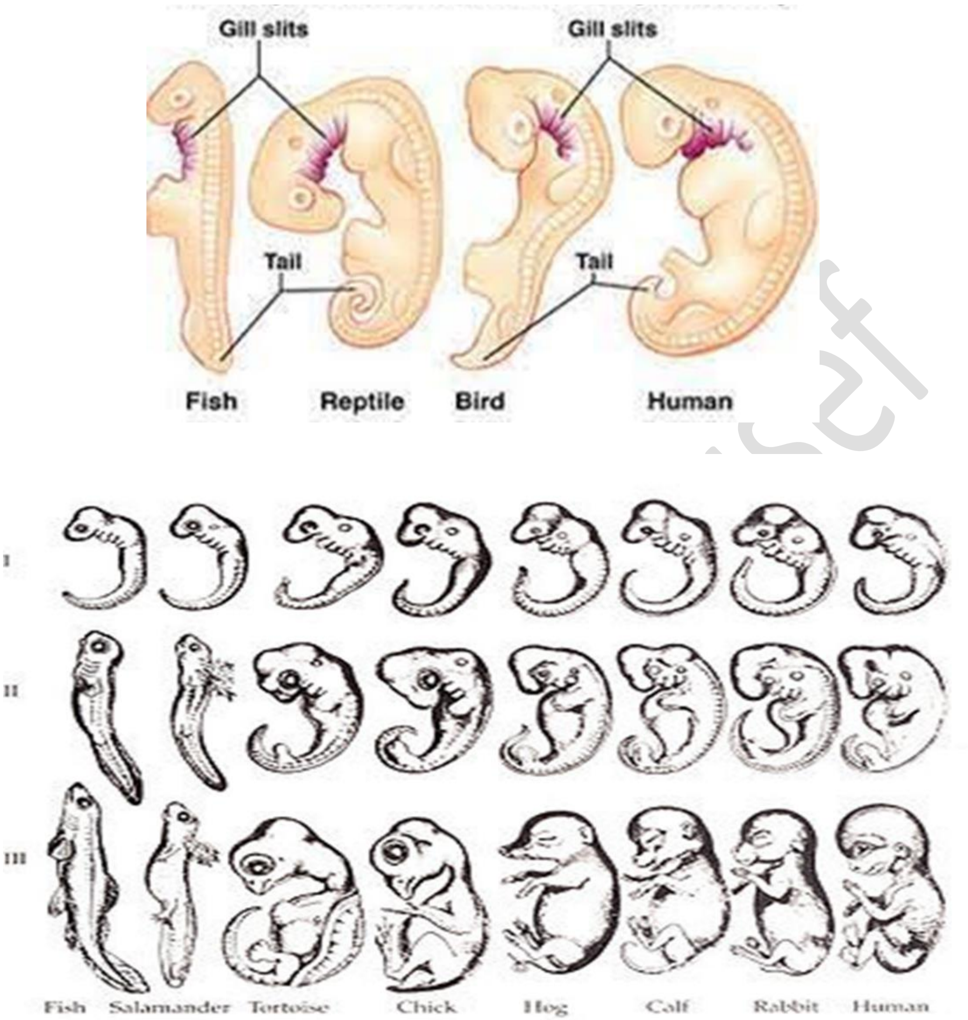


Figure2 :Embryos and Receptulation theory

Branches of Embryology

1-Descriptive embryology

Describes developmental stages of an animal with direct observation and description. (Development of a new animal begins with a sperm fertilizing an egg.)

2-Experimental embryology

Experiments are used for studying the developmental. It helps to understand the fundamental developmental mechanisms. In experimental embryology the various parts of developing embryo are removed, transplanted, parts exchanged or the environmental conditions altered. This helps to understand induction, gradient system, etc.

3-Teratology

It is a branch of embryology concerned with the study of malformations. During this century, great effort is being spent to identify and eliminate genetic and environmental factors that cause congenital defects.

4-Comparative Embryology

The embryological development of different animals are studied and compared. In recent years, comparative embryology has undergone a resurgence through the investigations of taxonomists, who have recognized that valuable clues to taxonomic relationships among species can be found by studying their embryonic development.

5- Developmental Biology

It includes not only embryonic but also development postnatal processes such as normal and neoplastic growth, metamorphosis, regeneration and tissue repair.

The value of Embryology

1- From embryology we can learn in one short, story how each individual grows into an adult.

2- Much of the new technology is based on the results of laboratory researches.

3- Recent techniques make possible the diagnosis and/or treatment of genetic diseases and birth defects before a baby is born.

4- Study of the gene action by transfer the genes from one species into the egg of another species.

5- Examination of a small amount of the amniontic fluid that surrounds an embryo makes it possible to determine the sex of a baby before it is born and to detect the presence of genetic conditions that could lead to a defective child.

6-The " test-tube baby (IVF) in vitro fertilization and , has allowed some childless couples to have children from their own genetic heritage.

Reproduction

The process of reproduction is one of the characteristics of living organisms, and necessary to maintain the type of the organism to extinct.

Types of Reproduction

A- Asexual Reproduction

Asexual reproduction is characterized by the transformation of a part of the old organisms into a new independent organism. This occurs through growth or budding or fission. The process of creating new individual using one parent organism. Asexual reproduction results in the generation of genetically identical offspring.

1- Fission :

Fission is the process where the body of the organism divides into two or more parts, each of them develops into a new organism. It is classified to simple binary fission, longitudinal or transverse binary fission.

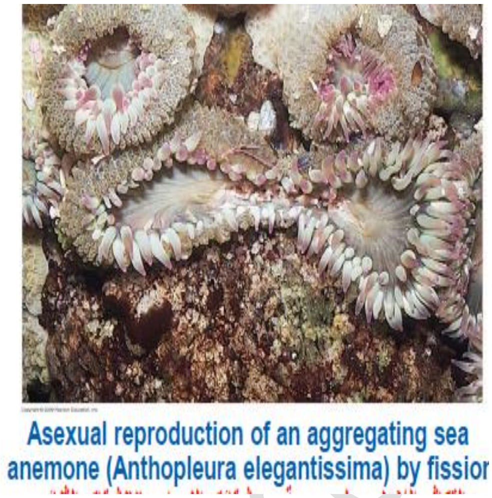
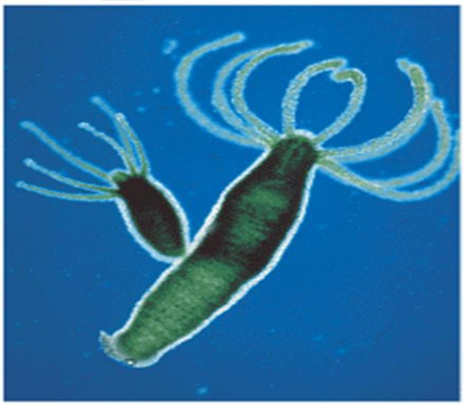


Figure**3** : Asexual reproduction by fission

2-Budding:

a new organism develops from an outgrowth or bud due to cell division at one particular site. The new organism remains attached as it grows, separating from the parent organism only when it is mature, leaving behind scar tissue. The budding may be simple (when one bud formed) or may be multiple (when many buds develop from the parental body simultaneously).



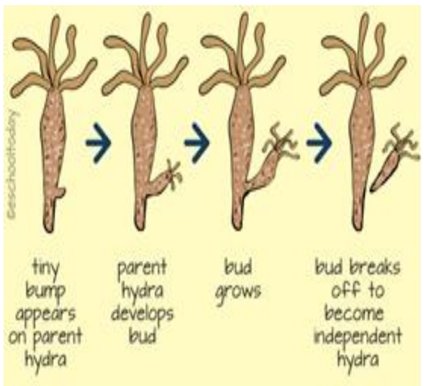


Figure4 : Asexual reproduction by budding

3- Sporulation:

The nucleus of the organism divides mitotically to produce a number of daughter nuclei. Then the entire organism having a number of daughter nuclei, secretes a hard and protective membrane to tide over the unfavorable conditions. When the favorable conditions come, each nucleus along with a bulk of cytoplasm develops into new individual.

4- Fragmentation:

In such reproduction, small parts of one organism split off and subsequently mature as daughter organism. As in sea anemone, in which parts of the base are detached and grow into adult individuals.

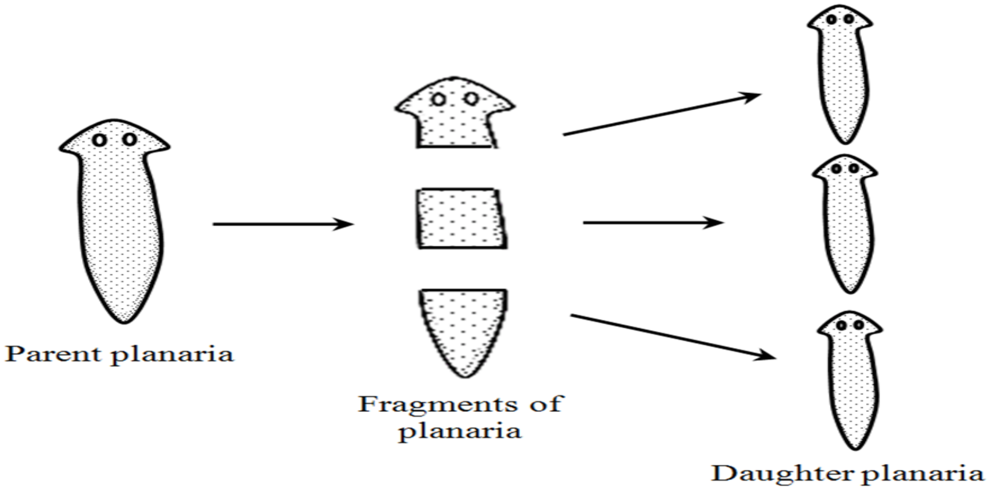


Figure 5: Fragmentation in Planaria

5- Regeneration:

Regeneration is equivalent to developing anew. Regeneration is employed to designate the reconstitution or new formation of an organ or part of an organism subsequent to remove the injury of these parts.

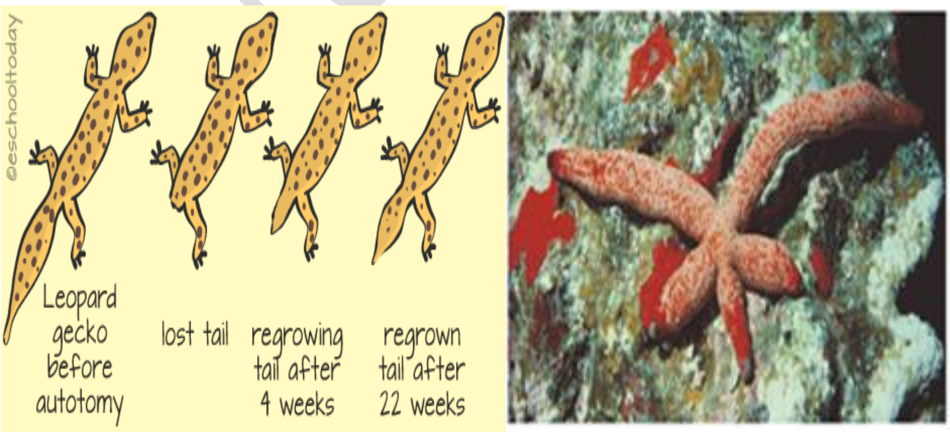


Figure6 : Asexual reproduction by regeneration

6-Parthenogenesis:

Is the phenomenon where the female gametes develop into new organisms without fertilization. The male and female gametes are formed but the male gametes fail to fertilize the female gametes.

Some organisms are able to do both sexual and asexual reproduction. This is particularly true for fungi and plants (and rarely, animals - as in parthenogenesis). Often, the type of reproduction that they undergo depends on their environmental conditions or the point in their growth cycles.

Figure 7: Parthenogenesis

B- Sexual Reproduction :

Sexual reproduction is characterized by fusion of male's smaller sperm and a female's large ovum (or egg). Each gamete contains half the number of chromosomes to form zygote. In some animals both kinds of gametes spermatozoa and ova are produced by a single individuals (Hermaphrodite). Process of creating new individual using two parent organisms. Sexual reproduction results in the generation of genetically unique offspring

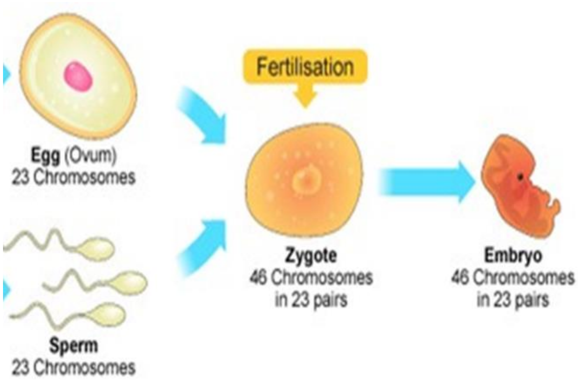


Figure 8:Sexual Reproduction

The Normal Sequence of Events in Embryology

1- Gametogenesis

2- Fertilization

3- Cleavage and blastula formation

4- Gastrulation

5- Organgenesis

SOME TERMS

Gamete: egg or sperm

Gametogenesis: production of eggs or sperm

Oogenesis: production of eggs

Spermatogenesis: production of sperm

Spermiogenesis: differentiation of sperm morphology

Follicle: where eggs mature in the ovary

Ovulation: release of egg from follicle

Polar body: nonfunctional product of meiotic divisions in oogenesis

Zygote: Fertilized egg

Oogonia: mitotically dividing cells in the ovary, will become oocytes

Primary oocyte: decision has been made to undergo meiosis, cell has grown. Cells are arrested at this stage until puberty.

Secondary oocyte: has completed first meiotic division, the division was unequal in terms of cytoplasm

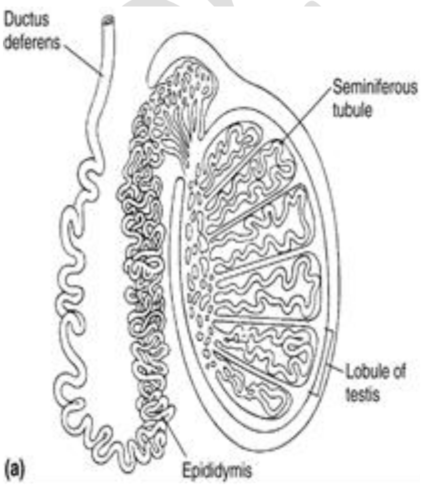
Ovum: Ovulated egg, ready to be fertilized. If fertilized, the second meiotic division will occur, another polar body will be given off.

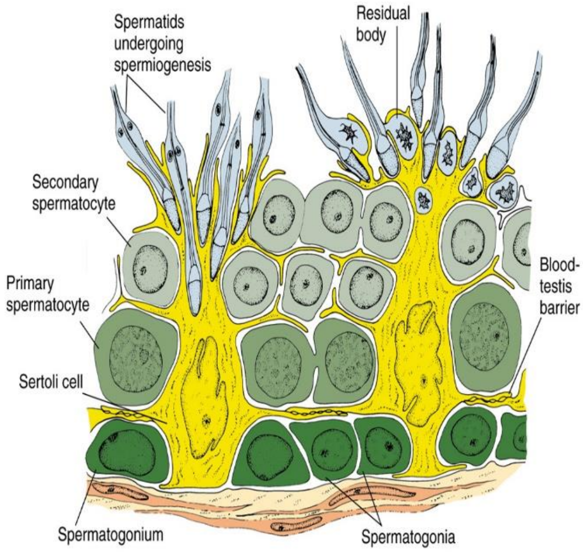
Diploid: Having the full chromosome number (46 in humans).

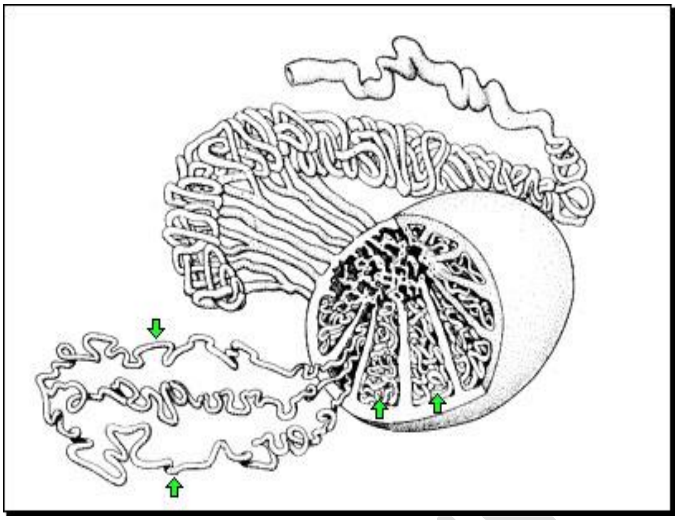
Haploid: Having half the full chromosome number (23 in humans).

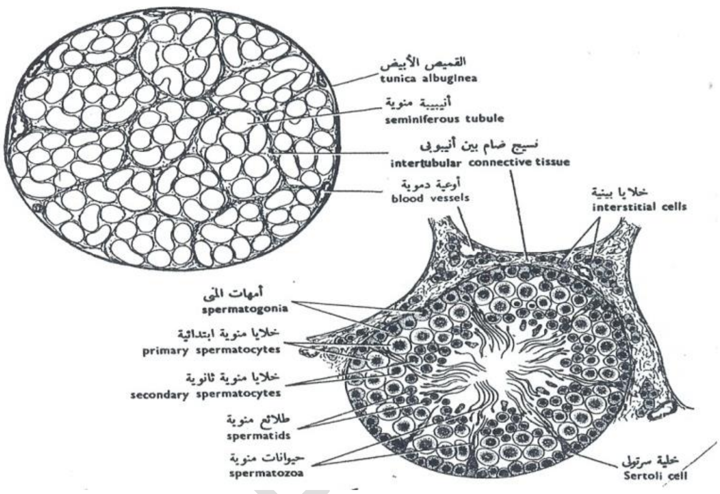
Male Reproductive System

The mammalian testes are divided into many lobules, and each lobule contains many tiny seminiferous tubules. Sperm develop in an ordered fashion in these tubules. Cells start to mature on the outside and move inward (towards the lumen) as the become mature sperm.




