Biyani's Think Tank

A concept based exclusive material

Development Biology

Dr Smita
Revised By: Priyanka Dadupanthi
Lecturer
Deptt. of Science
Biyani Girls College, Jaipur

Published by :
Think Tanks
Biyani Group of Colleges

Sector-3, Vidhyadhar Nagar,
Jaipur-302 023 (Rajasthan)
Ph : 0141-2338371, 2338591-95 • Fax : 0141-2338007
E-mail : acad@biyanicolleges.org
Website :www.gurukpo.com; www.biyanicolleges.org

ISBN:

Edition : 2011
Price :

Leaser Type Setted by :
Biyani College Printing Department

Preface

I am glad to present this book, especially designed to serve the needs of the students. The book has been written keeping in mind the general weakness in understanding the fundamental concepts of the topics. The book is self-explanatory and adopts the "Teach Yourself" style. It is based on question-answer pattern. The language of book is quite easy and understandable based on scientific approach.

Any further improvement in the contents of the book by making corrections, omission and inclusion is keen to be achieved based on suggestions from the readers for which the author shall be obliged.

I acknowledge special thanks to Mr. Rajeev Biyani, *Chairman* & Dr. Sanjay Biyani, *Director* (*Acad.*) Biyani Group of Colleges, who are the backbones and main concept provider and also have been constant source of motivation throughout this Endeavour. They played an active role in coordinating the various stages of this Endeavour and spearheaded the publishing work.

I look forward to receiving valuable suggestions from professors of various educational institutions, other faculty members and students for improvement of the quality of the book. The reader may feel free to send in their comments and suggestions to the under mentioned address.

Note: A feedback form is enclosed along with think tank. Kindly fill the feedback form and submit it at the time of submitting to books of library, else NOC from Library will not be given.

DEVELOPMENTAL BIOLOGY

BT-201

Note : Question No 1 shall consist of questions requiring short answers and shall cover entire paper. The paper is divided into four sections. Student are required to attempt five questions in all, selection not more than one questions from each section. All questions carry equal marks.

Section A

Plant development, plant versus animal development, development of plant embryo, development of seeding, shoot apex organization vegetative and floral apex, root, shoot,leaf and flower development Programmed cell death, ageing and senescence.

Section B

Genes and their role in devlopment, signal tranduction in development, cell division cycle, cytoskeleton, cell adhesion and the extracellular matrix:
Unicellular models, sporulation in Bacillus subtilis,mating type switching in yeast aggregation and culmination in Dicyostelium discordeum

Section C

Sex gametes and fertilization, germ line speciation, germ cell migration, gametogenesis, gastrulation in invertebrate and vertebrate,cell, lineage, Axis specification in vertebrates, fate of ectoderm,measoderm and endoderrn.

Section D

Cell differentiation mechanism and factors affecting it developmental gradient in hydra, axial gradients in Drosophild development.Orgaogenesis in invertebrates and vertebrates.

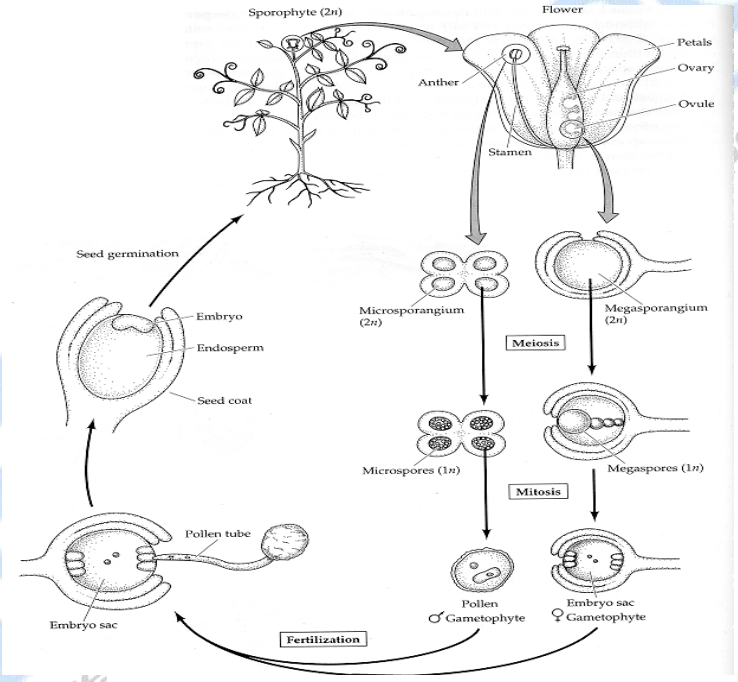
Section A

Plant development

Q. 1 What are the similarities between plant and animal development ?
Ans.

1. 1N sperm nucleus fertilizes 1N (haploid) egg cell.
2. Cell division and growth help in the creation of the shape of the embryo.
3. Different cell types generate from molecular mechanisms of determination.

Q.2 Explain the angiosperm life cycle through a diagram.



From: Susan Singer

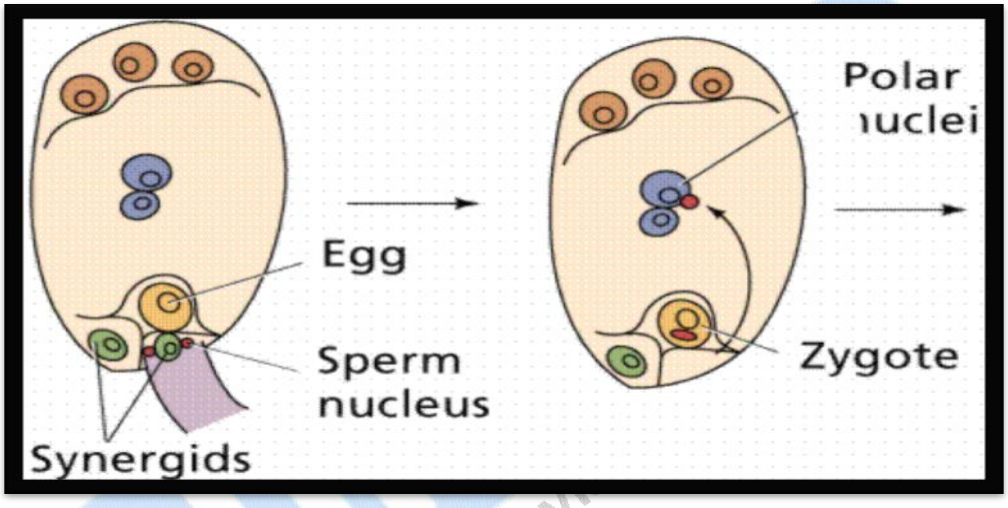
Q. 3 How plant development is differs from animal development?
Ans.

