ECOLOGY AND Embryology

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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.
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

The community and the physical environment make up the ecosystem.
So, the ecosystem has many levels. One level individual organisms. 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 organism are constantly interacting with their environment.
Animals consume plants and other animals. They diest 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 organism 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 enzyme. 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 its 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

<u>Range of tolerance</u>

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.

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 point (minimum and maximum) at which the survival intercepts the X axis represent the environment 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 <u>*environment tolerance*</u> of the organisms.

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

However, organisms depend upon a wide range of environment 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.

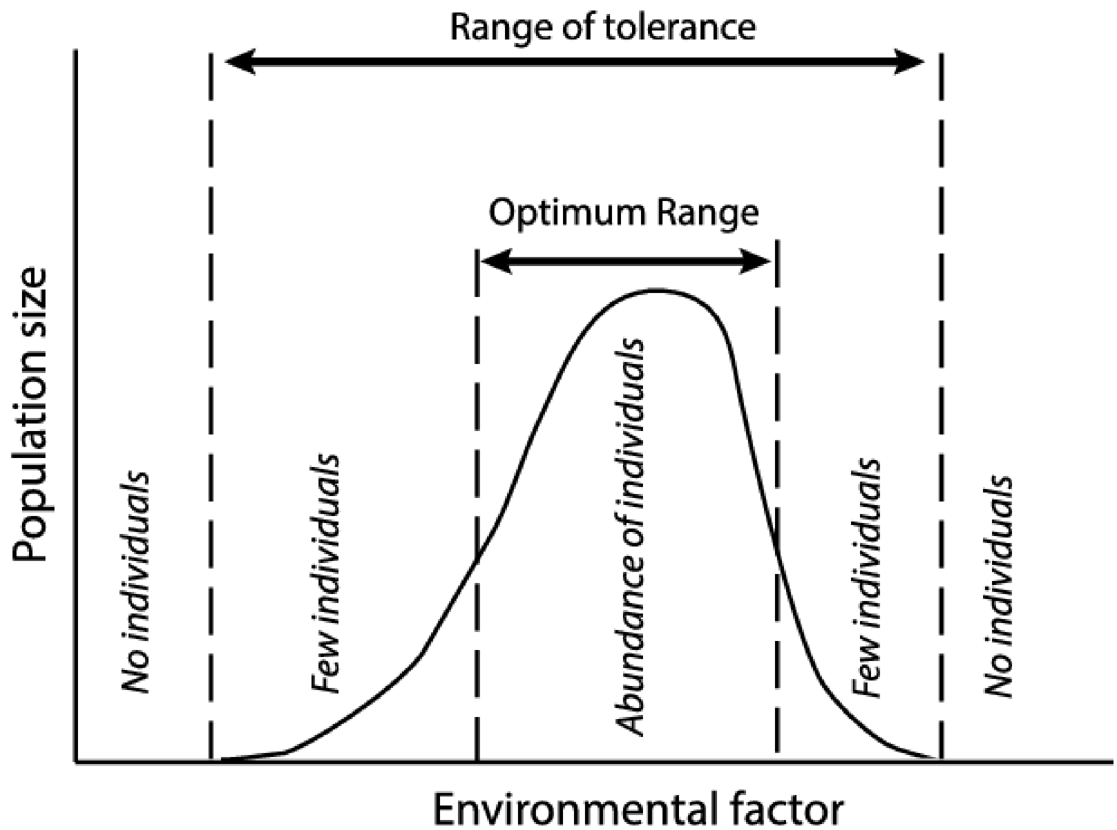
Hot conditions demand increase in water intake.

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 <u>*laws of tolerance*</u>.

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



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 outher 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 microclimate 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 influences the daily and seasonal activities of terrestrial and shallow water organisms.
Of the total range of solar radiation reaches Earth's atmosphere, the wave lengths 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) absorbe nearly all wavelengths, especially the violets and blues of the visible light.
Molecules of atmosphere gases scatter long wavelengths.

<u>Periodicity</u>

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.

<u>Living organisms possess innate rhythms of activity</u>

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 conform 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 in doors 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 a 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 he 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 sensivity 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 fit 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.

and reproduction, too.

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Lecture 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 every where 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 photoreceptor 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.

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.

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. 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.

In other parts of the earth, such as the tropics and some deserts, photoperiod may change little, or a change from dry to wet season may be the important seasonal change, The seasonal tropics have alternate wet and dry seasons.

The beginning of rainy season is a dependable environment cue by which plants and animals become synchronized to seasonal changes.

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 animals temperature is highest.

Lecture 4

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 :
Heat gain (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*. They 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.
Environment temperature control the rates of metabolism and activity among most Poikilotherms.
Rising temperature increase 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 activity 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 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 sun. most warm up by shivering their flight muscles in the thorax. Moth and butterflies vibrate their wings to raise thoracic temperature above ambient.

Regulating body temperature

To maintain a tolerable and fairly 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 become 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.

<u>Insulation</u>

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 coat could reduce their ability to move. Mammals change the thickness of their fur with season.

<u>Evaporative cooling</u>

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, feaces and water evaporated problem in maintaining water balance. All animals however possess a more or less 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 wastes. Freshwater fish maintain osmotic balance by absorbing and retaining salts in special cells and producing plentiful amount of watery urine. Amphibians balance the loss of salts through the skin by aborbing 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 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 inhales 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 salts environment faces problems opposite to these in fresh water. These organism have to retain their body fluids. When the concentration of salts is greater outside the body than within, organisms tend to dehydrates. Osmosis draws water out of the body into the surrounding environment. In marine and brackish environment, 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 a cost of metabolic energy. Sharks retain a sufficient amount of 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:

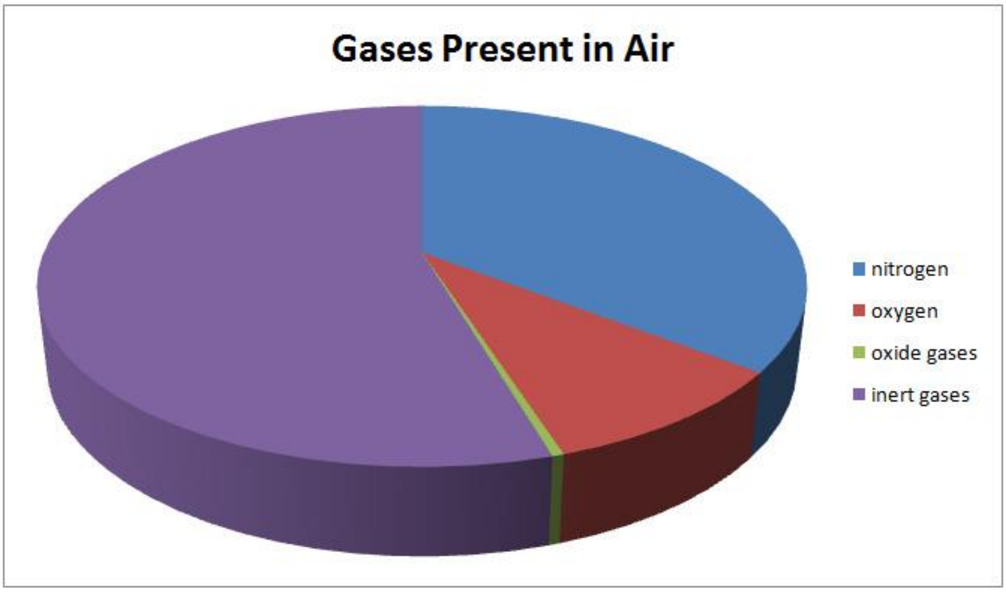
- From the name itself, we can understand that water pollution is a type of pollution which involves contamination of many water bodies. Many creatures which live in these water bodies are totally dependent on these water bodies.
- **Causes of water pollution:** causes of water pollution are mentioned 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 the 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 to enter inside the 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.
- 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 atmosphere are called as air pollution. Respiration is a vital life process which needs air. If we breathe the 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 of rubber, wood, and discarded plastic release gases called carcinogenic gases into atmosphere.
- Few industries release gases like sulfur dioxide, 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 atmosphere which are poisonous.

Greenhouse Effect

- Generally, a physical property of the atmosphere of earth is referred 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 absorbs infrared radiation balance of energy of planet gets damage and along with this, there will be a dissimilarity in temperature. During present state, 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 compound 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 to 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 have the ability to cause mutative diseases and cancer. This type of pollution happens because of following reasons:
- Damage to nuclear reactors which 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 as 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 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 have 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 influence 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

Lecture 7

Mid -Term Exam

Lecture 8

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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 populations.

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 spaces, 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. A biologists might estimate the number of deer living in a square kilometer. The deer, however, might avoid half the area, because human habitation, land use, and lack of cover and food.

Dispersion

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

By contrast, individuals distributed *uniformly* are more or less evenly spaced. In the animals 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**

Population has age structure. Because reproduction is restricted to certain age classes and mortality is most prominent in others, the ratio of the age groups bears on how quickly or slowly populations grow.
Population divide into three ecological period : prereprouductive reprouductive, and postreprouductive.
The length of each period depends largely on the life history of organisms.
Among annual species the length of the prereproductive period has little influence on the rate of population growth. In longer lived animals, the length of the prereproductive period has a pronounced effect on the population's rate of growth. Organisms with a short prereproductive period often increase rapidly, with a short span between generations. Organisms with a long prereproductive 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 organisms to accomplish that successfully is termed its _fitness_. Fitness is equated with the ability of an organisms 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 gometes: 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, non 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, and 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 produce a large number of young, it can afford only minimal investment in each one. In such 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 environment 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 live.

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. 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.

Lecture 9

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 determines 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, organism 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 of time, because they would run out of food and living space, and poisonous body wastes would accumulate in their vicinity.

Lecture 10

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 resources is in short supply relative to the number seeking it. As long as 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 resource 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 become 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 decrease birth and increased infant mortality.

Social behavior

Intraspecific competition express 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.

Lecture 11

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 commensalisms.

Interspecific Competition

Interspecific Competition, as in Interspecific Competition, individual 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 Vittora 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 were grown 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 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 tends 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 exactly 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.

coexcistence

two or more competing species can coexist, although such competition reduces the fitness of all parties. Among some animals, notably dirds, 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 benefits 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 eater and the eaten. The numbers of some predators may depend upon the abundance of their prey. Each can influences 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 population, 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 counteradaption. Coevolution is found between parasites and hosts. And between mutualalism.

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, the 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 perdation, 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 awide 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 favovrable 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.

Lecture 12

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 the 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 *dominants*.

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 aquatic environment. It also reflect 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 characterstics 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 tress die or harvested.

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 a 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 bidogical environment. In terrestrial Communities, soil structure, soil fertility, moisture sonditions and aspect influence the microdistribution 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 distribances such as wind and fire. Like vertical structure, horizontal patchiness of plant life influences the distribution and diversity of animals 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 organisms 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 life style 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 in actuality. An organism is usually capable of utilizing much more of its environment's resources or living in a wider assortment of habitats than it actually does, but various factors such as competition with other species may exclude it from part of its fundamental niche.

Lecture 13

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 consists 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 plant 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*. Nonphotosynthetic 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 states 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 transfere 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 organism, 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 goining 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 illustrate 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.

Lecture 14

General Discussion Of All The Above Lectures

Answer the following questions:

Question 1: Choose the correct answer from (A, B, C, D)

1-The natural world that surrounds an organism is called the organism's:

A- Energy B- Environment C- Population D- Nutrients

2- The Earth is tilted relative to the sun

A-Water B-Axis C- Poles D- Heat

3- Ecology is the study of how:

A- The physical environment changes over time.

B- Biotic factors change over time.

C- Matter interacts with energy in our environment.

D- Living things interact with each other and their environment.

4- An unusually cold winter causes the squirrel population to decrease. This is an example of temperature as a

A- Abiotic factor B-limiting factor

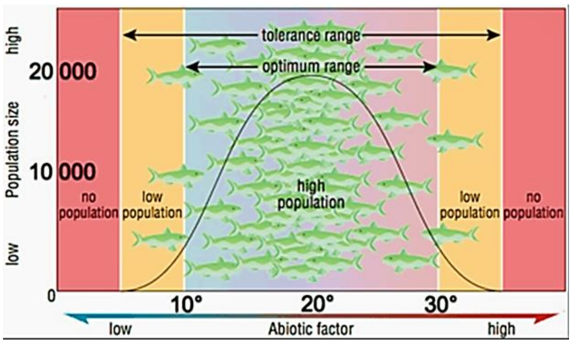
C- Climax community D- Pattern in space

5- Concentrates on factors that affect how many individuals of a species live in an area

A-Population ecology B-Operant conditioning

C-Reproductive table D-Coniferous forest

6- At which temperature would this fish population be in the zone of physiological stress because the temperature was too hot?
A-32 degrees B-8 degrees C-20 degrees
D-40 degrees



7- Shelford's law of tolerance suggests that organisms with a wide tolerance limit for environmental factors show: -
A- Narrow distribution with low population
B- Wide distribution with high population
C-Wide distribution with low population
D- Narrow distribution with high population

<u>Question 2: Read the following sentences and then determine if its True (T) or False (F)</u>

1- One male competes for, and breeds with, many females, they do not usually assist with rearing the offspring
→ Polygyny
(T) or (F)

2 -A population in which the proportion of individuals in each age class is constant

→Generalists
(T) or (F)

3- Innate biological rhythms which approximate the daily rotation of the earth

→ Circadian rhythms
(T) or (F)

4-The point where the energy being produced through photosynthesis equals the amount of energy used in metabolism → homeostasis (T) or (F)

5 -Can tolerate a large range of temperatures → Eurytherm (T) or (F)

6 -Aquatic animals usually face more of a diurnal change in water temps than animals in terrestrial locations
(T) or (F)

7 -The body temp of amphibians and reptiles, fish and invertebrates conform to outside temp of the environment called ectotherms (T) or (F)

8 -Approximately one year" → Circannual
(T) or (F)

9 -Limiting factors are sometimes helpful because they can keep the population from getting too large.
(T) or (F)

10 -A population pyramid with a very wide base is a sign that the population is decreasing.
(T) or (F)

1-Write on each of the following:-
 a- Poikilotherms and regulation their body temperature.
 b- Photoperiod.
 c- Food chains and food webs.

2- Write as essay about the energy flow within ecosystem.

3- Explain 3 points from the following:-
 a- Range of tolerance.
 b- Water problem in aquatic habitat.
 c- pond as an ecosystem.
 d- Competition between animals.
 e- Energy pyramids.

إعداد

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2023-2024

.

The Normal Sequence of Events in Embryology

1- Gametogenesis 2-Fertilization 3- Cleavage and blastula formation 4- Gastrulation 5- Organgenesis

1-Gametogenesis

The embryogenesis is started from the time of differentiation and organization of haploid male and female sex cells, *viz*., *sperm* and *ova* respectively, from diploid somatic cells of each parent during a process called gametogensis. The gametogenesis include spermatogenesis and oogenesis. The spermatogenesis is a process which occurs in male gonads (testes) and produces small-sized, motile, haploid sex cell, the *sperms* or *spermatozoa*. The oogenesis occurs in female gonads (ovaries) and produce a large, non-motile, nutrient-*polar bodies* or *polocytes*.

2-Fertilization

Fertilization is the initial event in development in sexual reproduction. Union of male and female gametes. Provides for recombination of paternal and maternal genes. Restores the diploid number. Activates the egg to begin development.

The process of fertilization involves a number of independent biological and physiological events

1-The nucleus and cytoplasm of spermatozoon fuse with the nucleus and cytoplasm of the egg

2- The cortical reaction in the egg cytoplasm to elevate a fertilization membrane outside the plasma membrane

3- Activation of egg to start its rapid cleavage by mitosis.

3-Cleavage and blastula formation

During third phase of embryogenesis, the *cellulation*, *segmentation* or *cleavage*, no growth of egg-cytoplasm (*ooplasm*) takes place, but, rate of synthesis of some macromolecules such as DNA and proteins is increased is increased at the expense of reverse food substances of egg (*viz*., glycogen, fats and yolk); and the fertilized egg undergoes repeated and successive mitotic cell divisions and produces a compact heap of cells or *blastomeres*, called *morula*. The blastomeres of morula soon get arranged in a hollow spherical body, a *blastula*, with a layer of blastomeres, called blastoderm, surrounding a fluid-filled central space or cavity, called *blastocoel*. The conversion of a fertilized egg into a multicellular blastula is called *blastulation*.

4-Gastrulation

Following blastulation a part of the blastoderm disappears from the surface of the blastula by *morphogenetic movements* of cells and is enclosed by the reminder of the blastoderm. The part of the blastoderm that remains on the surface becomes *ectoderm*; the part of migrating into the interior becomes *endoderm* and *mesoderm*. In this way a simple spherical body becomes converted into two or three layered embryo known as the *gastrula*. The process involved in gastrula formation is called *gastrulation*, (gastrula, diminutive from the greek word gaster , meaning stomach) and the cellular layers of gastrula are known as the *primary germinal layer*. The germinal layers are complex rudiments from which various organs of the animal's body are derived.

The fully formed gastrula has a cavity called *archenteron,* which is lined by endoderm. The opening leading from this cavity to the exterior is called the *blastopore*. During later development, the archenteron or part of it eventually gives rise to the cavity of the alimentary canal.

The fate of blastopore (the opening from the outside into the archenteron) differs in the three main groups of metozoa:

1- In Coelenterate it becomes the mouth.
2- In Protostomia (including Annelida , Mollusca, Arthropoda and allied groups), it becomes subdivided into two opening, one of which becomes the mouth and other the anus.
3- In Deuterostomia (including Echinodermata and Chordata), only the anus is formed.

5-Organogenesis

During the fifth phase of development, the *organogenesis* or organs formation, the continuous masses of cells of the three germinal layers split up into smaller groups of cells, called the *primary organ rudiments*, each of which is destined to produce a certain organ or part of the adult animal body. The primary organ rudiments, further, subdivide into *secondary organ rudiments* which are rudiments of the subordinate and simpler organs and parts. With the appearance of primary and secondary organ rudiments the embryo begins to show some similarity to the adult animal, or to the larva, if the development includes a larval stage.

Gametogenesis

The reproductive cells, which unite to initiate the development of a new individual, are known as *gametes*- the *ova* of the female and the *spermatozoa* of the male. The gametes themselves and the cells that give rise to them constitute the individual's *germ plasm*. The other cells of the body, which take no direct part in the production of gametes, are called somatic cells or, collectively, the *somatoplasm*. The somatoplasm can thus be regarded as the material that protects and nourishes the germ plasm.

Gametogenesis (oogenesis in the female and spermatogenesis in the male) is a broad term that refers to the processes by which germ plasm is converted into highly specialized sex cells that are capable of uniting at fertilization and producing a new being. Commonly, gametogenesis is divided into four major phases:

1-The origin of the germ cells and their migration to the gonads

2- The multiplication of the germ cells in the gonads through the process of mitosis

3- Reduction of the number of chromosomes by one-half by meiosis

4- The final stages of maturation and differentiation of the gametes

Into spermatozoa or ova.

Primordial germ cells

The cells which are destined to develop into gametes are called primordial germ cells. The germ cells either arise from the germinal epithelium of grads (*germinal epithelial origin*) or may arise outside the gonad at an early period of embryonic development and then migrate to garads (extra gonadal origin).

<u>**The origin of primordial germ cells and their migration to the gonads**</u>.

Primordial germ cells of birds, reptiles, and mammals arise in the epiblast of the early embryo and then take up temporary residence in the extraembryonic tissue before returning to the body of the embryo proper. In birds they are recognizable in the *germinal crescent*, which is located well beyond the future head region of the embryo.