Spermatids undergoing spermiogenesis
Residual body
Secondary spermatocyte
Primary spermatocyte
Blood-testis barrier
Sertoli cell
Spermatogonium
Spermatogonia




القميص الأبيض
tunica albuginea
أنيبيبة منوية
seminiferous tubule
نسيج ضام بين أنيبوبي
intertubular connective tissue
أوعية دموية
blood vessels
خلايا بينية
interstitial cells
أمهات المني
spermatogonia
خلايا منوية ابتدائية
primary spermatocytes
خلايا منوية ثانوية
secondary spermatocytes
طلائع منوية
spermatids
حيوانات منوية
spermatozoa
خلية سرتولي
Sertoli cell

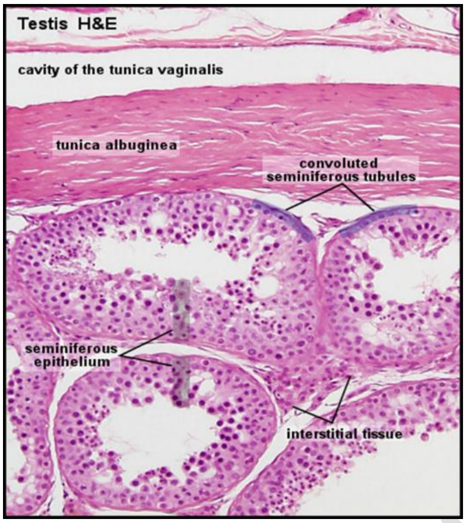


Figure 9: T.S. of testis

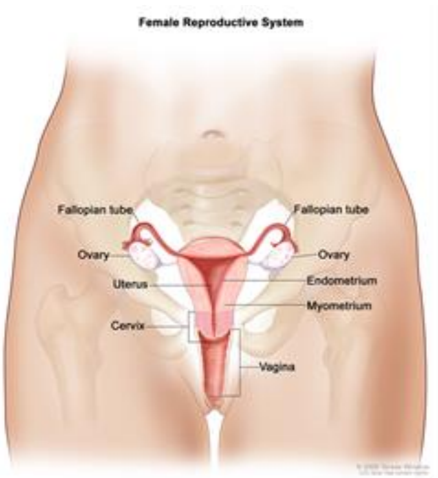
The testes contain millions of *spermatogonia*. Spermatogonia are the most primative cells.

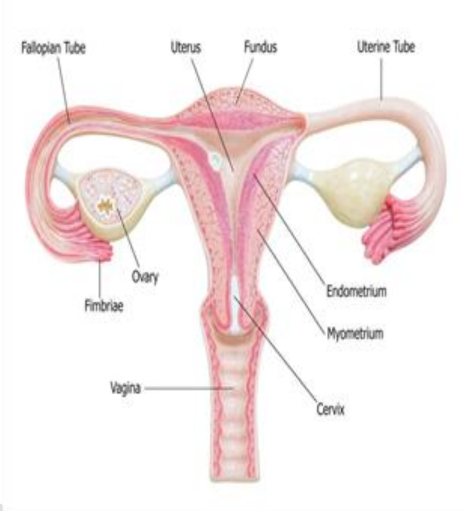
Each of these cells can develop into a primary spermatocyte.

-A primary spermatocyte will undergo Meiosis Division I to produce two secondary spermatocytes.

-Finally, each secondary spermatocyte undergoes Meiosis Division II resulting in four sperm cells.

- Each sperm cell receives the same amount of cytoplasm. Spermatogenesis results in equal distribution of the cytoplasm, in contrast to oogenesis which has unequal cytoplasmic division.



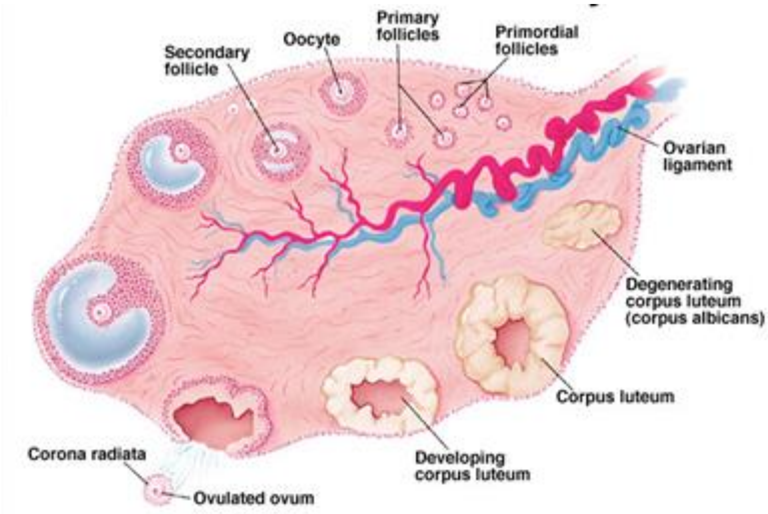


The ovary has three main histological features

Surface – formed by simple cuboidal epithelium (known as germinal epithelium). Underlying this layer is a dense connective tissue capsule.

Cortex – comprised of a connective tissue stroma and numerous ovarian follicles. Each follicle contains an oocyte, surrounded by a single layer of follicular cells.

Medulla -formed by loose connective tissue and a rich neurovascular network, which enters via the hilum of the ovary.



1- Gametogenesis

Is the formation of the germ cells or gametes.

- Each gamete contains haploid number of chromosomes.

- Both kinds of gametes are produced by different individuals of an animal species

The cells which are destined to develop into gametes are called primordial germ cells.

The primordial germ cells originate in the endoderm of adjoining region of the yolk sac in human before migrating into the gonds (tests or ovary).

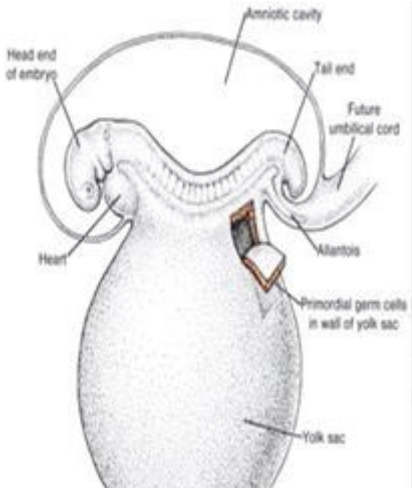


Figure 10 : Human embryo (4 weeks old)

The timing of meiosis differs in females and males

In males, the spermatogonia enter meiosis and produce sperm from puberty until death. The process of sperm production takes only a few weeks.

In females, this process is more complex. The first meiotic division starts before birth but fails to proceed. It is eventually completed about one month before ovulation in humans. In humans, the second meiotic division occurs just before the actual process of fertilization occurs.

Thus, in females, the completion of meiosis can be delayed for over 50 years. This is not always good.

Only I egg produced

In addition, all meiosis is ended in females at menopause.

Spermatogenesis

Spermatogenesis occurs in the seminiferous tubules

Vitellogenesis

Vitellogenesis is the process of producing the major yolk proteins Yolk. Animal eggs contain large amounts of protein, lipid, and glycogen to nourish the embryo. These materials are collectively called yolk. Yolk proteins are synthesized in the liver in vertebrates, or in the fat body of insects.

Yolk is minimal in animal eggs that sustain only the first portion of embryogenesis (humans and many mammals that have a placenta need only support cleavage for several days before implantation into the uterus). Yolk is stored in large amounts in the eggs of birds and reptiles because their eggs have to support the entire process of development.

When little yolk is present, young develop into larval stages that can feed (Indirect development). When lots of nourishing yolk is present, embryos develop into a miniature adult (Direct development). Mammals have little yolk, but nourish the embryo via the placenta.

Polarity and types of eggs

Figure :11Animal – vegetal polarity

On the basis of presence or absence and amount of yolk particles, the eggs classified as follows:

A- According to the amount of yolk

the egg arranged into the following

1-Alecithal type

When the yolk particles are entirely lacking as in placentals (Mammals).

2- Oligolecithal type

Here the yolk particles are present but in little amount as in Echinodermata Amphioxus, hydra.

3-Mesolecithal type: The yolk particles are present in Moderate amount as in toad.

4-Macrolecithal type

In birds and repticles and egg laying mammals, the yolk particles are in good amount. The yolk is concentrated in the vegetal pole Here, in such cases the size of nucleus and cytoplasm reduce and lie in the form of a small germinal disc at the animal pole.

B- According to distribution of yolk

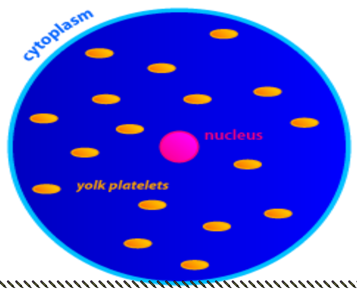
Isolecithal type when yolk particles are distributed evenly throughout the cytoplasm as in fishes.

Centrolecithal type

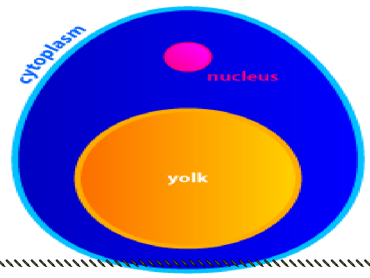
In insects and other Arthropods the yolk particles are restricted to the center of the egg.

Telolecithal type

When the yolk increases in quantity and becomes accumulated at one end or pole of the egg as in frog, toad

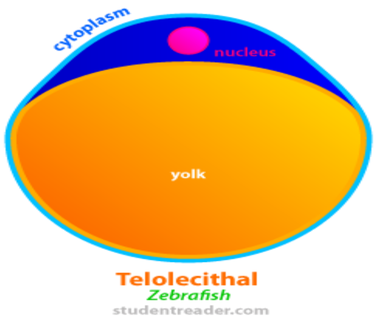


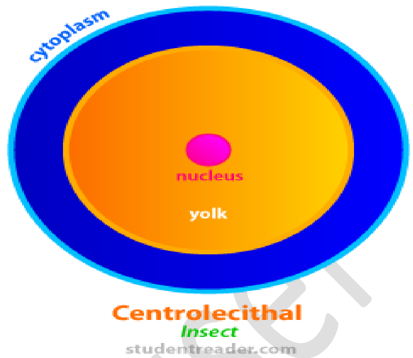
Alecithal
Mammal
studentreader.com



Telolecithal (Megalecithal)
Bird
studentreader.com

and some fishes.





Figur Figure 13 : Telolecithal and gg
macrolecithal

Fi Figure 15:Centrlecithal egg

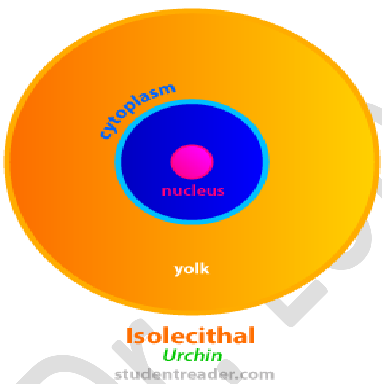


Figure 14 :Isolecithal egg

2- Fertilization

Definition: The process by which the male and female gametes (sperm and ovum) unite to give rise to zygote.

Types of Fertilization

External fertilization:

When the fertilization occurs in the aquatic medium outside the bodies of male and female parents.

Internal fertilization:

In terrestrial forms, particularly where eggs are completely enclosed in impermeable envolpes before being laid (birds), or where they are retained within the maternal body throughout development (mammals), thus the fertilization occurs inside the body of the female.

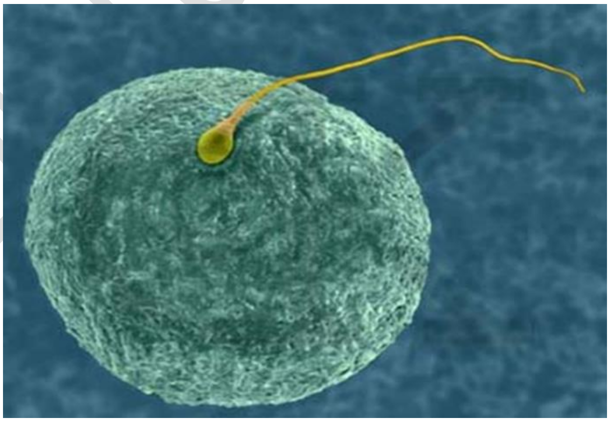


Figure 16:Fertilization

The main results of fertilization are as follows:

1- Restoration of the diploid number of chromosomes**,** half from the father and half from the mother. Hence, the zygote contains a new combination of chromosomes different from both parents.

2- Determination of the sex of the new individual. An X-carrying sperm produces a female (XX) embryo, and a Y-carrying sperm produces a male (XY) embryo. Hence, the chromosomal sex of the embryo is determined at fertilization.

3- Initiation of cleavage**.** Without fertilization, the oocyte usually degenerates 24 hours after ovulation.

Zygote is a fertilized egg. A fertilized egg becomes an embryo as soon as the first cleavage occurs.The zygot ultimately, produced a diploid multicellular organism by the several repeated and organised mitotic divisions and cellular differentiation.

3- Cleavage

The development of a normal, adult animal from a zygote involves a series of distinct steps in which specific takes are accomplished, *cleavage*, the mitotic division of the egg or , is the first step after fertilization and is a universally occurring phenomenon among metazoan animals, very little growth occurs. The cells that arise from cleavage are known as blastomeres.

-The pole of the egg with the highest concentration of yolk is referred to as the vegetal pole while the opposite is referred to as the animal pole.

Influence of yolk on cleavage, in two ways:

1- It affects the rate of cleavage
2- It determines the pattern of cleavage

When the yolk is abundant, it tends to retard and even inhibit the process of cleavage. As a result, the blastomeres which are rich in yolk tend to divided at a slower rate, and consequently they remain larger than those which have less yolk. The yolk is more concentrated at the vegetal pole. Therefore at the vegetal pole the cleavage in most retarded, and also where the blastomeres are larger in size.

Planes of cleavage

Cleavage is initiated by the appearance of a groove or constriction called cleavage furrow. The furrow appears first at one point of the egg. For example, the furrow appears at the animal pole. The furrow then deepens and extends downward on both sides. The two ends meet at the vegetal pole. The furrow then extendeds inwards radially, finally constricting the egg into two blastomeres.

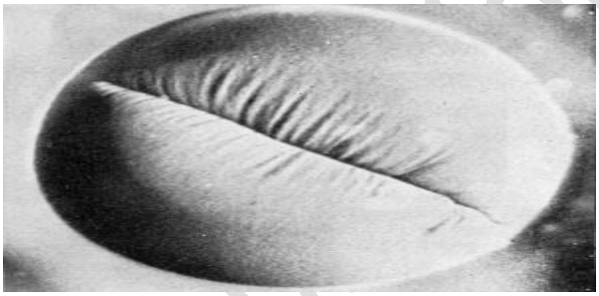


Figure 17:cleavage

The cleavage furrow divide the egg at different angles or plans. There are four main planes of cleavage. They are as follows:

1- Meridional plane

The cleavage furrow passes through the center of animals-vegetal axis and bisects the both poles of the egg.

2- Vertical plane

The cleavage tend to pass in a direction from the animal pole toward the vegetal pole. It does not pass through the median axis of the egg.

3- Equatoril plane

The cleavage furrow bisects the egg at right angles to the main axis and half way between the animal and vegetal poles.

4- Latitudinal plane

The cleavage furrow is similar to the equatorial but it courses through the cytoplasm on either side of the equatorial plane. It also called transverse or horizontalplane.

Patterns of cleavage

Determinate cleavage

Determinate cleavage (also called mosaic cleavage) is in most protostomes. It results in the developmental fate of the cells being set early in the embryo development. Each blastomere produced by early embryonic cleavage does not have the capacity to develop into a complete embryo

Indeterminate cleavge

A cell can only be indeterminate (also called regulative) if it has a complete set of undisturbed animal/vegetal

cytoarchitectural features. It is characteristic of deuterostomes – when the original cell in a deuterostome embryo divides, the two resulting cells can be separated, and each one can individually develop into a whole organism.

In the absence of a large concentration of yolk, four major cleavage types can be observed in isolecithal cells (cells with a

small even distribution of yolk) or in mesolecithal cells (cells with a moderate amount of yolk)

1- Bilateral holoblastic cleavage 2- Radial holoblastic cleavage 3- Rotational holoblastic cleavage 4- Spiral holoblastic cleavage.

In holoblastic eggs, the first cleavage always occurs along the vegetal-animal axis of the egg, the second cleavage is perpendicular to the first. From here, the spatial arrangement of blastomeres can follow various patterns, due to different planes of cleavage, in various organisms.

1- Complate or holoblastic cleavage

In holoblastic, total or complete cleavage, the entire egg divides by each cleavage furrow. It may be :

1-Bilateral holoblastic cleavage.