1. Bacteria or animal cells migrate but plant cells do not . Plant shape forms based on the rate of cell division and the direction of elongation.
2. Plants although develop from three basic tissue systems which are dermal, ground, and vascular but they don't rely on gastrulation for the establishment of this layered system of tissues.

3. Plant development is a continuous process. New plant organs are formed throughout their life by clusters of embryonic cells called meristem.
4. Plants have tremendous developmental plasticity. They can regerate very easily. Lost plant parts can be regenerated by meristems, and even entire plants can be regenerated from single cells.

Q. 4 Make a diagram of double fertilization.

Ans



Q. 5 Describe the process of plant embryogenesis.

Ans. In the process of plant embryogenesis a plant embryo from a fertilized ovule by the differentiation of undifferentiated cells into tissues and organs and asymmetric cell division. It occurs during seed development, when the single-celled zygote undergoes a programmed pattern of cell division resulting in a mature embryo.

The result of sexual fertilization is seeds embryogenesis which occurs naturally and the form the zygotic embryos. The embryo along with other cells from the mother plant develops into the seed or the next generation, which, after germination, grows into a new plant.

Embryogenesis may be divided up into two phases

The first involves morphogenetic events which form the basic cellular pattern for the development of the shoot-root body and the primary tissue layers; it also programs the regions of meristematic tissue formation.[clarification needed.

The second phase, or postembryonic development, involves the maturation of cells, which involves cell growth and the storage of macromolecules (such as oils, starches and proteins) required as a 'food and energy supply' during germination and seedling growth. Embryogenesis involves cell growth and division, cell differentiation and programed cellular death. The zygotic embryo is formed following double fertilisation of the ovule, giving rise to two distinct structures: the plant embryo and the endosperm which together go on to develop into a seed. Seeds may also develop without fertilization, which is referred to as apomixis. Plant cells can also be induced to form embryos in plant tissue culture; such embryos are called somatic embryos.

Following fertilization, the zygote undergoes an asymmetrical cell division that gives rise to a small apical cell, which becomes the embryo and a large basal cell (called the suspensor), which functions to provide nutrients from the endosperm to the growing embryo. From the eight cell stage (octant) onwards, the zygotic embryo shows clear embryo patterning, which forms the main axis of polarity, and the linear formation of future structures. These structures include the shoot meristem, cotyledons, hypocotyl, and the root and root meristem: they arise from specific groups of cells as the young embryo divides and their formation has been shown to be position-dependent.

In the globular stage, the embryo develops radial patterning through a series of cell divisions, with the outer layer of cells differentiating into the 'protoderm.' The globular embryo can be thought of as two layers of inner cells with distinct developmental fates; the apical layer will go on to produce cotyledons and shoot meristem, while the lower layer produces the hypocotyl and root meristem. Bilateral symmetry is apparent from the heart stage; provascular cells will also differentiate at this stage. In the subsequent torpedo and cotyledonary stages of embryogenesis, the embryo completes its growth by elongating and enlarging.

In a dicot embryo, the hypophysis, which is the uppermost cell of the suspensor, differentiates to form part of the root cap. Plant cells can also be induced to form embryos in plant tissue culture; these embryos are called somatic embryos, which are used to generate new plants from single cells. Plant growth and buds

Embryonic tissue is made up of actively growing cells and the term is normally used to describe the early formation of tissue in the first stages of growth. It can refer to different stages of the sporophyte and gametophyte plant; including the growth of embryos in seedlings, and to meristematic tissues,[4] which are in a persistently embryonic state, to the growth of new buds on stems.

In both gymnosperms and angiosperms, the young plant contained in the seed, begins as a developing egg-cell formed after fertilization (sometimes without fertilization in a process called apomixis) and becomes a plant embryo. This embryonic condition also occurs in the buds that form on stems. The buds have tissue that has differentiated but not grown into complete structures. They can be in a resting state, lying dormant over winter or when conditions are dry, and then commence growth when conditions become suitable. Before

they start growing into stem, leaves, or flowers, the buds are said to be in an embryonic state.

Q. 6 Explain Somatic Embryogenesis.

Ans. Somatic embryos are formed from plant cells that are not normally involved in the development of embryos, i.e. ordinary plant tissue. No endosperm or seed coat is formed around a somatic embryo. Applications of this process include: clonal propagation of genetically uniform plant material; elimination of viruses; provision of source tissue for genetic transformation; generation of whole plants from single cells called protoplasts; development of synthetic seed technology. Cells derived from competent source tissue are cultured to form an undifferentiated mass of cells called a callus. Plant growth regulators in the tissue culture medium can be manipulated to induce callus formation and subsequently changed to induce embryos to form from the callus. The ratio of different plant growth regulators required to induce callus or embryo formation varies with the type of plant.[7] Asymmetrical cell division also seems to be important in the development of somatic embryos, and while failure to form the suspensor cell is lethal to zygotic embryos, it is not lethal for somatic embryos. Ref: Wikipedia

Q.7 What do you understand by the term germination?

Ans. Germination is the process in which a plant or fungus emerges from a seed or spore, respectively, and begins growth. The most common example of germination is the sprouting of a seedling from a seed of an angiosperm or gymnosperm. However the growth of a sporeling from a spore, for example the growth of hyphae from fungal spores, is also germination. In a more general sense, germination can imply anything expanding into greater being from a small existence or germ.

Q.8 Write a note on factors affecting seed germination.

Ans. Seed germination depends on both internal and external conditions. The most important external factors include temperature, water, oxygen and sometimes light or darkness. Various plants require different variables for successful seed germination, often this depends on the individual seed variety and is closely linked to the ecological conditions of a plant's natural habitat. For some seeds, their future germination response is affected by environmental conditions during seed formation; most often these responses are types of seed dormancy.

Water - is required for germination. Mature seeds are often extremely dry and need to take in significant amounts of water, relative to the dry weight of the seed, before cellular metabolism and growth can resume. Most seeds need enough water to moisten the seeds but not enough to soak them. The uptake of water by seeds is called imbibition, which leads to the swelling and the breaking of the seed coat. When seeds are formed, most plants store a food reserve with the seed, such as starch, proteins, or oils. This food reserve provides nourishment to the growing embryo. When the seed imbibes water, hydrolytic enzymes are activated which break down these stored food resources into metabolically useful chemicals. After the seedling emerges from the seed coat and starts growing roots and leaves, the seedling's food reserves are typically exhausted; at this point

photosynthesis provides the energy needed for continued growth and the seedling now requires a continuous supply of water, nutrients, and light.

Oxygen - is required by the germinating seed for metabolism. Oxygen is used in aerobic respiration, the main source of the seedling's energy until it grows leaves. Oxygen is an atmospheric gas that is found in soil pore spaces; if a seed is buried too deeply within the soil or the soil is waterlogged, the seed can be oxygen starved. Some seeds have impermeable seed coats that prevent oxygen from entering the seed, causing a type of physical dormancy which is broken when the seed coat is worn away enough to allow gas exchange and water uptake from the environment.