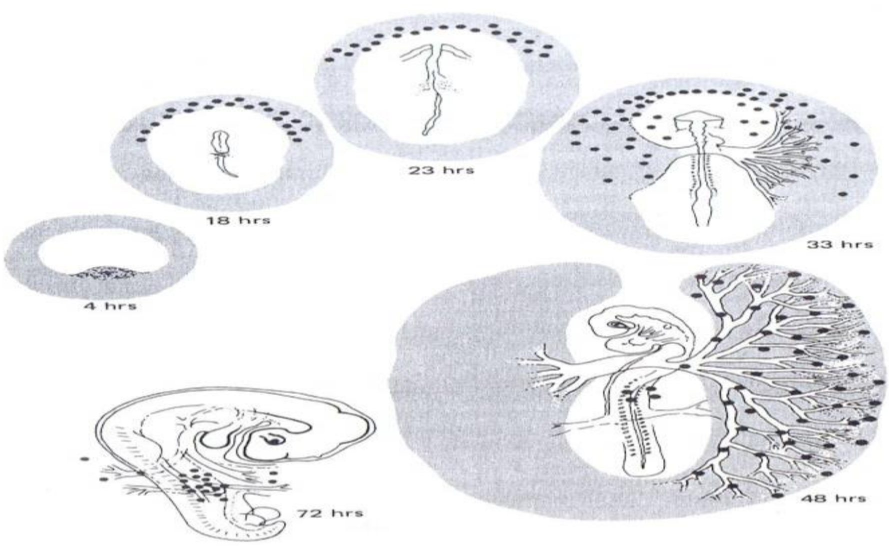
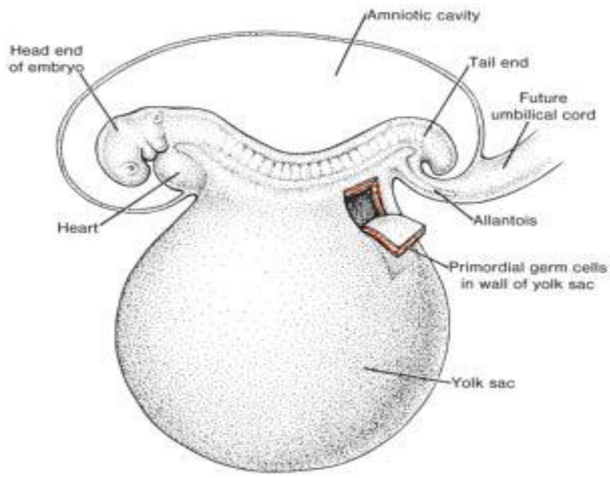


FIGURE 3-3
The migration of primordial germ cells (*dark circles*) in the avian embryo: 4 hours—no identifiable germ cells before the primitive streak is formed; 18 and 23 hours—passive accumulation of primordial germ cells in the anterior germinal crescent; 33 hours—active penetration into blood islands and their entry into the circulation; 48 hours—circulation of germ cells and their early egress into the gonadal primordia; 72 hours—colonization of the gonads. (*Redrawn from Nieuwkoop and Sutasurya, 1979.*)

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



Primordial germ cells in vertebrates migrate to the gonads by to principal mechanisms. In birds and reptiles, they pass through the walls of local blood vessels and enter the circulation. From the bloodstream they are apparently able to recognize the blood vessels of the gonads, because there they penetrate the walls of the blood vessels and settle down in the gonads.

Spermatogenesis

The transition from mitotically active primordial germ cells to mature spermatozoa is called *spermatogenesis*, and it involves a sweeping series of structural transformation. Although is a wide variety in the morphology of mature, the overall process of spermatogenesis is much the same throughout the vertebrate classes. This process can be broken down into three principal phases: (1) mitotic multiplication, (2) meiosis, and (3) spermiogenesis.

Mitosis of sperm-forming cells occurs throughout life, and the mitotically active cells within the seminiferous tubules are known as *spermatogonia*. These cells are concentrated near the outer wall of the seminiferous tubules. Spermatogonia have been subdivided into two main populations. *Type-A spermatogonia* represent the stem-cell population. Within this population is a group of noncycling dark A cells that may be long-term reserve cells. Some of these cells become mitotically active pale A cells, which ultimately give rise to *type-B spermatogonia*. These are cells that have become committed to leaving the mitotic cycle and which go on to finish the process of spermatogenesis.

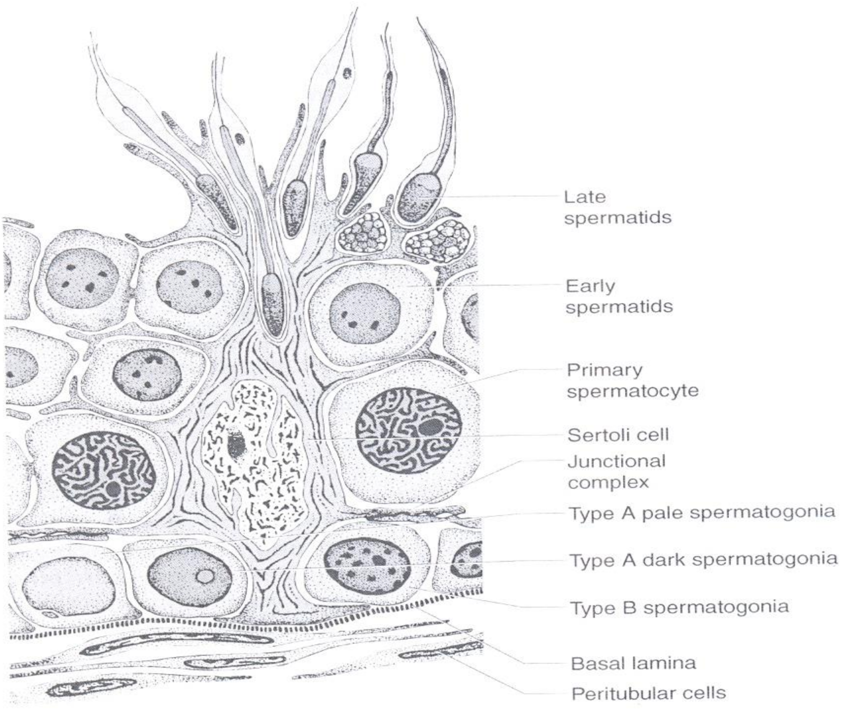
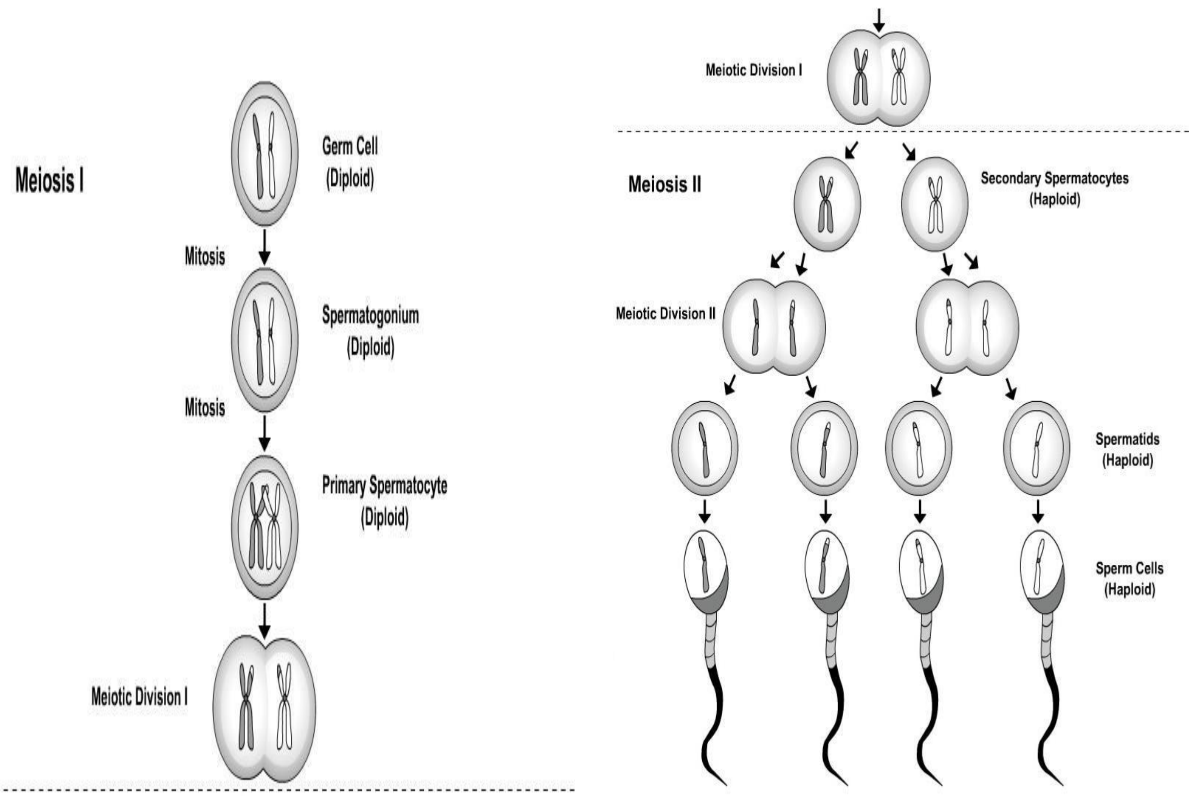


Figure 1.24 Sertoli cells and maturing spermatocytes. Spermatogonia, spermatocytes, and early spermatids occupy depressions in basal aspects of the cell; late spermatids are in deep recesses near the apex.

During the first meiotic division each *primary spermatocytes* divides into two equal daughter cells. With the onset of the second meiotic division these cells are known as *secondary spermatocytes*. In the human the first meiotic division lasts for several weeks, whereas the second one is completed in about 8 hours. Four haploid *spermatids* result from the meiotic phase of spermatogenesis.

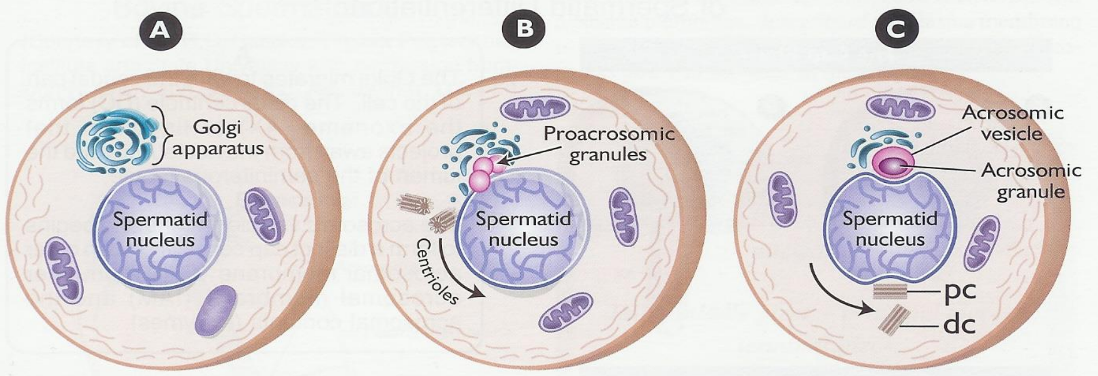


Although they no longer divide, the spermatids undergo a profound transformation from relatively ordinary looking cells to extrermely specialized *spermatozoa*.

<u>The third phase in spermatogenesis is called spermiogenesis</u>.

The cytoplasm streams away from the nucleus, which will become the sperm head, leaving only a thin layer covering the nucleus. At the apical end the developing sperm head, the Golgi complex forms proacrosomal granules, which fuse to form the *acrosome* . within the cytoplasm the centrioles become more conspicuous and appear to be a point of anchorage for the developing flagellum. The distal centriole moves away from the proximal one, and microtubules from it become continuous with microtubules in the flagellum. Mitochondria begin to form a spiral investment around the proximal part of the flagellum. As spermiogenesis continues, the remaining cytoplasm becomes aggregated into a remnant, or residual bodies, which sloughed off and phagocytized by the Sertoli cells.

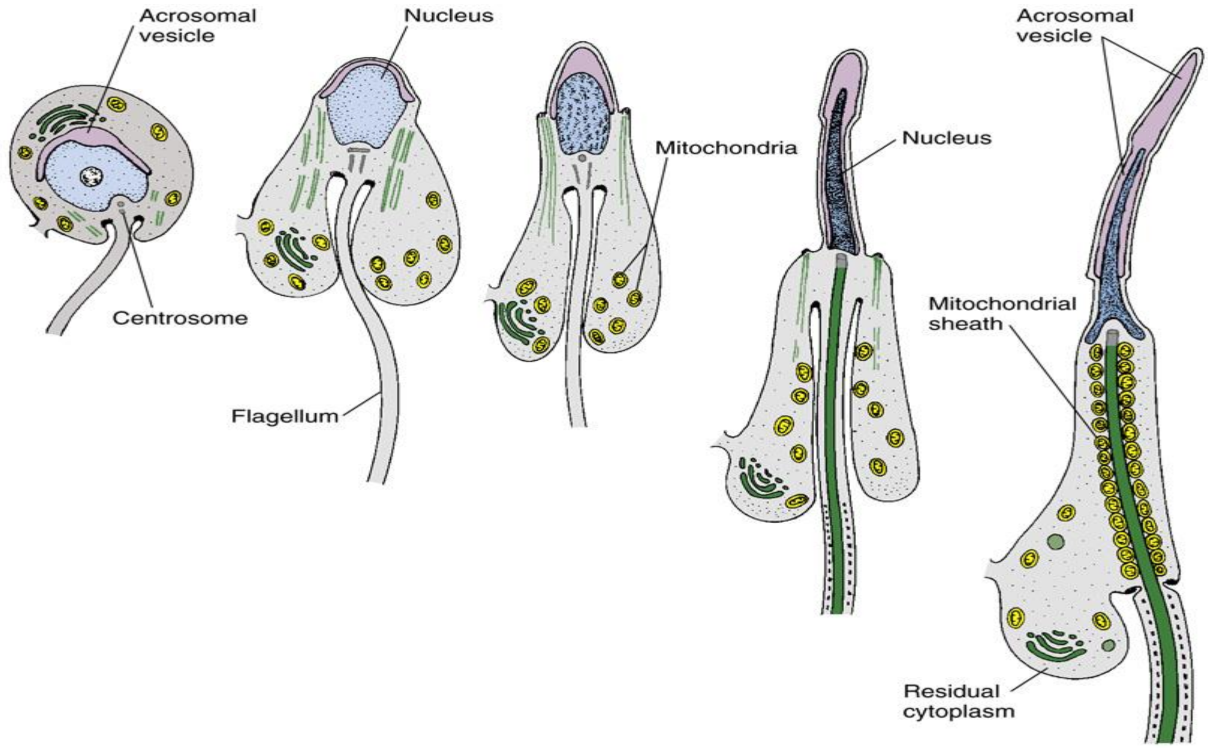
Figure 10-6. The Golgi Phase of Spermatid Differentiation



The newly formed spermatid is almost perfectly spherical and has a well developed Golgi apparatus.

Small vesicles of the Golgi fuse, giving rise to larger secretory granules called pro-acrosomic granules. The centrioles start to migrate to a position beneath the nucleus that is opposite the acrosomic vesicle.

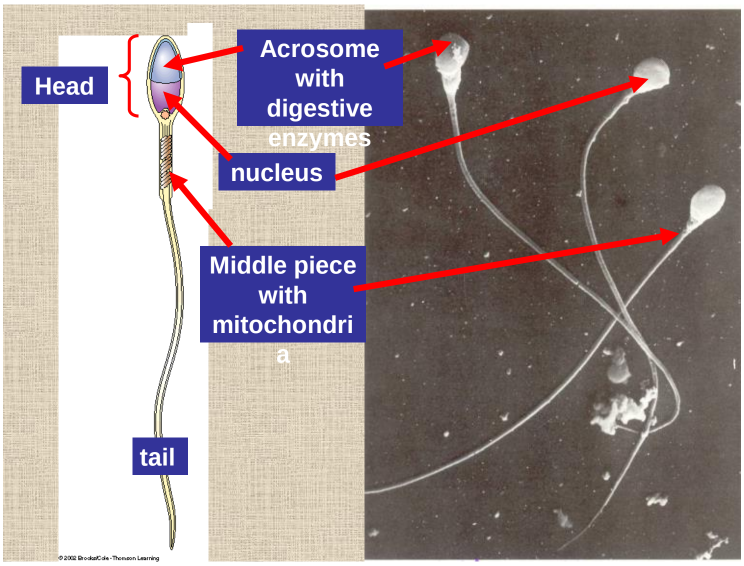
Vesicle fusion continues until a large acrosomic vesicle is formed that contains a dense acrosomic granule. The proximal centriole (PC) will give rise to the attachment point of the tail. The distal centriole (DC) will give rise to the developing axoneme (central portion of the tail) inside the cytoplasm of the spermatid.



This leaves the mature spermatozoon stripped of all nonessential parts. It consists of,

1- A head containing the nucleus and acrosome
2- A neck containing the proximal centriole
3- A middle piece containing the proximal part of the flagellum, the centrioles, and the mitochondrial helix, which acts as an energy source.
4- The tail, a highly specialized flagellum (Fig.).

During spermatogenesis, the cells are also closely associated with Sertoli cells, which lie at regular intervals along the seminiferous tubule (Fig.). Sertoli cells serve a wide variety

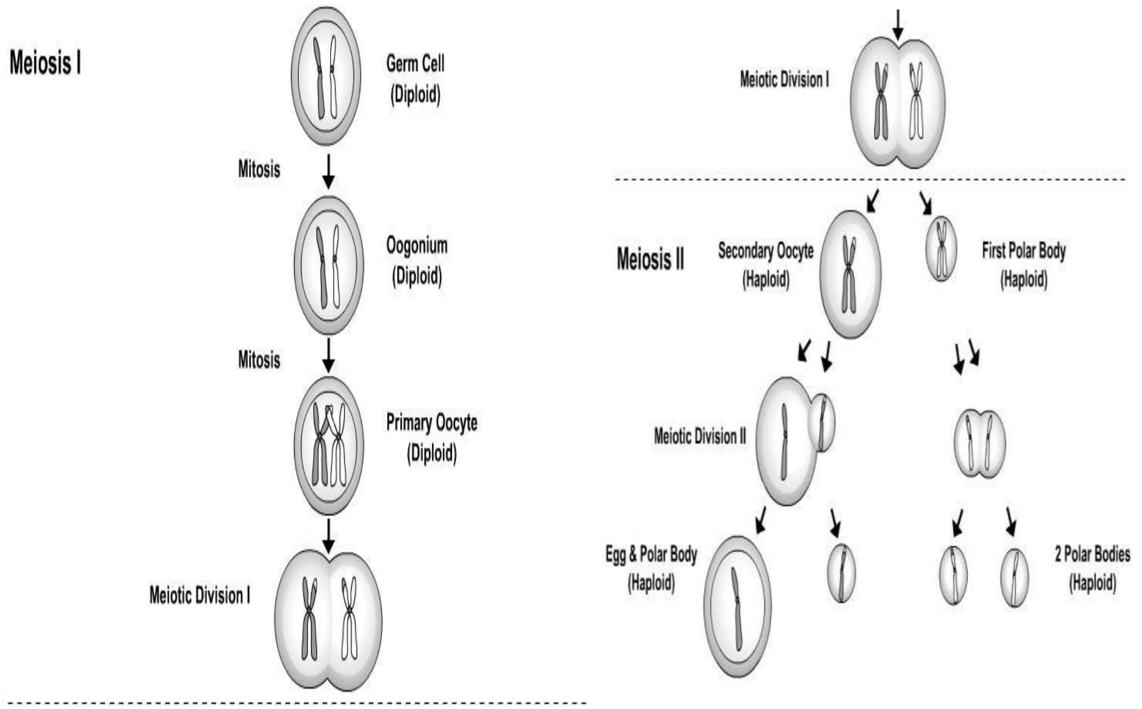


Oogenesis

The goal of oogenesis is to produce one egg with massive amounts of cytoplasm

1-The primary oocyte divides by Meiosis Division I to produce a secondary oocyte.The other nucleus resulting from Division I is a throw-away nucleus known as a polar body.

2- The secondary oocyte divides by Meiosis Division II to produce the egg cell and a polar body. The earlier polar body also divides to form two polar bodies.



Oogenesis in mammals

Maturation of Oocytes Begins Before Birth

1- Once primordial germ cells have arrived in the gonad of a genetic female, they differentiate into **oogonia**

These cells undergo a number of mitotic divisions and, **by the end of the third month**, are arranged in clusters surrounded by a layer of flat epithelial cells, known as **follicular cells,** originate from surface epithelium covering the ovary. The majority of oogonia continue to divide by mitosis, but some of them arrest their cell division in prophase of meiosis I and form **primary oocytes**

During the next few months, oogonia increase rapidly in number, and **by the fifth month**, the total number of germ cells in the ovary reaches **7 million**. At this time, cell death begins, and many oogonia as well as primary oocytes become atretic.