The first cleavage results in bisection of the zygote into left and right halves. The following cleavage planes are centered on this axis and result in the two halves being mirror images of one another. In bilateral holoblastic cleavage, the divisions of the blastomeres are complete and separate; compared with bilateral meroblastic cleavage, in which the blastomeres stay partially connected.

2- Meroblastic (partial)cleavage

In meroblastic cleavage, only a portion of the egg divides (partial or incomplete cleavage. It is characteristic of telolecithal eggs.

a- Discoidal meroblastic cleavage

It occurs in fishes, reptiles, and birds. Here the cytoplasm is placed at the animal pole as a disc called blastodisc, and this disc alone divides, the huge mass of yolk does not participate in cleavage.

b- Superficial meroblastic cleavage

In centrolecithal ovum, the cleavage remains restricted to the peripheral cytoplasmic investment. As in insects, where there is a moderate to large amount of yolk, and it is concentrated in the center of the egg. This means that although there is resistance to cleavage plane development in the center of the egg, it is easier to develop cleavage plane at the periphery of the egg – and thus early zygote.

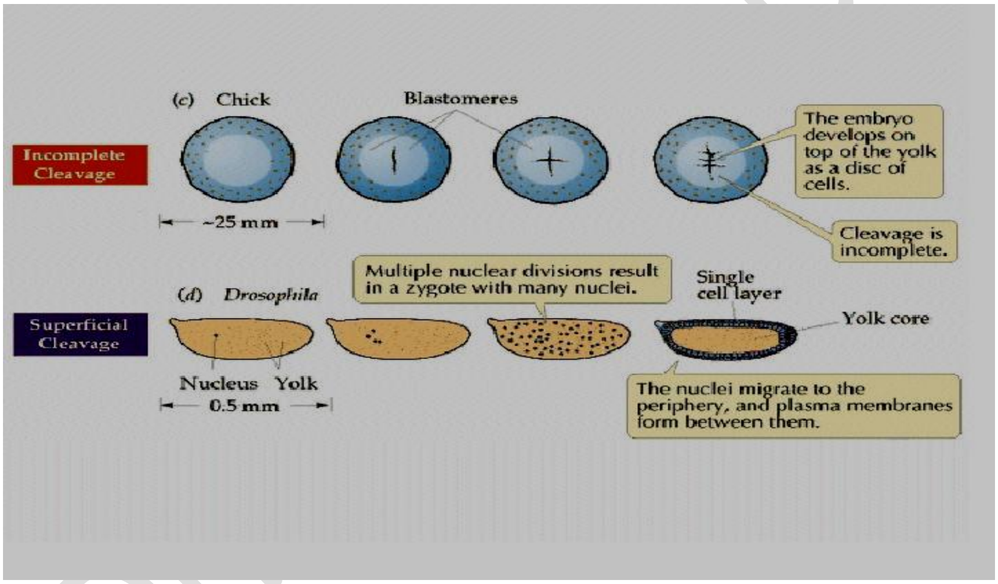


Figure 18: Meroblastic cleavage

3-Radial cleavage

In radial cleavage the cleavage furrows appears in such that each of blastomeres of the upper tier lies over the corresponding blastomeres of the lower tiers

This pattern of cleavage is one in which the organism viewed from above (dorsal, animal pole) is essentially radial in symmetry- where a dorso-ventral slice in any plane will yield a set of mirror images. As in deuterostomes.

4-Spiral cleavag

Spiral cleavage is an early cleavage pattern in which cleavage planes are not parallel or perpendicular to the animal-vegetal pole axis of the egg. Cleavage takes place at oblique angles, forming a "spiral" pattern of daughter blastomeres. As in Protostomes

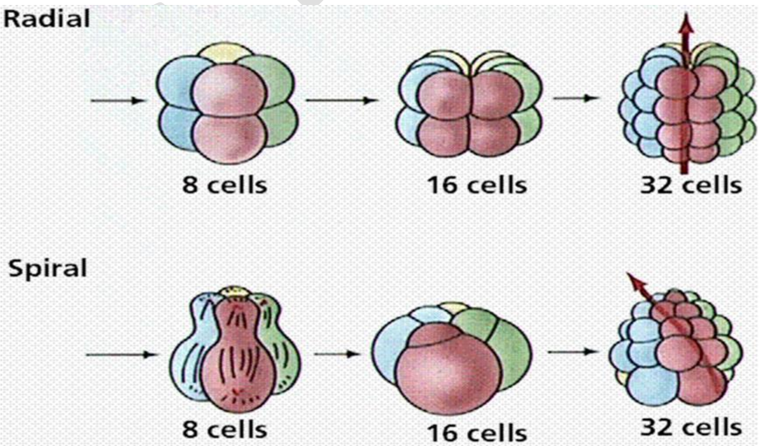


Figure 19:Radial and spiral cleavage

Embryonic development of Amphioxus

Phylum: Chordata – Class: Cephalochordata

Fertilization : External.

Type of Egg: According to amount of yolk oligolecithal. According to distribution of yolk isolecithal.

Type of cleavage: Equal holoblastic cleavage.

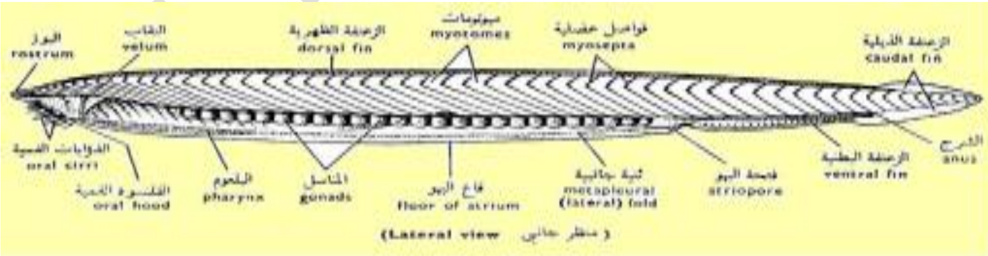


Figure 20: Lateral view of Amphioxus

Cleavage and blastula formation of Amphioxus

The first cleavage is longitudinal and gives two equal blastomeres.

The second cleavage is vertical on the first and gives 4 equal blastomeres.

The third is horizontal above the equatorial line and gives 8 blastomeres, 4 small upper micromeres and 4 large lower (yolkier) macromeres.

The Fourth : two vertical cleavage gives 16 blastomeres.

The Fifth : two Meridional (horizontal) gives 32 blastomeres.

The cleavage proceeds with irregular manners with increased in the number of cells. Up to this stage, the blastomeres remain loosely packed and form the embryonic stage, called **morula.**

Meanwhile, a semifluid materials accumulates in the centre of this mass of cells. This fluid serves to push all the blastomeres outwards, so that they become arranged in single layer called blastoderm, enclosing a central fluid filled cavity, the blastocoel.

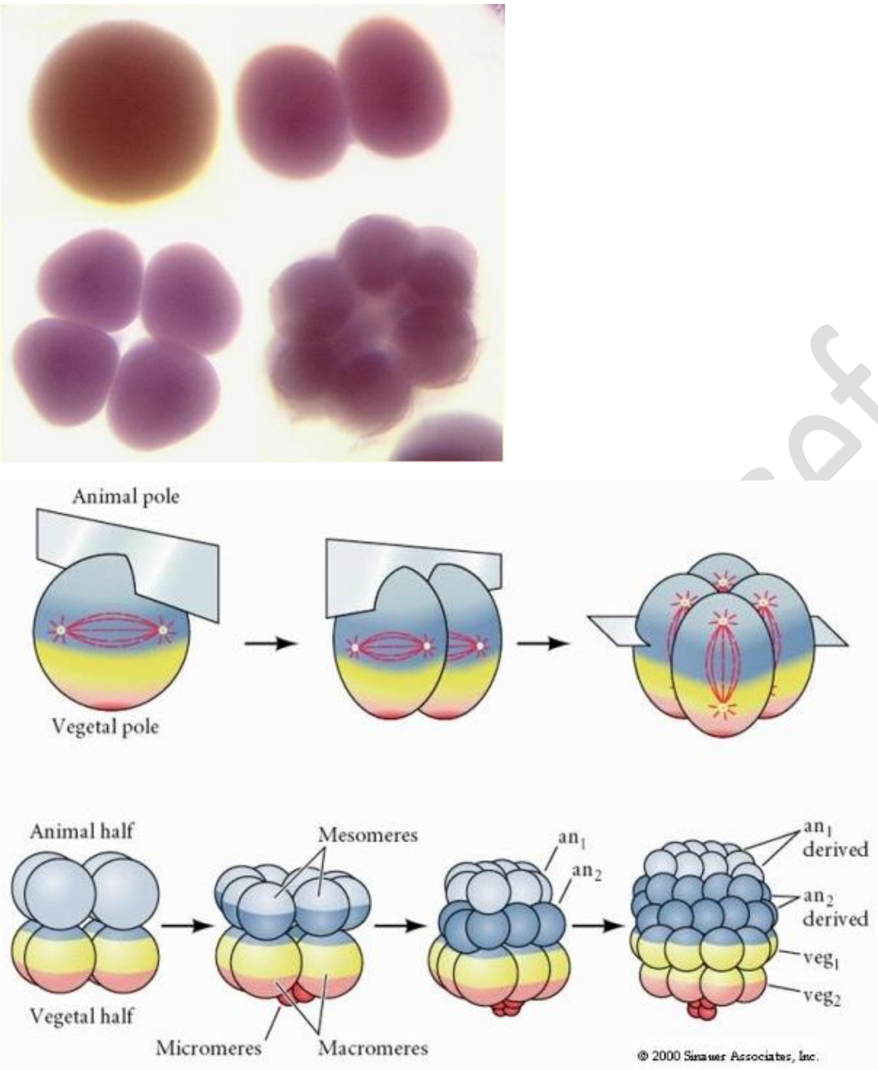


Figure 21 :Cleavage of Amphioxus

-The Blastula

is a hollow ball of a single layer of cells. The cavity of the blastula (the blastocoele), is centric. The cells of the vegetal hemisphere (the prospective endoderm) are somewhat richer in the yolky material than the other cells and slightly larger than those of the animal hemisphere (the prospective ectoderm).

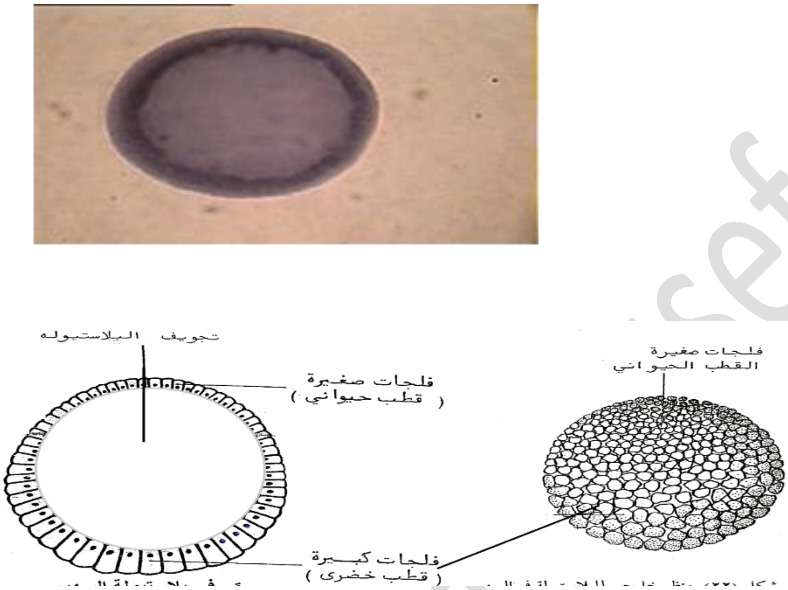
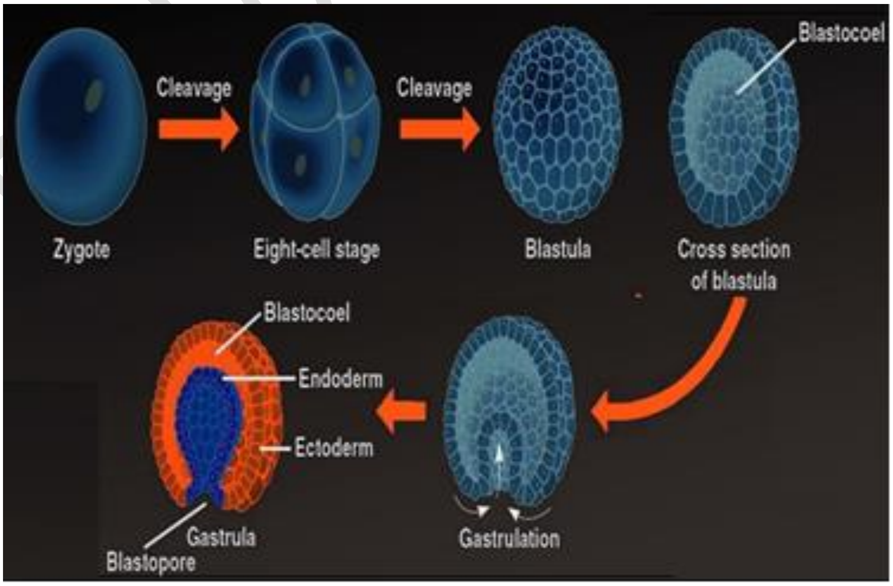


Figure 22: T.S. of blastula



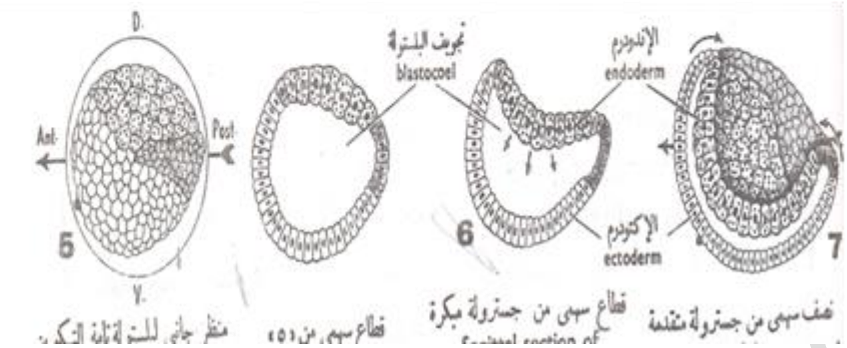


Figure 23: Formation of gastrula (gastrulation)

Gastrulation

This occurred as a result of different cell movements simply by invagination of the macromeres inwards the micromeres, thus the blastocoel decreased in size and a new cavity appears called gastrocoel or archenteron. Gastrulation rearranges the blastula to form a three-layered embryo with a primitive gut

The three germ layers are outer ectoderm, inner endoderm and mesoderm in between.

Diploblastic gastrula **= 2** germ layers.

Triploblastic = **3** germ layers

Fates of the Primary Germ Layers

Ectoderm

– hair, nails, epidermis, brain, nerves

Mesoderm

– Notochord, dermis, blood vessels, heart, bones, cartilage, muscle

Endoderm

– internal lining of the gut and respiratory pathways, liver, pancreas

Embryonic development of Toad

Phylum: Chordata – Class: Amphibia

Fertilization : External.

Type of Egg: According to amount of yolk mesolecithal. According to distribution of yolk telolecithal.

Type of cleavage: Unequal holoblastic cleavage.

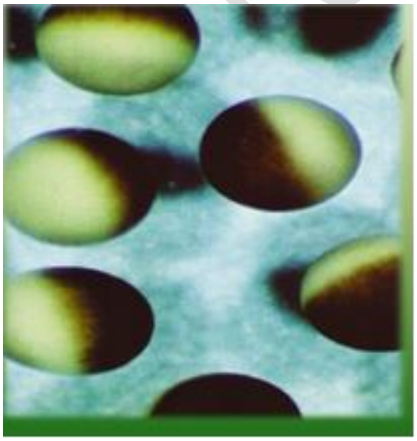
Adult toads live on land most of the time and rely on water for hydration, breeding, and temperature regulation.

Figure 24: Toad egg

The toad eggs

The upper hemisphere of the frog egg is black due to the presence of many pigment granules which is called animal hemisphere or animal pole. The dark colour of the egg is an adaptation for absorbing and retaining heat as eggs are laid in water when ponds and streams are very cold. The other half is lighter in colour provided with yolk; this is called vegetal pole or yolk pole. The nucleus is situated in the upper pigment part.

During fertilization: The whole spermatozoon enters the ovum. The tail then disintegrates, the head and middle piece travel carrying a trail of black pigment behind it which results an area opposite the sperm entrance point, to have a slightly decreased pigment content. This lighter pigmented area is called the gray crescent.



Cleavage:-

The first cleavage plane is meridional. This cleavage furrow first appear near the animal pole and progressively extend towards the vegetal pole of the egg. It cuts the egg through its median animal-vegetal polar axis and results in 2 equal sized blastomeres.