Temperature - affects cellular metabolic and growth rates. Seeds from different species and even seeds from the same plant germinate over a wide range of temperatures. Seeds often have a temperature range within which they will germinate, and they will not do so above or below this range. Many seeds germinate at temperatures slightly above room-temperature 60-75 F (16-24 C), while others germinate just above freezing and others germinate only in response to alternations in temperature between warm and cool. Some seeds germinate when the soil is cool 28-40 F (-2 - 4 C), and some when the soil is warm 76-90 F (24-32 C). Some seeds require exposure to cold temperatures (vernalization) to break dormancy. Seeds in a dormant state will not germinate even if conditions are favorable. Seeds that are dependent on temperature to end dormancy have a type of physiological dormancy. For example, seeds requiring the cold of winter are inhibited from germinating until they take in water in the fall and experience cooler temperatures. Four degrees Celsius is cool enough to end dormancy for most cool dormant seeds, but some groups, especially within the family Ranunculaceae and others, need conditions cooler than -5 C. Some seeds will only germinate after hot temperatures during a forest fire which cracks their seed coats; this is a type of physical dormancy.

Most common annual vegetables have optimal germination temperatures between 75-90 F (24-32 C), though many species (e.g. radishes or spinach) can germinate at significantly lower temperatures, as low as 40 F (4 C), thus allowing them to be grown from seed in cooler climates. Suboptimal temperatures lead to lower success rates and longer germination periods.

Light or darkness - can be an environmental trigger for germination and is a type of physiological dormancy. Most seeds are not affected by light or darkness, but many seeds, including species found in forest settings, will not germinate until an opening in the canopy allows sufficient light for growth of the seedling.

Scarification mimics natural processes that weaken the seed coat before germination. In nature, some seeds require particular conditions to germinate, such as the heat of a fire (e.g., many Australian native plants), or soaking in a body of water for a long period of time. Others need to be passed through an animal's digestive tract to weaken the seed coat enough to allow the seedling to emerge .From: Wikipedia

Q. 9 Explain different theories of plant senescence.

Ans Annual versus perennial benefits – theory Some plants have evolved into annuals which die off at the end of each season and leave seeds for the next, whereas closely related plants in the same family have evolved to live as perennials. This may be a programmed "strategy" for the plants.

The benefit of an annual strategy may be genetic diversity, as one set of genes does continue year after year, but a new mix is produced each year. Secondly, being annual may allow the plants a better survival strategy, since the plant can put most of its accumulated energy and resources into seed production rather than saving some for the plant to overwinter, which would limit seed production.

Conversely, the perennial strategy may sometimes be the more effective survival strategy, because the plant has a head start every spring with growing points, roots, and stored energy that have survived through the winter. In trees for example, the structure can be built on year after year so that the tree and root structure can become larger, stronger, and capable of producing more fruit and seed than the year before, out-competing other plants for light, water, nutrients, and space.

Plant self pruning – theory There is a speculative hypothesis on how and why a plant induces part of itself to die off. The theory holds that leaves and roots are routinely pruned off during the growing season whether they are annual or perennial. This is done mainly to mature leaves and roots and is for one of two reasons; either both the leaves and roots that are pruned are no longer efficient enough nutrient acquisition-wise or that energy and resources are needed in another part of the plant because that part of the plant is faltering in its resource acquisition.

Poor productivity reasons for plant self pruning - the plant rarely prunes young dividing meristematic cells, but if a fully grown mature cell is no longer acquiring nutrients that it should acquire, then it is pruned.

Shoot efficiency self pruning reasons - for instance, presumably a mature shoot cell must on average produce enough sugar, and acquire enough oxygen and carbon dioxide to support both it and a similar sized root cell. Actually, since plants are obviously interested in growing it is arguable, that the "directive" of the average shoot cell, is to "show a profit" and produce or acquire more than enough sugar and gases than is necessary to support both it and a similar sized root cell. If this "profit" isn't shown, the shoot cell is killed off and resources are redistributed to "promising" other young shoots or leaves in the hope that they will be more productive.

Root efficiency self pruning reasons - similarly a mature root cell must acquire on average, more than enough minerals and water needed to support both it and a similar sized shoot cell that does not acquire water and minerals. If this does not happen, the root is killed off and resources sent to new young root candidates.

Shortage/need-based reason for plant self pruning - this is the other side of efficiency problems.

Shoot shortages - if a shoot is not getting enough root derived minerals and water, the idea is that it will kill part of itself off, and send the resources to the root to make more roots.

Root shortages - the idea here is that if the root is not getting enough shoot derived sugar and gases it will kill part of itself off and send resources to the shoot, to allow more shoot growth.

This is an oversimplification, in that it is arguable that some shoot and root cells serve other functions than to acquire nutrients. In these cases, whether they are pruned or not would be "calculated" by the plant using some other criteria. It is also arguable that, for example, mature nutrient-acquiring shoot cells would have to acquire more than enough shoot nutrients to support both it and its share of both shoot and root cells that do not acquire sugar and gases whether they are of a structural, reproductive, immature, or just plain, root nature.

The idea that a plant does not impose efficiency demands on immature cells is that most immature cells are part of so called dormant buds in plants. These are kept small and non-dividing until the plant needs them. They are found in buds, for instance in the base of every lateral stem.

Hormonal induction of senescence – theory There is not a lot of theory on how plants induce themselves to senesce, although it is reasonably widely accepted that some of it is done hormonally. Plant scientists generally concentrate on ethylene and abscisic acid as culprits in senescence, but neglect gibberellin and brassinosteroid which inhibits root growth if not causing actual root pruning. This is perhaps because roots are below the ground and thus harder to study.

1. Shoot pruning - it is now known that ethylene induces the shedding of leaves much more than abscisic acid. ABA originally received its name because it was discovered to have a role in leaf abscission. Its role is now seen to be minor and only occurring in special cases.

   Hormonal shoot pruning theory - a new simple theory says that ethylene induces senescence in leaves due to a run away positive feedback mechanism.[4] What supposedly happens is that ethylene is released by mostly mature leaves under water and or mineral shortages. The ethylene acts in mature leaf cells however, by pushing out minerals, water, sugar, gases and even the growth hormones auxin and cytokinin (and possibly salicylic acid in addition). This causes even more ethylene to be made until the leaf is drained of all nutrients.

2. Root pruning - the concept that plants prune the roots in the same kind of way as they abscise leaves, is not a well discussed topic among plant scientists, although the phenomena undoubtedly exists. If gibberellin and brassinosteroid are known to inhibit

root growth it takes just a little imagination to assume they perform the same role as ethylene does in the shoot, that is to prune the roots too.