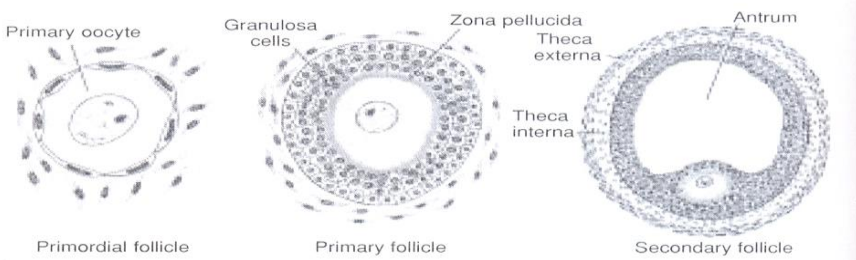


Figure 2.1 From the pool of primordial follicles, every day some begin to grow and develop into secondary (preantral) follicles, and this growth is independent of FSH. Then, as the cycle progresses, FSH secretion recruits primary follicles to begin development into secondary (antral, Graafian) follicles. During the last few days of maturation of secondary follicles, estrogens, produced by follicular and thecal cells, stimulate increased production of LH by the pituitary (Fig. 2.13), and this hormone causes the follicle to enter the preovulatory stage, to complete meiosis I, and to enter meiosis II where it arrests in metaphase approximately 3 hours before ovulation.

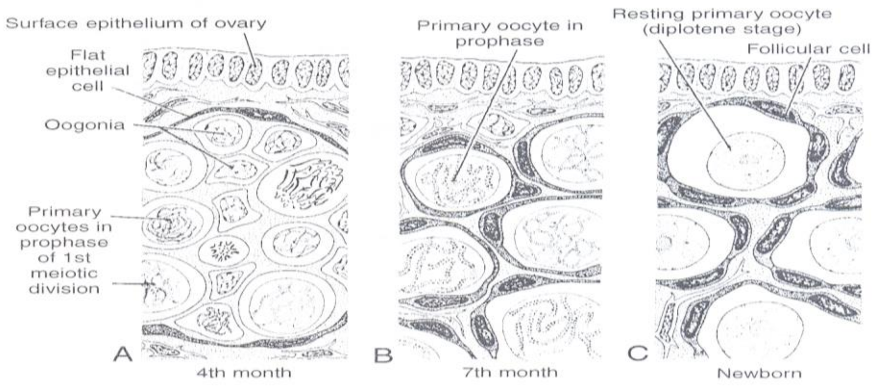


Figure 1.17 Segment of the ovary at different stages of development. **A.** Oogonia are grouped in clusters in the cortical part of the ovary. Some show mitosis; others have differentiated into primary oocytes and entered prophase of the first meiotic division. **B.** Almost all oogonia are transformed into primary oocytes in prophase of the first meiotic division. **C.** There are no oogonia. Each primary oocyte is surrounded by a single layer of follicular cells, forming the primordial follicle. Oocytes have entered the diplotene stage of prophase, in which they remain until just before ovulation. Only then do they enter metaphase of the first meiotic division.

By the seventh month, the majority of oogonia have degenerated except for a few near the surface. All surviving primary oocytes have entered prophase of meiosis I, and most of them are individually surrounded by a layer of flat epithelial cells known as a **primordial follicle**.

Near the time of birth, all primary oocytes have started prophase of meiosis I, and enter the **diplotene stage,** a resting stage during prophase. **Primary oocytes remain in prophase** and **do not finish their first meiotic division before puberty is reached,** apparently because of **oocyte maturation inhibitor** (OMI), a substance secreted by follicular cells.

The total number of primary oocytes at birth is estimated to vary from **700,000 to 2 million**. During childhood most oocytes become atretic; only approximately **400,000** are present **by the beginning of puberty**, and fewer than **500 will be ovulated**.

Some oocytes that reach maturity late in life have been dormant in the diplotene stage of the first meiotic division **for 40 years** or more before ovulation.

Whether the diplotene stage is the most suitable phase to protect the oocyte against environmental influences is unknown. The fact that the risk of having **children with chromosomal abnormalities** increases with maternal age indicates that primary oocytes are vulnerable to damage as they age.

At puberty, Each month, 15 to 20 follicles begin to mature, passing through three stages:

1) **primary** or **preantral**
2) **secondary** or **antral** (also called **vesicular** or **Graafian)** the longest stage
3) **preovulatory. (** 37 hours before ovulation **)**

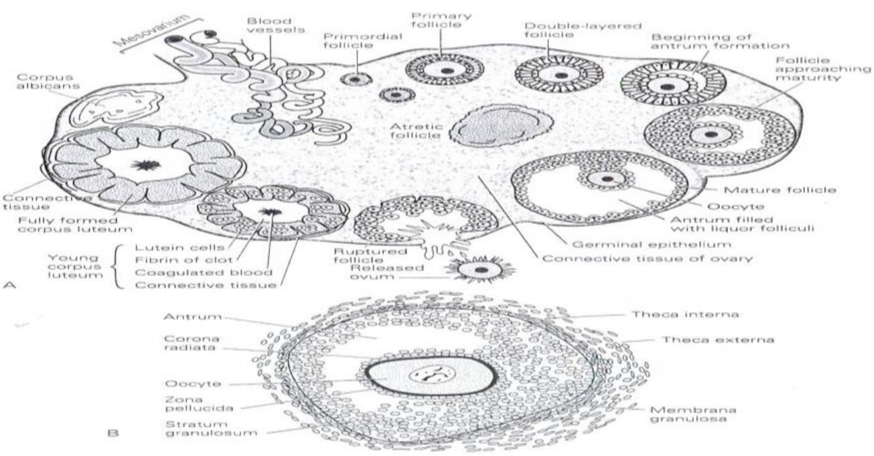
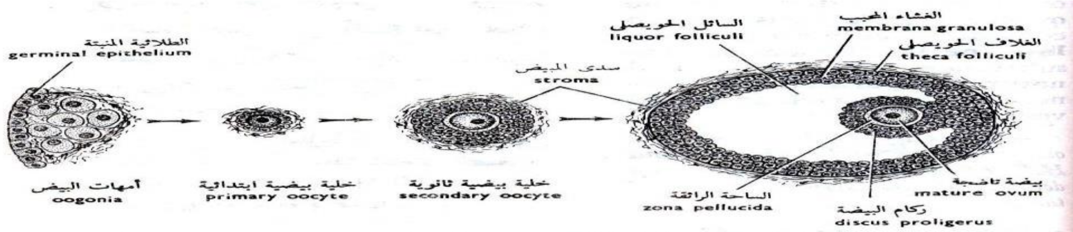
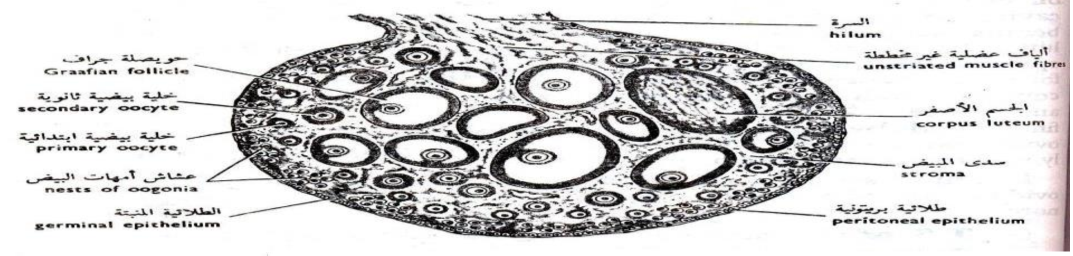


FIGURE 3-21
(A) Schematic diagram of ovary showing sequence of events in origin, growth, and rupture of ovarian (Graafian) follicle and in formation and retrogression of corpus luteum. Follow clockwise around ovary, starting at mesovarium. (B) Drawing of a secondary follicle.



مراحل تكوين حويصلة جراف
Developmental stages of a Graafian follicle



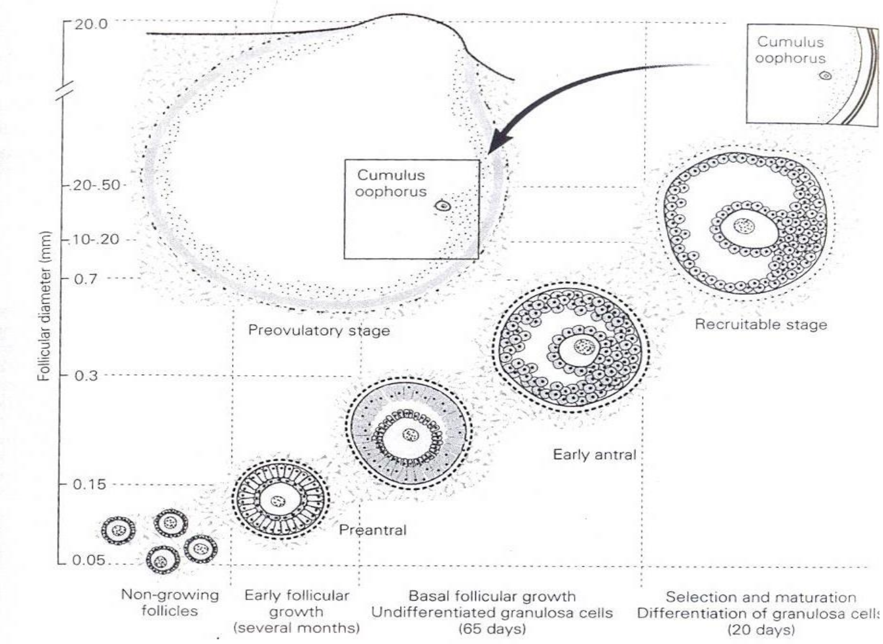


FIGURE 3-22
Representation of the growth and development of the human oocyte. (*After A. Gougeon, 1993.*)

As the **primary oocyte** begins to grow, surrounding follicular cells change from flat to cuboidal and proliferate to produce a stratified epithelium of **granulosa cells,** and the unit is called a **primary follicle**

Granulosa cells rest on a basement membrane separating them from surrounding stromal cells that form the **theca folliculi.**

Granulosa cells and the oocyte secrete a layer of glycoproteins on the surface of the oocyte, forming the **zona pellucida**.

Theca folliculi organize into an inner layer of secretory cells, the **theca interna,** and an outer fibrous capsule, the **theca externa.** Also, small, finger-like processes of the follicular cells extend across the zona pellucida and interdigitate with microvilli of the plasma membrane of the oocyte. These processes are important for transport of materials from follicular cells to the oocyte. As development continues, fluid-filled spaces appear between granulosea cells. Coalescence of these spaces forms the **antrum,** and the follicle is termed a **secondary (vesicular, Graafian) follicle.** Initially, the antrum is crescent shaped, but with time, it enlarges. (Granulosa cells surrounding the oocyte remain intact and form the **cumulus oophorus.** At maturity, the **secondary follicle** may be **25 mm** or more in diameter.

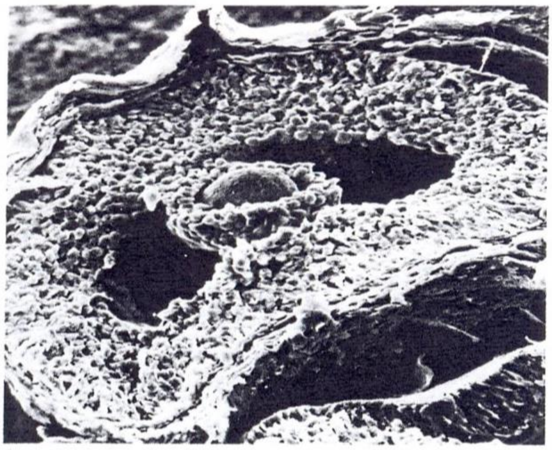
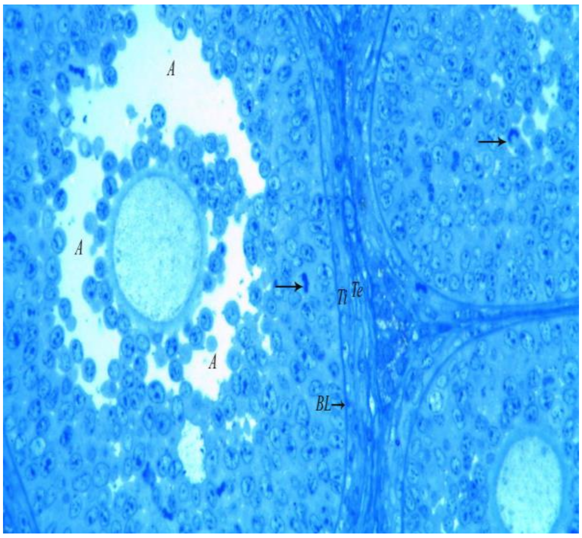


FIGURE 3-23
Scanning electron microscope of a mature follicle in the rat, showing the spherical oocyte (*center*) surrounded by smaller cells of the corona radiata, which projects into the antrum. x840. (*Courtesy of P. Bagavandoss.*)



With each ovarian cycle, a number of follicles begin to develop, but usually only one reaches full maturity. The others degenerate and become atretic.

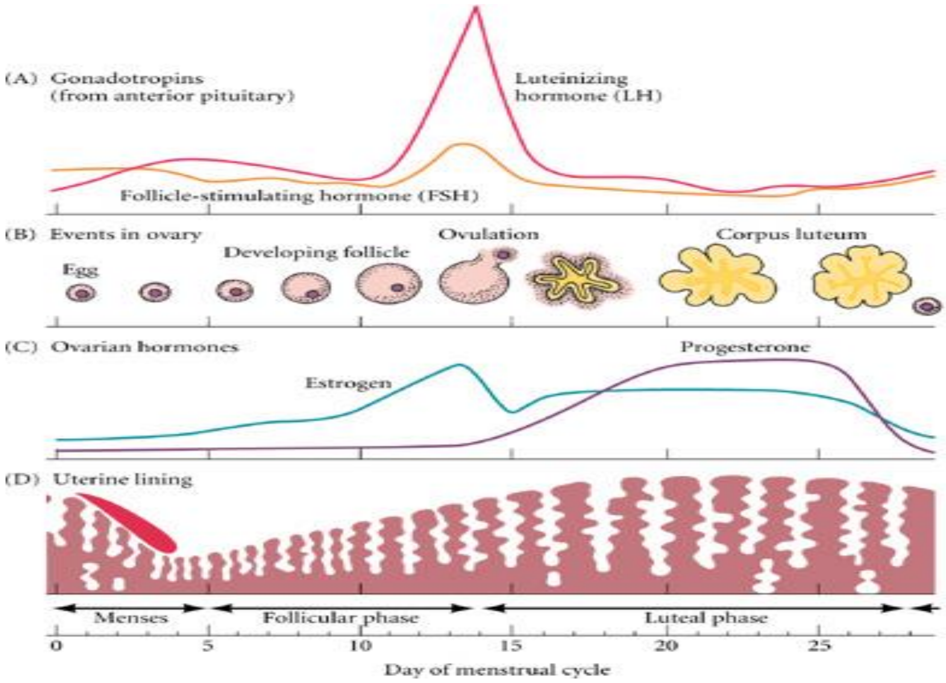
When the secondary follicle is mature, a surge in **luteinizing hormone (LH)** induces the preovulatory growth phase. **Meiosis I is completed**, resulting in formation of two daughter cells of unequal size, each with 23 double structured chromosomes.

- One cell, the **secondary oocyte,** receives most of the cytoplasm; the other, the **first polar body**, receives practically none. The first polar body lies between the zona pellucida and the cell membrane of the secondary oocyte in the perivitelline space.

The cell then enters **meiosis II** but arrests in metaphase approximately 3 hours before ovulation. Meiosis II is completed only if the oocyte is fertilized; otherwise, the cell degenerates approximately 24 hours after ovulation. The first polar body also undergoes a second division.

Ovarian Cycle

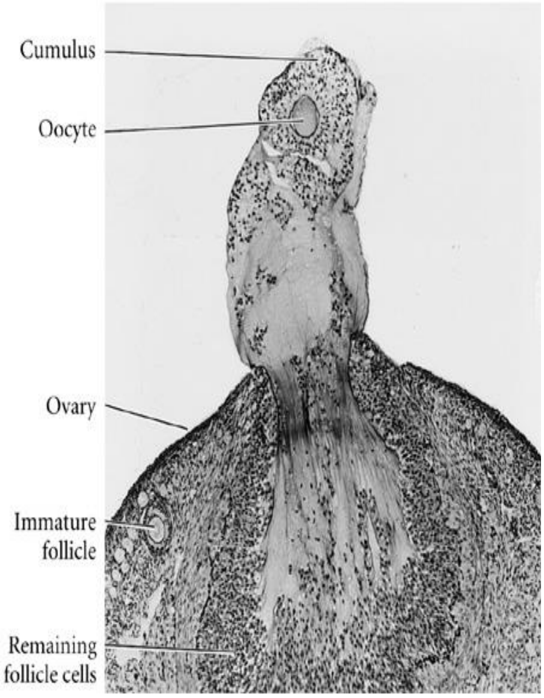
At puberty, the female begins to undergo regular monthly cycles. These **sexual cycles** are controlled by the hypothalamus. **Gonadotropin-releasing hormone (GnRH)** produced by the hypothalamus acts on cells of the anterior pituitary gland, which in turn secrete **gonadotropins.** These hormones, **follicle-stimulating hormone (FSH)** and **luteinizing hormone (LH),** stimulate and control cyclic changes in the ovary.



At the beginning of each ovarian cycle, 15 to 20 primary (preantral) stage follicles are stimulated to grow under the influence of FSH. Under normal conditions, only one of these follicles reaches full maturity. The others degenerate and become atretic. When a follicle becomes atretic, the oocyte and surrounding follicular cells degenerate and are replaced by connective tissue, forming a **corpus atreticum.** FSH also stimulates maturation of **follicular (granulosa)** cells surrounding the oocyte.

OVULATION

In the days immediately preceding ovulation, under the influence of FSH and LH, the secondary follicle grows rapidly to a diameter of 25 mm. Increase in LH causes the primary oocyte to complete meiosis I and the follicle to enter the preovulatory stage. Meiosis II is also initiated, but the oocyte is arrested in metaphase approximately 3 hours before ovulation. In the meantime, the surface of the ovary begins to bulge locally, and at the apex, an avascular spot, the **stigma,** appears. The high concentration of LH increases collagenase activity, resulting in digestion of collagen fibers surrounding the follicle. The muscular contractions in the ovarian wall extrude the oocyte, which together with its surrounding granulosa cells from the region of the cumulus oophorus, breaks free **(ovulation)** and floats out of the ovary.



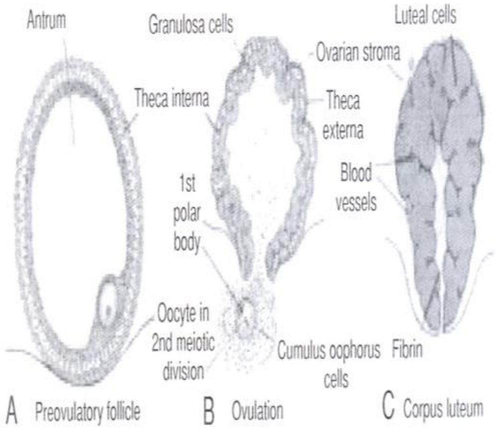


Figure 2.2 A. Preovulatory follicle bulging at the ovarian surface. **B.** Ovulation. The oocyte, in metaphase of meiosis II, is discharged from the ovary together with a large number of cumulus oophorus cells. Follicular cells remaining inside the collapsed follicle differentiate into lutean cells. **C.** Corpus luteum. Note the large size of the corpus luteum, caused by hypertrophy and accumulation of lipid in granulosa and theca interna cells. The remaining cavity of the follicle is filled with fibrin.

During ovulation, some women feel a slight pain, known as **middle pain** because it normally occurs near the middle of the menstrual cycle. Ovulation is also generally accompanied by a rise in basal temperature.