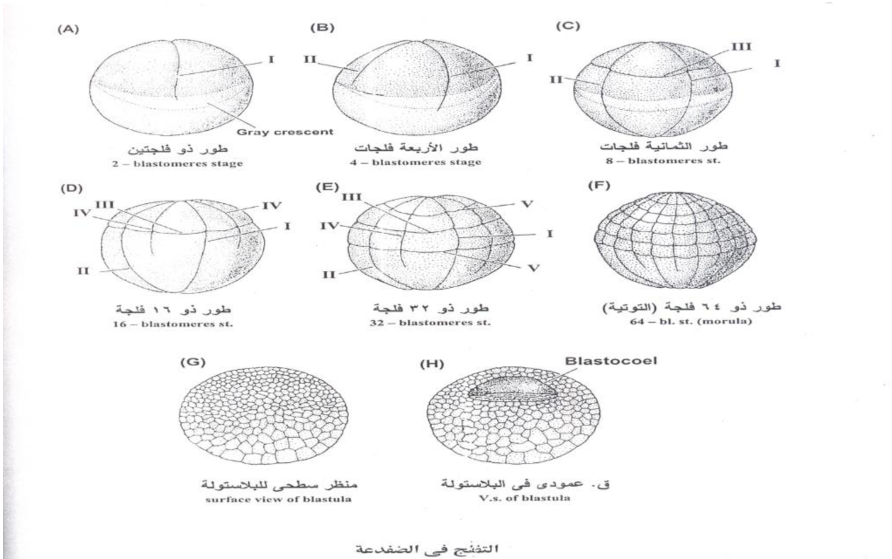
The second division is holoblastic and equal, and the planes are meridional, but at the right angle to the first plane and results in 4 equal sized blastomeres.

The third division is latitudinally parallel to the axis, and displaced as they are toward the animal pole, due to the unequally distributed yolk.The resulted 8 blastomeres consists of four small-sized (the micromeres) and four large-sized yolk- rich, vegtal cells (the macromeres).

The fourth cleavage is usually double. It tends to be vertical,. The furrows begin near the center of the animal pole and progress vegetally, dividing each of the original four blastomeres of the animal hemisphere resulted in 16 blastomeres. The uppermost cells (micromeres) divides most rapidly, while the vegetative cells divides more slowly.

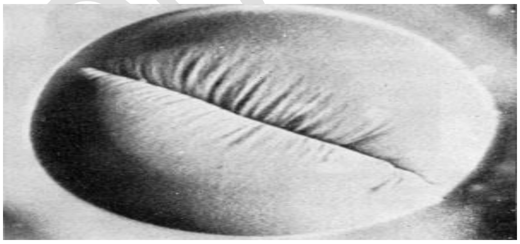
The fifth cleavage (also double), which should provide a 32-cell. The smallest cells, which contain the most pigment, are now found at the animal pole, and the largest blastomeres with no pigment and the most yolk are at the vegetal pole.

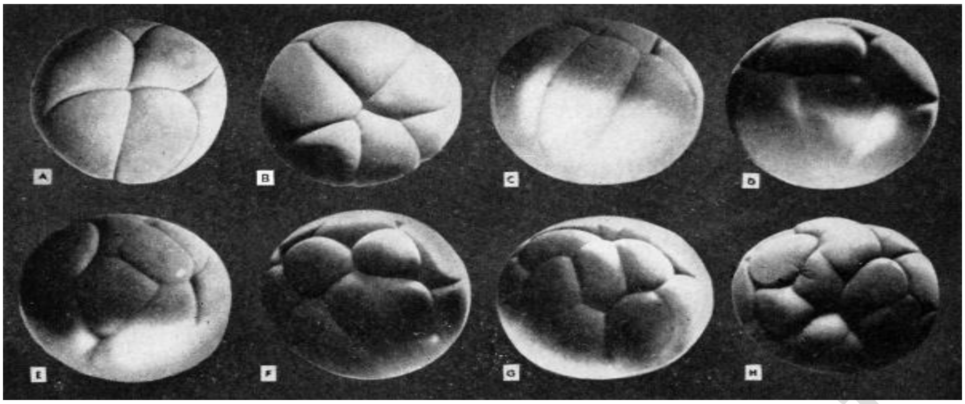
The cleavage proceeds with irregular manners with increased in the number of cells



Cleavage of a frog egg. Cleavage furrows are designated by Roman numerals in order of appearance. The vegetal yolk impedes the cleavage such that the second division begins in the animal region of the egg before the first division has divided the vegetal cytoplasm. The third division (C) is displaced toward the animal pole. The vegetal hemisphere ultimately contains longer and fewer blastomeres than the animal half. (After Carlson, 1981.)

Figure **25: Cleavage and blastula formation of toad**



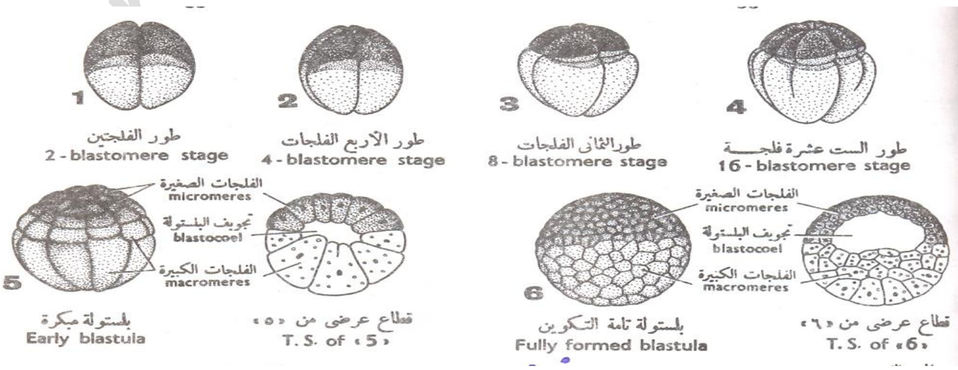


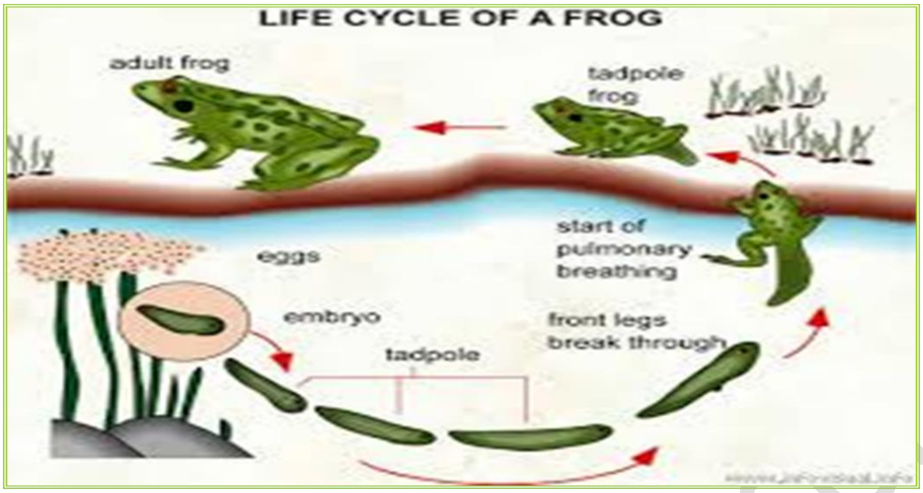
The toad blastula

Blastula is a hollow spherical embryonic stage. The blastoderm remains two-cell thick towards the animal pole of the egg, the sides and floor of the blastoceol are multilayered blastoderm of large yolky blastomeres.

-The blastoderm encloses ecenteric (peripheral) blastocoel.

-The blastocoel becomes infiltered by water and albuminous fluid secreted by the surrounding blastomeres.




LIFE CYCLE OF A FROG
adult frog
tadpole
frog
start of
pulmonary
breathing
eggs
embryo
front legs
break through
tadpole

Embryonic Development of Birds

Phylum: Chordata – Class: Aves (birds)

Fertilization : Internal.

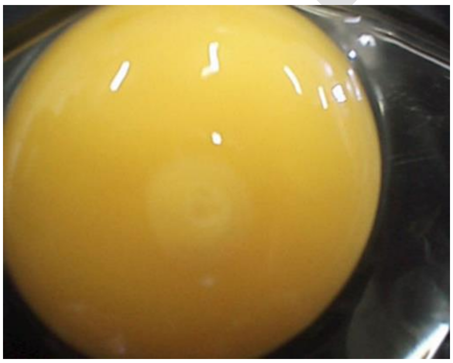
Type of egg : According amount of yolk : Macrolecithal. According to distribution of yolk: telolecithal.

Type of cleavage : Discoidal meroblastic cleavage.(Cleavage is restricted to the blastodisc).

BLASTODISC is the portion where the embryo will form.

Reptiles and birds laid eggs with protective shell and a series of cellular membranes surrounding the embryonic .body

These membranes assist the embryo in vital functions, such as nutrition, gas exchange, and removal or storage of waste materials.



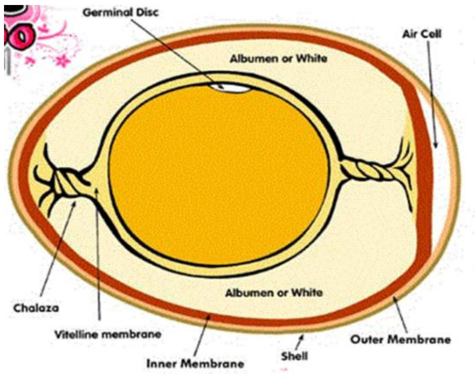
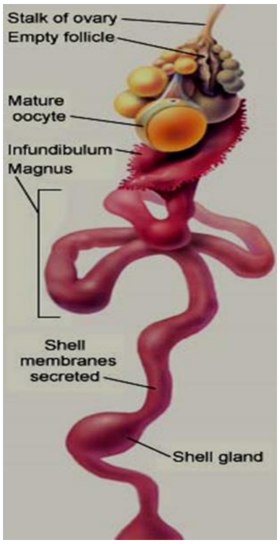
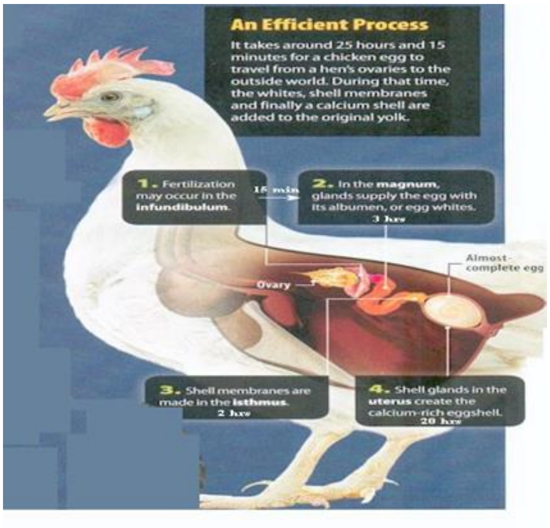


Figure 26: birds egg





Early embryonic development of birds

The first Cleavage is vertical and give two blastomeres, the cleavage don't even pass entirely through the blastodisc.

The second cleavage at right angle to the first and give 4 blastomeres.

The third cleavage is two parallel furrows lies at right angles to the second cleavage result in 8 blastomeres.The furrows do not even reach the edge of the blastodisc.

The fourth cleavage also two furrows result in 16 blastomeres.

-The cleavage proceeds with irregular manners with increased in the number of cells and spread over the surface of the yolk. After awhile we can distinguish two groups of blastomeres.

- Central blastomeres that are completely bounded.
- Marginal blastomeres that are continuous with the rest of the undivided blastodisc

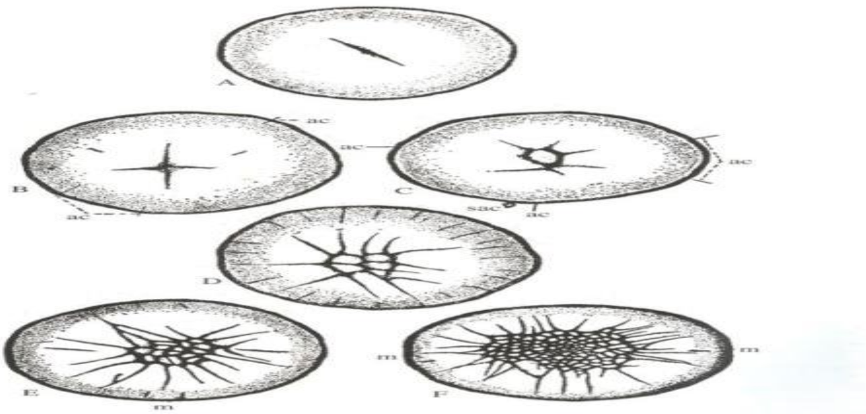
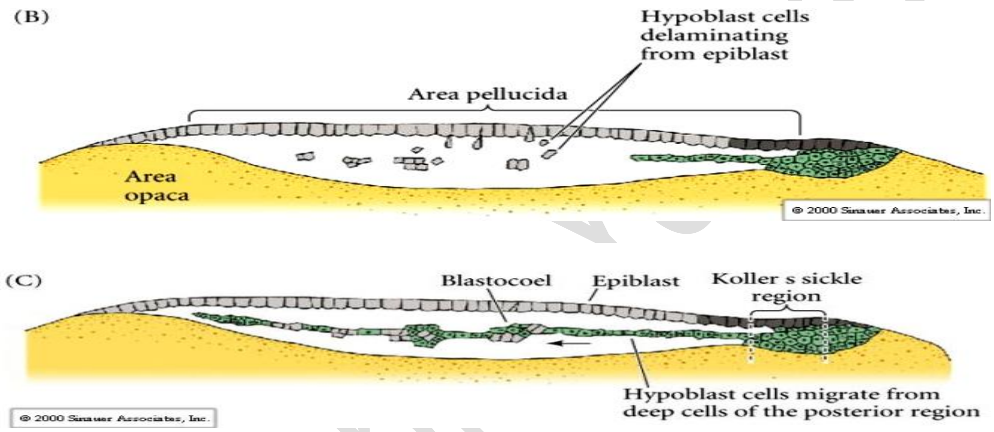


Figure 27: Cleavage and blastula formation of birds

BLASTODERM is a multilayered plate formed with a cavity beneath it. The cavity below it is called the subgerminal space.

The Blastula stage:

Some of the cells of the blastoderm above the subgerminal space are somewhat more heavily laden with yolk than others. they migrate down closer to the subgerminal space. It results in a two-layered embryo. The upper layer is called the epiblast and the lower layer is called the hypoblast. Then, a space develops between the epiblast and the hypoblast, called blastoceol



Embryonic Development of Mammals

Mammals classification according the embryonic development

into

1- Prototheria (primitive mammals) that lay eggs

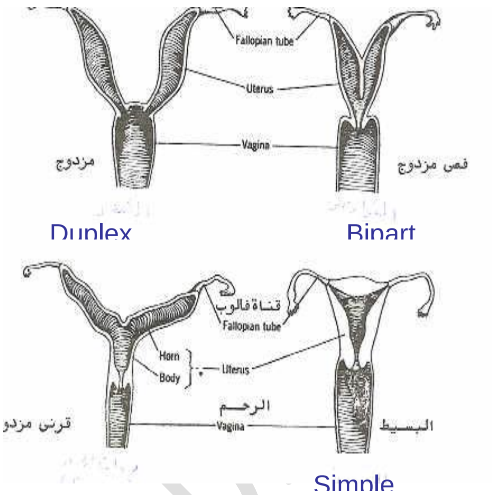
2- Metatheria (pouched mammals)

3- Eutheria (placental mammals) Represent 94% of the class Mammalia.

Types of Mammals Uterus

1- Simple uterus 2- Duplex uterus

3- Bipartite 4- Bicornate uterus



Bicornate

Early Embryonic Development of human

Fertilization : Internal. Type of eggs : Alecithal type.

Type of cleavage: Holoblastic.

First Cleavage: Occurs at right angles to the axis and results in the formation of two blastomeres, takes place while embryo is still in the uterine tubes of the mother.

Second Cleavage: Mammals have what’s known as ROTATIONAL CLEAVAGE wherein one of the blastomeres divides meridianally, and the other equatorially.

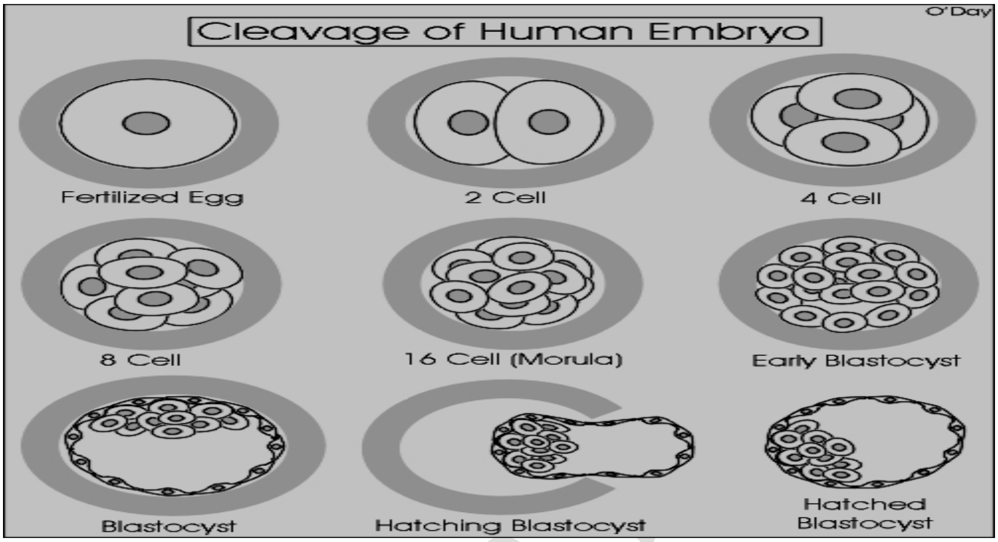


Figure **28:cleavage and blastula formation of mammals**

Subsequent Cleavages are relatively less organized. At 3 days : The morula stage is formed. At 4-5 days :blastula stage is formed with The outer periphery trophoblast cells and the inner cell mass. The embryo still surrounds by zona pellucida to make close contact of the blastomeres.