Hormonal root pruning theory - in the new theory just like ethylene, GA/BA are seen both to be induced by sugar and gas shortages in the roots, and to push sugar and gases, as well as minerals, water and the growth hormones out of the root cell causing a positive feedback loop resulting the emptying and death of the root cell.

3. Parallels to cell division - the theory, perhaps even more controversially, asserts that just as both auxin and cytokinin seem to be needed before a plant cell divides, in the same way perhaps ethylene and GA/BA are needed before a cell would senesce.

4. Discussion of the complete mechanism - what really may occur is that because ethylene pushes out all nutrients out of the shoot cell including sugar and gases, eventually this causes a shortage of these nutrients in the organ (the shoot) which is supposed to procure them. This shortage leads to GA/BA synthesis in the rapidly declining shoot cell, and this simply adds fuel to the fire.

5. A role for abscisic acid - finally a question may be to ask, what is the role of abscisic acid, the hormone which was first thought to be the primary mover in this department? According to author of this theory, ABA is induced when plant cells are encountering stress other than that of a nutrient shortage kind. In this case a senescing cell experiencing a drain of nutrients may experience a strain which causes it to produce ABA. Indeed it may not be that ethylene and GA/BA alone are needed for programmed cell senescence, but that all three are needed.

Q. 10 What do you understand by programmed cell death?

Ans. Programmed cell-death (or PCD) is death of a cell in any form, mediated by an intracellular program. In contrast to necrosis, which is a form of cell-death that results from acute tissue injury and provokes an inflammatory response, PCD is carried out in a regulated process which generally confers advantage during an organism's life-cycle. PCD serves fundamental functions during both plant and metazoa (multicellular animals) tissue development.

Section B

Cell structure

Q.1 What do you understand by the term signal transduction?

Ans. Most signal transduction involves the binding of extracellular signaling molecules (and ligands) to cell-surface receptors. While triggering events inside the cell, such receptors typically face outward from the plasma membrane. Intracellular signaling cascades can also be triggered through cell-substratum interactions. One example is integrins, which bind ligands found within the extracellular matrix. Steroids are another example of extracellular signaling molecules that may cross the plasma membrane due to their lipophilic or hydrophobic nature. Many, but not all, steroid hormones have receptors within the cytoplasm, and usually act by stimulating the binding of their receptors to the promoter region of steroid-responsive genes. Within multicellular organisms, numerous small molecules and polypeptides coordinate cell activity. Signaling molecules have been functionally classified as:

1. **hormones (e.g., melatonin)**
2. growth factors (e.g. epidermal growth factor)
3. extra-cellular matrix components (e.g., fibronectin)
4. cytokines (e.g., interferon-gamma)
5. chemokines (e.g., RANTES)
6. neurotransmitters (e.g., acetylcholine)
7. neurotrophins (e.g., nerve growth factor)
8. reactive oxygen species and other electronically-activated compounds

Q.2 Write a short note on microtubules.

Ans. Microtubules : Microtubules in a gel fixated cell.Main article: microtubule

Microtubules are hollow cylinders about 23 nm in diameter (lumen = approximately 15 nm in diameter), most commonly comprising 13 protofilaments which, in turn, are polymers of alpha and beta tubulin. They have a very dynamic behaviour, binding GTP for polymerization. They are commonly organized by the centrosome.

In nine triplet sets (star-shaped), they form the centrioles, and in nine doublets oriented about two additional microtubules (wheel-shaped) they form cilia and flagella. The latter formation is commonly referred to as a "9+2" arrangement, wherein each doublet is connected to another by the protein dynein. As both flagella and cilia are structural components of the cell, and are maintained by microtubules, they can be considered part of the cytoskeleton.

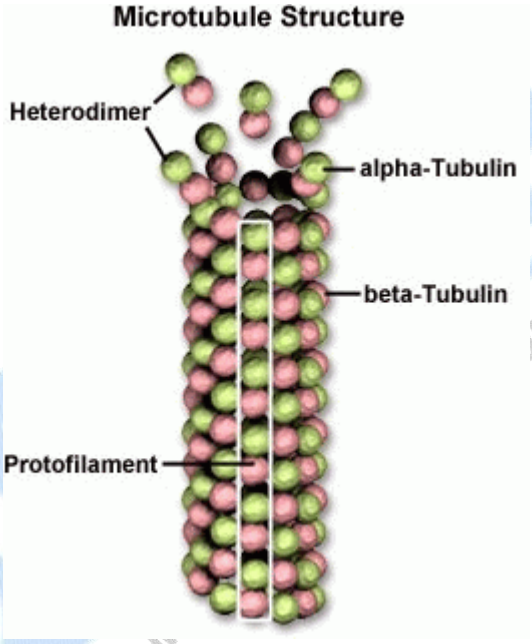
They play key roles in:

intracellular transport (associated with dyneins and kinesins, they transport organelles like mitochondria or vesicles).

the axoneme of cilia and flagella.

the mitotic spindle.

synthesis of the cell wall in plants



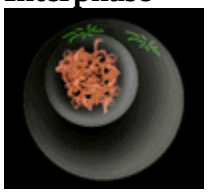
Q. 3 Define mitosis?

Ans . Mitosis is nuclear division plus cytokinesis, and produces two identical daughter cells during prophase, prometaphase, metaphase, anaphase, and telophase. Interphase is often included in discussions of mitosis, but interphase is technically not part of mitosis, but rather encompasses stages G1, S, and G2 of the cell cycle.

Q. 4 Write a short note on mitosis.

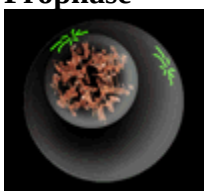
Ans.

Interphase



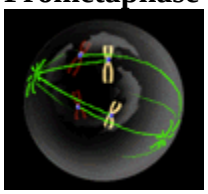
The cell is engaged in metabolic activity and performing its prepare for mitosis (the next four phases that lead up to and include nuclear division). Chromosomes are not clearly discerned in the nucleus, although a dark spot called the nucleolus may be visible. The cell may contain a pair of centrioles (or microtubule organizing centers in plants) both of which are organizational sites for microtubules.

Prophase



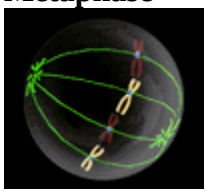
Chromatin in the nucleus begins to condense and becomes visible in the light microscope as chromosomes. The nucleolus disappears. Centrioles begin moving to opposite ends of the cell and fibers extend from the centromeres. Some fibers cross the cell to form the mitotic spindle.