CORPUS LUTEUM

After ovulation, granulosa cells remaining in the wall of the ruptured follicle, together with cells from the theca interna, are vascularized by surrounding vessels. Under the influence of LH, these cells develop a yellowish pigment and change into **lutean cells,** which form the **corpus luteum** and secrete the hormone **progesterone** (Fig. 2.2*C*). Progesterone, together with estrogenic hormones, causes the uterine mucosa to enter the **progestational** or **secretory stage** in preparation for implantation of the embryo.

CORPUS ALBICANS

If fertilization does not occur, the corpus luteum reaches maximum development approximately 9 days after ovulation. It can easily be recognized as a yellowish projection on the surface of the ovary. Subsequently, the corpus luteum shrinks because of degeneration of lutean cells and forms a mass of fibrotic scar tissue, the **corpus albicans.** Simultaneously, progesterone production decreases,precipitating menstrual bleeding.

If the oocyte is fertilized, degeneration of the corpus luteum is prevented by **human chorionic gonadotropin** (hCG), a hormone secreted by the developing embryo. The corpus luteum continues to grow and forms the **corpus luteum of pregnancy (corpus luteum graviditatis).**

By the end of the third month, this structure may be one-third to one-half of the total size of the ovary. Yellowish luteal cells continue to secrete progesterone until the end of the fourth month; thereafter, they regress slowly as secretion of progesterone by the trophoblastic component of the placenta becomes adequate for maintenance of pregnancy. Removal of the corpus luteum of pregnancy before the fourth month usually leads to abortion.

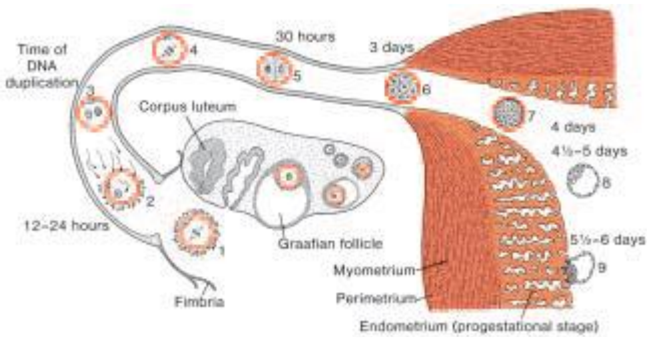
The timing of meiosis differs in females and males

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

Uterus at Time of Implantation

The wall of the uterus consists of three layers: (a) endometrium or mucosa lining the inside wall; (b) myometrium, a thick layer of smooth muscle; and (c) perimetrium, the peritoneal covering lining the outside wall. From puberty (11–13 years) until menopause (45–50 years), the endometrium undergoes changes in a cycle of approximately 28 days under hormonal control by the ovary. During this menstrual cycle, the uterine endometrium passes through three stages, the follicular or **proliferative phase**, the secretory or **progestational phase**, and the **menstrual phase**.

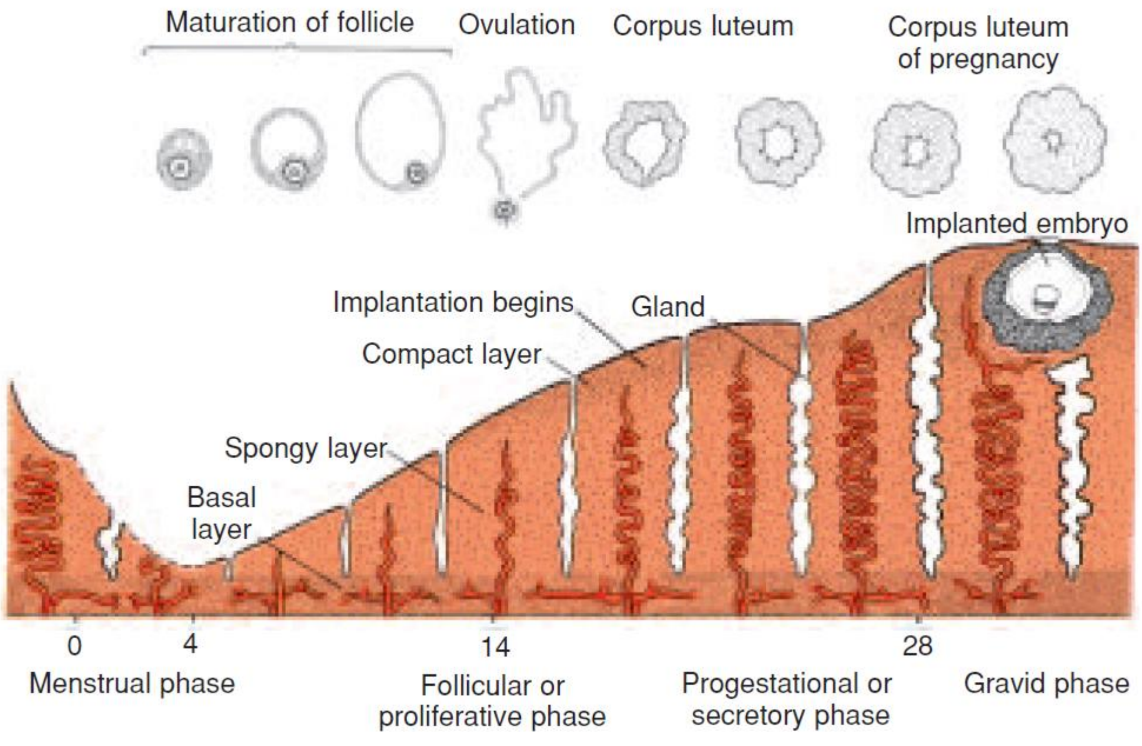
The proliferative phase begins at the end of the menstrual phase, is under the influence of estrogen, and parallels growth of the ovarian follicles. The secretory phase begins approximately 2 to 3 days after ovulation in response to progesterone produced by the corpus luteum. If fertilization does not occur, shedding of the endometrium marks the beginning of the menstrual phase. If fertilization does occur, the endometrium assists in implantation and contributes to formation of the placenta.



Events during the first week of human development. 1, Oocyte immediately after ovulation. 2, Fertilization, approximately 12 to 24 hours after ovulation. 3, Stage of the male and female pronuclei. 4, Spindle of the first mitotic division. 5, Twocell stage (approximately 30 hours of age). 6, Morula containing 12 to 16 blastomeres (approximately 3 days of age). 7, Advanced morula stage reaching the uterine lumen (approximately 4 days of age). 8, Early blastocyst stage (approximately 4.5 days of age). The zona pellucida has disappeared. 9, Early phase of implantation (blastocyst approximately 6 days of age). The ovary shows stages of transformation between a primary follicle and a preovulatory follicle as well as a corpus luteum. The uterine endometrium is shown in the progestational stage.

At the time of implantation, the mucosa of the uterus is in the secretory phase , during which time uterine glands and arteries become coiled and the tissue becomes succulent. As a result, three distinct layers can be recognized in the endometrium: a superficial **compact layer**, an intermediate **spongy layer**, and a thin **basal layer**. Normally, the human blastocyst implants in the endometrium , where it becomes embedded between the openings of the glands;

If the oocyte is not fertilized, venules and sinusoidal spaces gradually become packed with blood cells, and an extensive diapedesis of blood into the tissue is seen. When the menstrual phase begins, blood escapes from superficial arteries, and small pieces of stroma and glands break away. During the following 3 or 4 days, the compact and spongy layers are expelled from the uterus, and the basal layer is the only part of the endometrium that is retained. This layer, which is supplied by its own arteries, the basal arteries, functions as the regenerative layer in the rebuilding of glands and arteries in the proliferative phase.

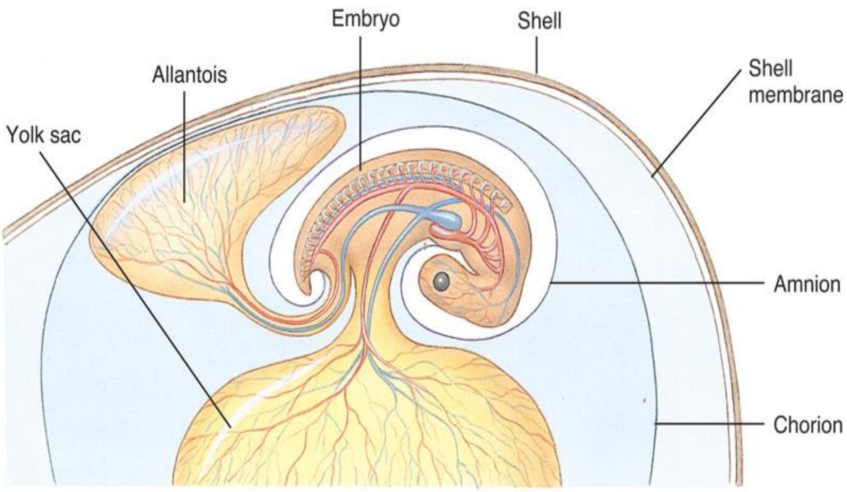


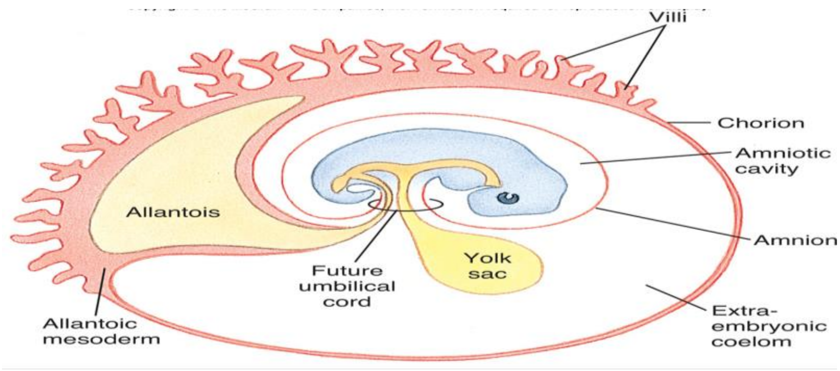
Changes in the uterine mucosa correlated with those in the ovary. Implantation of the blastocyst has caused development of a large corpus luteum of pregnancy. Secretory activity of the endometrium increases gradually as a result of large amounts of progesterone produced by the corpus luteum of pregnancy.

Extraembryonic Membranes

An almost universal requirement of embryonic development is that the embryo develop in a moist, protective environment. In most fishes, this requirement is met by laying and fertilizing massive numbers of eggs in water . The eggs that are fertilized develop within simple spherical membranes. Amphibians must return at each spring to pounds and streams to lay eggs which, upon fertilization, develop within simple noncellular membranes.

A significant evolutionary step occurred when the first reptiles laid eggs capable of developing on land. This made possible by the elaboration of a 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. Four sets of extraembryonic membranes are common to the embryo of the terrestrial vertebrates.





1- **The amnion** is a thin ectodermally derived membrane which eventually encloses the entire embryo in a fluid-filled sac. The amniotic membrane is functionally specialized for the secretion and absorption of the amniotic fluid that bathes the embryo. So characteristic is this structure that the reptiles, birds, and mammals as a group are often called amniotes. The fishes and amphibians, lacking an amnion, are collectively called anamniotes.

2- The yolk sac : The endodermal yolk sac is intimately involved with nutrition of the embryo in large-yolked forms such as reptiles and birds. Despite the lack of stored in mammalian eggs, the yolk sac has been preserved, possibly because other important secondary functions are associated with it. For example, the yolk sac endoderm induces the surrounding extraembryonic mesoderm to form the first blood cells and blood vessels.

3- The allantois is an endodermally lined evagination originating from the ventral surface of the early hindgut. Its principal functions are to act as a reservoir for storing or removing urinary wastes and to mediate gas exchange between the embryo and its surroundings.

In reptiles and birds the allantois is a large sac, and because the egg is a closed system with respect to urinary wastes, the allantois must sequester nitrogenous by-product so that they do not subject the embryo to osmotic stress or toxic effects.

In mammals the role and prominence of the allantois vary with the efficiency of the interchange that takes place at the fetal-maternal interface. The allantois of the pig embryo rivals that of the bird in both size and functional importance, whereas the human allantois has been reduced to a mere vestige that contributes only a well-developed vascular network to the highly efficient placenta.

4-The chorion is the outermost extraembryonic membrane, which abuts onto the shell or the maternal tissue and thus represents the site of exchange between the embryo and the environment around it.

In reptiles and birds, the principla function of the chorion is the respiratory exchange of gases.

In mammals, the chorion serves a much more all-embracing function which includes not only respiration but also nutrition, excertion, filtration, and synthesis-with hormone production begin an important example of the last function.

Embryonic development of mammals

Gametes

The sperm: It is microscopic. It is formed of a head, a middle piece and a tail.

- The head is pear-shaped. It has a nucleus and an acrosome surrounded by a plasma membrane.
- The middle piece is connected with head by a neck , and contain two centrioles and the mitochondria.
- The tail is long. Its central core is occupied by an axial filament.

The egg: is spherical in shape. In therian mammals (both marsupials and placentals) the eggs are very small. Placentals: range from 0.1 - 0.2 mm.

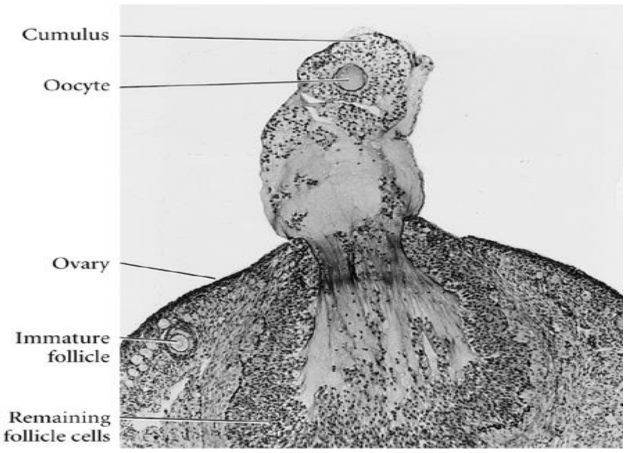
(Humans ~0.15 mm). Eggs - microlecithal - cleavage - holoblastic. the egg is released from the ovary surrounded by three membranes

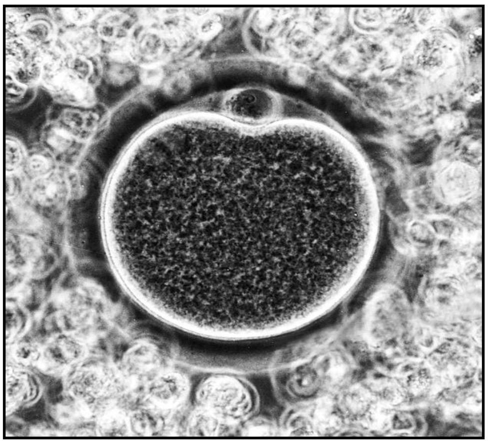
1- Corona radiate (formed of follicle cells)

2 - A middle zona pellucida

3 - An inner plasma membrane.

There is a fluid-filled space between zona pellucida and the surface of the egg and it is called perivitelline space.



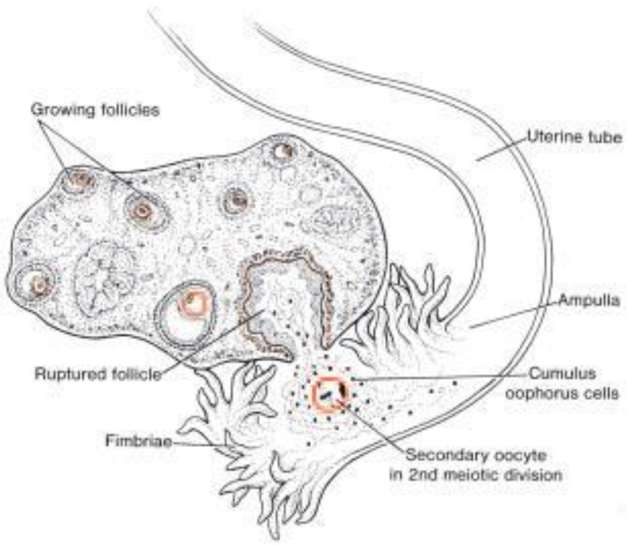


<u>**Fertilization in mammals**</u>

Fertilization, the process by which male and female gametes fuse, occurs in the **ampullary region of the uterine tube.** This is the widest part of the tube and is close to the ovary. Spermatozoa may remain viable in the female reproductive tract for several days. Only 1% of sperm deposited in the vagina enter the cervix, where they may survive for many hours. The trip from cervix to oviduct requires a minimum of 2 to 7 hours, and after reaching the isthmus, sperm become less motile and cease their migration. Spermatozoa are not able to fertilize the oocyte immediately upon arrival in the female genital tract but must undergo (*a*) **capacitation** and (*b*) the **acrosome reaction** to acquire this capability.

(a)-Capacitation is a period of conditioning in the female reproductive tract that in the human lasts approximately 7 hours. Much of this conditioning, which occurs in the uterine tube, entails epithelial interactions between the sperm and mucosal surface of the tube. During this time a glycoprotein coat and seminal plasma proteins are removed from the plasma membrane that overlies the acrosomal region of the spermatozoa. Only capacitated sperm can pass through the corona cells and undergo the acrosome reaction.

(b) The **acrosome reaction,** which occurs after binding to the zona pellucida, is induced by zona proteins. This reaction culminates in the release of enzymes needed to penetrate the zona pellucida, including acrosin and trypsin-like substances.



Fimbriae collect the oocyte and sweep it into the uterine tube.

The phases of fertilization

Phase 1, penetration of the corona radiate.

phase 2, penetration of the zona pellucida.

phase 3, fusion of the oocyte and sperm cell membranes.

PHASE 1: PENETRATION OF THE CORONA RADIATA

Of the 200 to 300 million spermatozoa deposited in the female genital tract, only 300 to 500 reach the site of fertilization. Only one of these fertilizes the egg. It is thought that the others aid the fertilizing sperm in penetrating the barriers protecting the female gamete. Capacitated sperm pass freely through corona cells.

PHASE 2: PENETRATION OF THE ZONA PELLUCIDA

The zona is a glycoprotein shell surrounding the egg that facilitates and maintains sperm binding and induces the acrosome reaction. Both binding and the acrosome reaction are mediated by the ligand ZP3, a zona protein. Release of acrosomal enzymes (acrosin) allows sperm to penetrate the zona, thereby coming in contact with the plasma membrane of the oocyte.

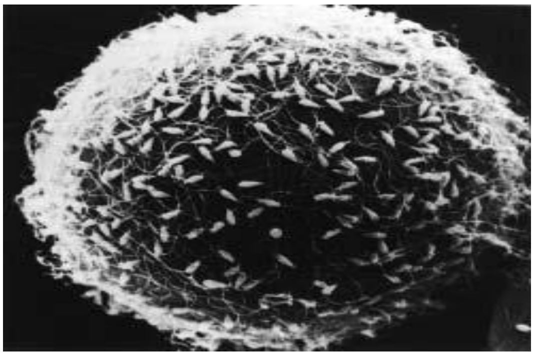
Permeability of the zona pellucida changes when the head of the sperm comes in contact with the oocyte surface. This contact results in release of lysosomal enzymes from cortical granules lining the plasma membrane of the oocyte. In turn, these enzymes alter properties of the zona pellucida **(zona reaction)** to prevent sperm penetration and inactivate species-specific receptor sites for spermatozoa on the zona surface. Other spermatozoa have been found embedded in the zona pellucida, but only one seems to be able to penetrate the oocyte. These reactions prevent polyspermy (penetration of more than one spermatozoon into the oocyte).