At the 6th day , the zona pellucida become lysed after the blastula reached to the proper side of the endometrium (Hatching of blastula). By the end of 8-10 days implantation is completed.

Twins

1-Binovular or dizygotic twins :

Occurred either naturally or as a result of ovarian stimulation lead to ovulate two eggs or more and then each fertilized by a sperm. The twins have totally different genetic characters.They may or may not be of different sex.

2- Identical or monozygotic twins:

Develops from a single fertilized ovum. They result from splitting of the zygote at various stages of development. Both have strong resemblance in blood groups, fingerprints, sex, and external appearance.

Modes of monozygotic twins

1-A cleaving embryo may split at an early stage of development, occur at the two-cell stage allowing the two portions to develop as completely separate embryos. And each embryo has its own placenta and chorionic sac.

2-At a later stage of development the inner cell mass may split into two separate masses within the same blastocyst cavity. The two embryos have a common placenta and a common chorionic cavity, but separate amniotic cavities.

3- If the inner cell mass does not become completely subdivided, conjoined twins may result. Conjugation may occurred in different parts of the body.

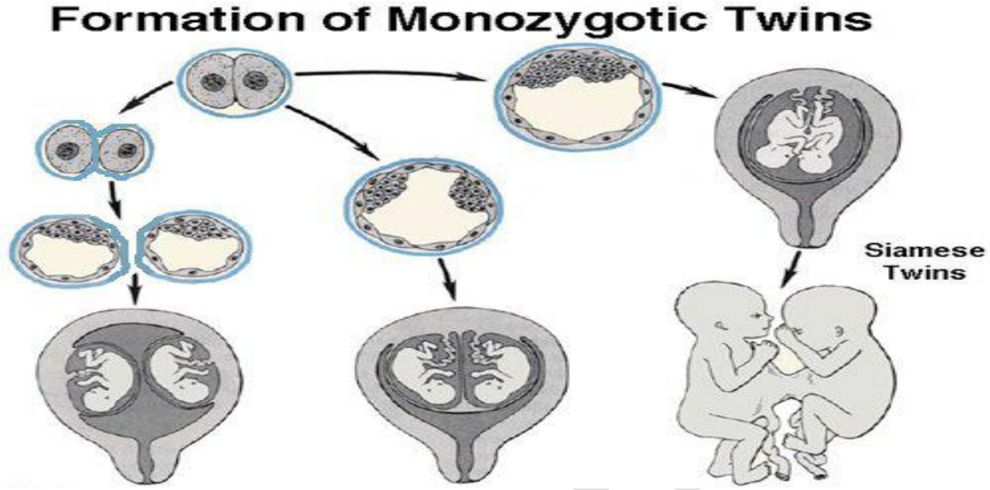


Figure **29: Formation of monozygotic twins**

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Ecology

Lecture 1

Ecology, according to the usual definition, is the scientific study of the relationship between organisms and their environment.

That definition is good so long as we consider relationship and environment in their fullest meaning.

The environment includes not only the physical but also the biological conditions under which an organism lives. relationship includes interactions with the physical world and with members of other and the same species.

The term ecology was originally coined by the German Zoologist Ernst Hackle in 1866. The term ecology comes from the Greek word "oikos" meaning "home".

A more informative definition has been suggested by Krebs (1974), who defined ecology as " the scientific study of the interactions that determine the distribution and abundance of organisms " This definition has the merit of pinpointing the ultimate subject matter of ecology:

the distribution and abundance of organisms, where they occur, how many there are and what they do.

Organisms interact with their environment within the context of the ecosystem.

The eco part of the word relates to the Environment.
The system part implies that the ecosystem is a system.
A system is a collection of related parts that function as a unit.
Thus, the ecosystem has interacting parts that support a whole. Broadly, the ecosystem consists of two basic interacting components: the living or biotic, and the physical or abiotic. For example, in a natural ecosystem; a forest, the physical component consists of the atmosphere, climate, soil, and water.

Ecosystem components

The various kinds of organisms that inhabit the forest make up populations.
The term population has many uses and meanings in other fields of study.
In ecology, " a population is a group of (potentially) interbreeding individuals occurring together in space and time ".
this definition implies that the individuals comprising the population are of the same species.
Population of plants and animals in the ecosystem do not function indepently of each other.
Some populations compete with populations for limited resource, such as food, water, or space.
In other cases, one population is the food resource for another.

Two populations may mutually benefit each other.
All populations within an ecosystem are referred to as a community and have some connection to one another.

Community and the physical environment make up the ecosystem.
So, the ecosystem has many levels. One level individual organism. Including humans, both respond to and influence the physical environment.
At the next level, individuals of the same species from the populations. Further, these populations interact with each other forming the community.
Combined, the ecosystem of Earth from the planetary ecosystem, or biosphere.

Mini-Glossary of Ecology Terms

Population : A group of organisms of the same species that live together.

Community : All the living organisms found in a particular environment. Includes all Populations of different species that are living together.

Ecosystem : A Community and environment. Includes all the interactions between living things and their physical environment.

Biosphere : All of the Earth's living organisms. Includes all the communities on Earth.

Ecosphere : The largest, worldwide ecosystem. It encompasses all the living things on Earth and their interactions with each other, the land, the water, and the atmosphere.

Organism and its Environment

All living organisms are constantly interacting with their environment.
Animals consume plants and other animals. They digest food, absorb, nutrients, and discharge waste products.
For an organism to succeed, it needs to find essential resources and supporting conditions.
If the organism can survive, grow, and reproduce under a given set of environment conditions, we say it is adapted to that environment.

If the environment does not offer the resources and conditions for its survival, the organism dies.

Variations in environment conditions

All organisms live in a varying physical environment of temperature moisture, light, and nutrient.
These factors differ from location to location – in latitude, region and locality.
In addition, at any location, the physical environment varies with time - yearly seasonally and daily.

Solar radiation directly influences air temperature, atmospheric moisture, and light. To a large extent, it defines the general physical environment in which organisms live.
The amount of solar radiation reaching any point of Earth's surface and the resulting patterns of surface air temperature vary both spatially and temporally.
Organisms at any location face both seasonal and daily variations in temperature.
The variations are greatest in the temperate regions, where differences between average daily temperature in the winter and summer can be extreme.

In an ever-changing physical environment, organisms must maintain a fairly constant internal environment, within narrow limits required by their cells, organs, and enzymes. For example, the human body must maintain internal temperature within a narrow range around 37.

An increase or decrease of only a few degrees from this value could prove fatal.

Likewise, organisms must maintain certain levels of water, acidity, and salinity to mention a few factors.

Maintaining these constant conditions requires continuous exchange of energy and materials between organisms and the external environment.

The organisms must consume and digest food to adjust their metabolism.

Then it must excrete by-products and wastes from these chemical processes.

The maintenance of conditions within the range that the organisms can tolerate is called ***homeostasis***.

Limiting factors: -

Limiting factor definition

In biology, the term *limiting factor* is defined as an environmental factor or variable that has the capacity to restrict growth, abundance, or distribution of a population in an ecosystem. These factors are present in limited supply. Thus, organisms tend to compete for their limited availability in the ecosystem.

Principles and laws

The principle of limiting factors is defined as the principle whereby a factor that is in shortest supply will limit the growth and development of an organism or a community.(1) Liebig's *law of the minimum*, Blackman's *law of limiting factor*, and Shelford's *law of tolerance* are the laws that explain the principles of limiting factors.

Liebig's Law of Minimum

In the 19th century, the German scientist Justus von Liebig formulated the "Law of the Minimum," which states that if one of the essential plant nutrients is deficient, plant growth will be poor even when all other essential nutrients are abundant.
In another definition: -
Growth is dependent on the amount of food stuff that is present in minimum quantity.

Blackman's *law of limiting factor*

The law of limiting factor was proposed in 1905 by the British plant physiologist, Frederick Frost Blackman. According to this law, a process that depends on multiple factors will have a rate limited by the pace of the slowest factor. Photosynthesis, for example, is a biological process that depends on multiple factors. The general chemical reaction of photosynthesis is $6CO_2+12H_2O+energy=C_6H_{12}O_6+6O_2+6H_2O$. Based on this equation, CO_2, H_2O, and light energy (sunlight) are the limiting factors of this reaction. If any of them become accessible at a pace slower or lower than the usual, the rate of photosynthesis is expected to become slow based on the pace of the slowest factor. For example, if CO_2 concentration becomes scarce (e.g. due to closure of stomatal openings in response to elevated temperatures in the environment), the rate of photosynthesis becomes slow even if H_2O and light energy levels are amply available. The same result will occur if light energy becomes less available or less intense, the rate of photosynthesis will be slower despite the abundance of CO_2 and H_2O. Light becomes a limiting factor in photosynthesis when the plant is unable to collect light, for instance, due to shade resulting from the dense population of plants.

Limiting factors by Shelford, 1932

Organisms may be limited in their growth and their occurrence not only by too little of an element or too low an intensity of factor but also by too much of an element.

Range of tolerance

As the example of body temperature shows, there are limits to the range of the environment conditions over which homeostasis work.

A graph illustrates this range.

The X axis represents some feature of the physical environment, e.g., temperature.

An axis represents the response of the organism.

The response of an organism to physical environment falls along a bell-shaped curve describing performance (in this case the probability of survival).

The point along the X axis where the response of the organisms is the highest is called the optimum, the probability of survival decreases.

The two points (minimum and maximum) at which the survival intercepts the X axis represent the environmental conditions beyond which these two points an organism can survive, but not necessarily grow or produce.

The minimum and maximum values of the environment are referred to as the *environmental tolerance* of the organisms.

The figure represents the response of an organism to a range of values for a single factor: temperature.

However, organisms depend upon a wide range of environmental factors, each having an optimum of tolerance. To complicate things further the factors, interact.

In the example of body temperature in humans, an important homeostatic response to rising body temperature is evaporative cooling or sweating.

This response requires water. Therefore, water needed to survive is related to temperature.

Hot conditions demand an increase in water intake.

Organisms, than are limited by a number of conditions, and often by an interaction among them.

Organisms live within ranges from too much to too little the limits of tolerance.

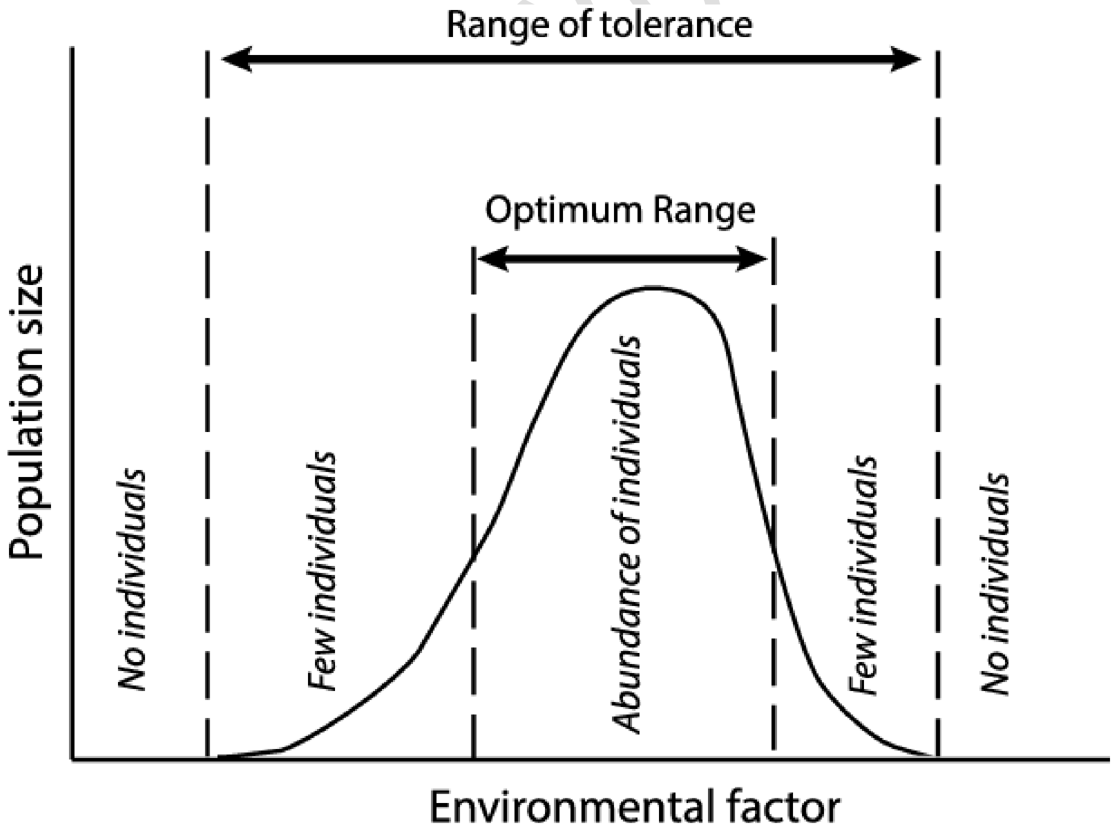
This concept, that minimum and maximum conditions limit the presence and success of an organism is called the *laws of tolerance*.

Minimum and maximum temperature tolerance define the limits of species and distribution.

Although conditions close to the tolerance may be sufficient to maintain survival, growth, and reproduction, their values will be much below those that occur closer to the optimum.

The nearer conditions approach the minimum and maximum tolerances of the organism, the fewer the individuals.

We would expect the abundance of a decrease to increase as we move toward optimal environment conditions.



Questions: -

1-What is the name of the feature that allows organisms to survive in the conditions of its habitat?

A. Adjustment

Lecture 2

ABIOTIC FACTORS

Abiotic (Physical) Factors

Climate is the combination of temperature, humidity, precipitation wind, cloudiness and other atmospheric conditions.

Climate determines the availability of heat and water. It influences the amount of solar energy that plants can capture.

Thus it controls the distribution and abundance of plants and animals.

Earth, immersed in sunlight, intercept solar radiation on the outer edge of its atmosphere.

The intercepted energy causes thermal patterns.

Coupled with Earth's rotation and movement around the sun, it generates the prevailing winds and ocean currents.

These movements of air and water in turn influence the distribution of rainfall.

Nevertheless, environmental conditions will be quite different underground or on the surface, beneath vegetation or on exposed soil or on mountain slopes.

Heat moisture, air movement, and light all vary greatly from one part of the landscape to another to create a whole range of localized climates. These microclimates define the conditions under which organisms live.

Light

Light is a driving force of life. Plants use visible light as an energy source to convert carbon dioxide and water to organic carbon compounds.

The hours of light and dark influence the daily and seasonal activities of terrestrial and shallow water organisms.

Of the total range of solar radiation that reaches Earth's atmosphere, the wavelengths making up the visible light are known as *photosynthetic active radiation*, because they include the wavelengths plants use in photosynthetic.

Wavelengths shorter than the visible range are ultraviolet.

Radiation with wavelengths longer than the visible range is infrared.

The ozone layer in the upper atmosphere (stratosphere) absorbs nearly all wavelengths, especially the violets and blues of the visible light.

Molecules of atmosphere gases scatter long wavelengths.

Periodicity

Daily and seasonal patterns govern life's activities. Bird song signals the arrival of dawn.

Butterflies, dragonflies and bees warm their wings, hawks being to circulate, and tree squirrels become active.

At dusk daytime animals retire, water-lilies fold, moonflowers open, and animals of the night appear.

Foxes, flying squirrels, owls, and Luna moths take over niches' others occupy during the day.

As seasons progress, day length changes, and activities shift.

Spring brings migrant birds and initiates the reproductive cycles of many plants and animals.

In fall the deciduous trees of temperate regions become dormant, insects and herbaceous plants disappear, summer birds return south, and winter birds arrive.

These rhythms are driven by the daily rotation of Earth on its axis and its 365- day revolution about the sun.

Through time, life has become attuned to the daily and seasonal changes in the environment. At one time biologists thought that organisms were responding only to external stimuli such as light intensity, humidity, temperature, and tides.

Laboratory investigations, however, have shown there is more.

Living organisms possess innate rhythms of activity.

At dusk in the forests of North America, the flying squirrel emerges from a tree hole. With a leap, the squirrel sails downward in along sloping glide, maintaining itself in flight.

Using its tail as a rudder and brake it makes a short upward swoop that lands it on the trunk of another tree.

It emerges into the forest world with the arrival of darkness, it retires to its nest before the first light of dawn.

The flying squirrel's day to day activity conforms to a 24 – hour cycle.

The correlation of the onset of activity with the time of sunset suggests that light has a direct or indirect regulatory effect.

If the flying squirrel is brought indoors and confined under artificial conditions of night and day, it will restrict its periods of activity to darkness and its periods of inactivity to light.

Whether the conditions under which the squirrel lives are 12 hours of darkness and 12 hours of light or 8 hours of darkness and 15 hours of light, the onset of activity always begins shortly after dark.

If we keep the same squirrel in constant darkness, it still maintains its pattern of activity and inactivity from day without any external cue.

Under these conditions the squirrel's activity rhythm deviates from the 24-hour periodicity defined by the diurnal cycle.

Its cycle of activity and inactivity in constant darkness varies from 22 hours 58 minutes to 24 hours, 21 minutes, the average is less than 24 hours. Because the cycle length deviates from 24 hours, the squirrel gradually drifts out of phase with the external world.

Circadian rhythm

This innate rhythm of activity and inactivity covering approximately 24 hours is characteristic of all living organisms, except bacteria. Because these rhythms approximate, but seldom match, the period of Earth's rotation, they are called *circadian rhythms* (from the Latin circa. "about" and dies, "day").