Prometaphase



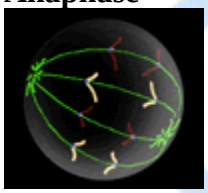
The nuclear membrane dissolves, marking the beginning of prometaphase. Proteins attach to the centromeres creating the kinetochores. Microtubules attach at the kinetochores and the chromosomes begin moving.

Metaphase



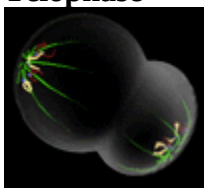
Spindle fibers align the chromosomes along the middle of the cell nucleus. This line is referred to as the metaphase plate. This organization helps to ensure that in the next phase, when the chromosomes are separated, each new nucleus will receive one copy of each chromosome.

Anaphase



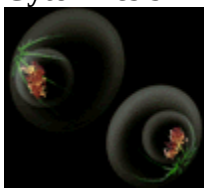
The paired chromosomes separate at the kinetochores and move to opposite sides of the cell. Motion results from a combination of kinetochore movement along the spindle microtubules and through the physical interaction of polar microtubules.

Telophase



Chromatids arrive at opposite poles of cell, and new membranes form around the daughter nuclei. The chromosomes disperse and are no longer visible under the light microscope. The spindle fibers disperse, and cytokinesis or the partitioning of the cell may also begin during this stage.

Cytokinesis



In animal cells, cytokinesis results when a fiber ring composed of a protein called actin around the center of the cell contracts pinching the cell into two daughter cells, each with one nucleus. In plant cells, the rigid wall requires that a cell plate be synthesized between the two daughter cells.

Q. 5 Why in some cases is mitosis a synonym of reproduction?

Ans. In some living beings asexual reproduction occurs by many means: binary division, schizogony, budding, grafting, etc. In asexual reproduction of eukaryotes mitosis is the mechanism by which the constituent cells of the new beings are made.

The term mitosis does not apply to prokaryotes since it involves nuclear division and eukaryotic structures.

Q. 6 What is the importance of mitosis for the embryonic development?

Ans. Every embryo grows from a single cell that suffers mitosis and generates other cells that also divide themselves by mitosis forming tissues and complete organs. The perfect regulation and control of each of those cell divisions are fundamental for the creation of a normal individual. Without mitosis the embryonic development would be impossible.

Q. 7 What are some examples of organs and tissues where mitosis is more frequent, less frequent or practically absent?

Ans. Generally in vertebrates mitosis is more frequent in tissues that require intense renewing due to their functions, like epithelial tissues and the bone marrow. In plants the meristem tissue has numerous cells undergoing mitosis.

Mitosis take place with low frequency in tissues of slow renovation, like the bones in adults and the connective tissues.

In some adult tissues mitosis is almost absent, like the nervous tissue and the striated muscle tissue (skeletal and cardiac). The nervous tissue develops from stimulus by development of new electrical networks between cells and the striated muscle tissue grows by cellular hypertrophy.

Q.**8 How does mitosis participate in the growth of pluricellular organisms?**

Ans. All pluricellular beings grow with the increase in quantity of their cells. This increase is produced by mitosis (although some types of growth occur by cellular hypertrophy or by deposition of substances in interstitial spaces).

Q.9 What is the uncontrolled mitotic process that occurs as disease in pluricellular beings called?

Ans. Uncontrolled mitotic cell division is called neoplasia. Neoplasia (the formation of new strange tissues) occurs when a cell suffers mutation in its genetic material, loses the ability to control its own division and the failure is transmitted to its descendants.

Cancers are malignant neoplasias. The term malignant means that neoplastic cells can disseminate to distant sites invading other organs and tissues. Neoplasias whose cells cannot disseminate to distant sites are called benign neoplasias.

Q. 10 What is cell cycle?

Ans. Cell cycle, or mitotic cycle, is the time period that begins when the cell is created and finishes when it is divided by mitosis creating two daughter cells. The cell cycle is divided into interphase and the mitotic phase.

Q.11. What is cellular regeneration? How is mitosis related to this process?

Ans. Some tissues are able to regenerate when injured. The liver, for example, regenerates when small pieces of hepatic tissue are removed, bones make new tissues in fracture regions, etc. Some animals, like planarias, are capable of regenerating their bodies when sectioned. In tissue regeneration cellular proliferation happens by mitosis.

Q.12. What is cell cycle?

Ans. Cell cycle, or mitotic cycle, is the time period that begins when the cell is created and finishes when it is divided by mitosis creating two daughter cells. The cell cycle is divided into interphase and the mitotic phase.

Section-C

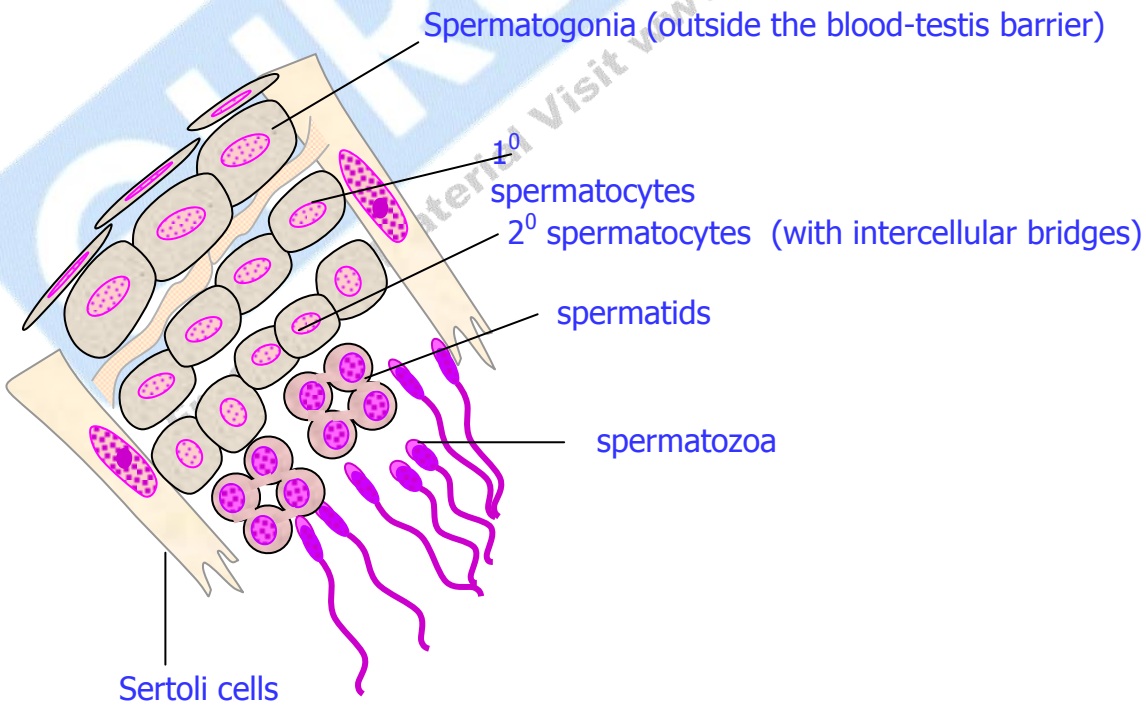
Gametogenesis

Q1. Define gametogenesis.