PHASE 3: FUSION OF THE OOCYTE AND SPERM CELL MEMBRANES

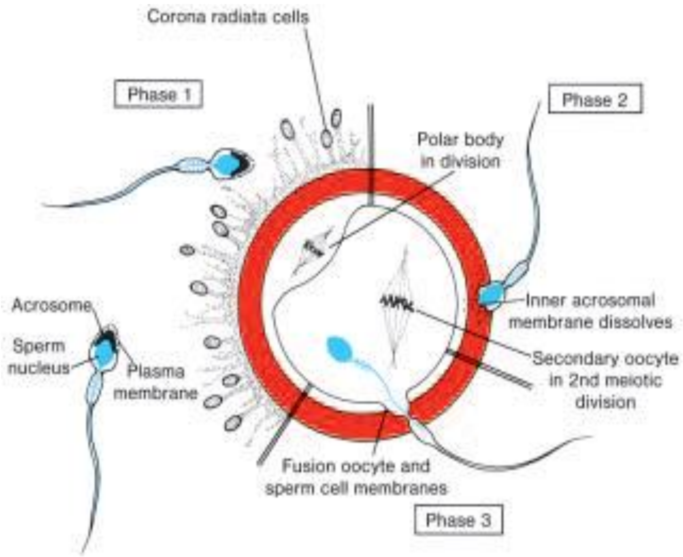
After adhesion, the plasma membranes of the sperm and egg fuse. Because the plasma membrane covering the acrosomal head cap disappears during the acrosome reaction, actual fusion is accomplished between the oocyte membrane

and the membrane that covers the posterior region of the sperm head. In the human, both the head and tail of the spermatozoon enter the cytoplasm of the oocyte, but the plasma membrane is left behind on the oocyte surface. As soon as the spermatozoon has entered the oocyte, the egg responds in three ways.
The oocyte finishes its second meiotic division immediately after entry of the spermatozoon. One of the daughter cells, which receives hardly any cytoplasm, is known as the **second polar body;** the other daughter cell is the **definitive oocyte.** Its chromosomes (22+X) arrange themselves in a vesicular nucleus known as the **female pronucleus**.

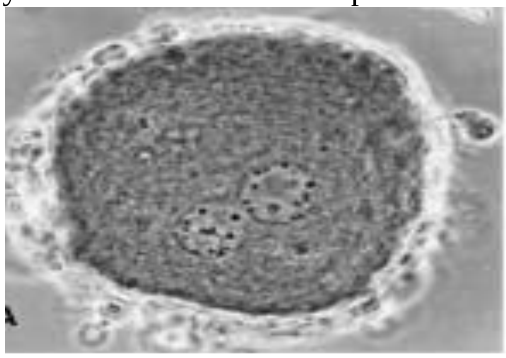
The spermatozoon, meanwhile, moves forward until it lies close to the female pronucleus. Its nucleus becomes swollen and forms the **male pronucleus** ; the tail detaches and degenerates. Morphologically, the male and female pronuclei are indistinguishable, and eventually, they come into close contact and lose their nuclear envelopes. Each pronucleus must replicate its DNA.



Scanning electron micrograph of sperm binding to the zona pellucida.



The three phases of oocyte penetration. In phase 1, spermatozoa pass through the corona radiata barrier; in phase 2, one or more spermatozoa penetrate the zona pellucida; in phase 3, one spermatozoon penetrates the oocyte membrane while losing its own plasma membrane. Inset. Normal spermatocyte with acrosomal head cap.



Phase contrast view of the pronuclear stage of a fertilized human oocyte with male and female pronuclei.

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.

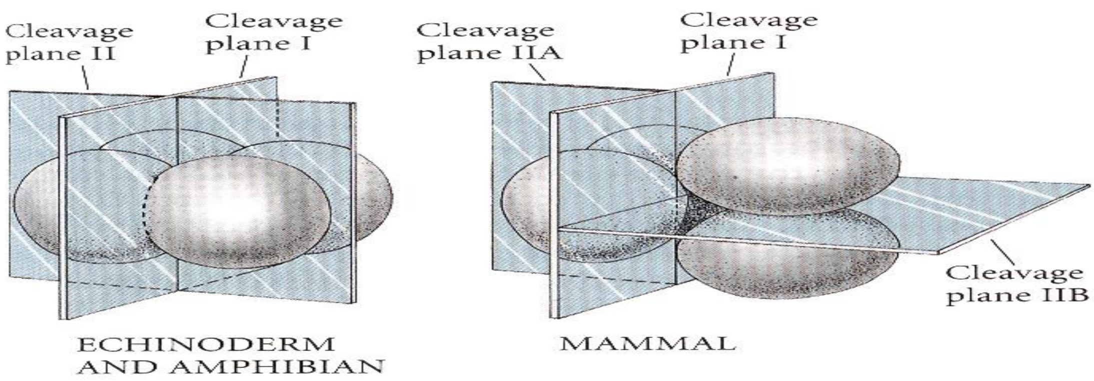
2- **Determination of the sex of the new individual**. An X-carrying sperm produces a female (XX) embryo, and a Y-carrying sperm produces a male (XY) embryo. Hence, the chromosomal sex of the embryo is determined at fertilization.

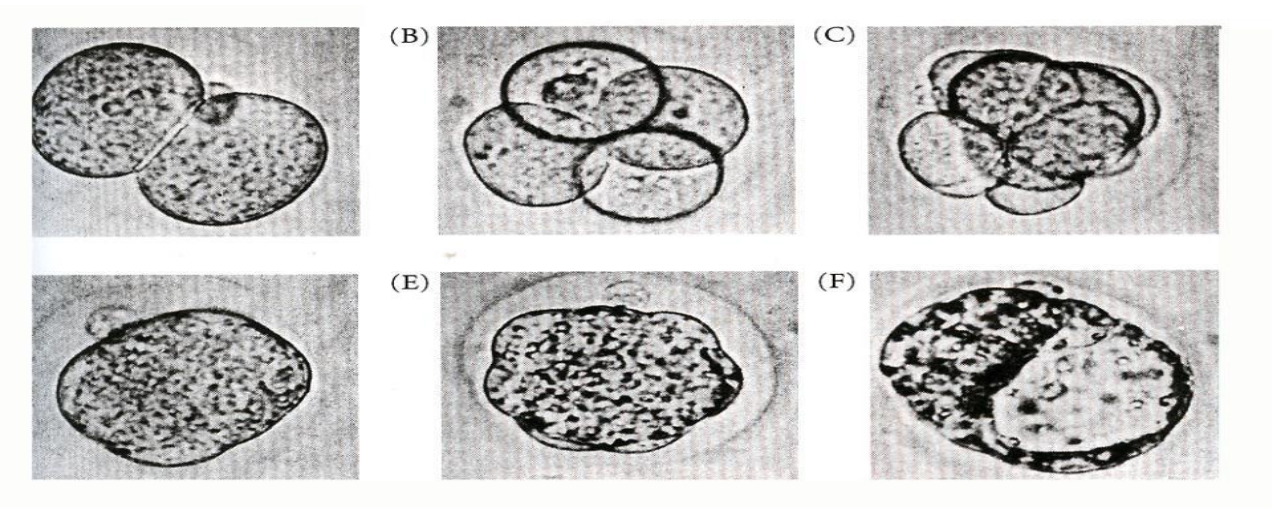
3- **<u>Initiation of cleavage</u>.** Without fertilization, the oocyte usually degenerates 24 hours after ovulation.

Early cleavage in mammals

Cell division occurs with travel down the tube and into the uterus. First Cleavage - takes place while embryo is still in the uterine tubes of the mother.

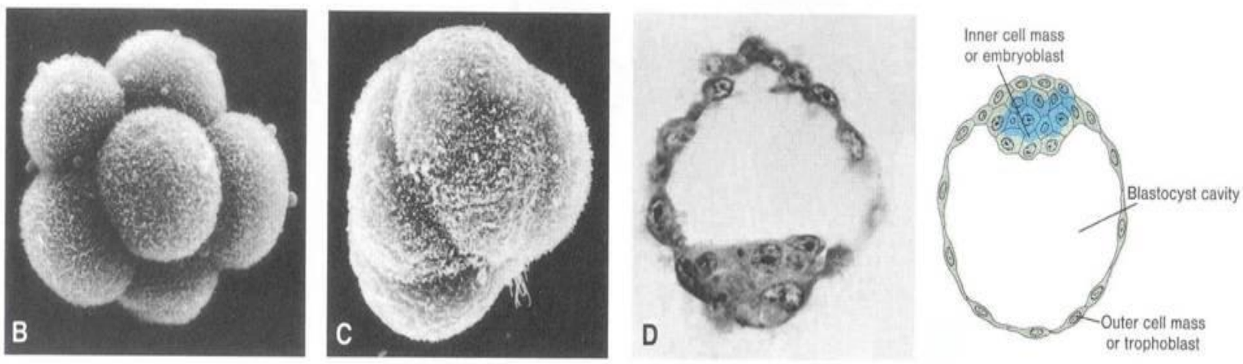
Second Cleavage: Mammals have what's known as rotational cleavage wherein one of the blastomeres divides meridianally, and the other equatorially. Subsequent cleavages are relatively less organized. Once the zygote has reached the two-cell stage, it undergoes a series of mitotic divisions, increasing the numbers of cells.These cells (blastomeres) become smaller with each cleavage division. After the third cleavage, blastomeres maximize their contact with each other, forming a compact ball of cells held together by tight junctions.





Development of the zygote from the two-cell stage to the late morula stage. The two-cell stage is reached approximately 30 hours after fertilization; the four-cell stage, at approximately 40 hours; the 12- to 16-cell stage, at approximately 3 days; and the late morula stage, at approximately 4 days. During this period, blastomeres are surrounded by the zona pellucida, which disappears at the end of the fourth day.

Approximately 3 days after fertilization, cells of the compacted embryo divide again to form a 16-cell morula. the developing organism has usually reached the uterus. It is about the size of a head of a pin. Inner cells of the morula constitute the inner cell mass, and surrounding cells compose the outer cell mass.

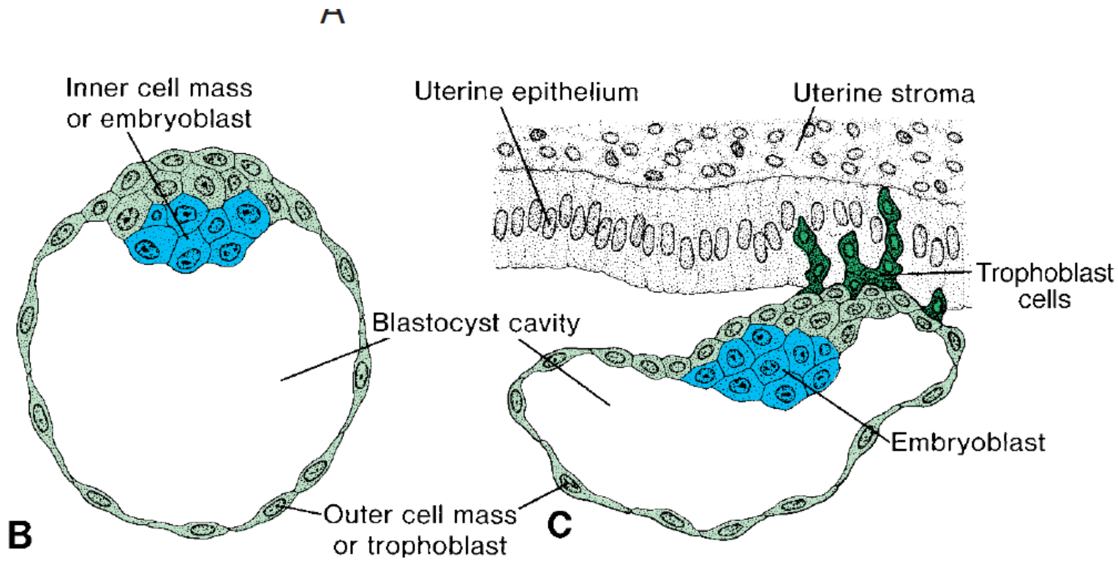


Scanning electron micrographs of uncompacted (B) and compacted (C) eight-cell mouse embryos. In the uncompacted state, outlines of each blastomere are distinct, whereas after compaction cell-cell contacts are maximized and cellular outlines are indistinct.

Blastocyst Formation

About the time the morula enters the uterine cavity, fluid begins to penetrate through the zona pellucida into the intercellular spaces of the inner cell mass.

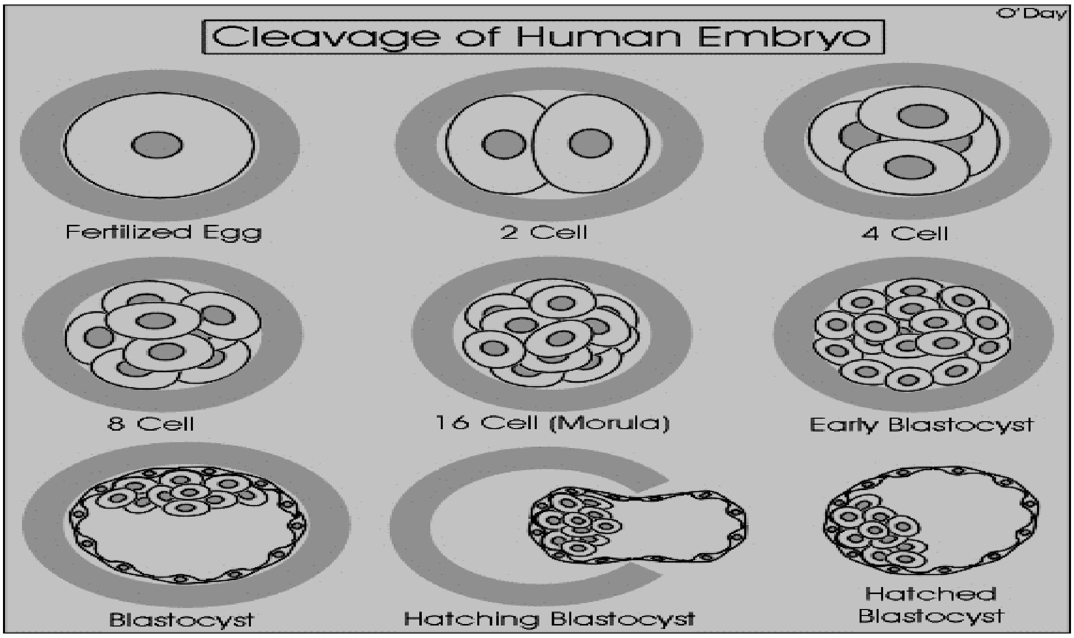
Gradually the intercellular spaces become confluent, and finally a single cavity, the blastocele, forms. this cavity is eccentrically placed. At this time, the embryo is a blastocyst. Cells of the inner cell mass, now called the embryoblast, are at one pole, and those of the outer cell mass, or trophoblast, flatten and form the epithelial wall of the blastocyst. The inner cell mass gives rise to tissues of the embryo proper the embryoblast, and the outer cell mass forms the trophoblast, which later contributes to the placenta.

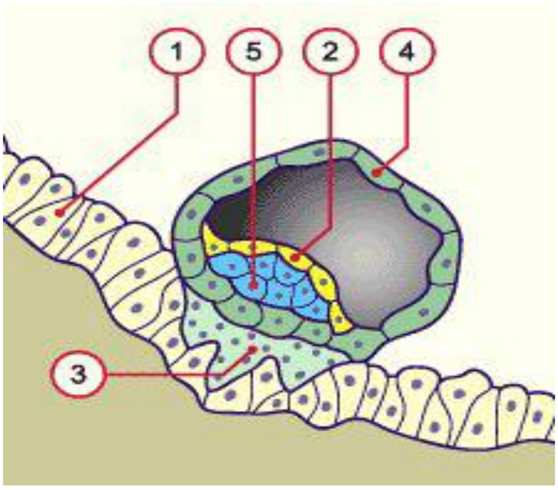


Implantation

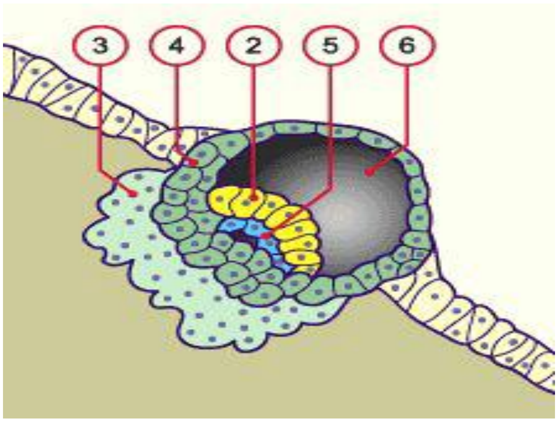
At the 6th day, the zona pellucida become lysed after the blastula reached to the proper side of the endometrium and disappeare (Hatching of blastula) allowing implantation to begin. At the time of implantation, the mucosa of the uterus is in the secretory phase, In the human, trophoblastic cells over the embryoblast pole begin to penetrate between the epithelial cells of the uterine mucosa about the sixth day. The trophoblast cells exert microvilli which exert a histolytic action on the endometrium epithelium facilitating penetration and implantation. By the end of 8 days implantation is completed. After implantation the endometrium is closed by fibrin clott.

- Abnormal site of implantation (Ectopic pregnancy):Tubal pregnancy, ovarian pregnancy and abdominal pregnancy.

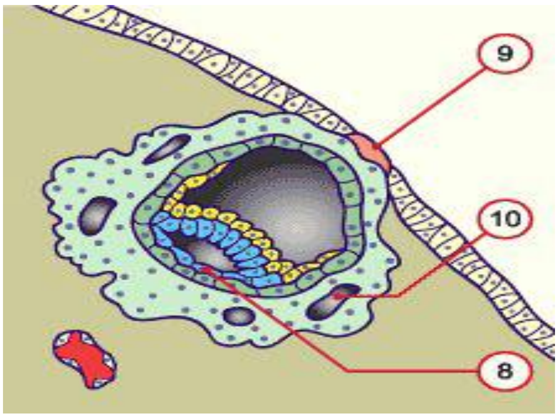




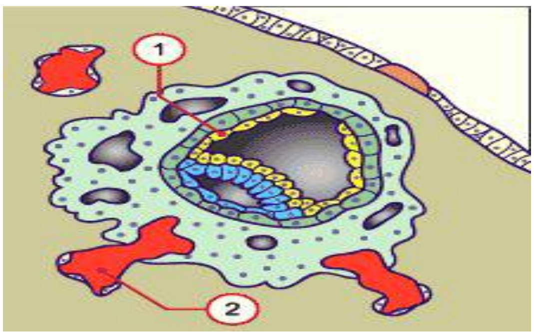
6-7 days



7-8 days



9 days



9-10 days

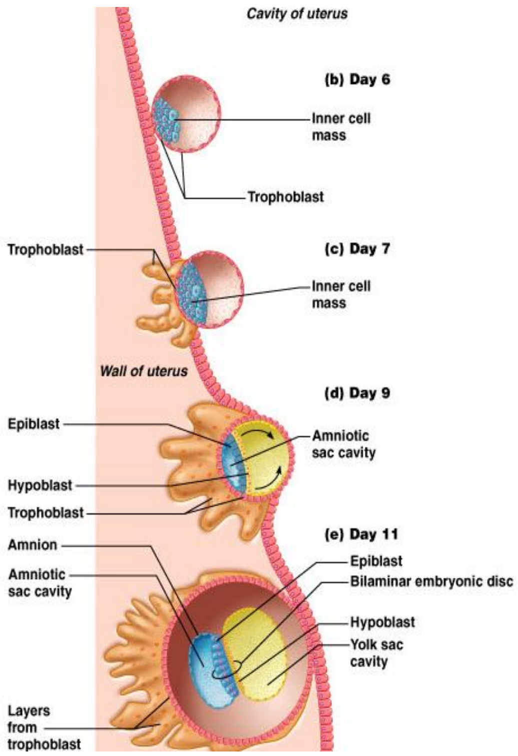
1 = uterine epithelium 2 and 5 = inner cell (mass or future embryo)

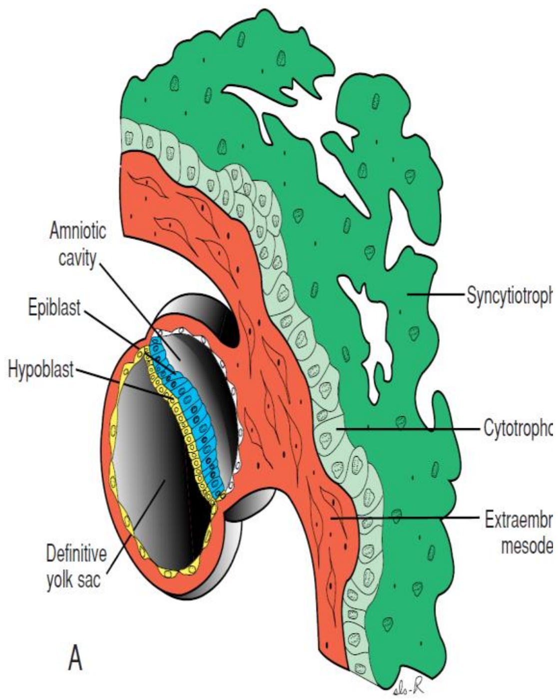
3 and 4 = trophoblast or future placenta 3 = syncytiotrophoblast 4 = cytotrophoblast

6 = yolk sac cavity 8 = Amnion 9 = Fibrin plug 10 = Intervillous spaces

Week 2

Inner cell mass divides into epiblast and hypoblast, two fluid filled sacs amniotic sac from epiblast and yolk sac from hypoblast. Bilaminar embryonic disc.