Circadian rhythms have a strong genetic component, transmitted from one generation to another.

Temperature changes have little effect on them, and they are not learned from or imprinted upon the organisms by the environment.

They do not adapt to specific local or regional environmental conditions.
Circadian rhythms influence not only the times of physical activity and inactivity, but also physiological processes and metabolic rates.
They provide a mechanism by which organisms maintain synchrony with their environment.

Thus, two daily periodicities – the external rhythm of 24 hours and the internal circadian rhythm of approximately 24 hours – influence the activities of plants and animals.
If the two rhythms are to be in phase, some external cue or time cue or time –setter must adjust the internal rhythm to the environment rhythm. The most obvious time setters are temperature, light, and moisture.
Of the three-master time – setter in the temperate zone is light. It brings the circadian rhythm of organisms into phase with the 24-hour photoperiod of their external environment.

Biological Clock

The circadian rhythm and its sensitivity to light and dark are the major mechanisms that operate the biological clock that timekeeper of physical and physiological activity in living things.
In multicellular animals the clock is within the brain.

To keep time, the clock has to have an internal mechanism with a natural rhythm of approximately 24 hours.

Recurring environmental signals such as changes in the time of dawn and dusk, should reset it.

The clock has to be able to run continuously in the absence of any environmental time-setter and the same at all temperatures Circadian.

Rhythm fits all these criteria.

Adaptive value of circadian rhythms

One adaptive value is that the biological clock provides the organism with a time-dependent mechanism.

It enables the organism to prepare for periodic changes in the environment ahead of time.

For example, trees of the African savanna begin leaf growth just prior to the onset of rainy season.

circadian rhythms help organisms with physical aspects of the environment other than light or dark. For example, the transition to night is accompanied by a rise in humidity and a drop in temperature.

Woodlice, centipedes, and millipedes, which lose water rapidly in dry air, spend the day in the darkness and damp under stones, logs and leaves. At dusk they emerge when humidity of the air is more favorable.

The circadian rhythms of many organisms relate to biotic aspects of their environment.

Predators such as insectivorous bats must match their feeding activity rhythm of their prey.

Moths and bees must seek nectar when flowers are open.

Flowers must open when insects that pollinate them are flying. The circadian clock lets insect, reptiles and birds orient themselves by the position of the sun. Organisms make the most economical use of energy when they adapt to the periodicity of their environment.

Critical day lengths trigger seasonal responses

In the middle and upper latitudes of the Northern and Southern hemispheres, the daily periods of light and dark lengthen and shorten with the seasons.

The activities of plants and animals are geared to the changing seasonal rhythms of night and day.

Most animals and plants of temperate regions have reproductive periods that closely follow the changing day lengths of the seasons.

For most birds the height of the breeding season is the lengthening days of spring for deer, the mating season is the shortening days of fall.

The signal for these responses is *critical day length*. When the duration of light (or dark) reaches a certain portion of the 24-hour day, it inhibits or promotes a photoperiodic response. Critical day length varies among organisms, but it usually falls somewhere between 10 and 14 hour.

Diapauses in insects of temperate regions, is controlled by photoperiod.

The time measurements in such insects is precise, usually 12 and 13 hours of light.

A quarter-hours difference in the light period can determine whether an insect goes into diapause or not.

The shortening days of late summer and fall forecast the coming of winter and call for diapause.

The lengthening days of late winter and early spring are the signals for the insect to resume development, pupate, energy as an adult, and reproduce.

Increasing day length induces spring migratory behavior, stimulate gonadal development, and brings on reproductive cycle in birds.

In mammals, photoperiod influences activity such as food storage and reproduction, too.

Seasonal changes: seasonality

In temperate zones, seasonal changes in plants and animals are clear, such as the unfolding of leaves in spring and the dropping of leaves in fall, the blooming of flowers and the ripening of seeds, and the migration of birds. In tropical regions, the dropping of leaves by some trees species and the fruiting by others mark the beginning of the dry season.

Such collective biological events, recurring with the seasons, make up *seasonality*.

Seasonality in temperate and arctic regions depends on changes in light and temperature. In a broad way, Seasonal changes in temperature and light cause alternate warm and cold periods.
The progression is gradual, however, and in temperate zones, seasons can be identified as early or late spring, early or late fall, and so on. Seasonality in tropical regions is keyed to rainfall.
The seasonal tropics have alternate wet and dry seasons, and their onset is abrupt.
The beginning of rainy season is a dependable environment cue by which plants and animals become synchronized to seasonal changes.

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America home of numerous species of fruit eating (frugivorous) bats, the reproductive periods track the seasonal production of food.

The birth periods of frugivorous bats coincide with the peak period of fruiting.

Young are born when both females and young will have adequate food insects and other arthropods reach their greatest biomass early in the rainy season in Costa Rican forests.

At this time the insectivorous bats give birth to their young.

Lect. 3

PHOTOPERIODISM

Photoperiod refers to the length of the light and dark portions of the 24- hours day. Because of the way in which the earth's axis is tilted, the length of day and night changes seasonally everywhere except at the equator.

In the northern hemisphere, the longest day occurs about June 21 and is called the summer solstice, the shortest day is December 21 , the winter solstice, the spring and autumn when day and night are each 21 hours occur on March and September,

the word photoperiodism mean the response of organisms to photoperiods. Photoperiodism should not be confused with the effect of light alone. Photosynthesis, phototaxis, and photoreceptors all have to do with the biological effects of light energy but are not necessarily involved in photoperiodism. Photoperiodism has to do with the biological effect of regulatory occurring periods of both light and dark.

Photoperiodism in Mammals

A number of internal physiological rhythms have been found in Mammals are related to photoperiodism

One of the simplest daily rhythms is that of hunger.

It is possible that the activity rhythm of an animal is determined by whether or not it is hungry. Perhaps the white footed mouse became active when it got hungry. Since its feeding behavior follows a day-to-day rhythm, hunger would account for the periodicity of its physical exercise.

Another well- known physiological rhythm is that of body temperature.

Mammals are worm-blooded, that is they maintain their body temperature at a rather constant level. But even so, there is a shallow daily cycle of temperature changes. Such a rhythm is more pronounced in a small mammal, such as a mouse, than in a larger one, such as a horse.

As the body temperature of the mouse reaches maximum in the middle of night. The lowest temperature of the day occurs around noon. During the middle of the daylight hours, the mouse will be rather quiet, and it is at this time that its body temperature is lowest. Mice are active at night, and it is at night that the animal's temperature is highest.

Lecture 4

TEMPERATURE

Temperature

Temperature has a pervasive influence on life. It affects rates of photosynthesis and energy storage in plants. It influences the need for moisture and the rates of chemical reactions in all living organisms.

It is a key to climate, microclimate, and distribution of organisms.

All organisms live and live and exchange energy with a thermodynamic environment – a world of heat and cold. They absorb solar radiation, which may be direct, diffused from the sky or reflected from the ground, as well as thermal radiation from rocks. Soil, vegetation and the atmosphere.

In addition, organisms produce heat during metabolic processes such as respiration and lose heat as infrared radiation.

To maintain a constant body temperature, organisms must both lose heat to and gain heat from the environment.

Green plants convert a considerable amount of incoming solar radiation.

To chemical energy through photosynthesis. They store this energy and pass it on to animals when consumed as food. Other radiation is converted directly to heat.

Whether produced by metabolism or absorbed, excess heat must be dissipated to the environment. When the surrounding or ambient temperature is lower than the temperature of the organisms. The problem, then, is for the organism to balance heat gains with heat losses to maintain a constant internal temperature.

The heat balance of an organism may be summarized by the following expression:

<u>Heat gain</u> (solar radiation + thermal radiation + food energy storage + conduction + convection) =

Heat loss (thermal radiation + conduction + convection + evaporation).

Physiological group of animals

Physiological animals can be divided into three group, according to the way they maintain temperature:

- One group, notably birds and mammals, relies primarily on stored energy to keep constant internal temperature independent of external temperature. This internal heat production is endothermy. These animals are *homeotherms*. They are popularly called " *warm-blooded*".
- A second group controls body temperature by external means. They gain heat through exposure to environmental sources and dissipate heat through conduction, convection and evaporation. This means of maintaining body temperature is *ectothermy*. Their body temperature is variable. These animals are *poikilotherms* and are often called *cold-blooded*. These animals include invertebrates' amphibians fish and reptiles.
- A third group regulates body temperature by endothermy at some time and by *ectothermy* at other times. These animals are *hetertherms*.

Poikilotherms

Poikilotherms gain heat easily from the environment and lose it just as fast.
Environmental temperature controls the rates of metabolism and activity among most Poikilotherms.
Rising temperature increases the rate of enzymatic activity, which controls metabolism and respiration.
For every 10 rise in temperature , the rate of metabolism in Poikilotherms doubles. They become active only when the temperature is sufficiently warm. Conversely, when ambient temperatures fall, metabolic activity declines, and they become sluggish.

Poikilotherms have an upper and lower thermal limit that they can tolerate. Most terrestrial Poikilotherms can maintain a relatively constant daytime body temperature by behavioral means, such as seeking sunlight or shade.
Lizards and snakes, for example, may vary their body temperature by no more than 4-5, and amphibians by 10 when active.
Aquatic Poikilotherms, completely immersed, do not maintain any appreciable difference between their body temperature and the surrounding water. They are poorly insulated.
Any heat produced in the muscles moves to the blood and on to the gills and skin, where heat transfers to the surrounding water by convection. Because seasonal water temperatures are relatively stable fish and aquatic

invertebrates maintain a fairly constant seasonal temperature. They exhibit a low range of temperature variation in any given season.

Fish and aquatic invertebrates adjust seasonally to changing temperature by *acclimatization*. They undergo physiological changes over a period of time. Poikilotherms have an upper and lower limit of tolerance to temperature that varies with the species. If they live at the upper end of their tolerable thermal range, Poikilotherms will adjust their physiology at the expense of being able to tolerate the lower range. Similarly, during periods of cold, the animals shift to a lower temperature range that would have been lethal before. Because water temperature changes slowly through the year, aquatic Poikilotherms can make the adjustment slowly. Fish are highly sensitive to rapid change in environmental temperatures. If they are subjected to a sudderl temperature change, they will die of thermal shock.

Homeotherms

Homeothermic birds and mammals meet the thermal constraints of the environment by being endothermic. They maintain body temperature by oxidizing glucose and other energy – rich molecules.

They regulate the gradient between body and air or water temperatures by seasonal changes in insulation (the type and thickness of fur, structure of feathers, and layer of fat), which Poikilotherms do not possess.

They rely on evaporative cooling and on increasing or decreasing metabolic heat production.

Homeothermy allows these animals to remain active regardless of environmental temperatures, although at high energy costs.

Insects are ectothermic and Poikilotherms, yet in the adult stage most species of flying insects are heterothermic.

When flying they high rates of metabolism, with heat production as great as or greater than heterotherms. Temperature is critical to the flight of insects.

Most cannot fly if the temperature of the thoracic muscles is below 30, nor can they fly if the muscle temperature is over 44. This constraint means that an insect has to warm up before it can take off, and it has to get rid of excess heat in flight.

With wings beating up to 200 time per second insects can produce a prodigious amount of heat.

Some insects, such as butterflies and dragonflies, warm up by orienting their bodies and spreading their wings to the sun. most warmup by shivering their flight muscles in the thorax. Moths and butterflies vibrate their wings to raise thoracic temperature above ambient.

Regulating body temperature

To maintain a tolerable and constant temperature during active periods, terrestrial and amphibian Poikilotherms resort to behavioral means. They seek out appropriate microclimates. Insects such as butterflies, moth bees, and dragonflies bask in the sun to raise their body temperature to the levels necessary to become highly active. When becomes too warm, these animals seek the shade.

Most reptiles are terrestrial and exposed to widely fluctuating temperatures. They bask in the sun to raise their body temperature. Snakes for example, heat up rapidly in the morning sun.

Endotherms also use microclimates to keep warm or cool. In the heat of a summer day, birds and mammals seek shady places. Desert mammals go underground by day and emerge at night. In winter, some mammals, such as rabbits go underground during periods of inactivity. Large mammals such as deer seek the thermal cover of conifer thickets. Mammals such as flying squirrels and birds such as penguins and quail huddle together during periods of cold, reducing individual surface area and conserving body heat.

Insulation

To regulate the exchange of heat between the body and the environment heterotherms and certain poikilotherms use some forms of insulation – a covering of fur, feathers, or body fat. For mammals, fur is a major barrier to heat flow, but its insulation value varies with thickness, which is greater on large mammals than on small ones. Small mammals are limited in the amount of fur they can carry, because thick coats could reduce their ability to move. Mammals change the thickness of their fur with season.

Evaporative cooling

Many birds and mammals, and even wasps employ evaporative cooling to reduce the body heat load. Birds and mammals lose some heat by evaporative of moisture from the skin. They accelerate evaporative cooling by sweating and panting. Only certain mammals have sweat glands, particularly horses and humans.

Lecture 5

Moisture

An organism's water balance is closely related to its thermal balance. It is difficult to discuss one without the other, sweating, which allows the evaporation of water is one-way animals reduce body heat generated metabolically during strong physical exertion.

Terrestrial animals and plants could never maintain their thermal and moisture balance without the unique features of water that make life on earth possible. Water is the medium by which elements and other materials make their never-ending odyssey through the ecosystem. Without the cycling of water decomposition and nutrient cycling could not proceed, ecosystems could not function, and life could not persist.

Water balance in animals

For animals the usual sources of gaining water are drinking water, water in food and metabolic water. Loss is through urine, faces and water evaporated problem in maintaining water balance. All animals, however, possess a universal mechanism, the excretory system, which is simple in some animals and complex in others.

Osmotic pressure moves water through cell membranes from the side of greater water concentration to the side of lesser water concentration, aquatic organisms living in fresh water have a higher salt concentration in their bodies than in the surrounding water.

Their problem is to prevent uptake or to rid themselves of excess water.
Protozoans accomplish that task by means of contractile vacuoles, which collect and expel waste. Freshwater fish maintain osmotic balance by absorbing and retaining salts in special cells and producing plentiful amounts of watery urine. Amphibians balance the loss of salts through the skin by absorbing ions directly from water and transporting them across the skin and gill membranes.

Terrestrial animals, such as birds and reptiles, have a salt gland and a cloaca, a common receptacle for the digestive, urinary and reproductive tracts. They absorb water from the cloaca back into the body. Mammals possess kidneys capable of producing urine with high osmotic pressure and ion concentrations.

In an arid environment, animals face a severe problem of water balance. They can solve the problem in one of two ways either by evading the drought or by avoiding its effects. Animals of semiarid and desert regions may evade drought by leaving the area during dry season. That is the strategy employed by many of the large African ungulates. The spade foot toad of the southern desert of the U.S.A aestivates below the ground and emerges when the rains return. Some invertebrates, such as flatworms which occupy ponds that dry up in summer, develop hardened cysts in which they remain for the dry period. Other aquatic or semi aquatic animals retreat deep into the soil until reach the level of groundwater. Many insects undergo diapauses.

Other animals remain active during the dry season but reduce respiratory water loss. Some small desert rodents lower the temperature of the air they breathe out. Moist air from the lungs passes over cooled nasal membranes, leaving condensed water on the walls. As the rodents inhale the warm, dry air is humidified and cooled by this water.

Some small desert mammals reduce water loss by remaining in burrows by day and emerging by night. Many desert mammals, such as camels, produce highly concentrated urine and dry feces and extract water metabolically from the food they eat.

In addition, some desert mammals can tolerate a certain degree of dehydration. Desert rabbits may withstand water losses of up to 50% and camels up to 27% of their body weight.

Animals in salty environment faces problems opposite to these in fresh water. These organisms must retain their body fluids. When the concentration of salts is greater outside the body than within, organisms tend to dehydrate. Osmosis draws water out of the body into the surrounding environment. In marine and brackish environments, organisms have to inhibit the loss of water by osmosis through the body wall and prevent an accumulation of salts in the body.

There are many solutions to this problem. Invertebrates get around it by possessing body fluids that have the same osmosis pressure as seawater. Marine bony fish absorb salt water into the gut. They secrete magnesium and calcium through the kidneys and pass these ions off as a partially crystalline paste. Fish excrete sodium and chloride, major, ions in seawater, by pumping the ions across special membranes in the gills.

This pumping process is one type of active transport. Salts move across a concentration gradient at the cost of metabolic energy. Sharks retain enough urea to maintain a slightly higher concentration of salt in the body than in surrounding seawater. Birds of the open sea can consume seawater because they possess special salt-secreting glands located on the surface of the cranium. Gulls and other seabirds excrete from these glands' fluids in excess of 5% salt.

In marine mammals the kidney is the main route for the elimination of salt. Porpoises have highly developed kidneys to eliminate salt loads rapidly. In marine mammals the urine has a greater osmotic pressure (ion concentration) than blood and seawater, their physiology is poorly understood.

Lecture 6

Pollution

Definition

Types of Pollution

Definition of pollution

Pollution is an unfavorable alteration in the physical, chemical or biological characteristics of air, water and land that may or will adversely affect human life, industrial life, industrial progress, living conditions and cultural assets.

Water pollution:

From the name itself, we can understand that water pollution is a type of pollution which involves contamination of many water bodies. Many creatures which live in these water bodies are totally dependent on these water bodies.

Causes of water pollution causes of water pollution are mentioned below:

Industrial waste which is dumped into water bodies and this dumped waste cause a chemical imbalance. This chemical imbalance results in the death of aquatic animals.

- The nearby streams and groundwater systems get insecticides, pesticides, and ripening chemicals which are used on plants.