Ans. Gametogenesis is a biological process by which diploid or haploid precursor cells undergo cell division and differentiation to form mature haploid gametes. Depending on the biological life cycle of the organism, gametogenesis occurs by meiotic division of diploid gametocytes into various gametes, or by mitotic division of haploid gametogenous cells. For example, plants produce gametes through mitosis in gametophytes. The gametophytes grow from haploid spores after sporic meiosis. The existence of a multicellular, haploid phase in the life cycle between meiosis and gametogenesis is also referred to as alternation of generations.

Q 2. Write a short note on spermatogenesis.

Ans Spermatogenesis is the process of formation of the male germ cells. It occurs in the seminiferous tubules of the testes. The developmental stages of the male germ cells can be observed sequentially from basement membrane to lumen.



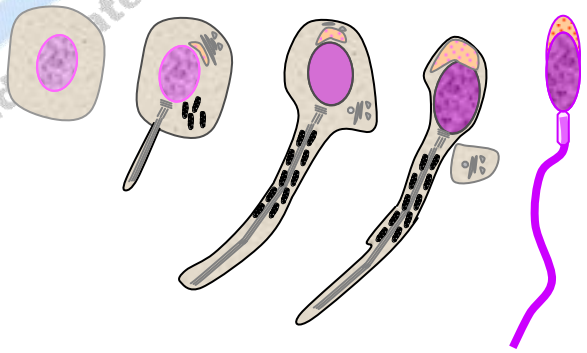
The sertoli cells are supporting cells that have several functions.
They form the blood-testes barrier: nutrients, and circulating substances do not directly reach the germ cells; the Sertoli cells determine which substances reach the germ cells. The spermatogonia are outside the blood-testis barrier. They form invaginations surrounding the spermatocytes, spermatids and developing spermatozoa and are nutritive to them. They also produce antigen-binding proteins, which are necessay for spermiogenesis.
The figure below is a light micrograph of a seminiferous tubule

Spermiogenesis is morphological development of spermatids to spermatozoa. It involves:

a. **Nuclear changes** - The nucleus becomes condensed and heterochromatic -histones are replaced by **protamines**, which allow a high degree of DNA compaction and makes DNA inaccessible for transcription

Cytoplasmic changes – These are directed to the formation of a motile sperm cell capable of penetrating the ovum and involves the following changes:

- The Golgi apparatus at one pole of the cell forms an acrosome containing proteolytic enzymes
- The centrriole at the opposite pole organises the formation of microtubules to form a flagellum
- Alignment of mitochondria in a spiral around the base of the flagellum – this forms the mid-piece of the spermatozoon
- The excess residual cytoplasm accumulates at one side of the cell and becomes detached to form a residual body

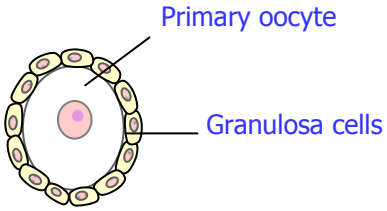


Q3. Write a short note on oogenesis.

Ans.

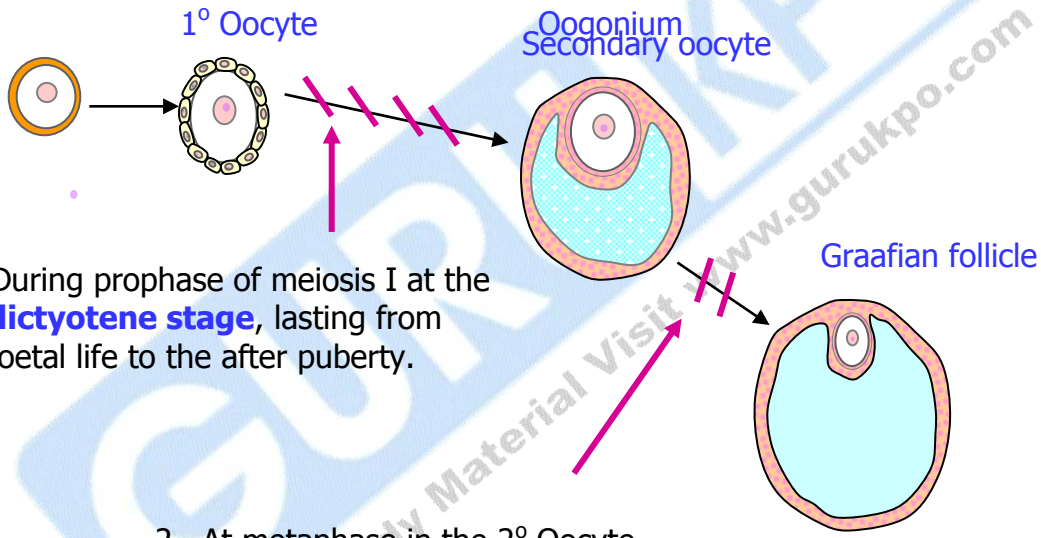
Oogenesis

At birth the ovary contains primordial follicles. They consist of a **primary oocyte** surrounded by **granulosa cells**. Gap junctions connect the oocyte to surrounding granulosa cells. The gap junctions permit passage of amino acids, glucose and



metabolites for growth of the oocyte. The follicular cells secrete a meiotic inhibitory factor that is responsible for the **first meiotic arrest.**

The developing oocyte undergoes two meiotic arrests:



1. During prophase of meiosis I at the **dictyotene stage**, lasting from foetal life to the after puberty.

2. At metaphase in the 2° Oocyte prior to ovulation.

The Ovarian follicle consists of the following:

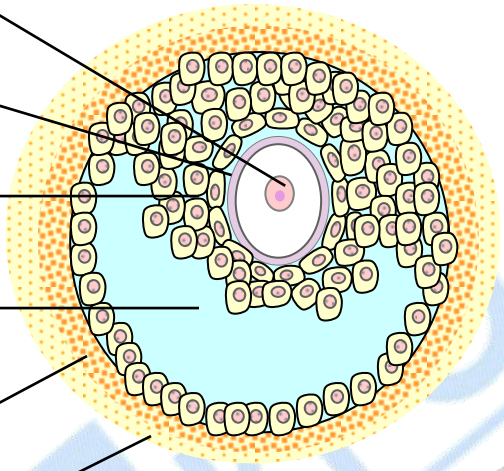
Secondary oocyte formed after Meiosis I is completed