Week 3

Bilaminar to Trilaminar disc :Three primary germ layers: all body tissues develop from these layers, ectoderm, endoderm and mesoderm.

1- Primitive streak (groove) on dorsal surface of epiblast

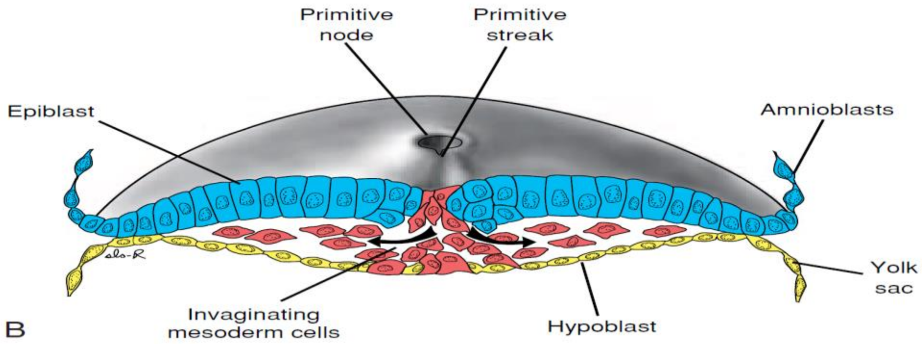
2- Grastrulation: invagination of epiblast cells

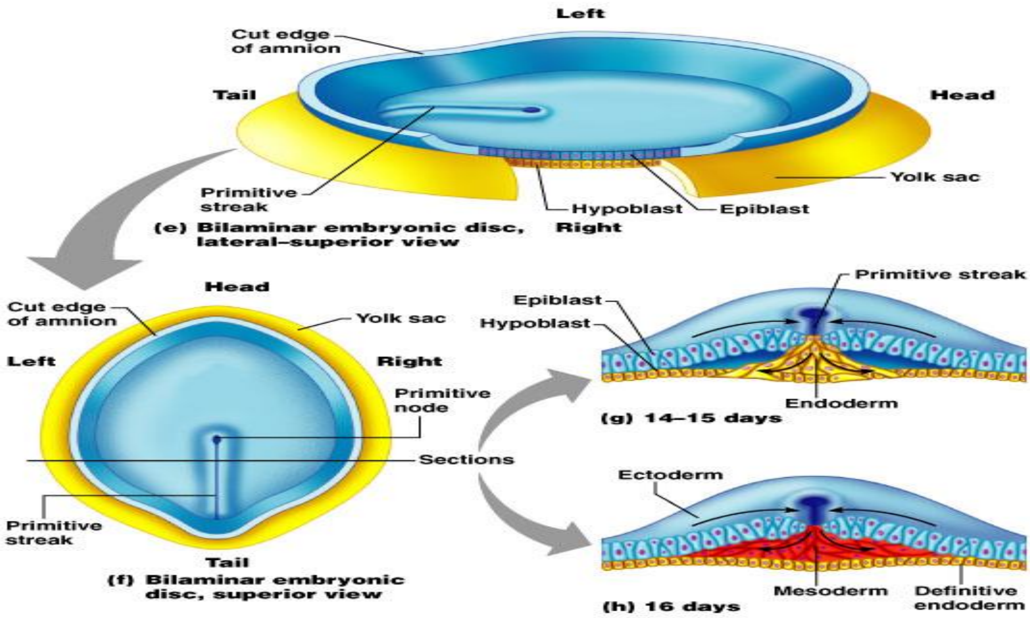
3- Days 14-15: they replace hypoblast becoming endoderm

4- Day 16: mesoderm (a new third layer) formed in between

5- Epiblast cells remaining on surface: ectoderm

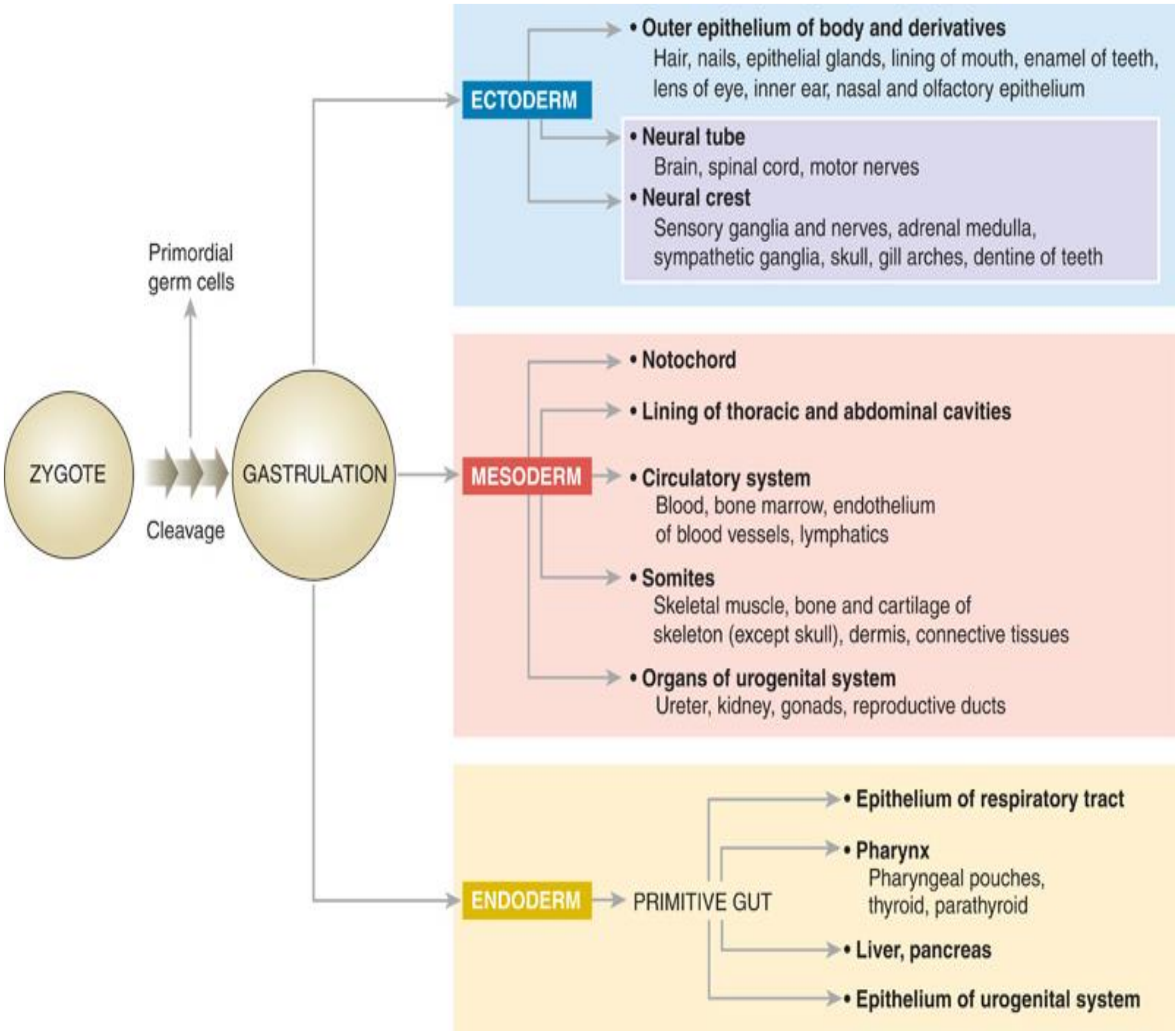
Ectoderm and endoderm are epithelial tissue (form sheets of tissue). Mesoderm is a mesenchyme tissuem, mesenchyme cells are star shaped and do not attach to one another, therefore migrate freely.





Organogenesis

Many different structures are derived from the three embryonic germ layers during organogenesis. By 8 weeks, about 2 months, all major organs are in place in at least a rudimentary form; this is why drugs early in pregnancy are so important to avoid many cause birth defects.



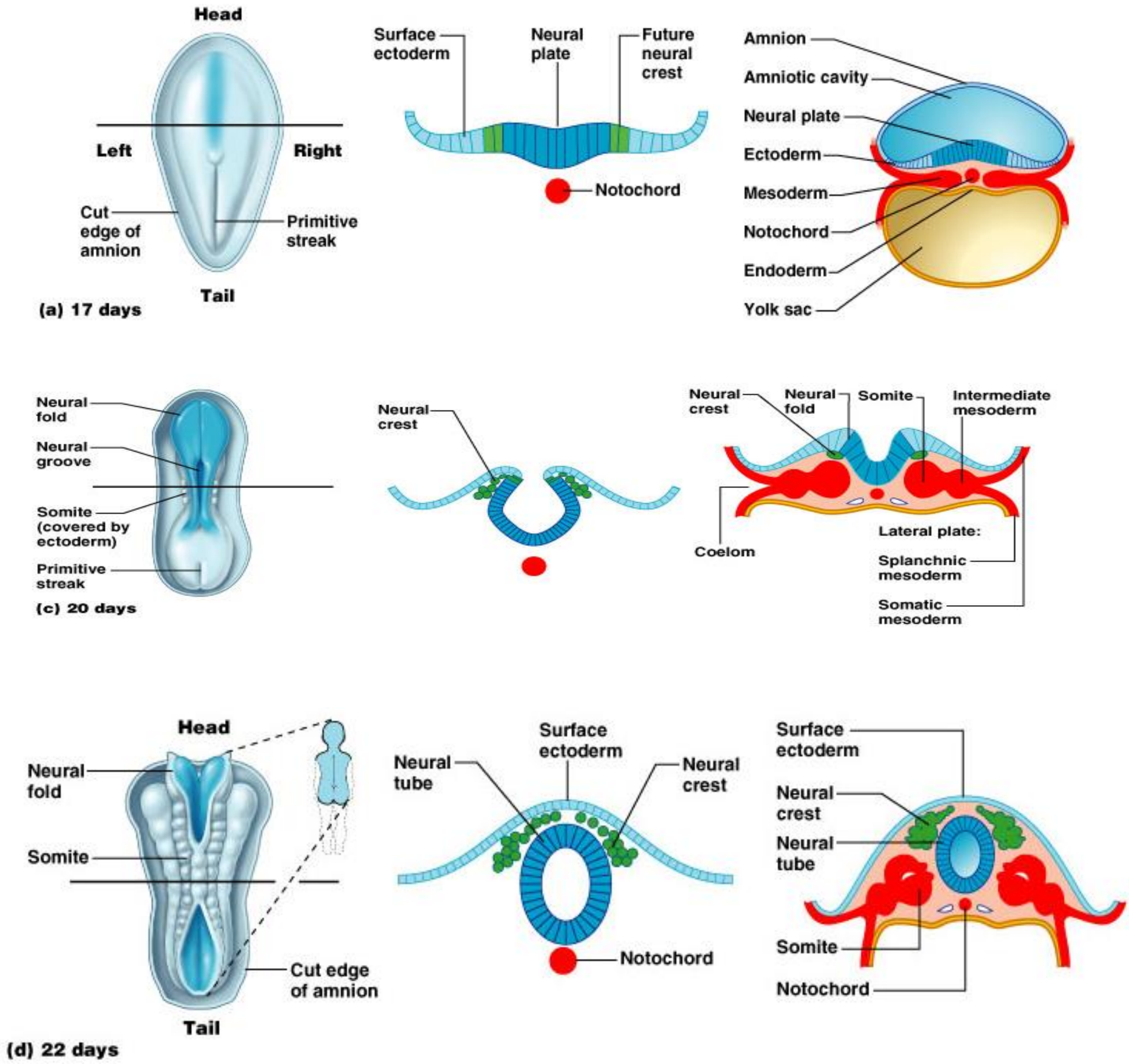
Notochord

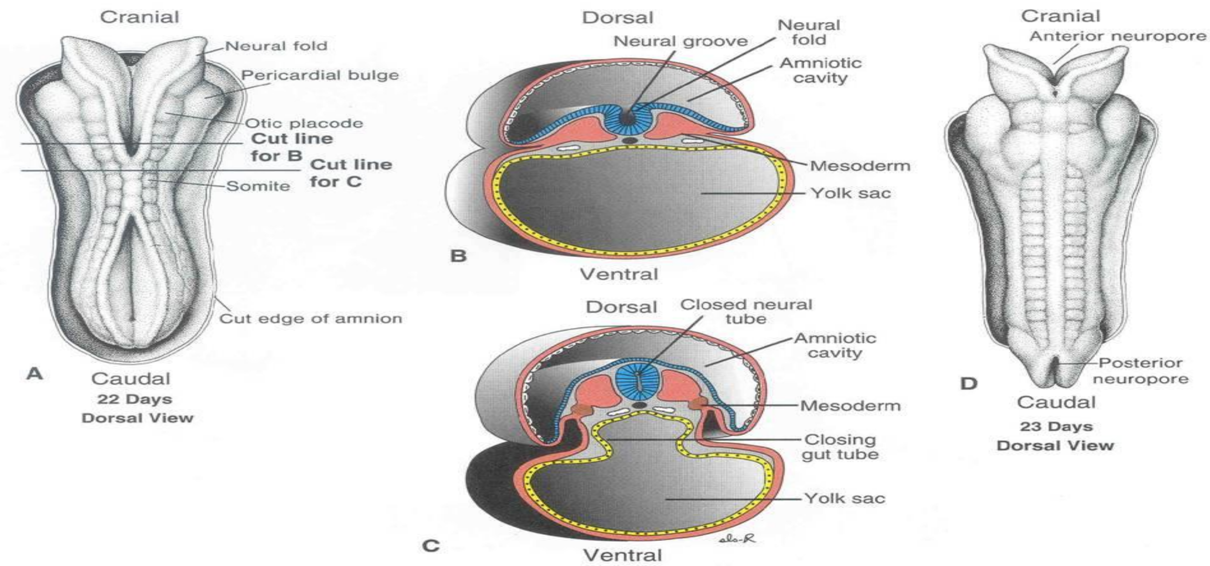
Days 16-18. Primitive node epiblast cells invaginate and migrate anteriorly with some endoderm cells. Rod defining the body axis is formed extends cranially and caudally (from head to tail or crown to rump). Future site of the vertebral column.

Derivatives of Ectoderm

Nervous System (Neurulation)

Just above the notochord (mesoderm), the ectoderm thickens to form a neural plate. (Notochord signals overlying ectoderm). Edges of the neural plate fold up to create an elongated, hollow neural tube. Anterior end of neural tube enlarges to form the brain and cranial nerves. Posterior end forms the spinal cord and spinal motor nerves. Closure of neural tube: begins at end of week 3; complete by end of week 4 (folic acid important for this step)





Neural crest lateral ectodermal cells pinch off from the neural tube. Give rise to Portions of cranial nerves , Pigment cells , Cartilage , Bone Ganglia of the autonomic system , Medulla of the adrenal gland , Parts of other endocrine glands. Neural crest cells are unique to vertebrates. Important in evolution of the vertebrate head and jaws.

At Week3, mesoderm begins to differentiate lateral to notochord. **Division of mesoderm** into three regions by end **week 4**,

- Somites: 40 pairs of body segments (repeating units, like building blocks).
- Intermediate mesoderm: just lateral to somites.
- Lateral plate: splits to form coelom (cavity)

Divisions of the mesodermal lateral plate

1- Somatic mesoderm: apposed to the ectoderm

2- Splanchnic mesoderm: apposed to the endoderm, Coelom in between will become the serous cavities of the ventral body cavity: Peritoneal , Pericardial , Pleural

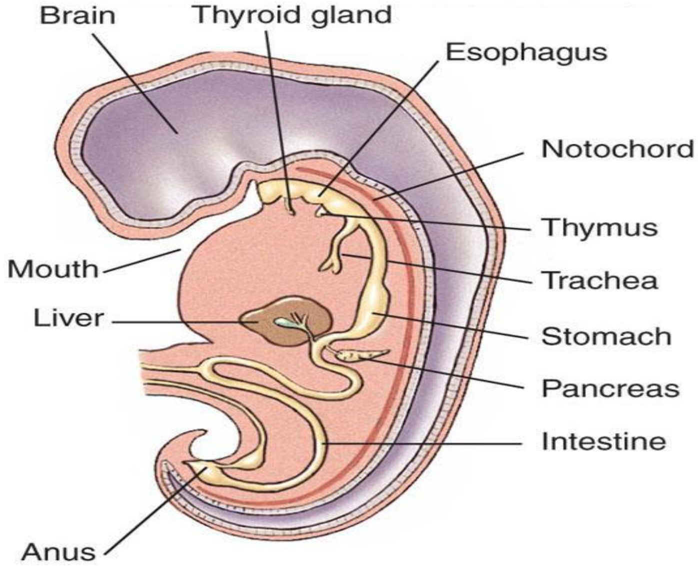
Derivatives of Endoderm: Digestive Tube and Gill Arches

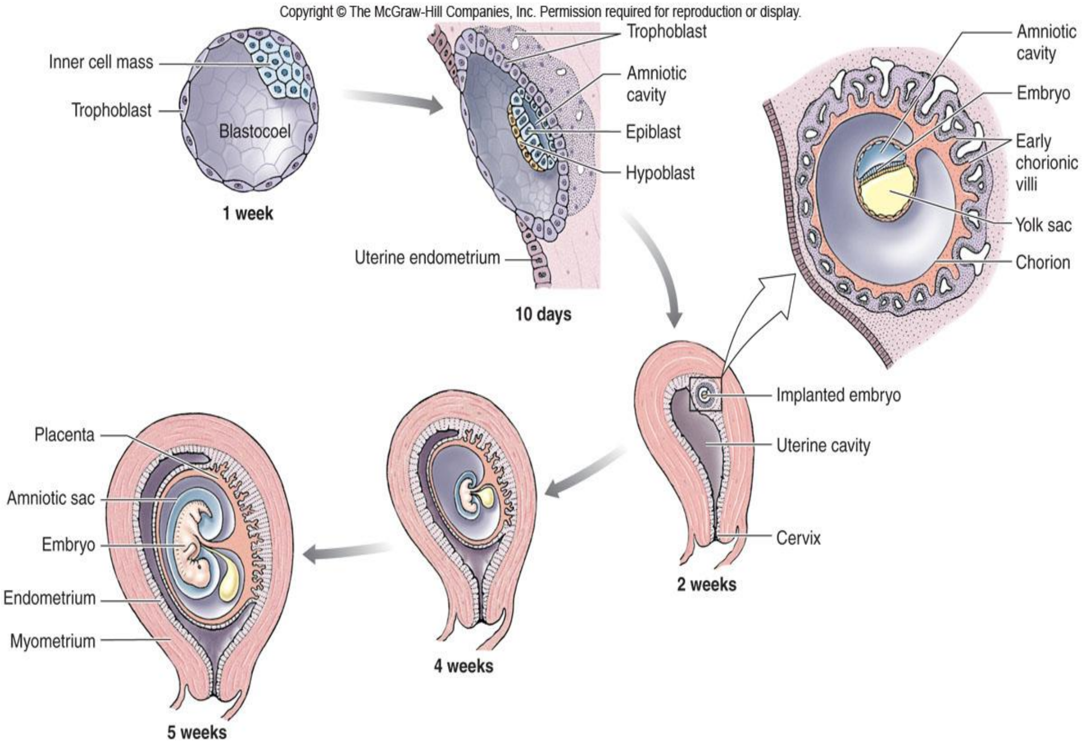
During gastrulation,the archenteron forms as the primitive gut. This endodermal cavity eventually produces: Digestive tract, Lining of pharynx and lungs, most of the liver and pancreas, thyroid, parathyroid glands and thymus.