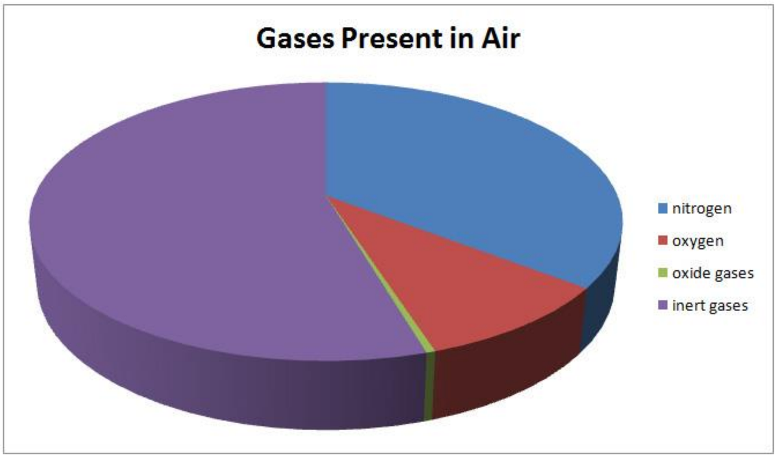
- Eutrophication is also a cause of water pollution and eutrophication is nothing but entering of detergent in lakes and rivers. This happens because of washing clothes near rivers and lakes. Eutrophication prevents sunlight from entering rivers and lakes; this prevention of sunlight decreases the value of oxygen in the water. Thus, results in an inhabitable environment.
- Damage to huge oil rigs and oil tankers which are present in oceans causes oil spills. This damage may be by either natural disaster or by human mistakes. Longtime damage is caused by oil spills because they also don’t allow sunlight to enter into water as oil is lighter than water and it floats on water.

- A few natural disasters like hurricanes and flash floods result in intermixing of harmful substances and water on land.

Air pollution

- Pollutants of air present in the atmosphere are called air pollution. Respiration is a vital life process which needs air. If we breathe air which has pollutants, then it will have bad effects on our health. Air is comprised of below gases:

Content of Gases Present in Air



- **Causes of air pollution** causes of air pollution are mentioned below:
- Burning rubber, wood, and discarded plastic release gases called carcinogenic gases into the atmosphere.

- Few industries release gases like sulfur dioxide and carbon monoxide and these gases mix with clouds and air and cause acid rains.
- Gases which are released from internal combustion of engines include gases into the atmosphere which are poisonous.

Greenhouse Effect

Generally, a physical property of the atmosphere of earth is referred to by an expression called greenhouse effect; if there is an absence of atmosphere then the temperature of the earth will be -18 degrees Celsius. Greenhouse gases absorb infrared radiation balance of energy of planet gets damage and along with this, there will be a dissimilarity in temperature. During present state, the atmosphere system of our planet maintains a balance in taking of solar radiation by emitting radiations of infrared in the balance.

Soil pollution

Soil pollution is nothing but stripping soil from its natural fertility by availing artificial chemicals like ripening agents, insecticides, and pesticides. Normally, plants are dependent on nitrogenous compounds for the purpose of their nutrition which is present in soil. Use of artificial chemicals like ripening agents, insecticides, pesticides absorbs the nitrogen which is present in soil and makes that soil unfit for plant's growth. Plants hold soil very firmly and when there is no growth of plants then it results in splitting of soil and at last causes soil erosion.

Thermal pollution:

Thermal pollution is the increase in temperature because of high amount of release of heat energy by unnatural methods or techniques and natural disasters. The heat energy released by manufacturing industries is transferred to water bodies and air. Outcome of thermal pollution is rise in temperature and this is an important cause for melting of polar ice caps.

Radioactive pollution:

- Radioactive pollution happens when radioactive metals release harmful beta rays. These beta rays could cause mutative diseases and cancer. This type of pollution happens because of following reasons:
- Damage to nuclear reactors results in radioactive contamination.
- Dumping of radioactive waste into water bodies which are produced from nuclear plants.
-

Noise pollution

- We have distinct qualities of sound and the sounds which are unpleasant to hear are known as noises. Thus, more noise in outdoors results to **noise pollution**. This kind of pollution has more physiological effects than physical effects. Noise pollution is caused because of the reasons mentioned below:
- Many vehicles honking at roads.
- Trains
- Clubs
- Overpopulated crowds
- If a heavy machinery is operated in an open area

Light pollution

Very bright lighting in big cities functions and much more causes pollution called light pollution. Bright lighting on retina not only causes discomfort to eyes but also results in straining of eyes and migraine.

Lecture 7
Populations

After studying the relationship of individual organisms to their physical environment, this part will turn to the biotic environment. How the individual interacts with others of its own species, and with competitors, predators, parasites, diseases, and mutualisms are the subjects of this part.

Properties of Populations

A population is a group of potentially interbreeding and interacting individuals of the same species living in the same place at the same time.

It is reproductively isolated from other such groups.

Population has unique features.

1 - They have an age structure,

2 - Density,

3 - and distribution in time and space.

4 -They exhibit a birthrate, a death rate, and a growth rate.

5 - They respond in their own ways to competition, to predation, and to other pressures.

6 - Individuals that make up a population affect one another in various ways.

7 - The relationship of one population with another influences the structure and function of whole ecosystems.

Density

Two outstanding attributes of a population are density and dispersion. Individuals in natural populations are affected by density. Trees in crowded stands may grow more slowly, and some may succumb to a lack of water, nutrients, and light, unequally shared. Scarce food may be denied to smaller or less aggressive mammals in a population.

Some birds may deny others access to nest sites when not enough sites exist to meet the demand. Having too few individuals in a population may reduce the chances of finding a mate or inhibit behavior essential to the welfare of the population. Low population density may raise an individual's risk of succumbing to predation. Affecting the welfare of individuals in all these ways, density in part controls a population's birth rates, death rates, and growth.

density is difficult to define and to determine. *Density* can be characterized as the number of individuals per unit of space, as so many per square kilometer, per hectare, or per square meter. That measure is *crude density*. The trouble with this measure is that individuals do not occupy all the space within a unit, because not all of it is suitable habitat. Biologists might estimate the number of deer living in a square kilometer. The deer, however, might avoid half the area, because of human habitation, land use, and lack of cover and food.

Dispersion

How organisms are dispersed over space has an important bearing on density. Individuals of the population may be distributed *randomly*, *uniformly* or in *clumps*. Individuals are distributed *randomly* if the position of each is independent of the others. some invertebrates of the forest floor, particularly spiders may be spaced at random.

By contrast, individuals distributed *uniformly* are evenly spaced. In the animal's world, uniform dispersion usually results from some form of competition, such *territoriality*.

The most common dispersion type is *clumped* dispersion, in scattered groups. Clumping results from responses to habitat differences, daily and seasonal weather changes, reproductive patterns, and social behavior. There are various degrees and types of clumping.

Group may be randomly or nonrandomly distributed over an area. Aggregation may range from small groups to a single centralized group. If environmental conditions encourage it, populations may be concentrated in long bands or strips along some features of the landscape, such as a river, leaving the rest of the area unoccupied.

Age structure

The population has an age structure. Because reproduction is restricted to certain age classes and mortality is most prominent in others, the ratio of the age groups depends on how quickly or slowly populations grow.

Population divide into three ecological period: prereproudductive reproudductive, and postreproudductive. The length of each period depends largely on the life history of organisms.

Among annual species the length of the prereproudductive period has little influence on the rate of population growth. In longer lived animals, the length of the prereproudductive period has a pronounced effect on the population's rate of growth. Organisms with a short prereproudductive period often increase rapidly, with a short span between generations. Organisms with a long prereproudductive periods, such as elephant and whales, increase slowly and have a long span between generations.

The age structure of a population is the ratio of the various age classes to each other at a given time. Age pyramids compare the sizes of age groups to help us visualize age structure. As the population changes with time, the number of individuals in each age class changes, and so do the ratios, a large number of young, which expands the base of the pyramid, characterizes a growing population.

This large class of young eventually moves up into the reproductive age classes. A high proportion of individuals moving into the older age classes characterize a declining population. With fewer young, fewer individuals will enter the reproductive age classes, further depressing the population. In this way age structure changes over time.

Life history Patterns

Reproductive is the major drive of all living organisms. The role of the reproductive drive is to transmit genetic characteristics from one generation to another. The ability of an organism to accomplish that successfully is termed its *fitness*. Fitness is equated with the ability of an organism to leave behind reproducing offspring. Individuals that leave behind the most reproducing offspring are supposedly the fitness. Achieving fitness involves, among other things, fecundity and survivorship, physiological adaptations, modes of reproduction age at reproduction, number of eggs or young produced, parental care, size, and time to maturity. How organisms achieve fitness becomes the organism's Life history Pattern.

Reproduction

Reproduction falls into two categories: *asexual* and *sexual*. *Asexual* reproduction creates new individuals genetically the same as the parent. The one – called *Paramecium* reproduces by dividing in two. Hydra reproduce by budding. Aphids produce eggs by normal cell division or mitosis that develop into female adults without fertilization. A process called *parthenogenesis*. However, organisms that rely heavily on asexual reproduction revert on occasion to sexual reproduction. Hydras at some time in their life cycle produce eggs and sperms. At the end of summer aphid resort to sexual reproduction to make males.

sexual reproduction: is common in multicellular organisms. Two individuals produce haploid gametes: egg and sperm, that combine to form a diploid cell or zygote. This halving and recombination of genes allow the gene pool to mix, producing genetic variability among offspring.
Some individuals possess male and female organs. They are *hermaphroditic.*

Mating strategies

The behavioral mechanisms and social organization involved in obtaining a mate make up a mating system.

Monogamy is the formation of a pair bond between one male and one female. It is most prevalent among birds and rare among mammals, except several carnivores, such as foxes and few herbivores, such as beavers and muskrat.

Monogamy occurs mostly among species in which cooperation by both parents is needed to rear young successfully.

Polygamy is the acquisition by an individual of two or more mates, none of which is mated to other individuals. It can involve one male and several females or one female and several males. A pair bond exists between the individuals and each mate.

A special form of polygamy is promiscuity, in which males and females copulate with one or many of the opposite sex and form no pair bonds.

Reproductive effort

Organisms spend their energy to meet many needs. Some energy must go to growth, to maintenance, to acquiring food, to defend territory, and to escape predators. Some must go to reproduction. To achieve optimal fitness, an organism has to budget its energy and time in reproduction. Allocation of time and energy make up an organism's "reproductive effort".

Energy investment and parental care

The same energy can produce many small young or one or two large ones. The number of offspring affects the investment each receives. If the parent produces a large number of young people, it can afford only minimal investment in each one. In such a case, animals provide no parental care. Such organisms usually inhabit disturbed sites, unpredictable environments, or places such as the open ocean, where opportunities for parental care are difficult. By diving energy for reproduction among as many young as possible, these parents increase the chances that some young will successfully settle somewhere.

Environmental conditions and number of young

Organisms living in variable environments or facing heavy predation produce numerous offspring, ensuring that some will survive. A large number of young is characteristic of short-lived mammals, insects, and species which reproduce only once in their life.

Having few young is a characteristic of long-lived species. Species reproducing many times in their life may adjust the number of young in response to environmental conditions and the availability of resources. The production of young often reflects the availability of food. In times of food scarcity, parents may fail to feed some offspring. In other situations, vigorous young kill their weaker sibs.

Populations growth

The study of Populations reviews the ways Populations change in size. Birth (natality) and deaths (mortality) account for most changes in the Populations. The differences between the two rates determine its growth or decline.

The number of births in a given time period is called " *natality rate*". Also the number of individual dying in a given time period is called " *mortality rate*". Mortality and natality are two major forces influencing Populations growth. Birth minus deaths (b-d) equals the rate of increase. When births exceed deaths, the Populations remains the same. When deaths exceed births, the Populations declines.

Two additional influences of Populations growth are immigration (i), and influx of new individuals into a Population and emigration (e), the dispersal of individuals from a Population. To account for those gains and losses a general formula for the rate of increase (or decrease) is $(b + i) – (d + e)$.

Maximum Populations growth

The maximum rate at which a Population could increase under ideal conditions is known as its "*biotic potential*". Different species have different biotic potential. A particular species biotic potential is influenced by several factors, including the age at which reproduction begins, the percentage of the life span during which the organism is capable of reproducing, and the number of offspring produced during each period of reproduction.

If one were to plot this increase versus time, the graph would have the "j" shape that is characteristic of "*exponential growth* " the constant reproducing rate that occurs under optimum conditions.

Limitation of Population growth

Certain Populations may exhibit exponential growth for a short period of time. However, organisms cannot reproduce indefinitely at their biotic potentials because the environment sets limits, which are collectively called "environmental resistance". Using the earlier example. Bacteria would never be able to reproduce unchecked for an extended period because they would run out of food and living space, and poisonous body wastes would accumulate in their vicinity.

Lecture 8

Interaspecific Population Regulation

No population continues to grow indefinitely. Even those with exponential growth confront the limits of the environment. Most populations, however, do not behave in an exponential fashion. As the density of a population changes, interactions set in among members of the population that tend to regulate its size.

Population regulation and density dependence

Involved in the concept of population regulation is density dependence. *Density-dependent* effects influence population in proportion to its size. At low density, there is no influence. Above that point, the larger the population becomes the greater is the population of individuals affected. Density – dependent mechanisms act largely through competition for abundant or scanty resources. If the effects of a particular influence do not change with population density, or if the proportion of individuals affected is the same at any density, then the influence is density- independent.

One aspect of population regulation is competition among individuals of the same species for environmental resources (intraspecific competition). Individuals compete only when a resource is in short supply relative to the number seeking it. If resources enable each individual to survive and reproduce, no competition exists. When resources are limited, a population may exhibit one of two responses: scramble competition and contest competition. *Scramble competition* occurs when no individual receives enough of the resources for growth and reproduction, as long as the population remains dense. *Contest competition* takes place when some individuals claim enough resources while denying others a share.

Intraspecific competition retards growth and reproduction

Because the intensity of intraspecific competition is density- dependent, it increases gradually at first affecting just the equality of life. Later it affects individual survival and reproduction.

As population density increases toward a point at which resources are insufficient, individuals in scramble competition reduce intake of food. That diet slows the rate of growth and inhibits reproduction. Tadpoles reared experimentally at high densities experienced slower growth, required a longer time to change from tadpoles to frog, and had a lower probability of completing this transformation. These that did reach threshold size were smaller than those living in less dense population. Fish living in overstocked ponds exhibit a similar response to density.

As population reaches a high density, individual living space becomes restricted. Often aggressive contacts among individuals increase. One hypothesis of population regulation is that increased crowding and social contact cause *stress*. Such stress triggers hyper activation of the system that controls the endocrine glands.

Profound hormonal changes suppress growth, curtail reproductive functions and delay sexual activity. They may also suppress the immune system and break down white blood cells, increasing vulnerability to disease. Social stress among pregnant females may increase intrauterine mortality and cause inadequate lactation. Thus, stress results in decreased birth and increased infant mortality.

Social behavior

Intraspecific competition expresses itself in social behavior, the degree to which individuals of the same species tolerate one another. Social behavior appears to be a mechanism that limits the number of animals living in a particular habitat, having access to a common food supply and engaging in reproductive activities. It excludes the others. Social behavior limits populations in a density dependent fashion. A population has a substantial portion of population consists of surplus animals that do not breed because they either die or attempt to breed and fail. Such individuals are prevented from breeding by dominant individuals.

Territoriality and population regulation

Territoriality is a situation in which an animal defends an exclusive area not shared with rivals. Defense follows definitive behavioral patterns-song and call, intimidation displays such as spreading wings and tail in birds and baring fangs in mammals, attack and chase, and marking with scents that evoke escape and avoidance in rivals. As a result, territorial individuals tend to occur in regular patterns of distribution.

In general territory size tends to be no larger than required. That size may vary from year to year, and from locality to locality, depending upon resources and number of animals seeking space.

Density – independent influences

As mentioned before, population growth and fecundity are heavily influenced be density – independent responses. However, there are other, often overriding influences on population growth. These influences are density – independent. By themselves, density – independent influences on the rate of increase do not regulate population growth. Regulation implies feedback. Density – independent influences, however, can have considerable impact on birthrates and death rates. They can mask or even eliminate density – independent regulation.

The influences of weather are irregular and unpredictable. It functions largely by influencing the availability of food. Pronounced changes in population growth often correlate directly with variations in moisture and temperature.

Lecture 9

Populations interactions

Although the most intense relationships exist between them, individuals of the same species do not live apart from individuals of other species. Living in close association, different species interact. They may compete for a shared resource. Such as food, light, space, or

moisture. One may depend upon the other as a source of food. They may provide mutual aid, or they may have no direct effect on each other at all.
Interactions between species include competition predation, parasitism, mutualism and commensalism.

Interspecific Competition

Interspecific Competition, as in Interspecific Competition, individuals seek a resource in short supply, but they are of two or more species. Both kinds of Competition may take place simultaneously. Grey squirrels for example. Compete among themselves for acorns during a poor crop year. At the same time, they compete with the white-footed mice, white-tailed deer and wild turkey for the same crop. Because of competition, individuals within a species may be forced to broaden the base of their foraging efforts. Population of various species may be forced to turn away from acorns to food less in demand. Thus, Interspecific Competition selects for a broadening of the use of the resource, whereas Interspecific Competition favors a reduction of the use of the resource base.
Like Intraspecific Competition, Interspecific Competition takes two forms. Interspecific Competition. Like contest Competition, is direct or aggressive. One Competitor interferes with another's access to resource.