A zona pellucida surrounds the oocyte

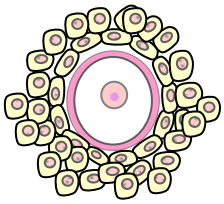
Cumulus oophorus surrounds the oocyte

A fluid-filled antrum forms between the follicular cells

Two layers formed from the ovarian stoma:
Theca interna - vascular
Theca externa - connective tissue capsule

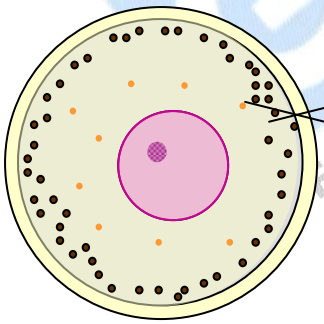


The zona pellucida:



- o Is secreted by the oocyte
- o Consists of glycoprotein and glycosaminoglycans
- o Contains sperm receptors necessary for fertilization

The oocyte cytoplasm contains:



- numerous ribosomes (produced by r-DNA amplification in nucleolus)
- Yolk droplets (nutritive)
- Cortical granules (formed in the Golgi apparatus).

Cortical granules are released on penetration of the vitelline membrane by a sperm. They cause a change in the zona pellucida to prevent double fertilization

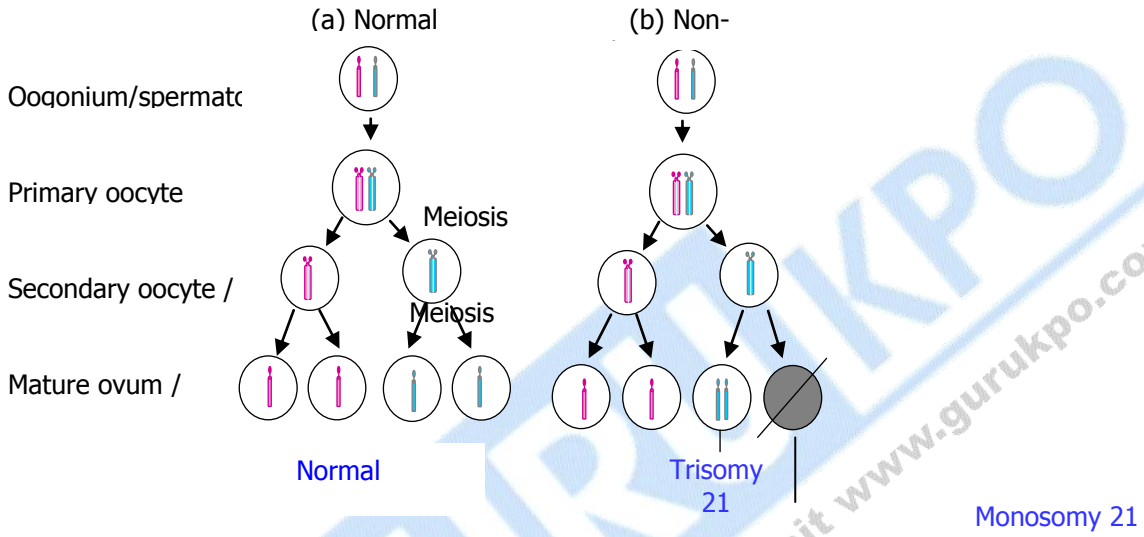
The Graafian follicle (tertiary follicle) is distended with liquor and points at the surface of the ovary like a blister. Rupture of the follicle occurs at ovulation releasing the secondary oocyte. At the time of ovulation the second meiotic division is still not completed. After ovulation the secondary oocyte is surrounded by a corona radiata.

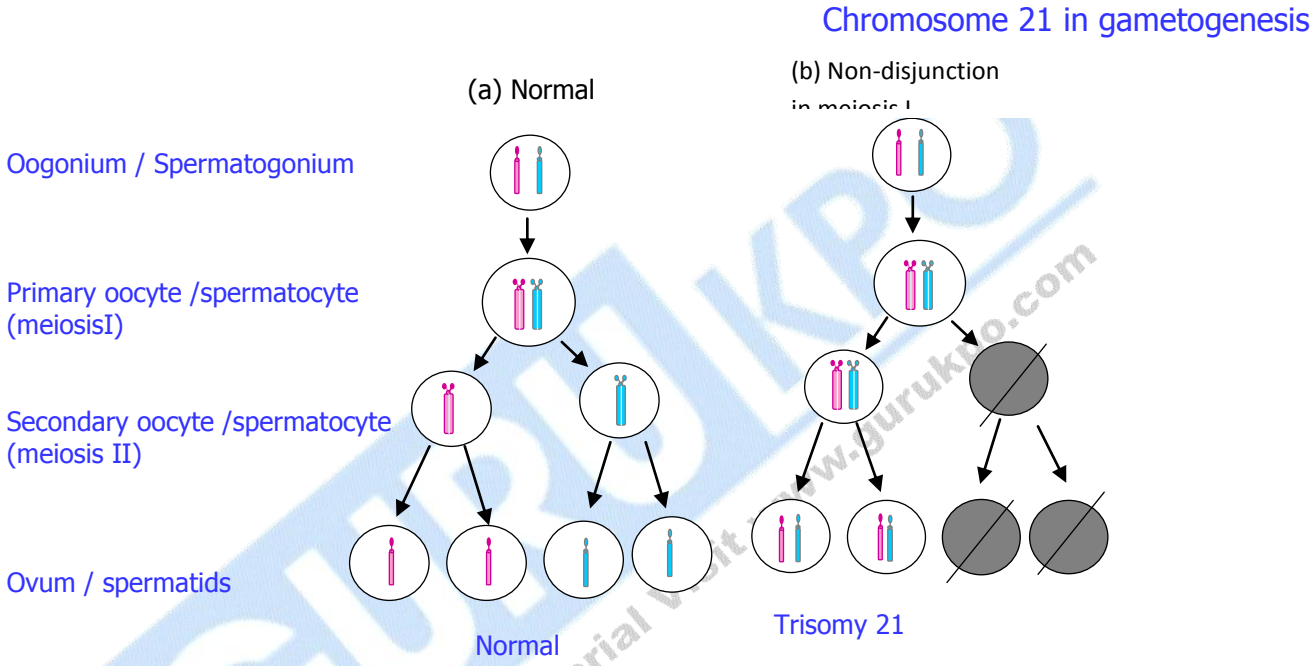
Abnormalities in meiosis may give rise to numerical chromosome abnormalitites. Non-disjunction is the usual mechanism by which abnormalities in chromosome number may occur.