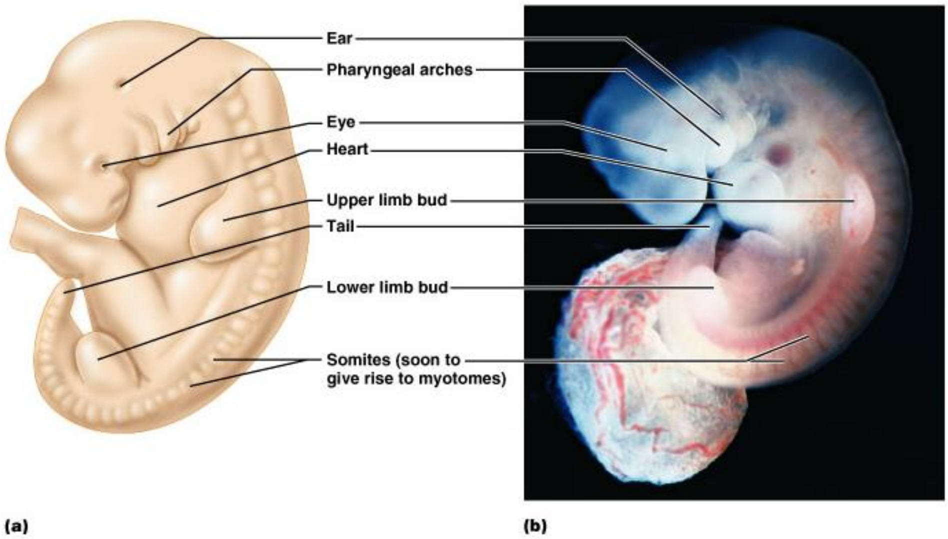
Pharyngeal pouches are derivatives of the digestive tract. Arise in early embryonic development of all vertebrates. During development, endodermally-lined pharyngeal pouches interact with overlying ectoderm to form gill arches.

In fish, gill arches develop into gills.

In terrestrial vertebrates: No respiratory function, 1st arch and endoderm-lined pouch form upper and lower jaws, and inner ear. 2nd, 3rd, and 4th gill pouches form tonsils, parathyroid gland and thymus.



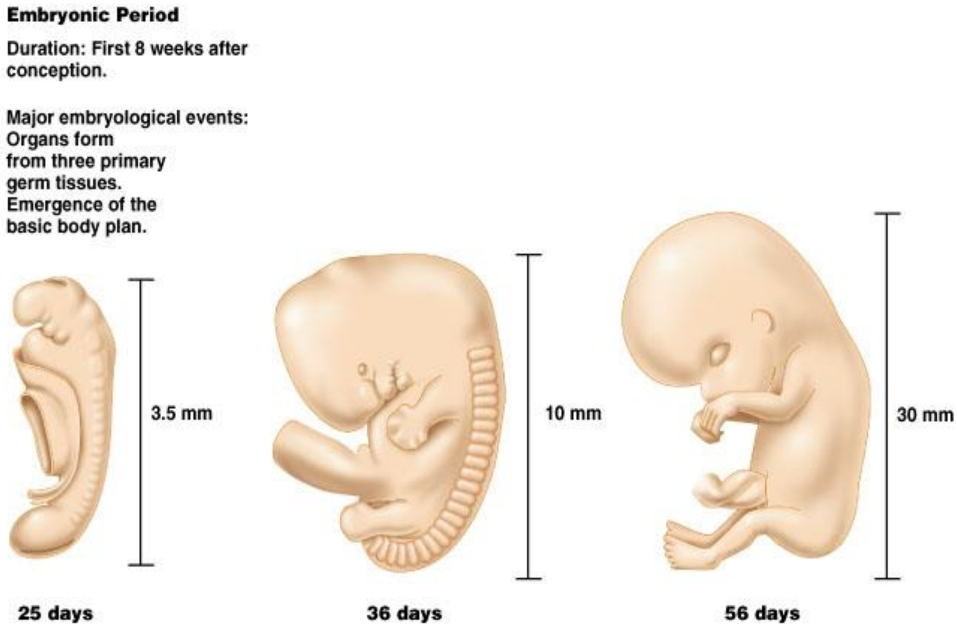


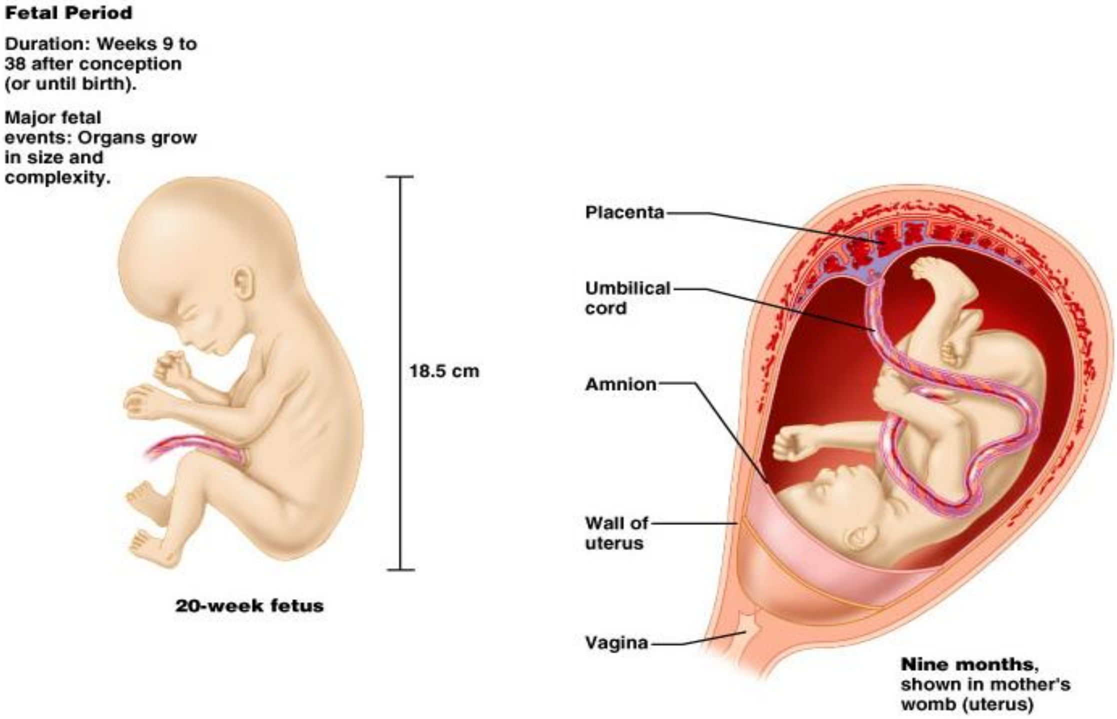


29 day embryo (this is when the heart starts pumping, about 4 weeks or 1 month, ½ cm size)

Prenatal period (before birth): 38 weeks from conception to birth. Date of conception has been difficult to time. Gynecologic timing has been from LMP (last menstrual period) LMP is on average two weeks before ovulation. (therefore refers to 40 weeks "gestational" age. By convention, pregnancies are dated in weeks starting from the first day of a women̉ s last menstrual peroid (LMP) . If her menstrual periods are regular and ovulation occurs on day 14 of her cycle, conception takes place about 2 weeks after her LMP. A women is therefore considered to be 6 weeks pregnant 2 weeks after her first missed period. A women̉ s obstetric date is different from the embryologic date (the age of the embryo). The obstetric date is about 2 weeks longer than the embryologic date. Traditional (artificial) division:

- Embryonic" period: first 8 weeks - All major organs formed
- Fetal" period: remaining 30 weeks - Organs grow larger and become more complex


Embryonic Period
Duration: First 8 weeks after conception.
Major embryological events: Organs form from three primary germ tissues. Emergence of the basic body plan.
3.5 mm
10 mm
30 mm
25 days
36 days
56 days


Fetal Period
Duration: Weeks 9 to 38 after conception (or until birth).
Major fetal events: Organs grow in size and complexity.
18.5 cm
20-week fetus
Placenta
Umbilical cord
Amnion
Wall of uterus
Vagina
Nine months, shown in mother's womb (uterus)

The " test-tube baby

The " test-tube baby" is now not only a reality but a commonplace event in many medical centers. In humans, the technique, called *in vitro fertilization and embryo transfer* (IVF). The process by which one or more eggs (oocytes) are fertilised outside the body and allowed some childless couples to have children from their own genetic heritage. It is used in cases where both the mother and father are capable of producing viable eggs and sperm cells, but because of a blockage in the women's uterine tubes the ovulated eggs are unable to be fertilized in her body and then to become transported to her uterus.

The first problem is obtaining fertile eggs from the mother. This is accomplished through **two technical advances**.

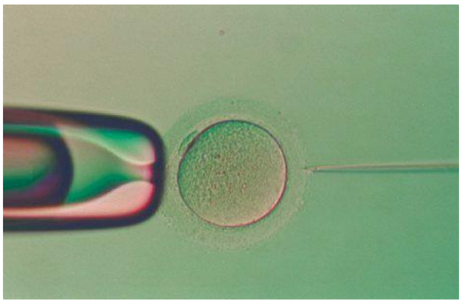
1- In vitro fertilization and embryo transfer (IVF)

The administration of a fertility-enhancing drug (gonadotropins) to the mother results in her producing several eggs, rather than the usual single egg, at the time of ovulation. (Many women who in recent years have given birth to four to seven babies at one time had previously taken fertility-promoting drugs.)

Just before the eggs would normally be shed from the ovary , a doctor, using a technique called ***laparoscopy***, inserts a tube into her pelvic cavity and under direct observation removes the ripe eggs from the ovary, just before ovulation the egg remove from ovarian follicles, without the need for a major surgical procedure.

When the oocyte is in the late stages of the first meiotic division. The egg is placed in a simple culture medium in a dish (hence the term *in vitro*, which means in glass) and father's sperm by placing a droplet of washed sperm

(~50,000) onto each egg immediately. If the sperm count is low a single sperm can be injected into each egg (Intra-Cytoplasmic Sperm Injection – ICSI).



The fertilized egg is then allowed to develop for a few days in an artificial incubator. Embryos can be placed into the uterus at the 6-8 cell stage (3-days culture) but some clinics culture the embryos for 5 or 6 days to ensure healthy blastocyst stage. After many years of unsuccessful attempts, reproductive biologists learned what environmental conditions are required for fertilization outside the body.

Meanwhile, the body of the mother is hormonally conditioned so that her uterus can accept the embryo. While the embryo still consists of just a tiny ball of the cells, it is sucked up into a tube and then released inside the cavity of the mother’s uterus, where if all goes well it will attach and then complete a normal pregnancy. It is still not possible to rise a mammalian embryo from conception to maturity entirely outside the body.

It is common to fertilize all of the woman’s eggs at the same time. After several embryos have been implanted in her uterus, the remainder are frozen. With the proper technique, a mammalian embryo can be frozen, stored, and even years later thawed as needed and then implanted into a uterus. This technique is routinely used with domestic animals and humans; if the first implanted embryos fail to survive, frozen ones can be thawed and implanted until the supply of embryos has run out. Thus embryo banks are now a reality. In actual practice the extra human embryos are destroyed when a baby resulting from an artificial conception is born.

Some women who are able to produce fertile eggs but are unable to carry an embryo to term in their own uteri have made arrangements with other women to act as *surrogate mothers.* The surrogate mother agrees to have another couple's embryo implanted into her uterus and bring it to term. (In some cases the surrogate mother herself supplies the egg.). When the baby is delivered, the surrogate mother turns the baby over to its genetic parent.

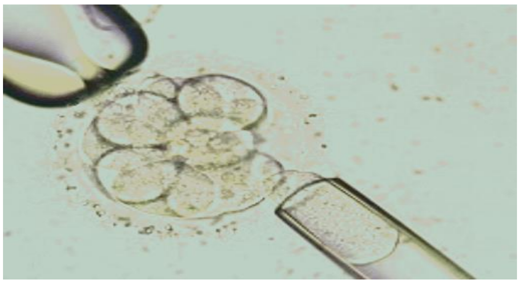
ICSI (intracytoplasmic sperm injection). Severe male infertility, in which the ejaculate contains very few live sperm (oligozoospermia) or even no live sperm (azoospermia), can be overcome using intracytoplasmic sperm injection (ICSI). With this technique, a single sperm, which may be obtained from any point in the male reproductive tract, is injected into the cytoplasm of the egg to cause fertilization. This approach offers couples an alternative to using donor sperm for IVF. The technique carries an increased risk for fetuses to have Y chromosome deletions but no other chromosomal abnormalities.

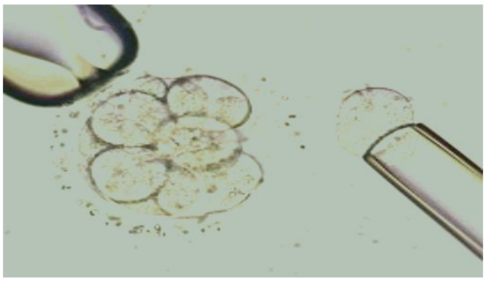
2- Another technique, **gamete intrafallopian transfer (GIFT)**, introduces oocytes and sperm into the ampulla of the fallopian (uterine) tube, where fertilization takes place. Development then proceeds in a normal fashion. In a similar approach, zygote intrafallopian transfer (ZIFT), fertilized oocytes are placed in the ampullary region. Both of these methods require patent uterine tubes.

IVF and Preimplantation Genetic Diagnosis

All cells in the early embryo (until about the 8-cell stage) are said to be totipotent. That means that each cell is capable of forming a complete human.

So couples using IVF can use genetic screening of their embryos by having a cell removed from their embryo(s) and tested for its genotype. The embryo will still develop normally. More than 100 diseases can be detected including hemophilia A, muscular dystrophy, Tay-Sachs disease, cystic fibrosis and Down syndrome.





A disadvantage of IVF is its low success rate; only 20% of fertilized ova implant and develop to term. Therefore, to increase chances of a successful pregnancy, four or five ova are collected, fertilized, and placed in the uterus. This approach sometimes leads to multiple births.

Contraceptive Methods

The contraceptive pill is a combination of estrogen and the progesterone analogue progestin, which together inhibit ovulation but permit menstruation.

Both hormones act at the level of FSH and LH, preventing their release from the pituitary. The pills are taken for 21 days and then stopped to allow menstruation, after which the cycle is repeated.

Depo-Provera is a progestin compound that can be implanted subdermally or injected intramuscularly to prevent ovulation for up to 5 years or 23 months, respectively.

A male “pill” has been developed and tested in clinical trials. It contains a synthetic androgen that prevents both LH and FSH secretion and either stops sperm production (70–90% of men) or reduces it to a level of infertility.

The intrauterine device (IUD) is placed in the uterine cavity. Its mechanism for preventing pregnancy is not clear but may entail direct effects on sperm and oocytes or inhibition of preimplantation stages of development.

The drug RU-486 (mifepristone) causes abortion if it is administered within 8 weeks of the previous menses. It initiates menstruation, possibly through its action as an antiprogesterone agent.

Vasectomy and tubal ligation are effective means of contraception, and both procedures are reversible, although not in every case.

Barrier techniques of contraception include the male condom, made of latex and often containing chemical spermicides, which fits over the penis; and the female condom, made of polyurethane, which lines the vagina. Other barriers placed in the vagina include the diaphragm, the cervical cap, and the contraceptive sponge.

Infertility

Infertility is a problem for 15% to 30% of couples.

Male infertility may be a result of insufficient numbers of sperm and/or poor motility. Normally, the ejaculate has a volume of 3 to 4 ml, with approximately 100 million sperm per ml. Males with 20 million sperm per ml or 50 million sperm per total ejaculate are usually fertile.

Infertility in a woman may be due to a number of causes, including occluded oviducts (most commonly caused by pelvic inflammatory disease), hostile cervical mucus, immunity to spermatozoa, absence of ovulation, and others.

Embryonic Development of Chick

Gastrulation

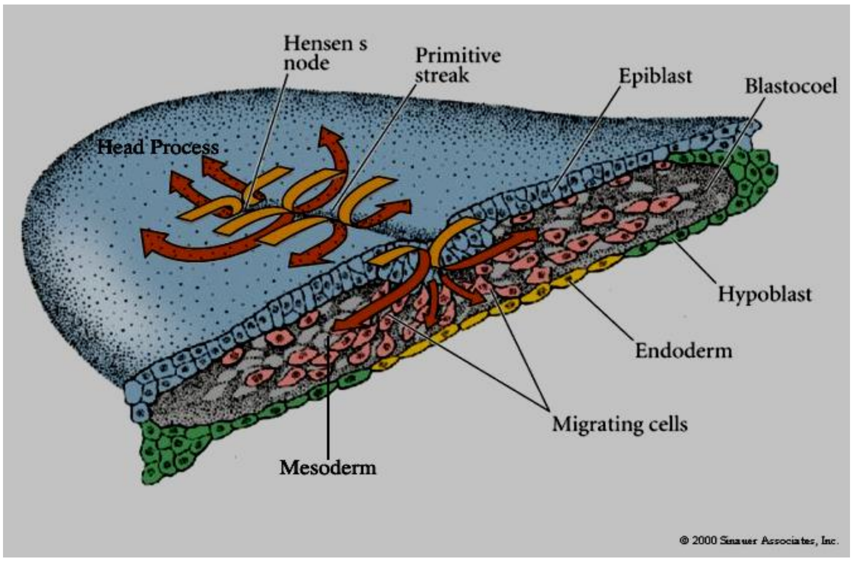
Gastrulation is a complex process where the simple blastula is transformed into a complex gastrula. There are two steps in gastrulation. They are

1-The formation of endoderm and

2- The formation of primitive streak , and mesoderm.

Formation of Endoderm

The endoderm or hypoblast develops as a single layer of cells inside the primary blastocoel. After the formation of he endoderm the upper layer is called epiblast or ectoderm. The space lying between them forms blastocoel. The cavity lying below the hypoplast and above the periplastis called archenteron.



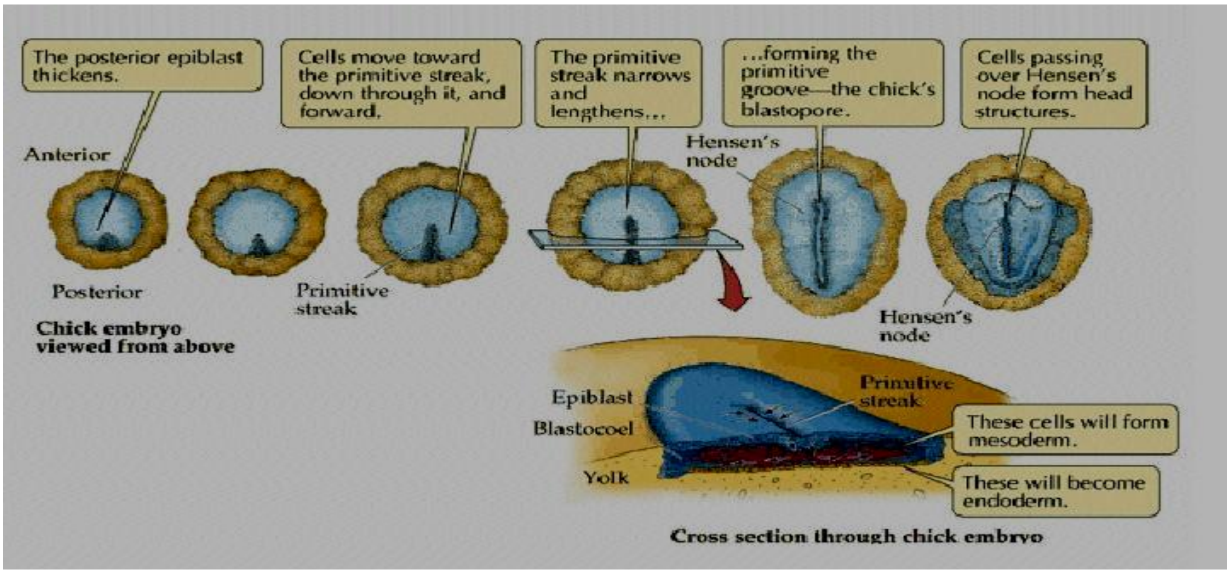
Formation of primitive streak and mesoderm

The second step in gastrulation is the development of primitive streak and the subsequent formation of mesoderm. **The primitive streak** appears as a thickened area in the middorsal line at the posterior region of area pellucida at about eight hours after incubation. The thickening is due to the convergence of the cells of blastoderm towards the center. In the early stage the primitive streak is broad and short. It gradually extends forwards and reaches the middle of the blastoderm. The primitive streak is well developed at about 18 to 19 hours of incubation.