Exploitative Competition. Similar to scramble Competition, reduces the abundance of shared resources. Each species indirectly reduces the abundance of the other species. The outcome depends on how attentively each of the Competitors use the resource.

Outcomes of interspecific Competition

Early in the twentieth century, two mathematicians. The American Alfred Lotka and the Italian Vittoria Volterra independently arrived at mathematical expressions to describe the relationship between two species using the same resource. Lotka – Volterra equations predict four different outcomes of interspecific completion:

., B.) In two situations, one species uins out over the other. In one case species 1 inhibits further increase in species 2 while continuing to increase itself. In this case species 2 is driven to extinction. In the other case species 2 inhibits further increase in species 1 continuing to increase itself, and species 1 disappears. The Russian biologist A.F. Gause (1934), grew in the laboratory, two of *Paramecium. P. Aurelia and P. Caudatum.* When the two species were grown in separate test tubes. Each species quickly increased its population to a high level. Which is maintained for some time thereafter. When the two grew together. However, only *P. Aurelia* thrived; *P.*

Caudatum dwindled and eventually died out. Under different sets of culture conditions. *P. Caudatum* prevailed over *P. Aurelia* which died out. Gause interpreted this to mean that one set of conditions favored one species, and a different set favored the other. Because the two were similar, given time one or the other would eventually triumph at the other's complete cost.

C) In the third situation each species, when abundant, inhibits the growth of the other species more than it inhibits its own growth. Both species hang on in an unstable equilibrium. In the long run one wins. The outcome depends upon which species is the most abundant and upon which species adapts better to environmental change.

D) In the fourth situation neither population can achieve a density capable of eliminating the other. Each species inhibits its own population growth more than that of the other species.

Competitive exclusion principle

In three of the four situations predicted by the lotka-Voltera equations one species drives the other to extinction. The results of the laboratory studies tend to support the mathematical models. These observations have led to the concept called the" Competitive exclusion principle" it states that complete competitors cannot coexist. Basically. If two non-interbreeding populations possess the same ecological requirement and live in exactly the same place. And if population A increases the least bit faster than population B. than A eventually will occupy the area completely. B will become extinct

The results of many field experimental studies do suggest that interspecific completion has a large overall effect that varies widely among organisms. For example. The studies show strong competition among toads. Frogs, and arthropods of flowing water. Among herbivores interspecific competition is less significant than intraspecific completion in controlling populations. Among most organisms the effects of intraspecific and intraspecific completion are equally strong.

coexistence

two or more competing species can coexist, although such competition reduces the fitness of all parties. Among some animals, notably birds, competing species exhibit territorial behavior. This interspecific territoriality reduces the number of breeding individuals of each species that occupy a given area of shared habitat.

Predation

Predation is the eating of one living organism (prey) by another (predator). One organism benefit at the other's expense. Predation includes not only carnivory, but parasitism, cannibalism, and herbivore. A fly or a wasp laying its eggs on a caterpillar of another species to develop there at the expense of its victim is exhibiting a form of predation called *parasitism.* The parasitoid attacks the host (the prey) indirectly by laying its eggs on the host's body. When the eggs hatch, the larvae feed on the host. Slowly killing it. A deer feeding on shrubs and grass and a mouse eating a seed are practicing a form of predation called *herbivore*. Seed consumption is outright predation because the embryonic plant is killed. A special form of predation is *cannibalism*, in which the predator and the prey are of the same species.

However, there is a close interaction between the predator and the prey. Each influences the fitness of the other. Predation is more than a transfer of energy. It is a direct and often complex interaction of two or more eaters and the eaten. The numbers of some predators may depend upon the abundance of their prey. Each can influence the population growth of the other and favor new adaptations.

Cannibalism

Cannibalism is a special form of Predation. Called Intraspecific Predation. Cannibalism is killing and eating an individual of the same species. It is common to a wide range of animals, aquatic and terrestrial, from protozoans and rotifers through centipedes, mites, and insects to frogs, toads, fish, birds, and mammals, including humans.

Cannibalism has been associated with stressed populations, particularly those facing starvation. Although some animals do not become cannibalistic until other foods run out, others do so when alternative foods decline and individuals are malnourished. Other conditions that may promote cannibalism are:

1) crowded conditions or dense populations. Even when food is adequate:

2) stress, especially when individuals of low social rank are attacked by dominant individuals:

3) the presence of vulnerable individuals – such as nestlings, eggs, or weak individuals that provide easy prey even in the presence of food.

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Parasitism and Mutualism

Coevolution

Sometimes two different species develop an intimate association so that, over time, the course of each species evolution is affected. We call a relation in which two interacting populations appear to strongly influence the evolution of traits in each other "coevolution". Any evolutionary change in one member changes the selective forces acting on the other. They play a game of adaptation and counteradaptation. Coevolution is found between parasites and hosts. And between mutualism.

Most coevolutionary responses appear to be general. For example, plants have evolved chemical defense against a diverse array of herbivorous insects. In turn, many insects have evolved the ability to detoxify a wide range of plant chemicals. Similarly, animals have evolved a generalized immune system in response to a wide range of parasites. Flowering plants and their animal pollinators provide an excellent example of coevolution. During millions of years over which these associations developed, Flowering plants evolved a number of ways to attract animal pollinators, such as attractive colors and scents. Also, animal pollinators, such as insects, hummingbirds, and bats, coevolved specialized body parts and behaviors that enabled them to both aid pollination and obtain nectar and pollen as a reward.

However, period interactions between certain parasites and their hosts or between certain mutualists suggest closer, more specific convolution.

Parasitism

Parasitism is a condition in which two organisms live together, one deriving is nourishment at the expense of the other. Parasites draw nourishment from the tissues of the larger host, a case of the weak attacking the strong (in predation, the strong predator attacks the weak prey). Mostly the Parasites do not kill their hosts as predators do, although the host may die from secondary infection or suffer stunted growth weakness or sterility.

Parasitic organisms belong to a wide range of taxonomic groups, including viruses, bacteria, protists, fungi, and an array of invertebrates among them arthropods.

Mutualism

Mutualism is the name given to associations between two species that bring mutual benefits. The individuals in a population of each mutualist species grow and/or survive and/or reproduce at a higher rate when in the presence of individuals of the other. Each mutualist gains one of a variety of kinds of advantage. Most often this involves food resources for at least one of the parties and frequently, for the other, protection from enemies or provision of a favorable environment in which to grow and reproduce. In other cases, the species that gets the food provide a service by ridding its partner of parasites (e.g. cleaner fish) or by bringing about pollination or seed dispersal

Commensalism

A " Commensal" organism lives on or around the individuals of some other species (which may be called host) and drives benefit from the association. The host suffers no negative effects.
Van Beneden (1876) wrote. " *The Commensal is simply a companion at the table*". Good examples of Commensals in this sense are the scavengers such as vultures that live on the scraps from the kills of large carnivores such as lions. The remora fish uses its suction cup on the top of

its head to attach itself to a shark. It thus travels with the shark and eats the leftovers from the big fish's meal.

The term " Commensalism" is now used in a broaden sense to refer to coactions in which the gain is something other than direct access to food provided by the host. Usually, the gain is some combination of *transportation, support or shelter*. The use of prairie dog burrows as nest sites for burrowing owls and the use of old bird's nests by deer mice as sites for their own nests are examples of Commensalism.

Lect. 10
Community and Ecosystem

Populations of organisms do not live apart from one another as separate entitles. Sharing environment and habitat they interact in various ways. These interactions came together in the concept of Community: as assemblage of species in a given place interacting directly and in directly with each other. The Community involves the biota only. The interaction of the biotic Community with a biotic environment forms the ecosystem.

Community Structure

Although ecologists classify communities in different ways, all communities have certain characteristics that define their biological and physical structure. These characteristics vary in both space and time.

biological structure

the mix of species, including their number and relative abundance defines the biological structure of a community. A community can be composed of a few common species: or it can have a wide variety of species, some common with high population density, but most rare with low population density. When a single or few species predominate within a community, these organisms are *dominant*.

Dominancy: It is not easy to determine the dominant species. The dominants in a community may be the most numerous, possess the highest biomass, occupy the most space, make the largest contribution to energy flow or nutrient cycling or by some other means control or influence the rest of the community. Some ecologists ascribe to dominant role to those organisms that are greatest in number, but abundance alone is not sufficient.

physical structure

Communities are characterized not only by the mix of species, the biological structure, but also by physical features. The physical structure of the community reflects Abiotic factors, such as the depth and flow of water in an aquatic environment. It also reflects biotic factors, such as the spatial configuration of organisms.
In a forest, for example, the size and height of the trees and the density and dispersion of their populations define the physical attributes of the community.

The form and structure of terrestrial communities reflect the vegetation. The plants may be tall or short evergreen or deciduous herbaceous or woody. Such characteristics can describe growth form. Thus, we might speak of shrubs, trees, and herbs.

Vertical structure

Each community has a distinctive vertical structure. On land, vertical structure is determined largely by the life form of the plants – their size branching and leaves – which in turn, influence and is influenced by the vertical gradient of light. The vertical structure of the plant

community provides the physical framework in which many forms of animal life are adapted to live.
A well-developed forest ecosystem, for example, has several layers of vegetation. From top to bottom, they are the canopy, the understory, the shrub layer, the herb or ground layer, and the forest floor. We could continue down into the root layer and soil strata.

The *canopy*, which is the primary site of energy fixation through photosynthesis, has a major influence on the rest of the forest. If it is fairly open, considerable sunlight will reach the lower layers, will have ample water and nutrients resulting in well-developed understory and shrub strata. If the canopy is dense and closed, light levels are low, and the understory and shrub layers will be poorly developed

The understory consists of tall shrubs. Understory trees and younger trees, some of which are the same species as those in the canopy. Species which are unable to tolerate shade will die. Survivors eventually reach the canopy after older trees die or harvest.

The nature of the *herb layer* will depend on the soil moisture and nutrients conditions, the slope position, the density of the canopy and understory, and the exposure of the slope, all of which vary from place to place throughout the forest.

The final *forest floor* is the site where the important process of decomposition takes place and where decaying organic matter release nutrients for reuse by the forest plants

Aquatic ecosystems such as lakes and oceans have strata determined by light penetration. They have distinctive profiles of temperature and oxygen. Layers are defined according to light penetration an upper zone, *the trophogenic zone* dominated by phytoplankton, which is the site of photosynthesis, and a lower zone, the *tropholytic zone* in which decomposition is most active.
All communities, both terrestrial and Aquatic, have a similar biological structure, related to these patterns of vertical layering. They possess an autotrophic layer concentrated where light is most available, which fixes the energy of the sun through photosynthesis, producing organic carbon compounds from CO_2. In forests this layer concentrates in the canopy, in grasslands in the herbaceous layer: in lakes and seas, in the upper layer of water. Communities also possess a heterotrophic layer that utilizes the carbon, stored by autotrophs as food source, transfers energy, and circulates matters by means of herbivory, predation in the broadest sense, and decomposition.

Horizontal structure

In a forest, for example, often there are patches of open grass and tall shrubs. Sometimes there are gaps, openings in the canopy caused by the death of a canopy tree, where dense thickets of new growth have claimed the sunlit openings.

The *horizontal patchiness* adds to the physical complexity of the Community. This patchy distribution of plants shows influences of both the physical and biological environment. In terrestrial Communities, soil structure, soil fertility, moisture conditions and aspect influence the micro distribution of plants. Patterns of light and shade shape the development of the understory vegetation.

Grazing animals have subtle but important effects on the patterning of vegetation, as do Abiotic disturbances such as wind and fire. Like vertical structure, horizontal patchiness of plant life influences the distribution and diversity of animal's life within the Community. Generally, Communities that are most highly stratified (vertically and horizontally) offer the richest variety of animal life because they contain the greatest assortment of habitats.

Niche

Every organism has its own role within the structure and functions of an ecosystem, this role is its ecological niche. An organism's ecological niche takes into account all aspects of the organism's existence – all the physical, chemical, and biological factors that the organism needs to survive, to remain healthy, and to reproduce.

Among other things, the niche includes the physical surrounding in which an organism lives (its habitat) and how it interacts with and is influenced by the nonliving components of its environment (light, temperature, and moisture). An organism's niche also encompasses the organisms it eats, the organisms that eat it, and the living organisms with which it competes. The niche, then, represents the totality of an organism's adaptations, its use of resources, and the lifestyle to which it is fitted.

There are two aspects to an organism's ecological niche: the role the organism could play in the Community, the potential or *fundamental niche*, and the role it actually fulfills: the *realized niche*. The niche may be far broader potentially than it is. An organism is usually capable of utilizing much more of its environment's resources or living in a wider assortment of habitats than it does, but various factors such as competition with other species may exclude it from part of its fundamental niche.

Lect. 11
PRODUCTION IN ECOSYSTEM

In the concept of the ecosystem, the biological and physical components of the environment are a single interaction system. Like the community, the ecosystem is a spatial concept: it has defined boundaries. The primary focus of ecosystem ecology is the exchange of energy and matter. Exchange from the surrounding environment into the ecosystem are *inputs*. Exchanges from inside the ecosystem to the surrounding environment are *outputs*.

Basic components of ecosystems

In the simplest terms, all ecosystems, both aquatic and terrestrial, consist of three basic components – the autotrophs, the consumers, and Abiotic matter. The *producers*, or *autotrophs*, are largely green plants. These organisms use the energy of the sun in photosynthesis to transform inorganic compounds into simple organic compounds.

The *consumers*, or *heterotrophs* use the organic compounds produced by the autotrophs as a source of food. The heterotrophic components of the ecosystem is often subdivided into two subsystems, consumers and decomposers. The consumers feed largely on living tissues, and the decomposers break down dead matter into simple inorganic compounds that are once again used by the producers.

The third, or *abiotic*, components consist of the soil sediments, particulate matter, dissolved organic matter in aquatic ecosystem, and litter in terrestrial ecosystems. All of the dead organic matter is derived from plants and consumer remains and is acted upon by decomposers. Such dead organic matter is critical to the internal cycling in the ecosystem.

The driving force of the system is the energy of the sun. The energy harnessed by the producers flows from producers to consumers to decomposers and eventually dissipates as heat.

Laws of thermodynamics govern energy flow.

Production in ecosystems involves the fixation and transfer of energy from the sun. Green plants fix solar energy in the process of photosynthesis. The products of Photosynthesis accumulate as plant *biomass*. Non photosynthetic organisms convert this stored energy into *heterotrophic biomass*. This fixation and transfer of energy through the ecosystem is governed by the laws of thermodynamics, which apply to all things in the universe.

Energy exists in two forms, potential and kinetic. *Potential energy* is stored energy. *Kinetic energy* is energy in motion, which performs work at the expense of Potential energy. The expenditure and storage of energy are governed by the laws of thermodynamics. The first laws of thermodynamics state that energy is neither created nor destroyed. It may change form, pass from one place to another, or act upon matter in various ways.
Regardless of what transfer and transformations take place, however, no gain or loss in total energy occurs. When wood burns, the potential energy lost from the molecular bonds of the wood equals Kinetic energy released as heat.

The transfer of energy involves the second law of thermodynamics. It states that when energy is transferred or transformed part of the energy assumes a form that cannot pass on any further. When coal is burned in a boiler to produce steam, some of the energy creates steam, and part is dispersed as heat to the surrounding air. The same thing happens to energy in the ecosystem. As energy is transferred from one organism to another in the form of food, a large part of that energy is degraded as heat –no longer transferable. The remainder is stored as living tissue.

The flow of energy through Ecosystem

The passage of energy in one direction through an ecosystem is known as energy flow. Energy enters an ecosystem in the form of the radiant energy of sunlight. Some of it is trapped by plants during the process of photosynthesis. Now in chemical form it is stored in the bonds of organic molecules such as glucose. When these molecules are broken apart by cell respiration, the energy becomes available to do work such as repairing tissues, producing body heat, or reproducing. As the work is accomplished the energy escapes the living organism and dissipates into the environment as heat. Ultimately, this heat energy radiates into space. Thus, once energy has been used by living organisms, it becomes unavailable for reuse.

The path of Energy Flow: Food Chains

Energy in ecosystem occurs in food chains, in which energy from food passes from one organism to the next in a sequence. Producers start the food chain by capturing the sun's energy through photosynthesis. Herbivores (and omnivores), who reap the energy stored in the herbivore's molecules. At the end of a food chain are decomposers, which use organic molecules in the remains (the carcasses and body wastes detritus) of all other members of the food chain.

Each level in a food chain is called a *trophic level*. The first trophic level is formed by the producers (green plants), the second trophic by primary consumers (herbivores), the third trophic level by secondary consumers (carnivores) and so on.

Ecological Pyramids:

An important feature of energy flow is that most of the energy going from one trophic level to another in a food chain or food web dissipates into the environment. The relative energy values of trophic levels are often graphically represented by ecological pyramids. There are three main types of pyramids: a Pyramids of numbers, a Pyramid of biomass, and a pyramid of energy.

A Pyramid of numbers shows the numbers of organisms at each trophic level in a given ecosystem, with greater numbers illustrated by wider section of the pyramid. In most pyramids of numbers, each successive trophic level is occupied by fewer organisms. Thus in a typical grassland the number of zebras and wildebeests (herbivores) is greater than the numbers of lions (carnivores).

Ecological Pyramids:

A pyramid of biomass: illustrates the total biomass of each trophic level. It also illustrates a progressive reduction of biomass in successive trophic levels.

A pyramid of energy illustrates the energy relationships of an ecosystem by indicating the energy content of the biomass of each trophic level.

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