Along the middle of the primitive streak, there runs a narrow furrow called the **primitive groove**. The edges of the groove are thick and are named **primitive folds**. At the anterior end of the primitive groove , there is a mass of closely packed cells called **Hensen's node** or primitive knot. The center of Hensen's node has a funnel-shaped depression called primitive pit.

The mesoderm cells migrate as two sheets on either side of the primitive streak inside the blastocoel (inbetween the epiblast and hypoblast). The mesoderm cells will not migrate anterior to the primitive streak. This mesoderm free area is called proamnion. This region is site for the development of the head.

The notochordal cells are proliferated from Hensen's node. The notochordal cells spreads under the epiblast infront of the primitive streak. Theses cells arrange themselves to form a cylindrical rod called head process or notochordal process. By the end of gastrulation, the primitive streak is reduced. The residue becomes partly incorporate into the tail bud.



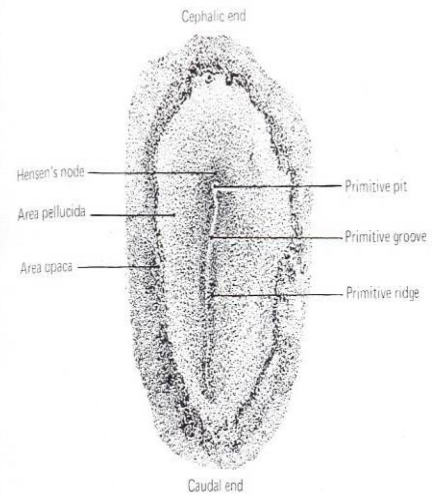
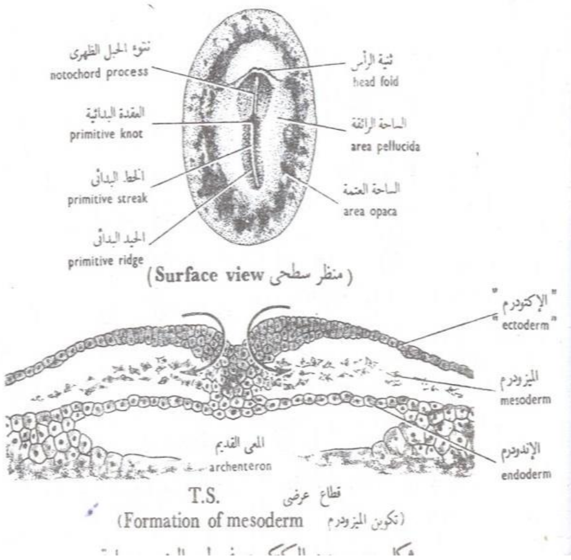


FIGURE 6-17
Dorsal view (×14) of entire chick embryo in the primitive-streak stage (about 16 hours of incubation).



<u>Stages of chick embryo development</u>

Between Laying and Incubation: No growth; stage of inactive embryonic life.

On the second day of incubation, the blood islands begin linking and form a vascular system, while the heart is being formed elsewhere. By the 44th hour of incubation, the heart and vascular systems join, and the heart begins beating. Two distinct circulatory systems are established, an embryonic system for the embryo and a vitelline system extending into the egg.

At the end of the **third day of incubation**, the beak begins developing and limb buds for the wings and legs are seen. **<u>Torsion and flexion</u>** continue through the fourth day. The chick's entire body turns 90o and lies down with its left side on the yolk. The head and tail come close together so the embryo forms a "C" shape. The mouth, tongue, and nasal pits develop as parts of the digestive and respiratory systems. The heart continues to enlarge even though it has not been enclosed within the body. It is seen beating if the egg is opened carefully. The other internal organs continue to develop.

By the end of **the fourth day of incubation**, the embryo has all organs needed to sustain life after hatching, and most of the embryo's parts can be identified. The chick embryo cannot, however, be distinguished from that of mammals.

By the seventh day. The embryo grows and develops rapidly, digits appear on the wings and feet, the heart is completely enclosed in the thoracic cavity, and the embryo looks more like a bird.

After the tenth day of incubation, feathers and feather tracts are visible, and the beak hardens. On the fourteenth day, the claws are forming and the embryo is moving into position for hatching. **After twenty days**, the chick is in the hatching position, the beak has pierced the air cell, and pulmonary respiration has begun.

Air cell is the air-filled pocket between the white and shell at the large end of the egg.The air cell in an egg provides the chick with air when it is ready to start breathing on its own and hatch from the egg. As the chick starts breathing, there is a buildup of carbon dioxide in the egg, which prompts the chick to break through the egg to get fresh air. Twentieth day - yolk sac completely drawn into body cavity; embryo occupies practically all the space within the egg except the air cell.

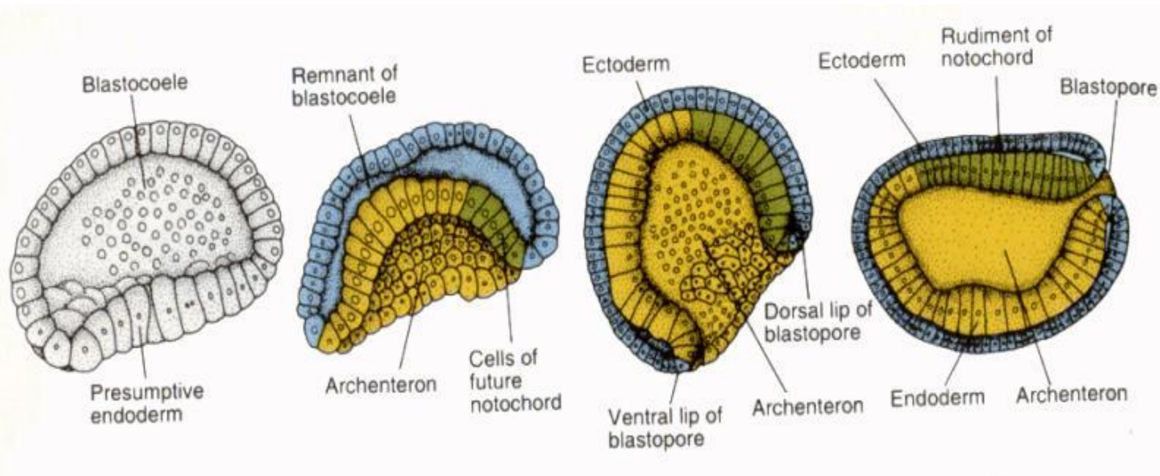
After 21 days of incubation, the chick finally begins its escape from the shell. The chick begins by pushing its beak through the air cell. The allantois, which has served as its lungs, begins to dry up as the chick uses its own lungs. The chick continues to push its head outward. The sharp horny structure on the upper beak (egg tooth) and the muscle on the back of the neck help cut the shell. The egg tooth makes the initial break in the shell.

Embryonic Development of Amphioxus

Gastrulation

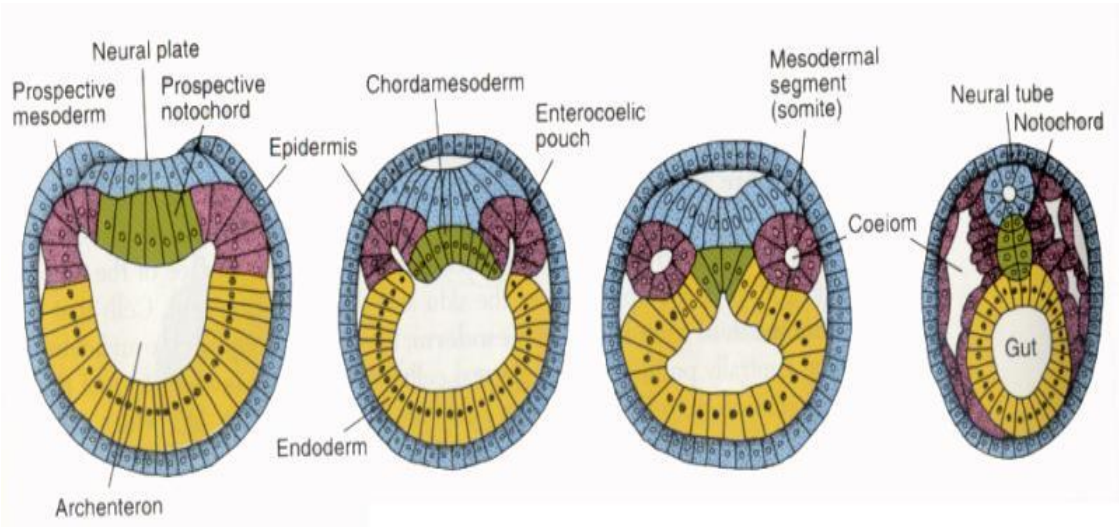
In Amphioxus, the gastrulation, by which a monoblastic blastula is converted into a diploblastic and stratified gastrula. The onset of gastrulation process is marked by flattening of blastoderm of vegetal pole, i.e., prospective endoderm. This endodermal plate then gradually invaginates, or folds inwardly, into the blastocoel. This invaginating layer of cells gradually eliminates that entire blastocoel and come to lie against the ectodermal micromeres. Thus, whole embryo, instead of being spherical, becomes converted into a cup-shaped structure, having a large cavity, the archenteron (gastrocoel), in open communication with the exterior by the blastopore. The cup has double walls, an external and internal epitheial layers, both of which remain continuous with each other over the rim of the cup-shaped embryo, the gastrula. The gatrula, at this stage, consists of two layers-an outer epiblast, consisting of neural and epidermal ectoderm, and an inner hypoblast encompassing prospective notochord mesoderm and endoderm. We now have an animal that is a tube within a tube.

The circular rim of the blastopore is termed the lip, the prospective mesoderm lies in the ventral lip of the blastopore and the prospective notochord lies in the dorsal lip of the blastopore.



Formation of the neural tube

With the completion of gastrulation, a strip of ectodermal cells in the region of midgut dorsal line enlarges to form the neural plate, which flattens and sinks inwards. The ectodermal on the sides of neural plate now rise up to form the neural folds is gradually extended round the lateral lips of blastopor. Then these folds start growing to meet each other over the neural plate, begining at the posterior end. These folds meet together in the mid-dorsal line. On the other hand, at the same time, the lateral edges of neural plate have grown towards each other, resulting the formation of the neural tube.



Formation of notochord

The chorda cells, in he gastrula are, present along the mid-dorsal wall of archenteron just below the neural plate. These chorda cells becomes in the form of strip due to a median groove. Later on, this groove deepens much resulting in coming together of the lateral sides of the strip of chorda cells. These sides finally meet each other restricting completely the cavity of the groove. In this way a solid rod-like notochord is formed just below central nervous systems.

Development of mesoderm and coelom

In gastrula the archenteron, is developed by invagination and is bounded by three types of cells namely chorda cells, mesodermal cells on the sides of the chorda cells and manly by endodermal cells. The chorda cells form the notochord. The mesodermal cells separate to form paired pouches or the mesodermal pouches. These pouches are in dorso-lateral position and ultimately develop into initial coelom. Each pouch is disconnected from archenteron and thus encloses a cavity. The remaining cavity with the archenteron becomes the cavity of the gut and persists as alimentary canal in the adult animal.

Formation of gut

The chorda cells and mesodermal cells of archenteron wall separate to form notochord and mesodermal pouches respectively and thus archenteron is left only with endodermal cells. The edges of the endoderm start growing towards each other (a rolling up process) and finally fuse with each other in mid-dorsal line just below the notochord, forming a tubular structure designated as mesenteron or gut.

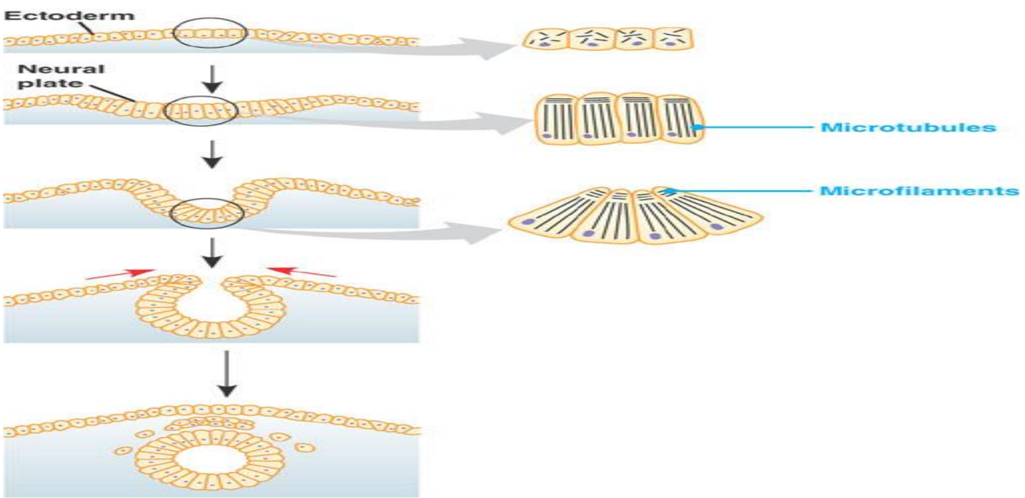
Embryonic Development of Toad

Organogenesis

Organogenesis concerns with the formation of and differentiation of various organs. Organogenesis converts an embryo into free swimming larva.

The formation of the neural tube

Neural tube is developed from prospective neurectoderm which during pregastrular processes takes its position some where in the mid dorsal region of the gastrula. Pear shaped neural plate is developed simply by the thickening of neurectodermal cells. The ectoderm on the sides of the ventral plate rises as a pair of neural folds. The edges of neural folds are developed by a process of differential growth and migration of cells called the convergence. The plate between the folds sinks down wards and form the neural groove. The elevation of neural folds increase dorsally and ultimately fuse over the neural groove to form the neural tube.



formation of the neural tube

Formation of notochord

The notochord develops from the chorda-mesoderm, lying in the mid dorsal line of the gastrula. Theses cells separate from mesoderm by a narrow cleft, by a process of delamination. Then these separated chorda cells very quickly expand and arrange themselves in the torm of a cylindrical rod.

Development of mesoderm

In the late gastrula after getting separation from chorda cells the mesodermal arrange themselves in such a precies manner that two mesodermal lateral sheets (several cell thick) are developed. These sheets are located at the right and left sides of the neural tube and notochord between the ectoderm and endoderm. Growing down toward the ventral side, the two mesodermal sheets unite in the mid ventral line. The dorso-lateral portion of the mesodermal sheets lying on each side of notochord forms the mesodermal somites or epimere. The remaining ventro-lateral portion of mesodermal sheets forms the lateral plate mesoderm.

Mesodermal somites which increase in number as the embryo grows larger, are arranged segmentally and from each somite three embryonic structure.

1- The dermatomes that portion of somite lying against the ectoderm from which the dermis of the skin is developed.

2- The myotomes from which the most of the body muscles are developed.

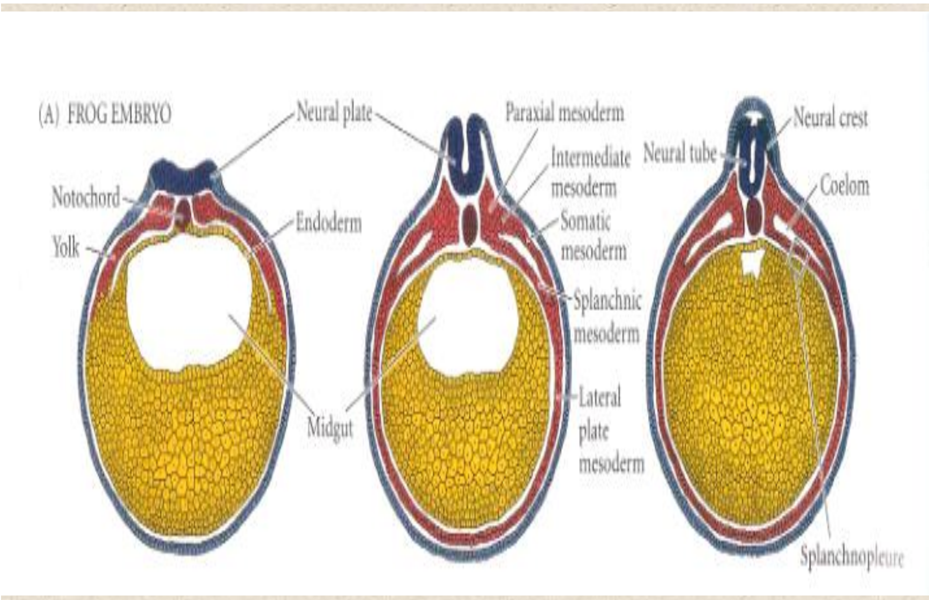
3- The sclerotomes lying against the notochord and neural tube, from which the axial skeleton is developed.

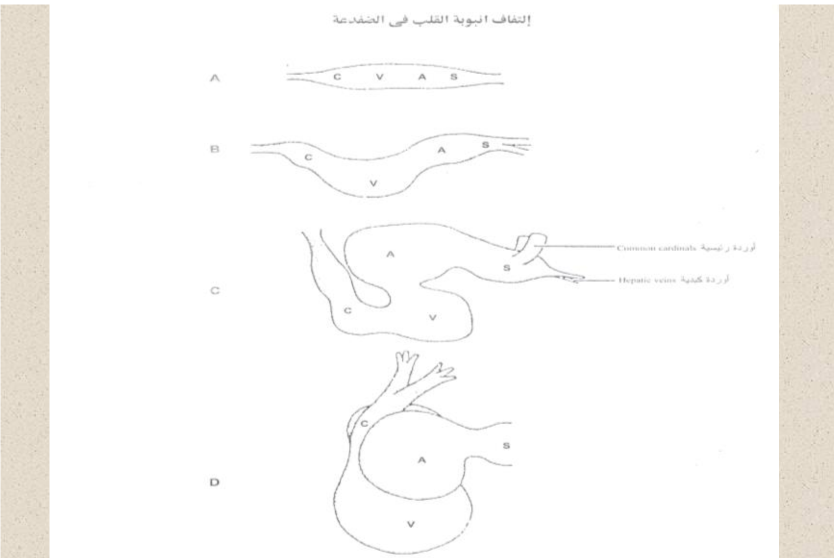
The lateral mesoderm is separated into two layers, an outer one of somatic mesoderm (somatopleure) which lines the ectoderm of the body and an inner of splanchnic mesoderm (splanchnopleure) which lines the gut.

Mesodermal derivatives

Development of heart

Heart is mesodermal in origin spechially from splanchnic mesoderm. A number of cells from splanchnic mesoderm are proliferated. Theses cells arrange themselves to form a tubular structure, the endocardial tube, which constitute the inner most layer of the heart. This tube is covered by epimyocardium. The epimyocardium form the middle layer the myocardium and the outermost layer the epicardium. The myocardium thickens to form the muscular wall of the heart. The heart is suspended in the pericardial cavity. In the latter stage of development the heart becomes S shaped in the pericardial cavity. The lumen of the heart is divided into chambers by the development of valves. These champers are sinus venosus, atrium (receive the blood from the bodyorgans), ventricle, and conus arteriosus (distributed the blood to every part of the body.





Heart rudiment of frog (and all vertebrates) develops as longitudial tube that differentiates i four heart chambers. A, Starting at the posterior end, they are sinus venosus, S; atrium. A; ventri V; and conus arteriosus. C. The heart tube bends on itself, B, forming an S-shaped structure, C. result of the bending, the atrium's final position is dorsal and anterior to the ventricle, D.