The following diagram illustrates chromosome 21 in meiosis I and II in (a) normal gametogenesis and (b) non-disjunction in meiosis I. Failure of separation of the chromosomes results in a secondary oocyte or a secondary spermatocyte with two chromosomes 21, which will form trisomy 21 after fertilisation. The other secondary oocyte or spermatocyte has does not contain a chromosome 21, and after fertilization, will result in monosomy 21. This is incompatible with survival and this condition is therefore not seen. Non-disjunction also occurs in common trisomies e.g. trisomy 18 or trisomy 13.

Non-disjunction may also occur in meiosis II, resulting from failure of separation of the chromatids, as shown in the following diagram. This type of non-disjunction is rare.

Chromosome 21 in gametogenesis





Q 4. Why is sexual reproduction necessary?

The main purpose of sexual reproduction is the formation of offspring who are genetically different from one another and from their parents.

Meiosis is the fundamental process underlying sexual reproduction. It involves two essential outcomes:

1. Reduction Division the process in which each gamete receives a haploid set (n) of chromosomes and genes.

The diploid number (2n) is restored on fusion of two gametes.

2. Rearrangement of genes on the maternal and paternal chromosomes.

This ensures that the offspring are genetically different from one another.

Q. 5 What do you understand by the term Primordial Germ Cells?
Ans.

A. Are the earliest precursors of all germ cells

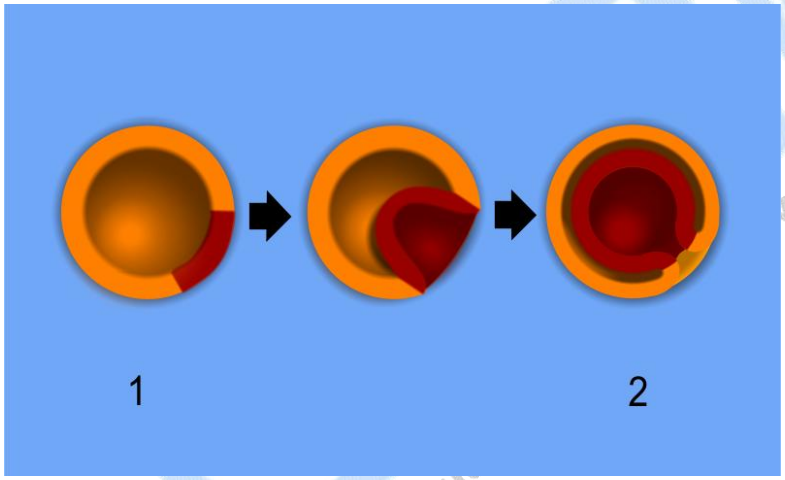
B. Are formed in the early stages of embryonic development

C. Are first recognizable close to the hindgut as large cells with high alkaline phosphatase

D. Proliferate and migrate into the gonad (testis or ovary)

E. Differentiate into male or female germ cells (determined by sex chromosomes)

Q.6 Define Gastrulation.
Ans. Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a trilaminar ("three-layered") structure known as the gastrula. These three germ layers are known as the ectoderm, mesoderm, and endoderm.



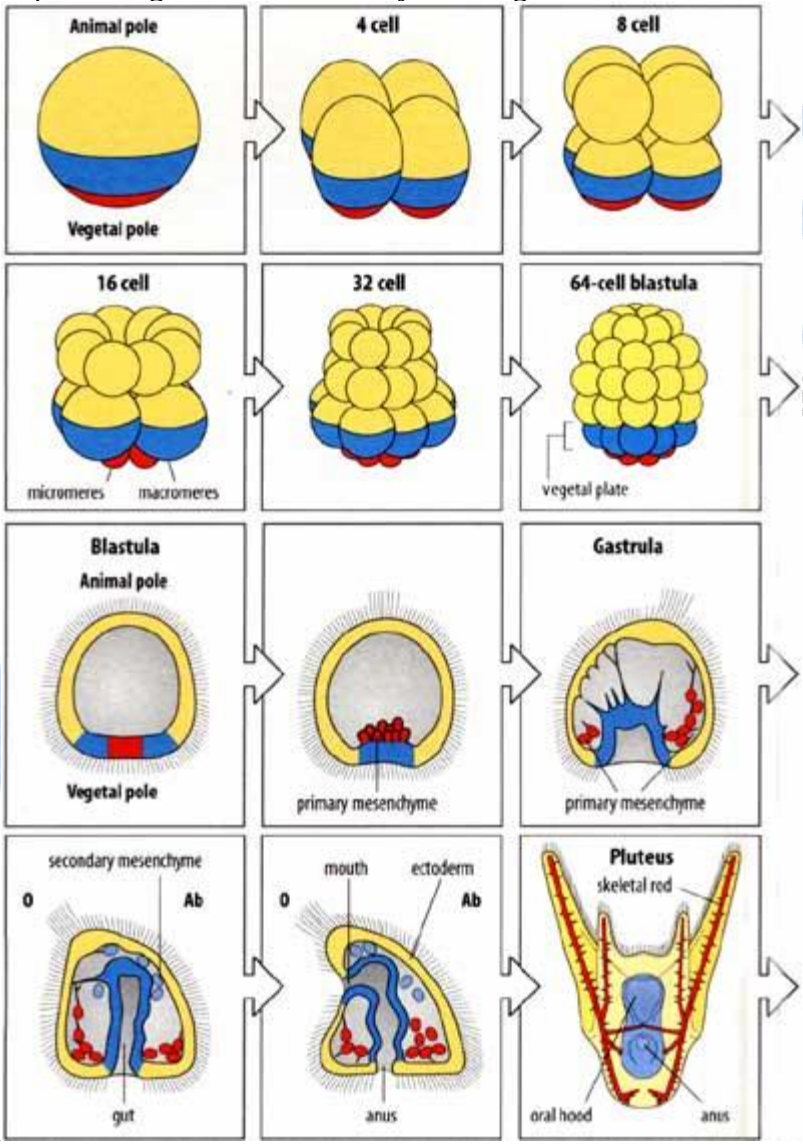
Gastrulation of a diploblast: The formation of germ layers from a (1) blastula to a (2) gastrula. Some of the ectoderm cells (orange) move inward forming the endoderm (red).

Q.7 Write down the difference between gastrulation process of invertebrates and vertebrates.
Ans. Invertebrates are protostomes which means 'mouth first' the lumen that forms begins at the mouth then the anus forms. For vertebrates, what will become the anus forms first and then the mouth forms. Vertebrates a considered deuterostomes which means 'mouth second'.

Q.28 Explain the process of gastrulation in invertebrates.
Ans. Gastrulation is a phase early in the embryonic development of most animals, during which the single-layered blastula is reorganized into a trilaminar ("three-layered") structure

known as the gastrula. These three germ layers are known as the ectoderm, mesoderm, and endoderm.

Echinoderms are one of the best systems for studying gastrulation. They're well characterized, and best of all, the embryos are transparent: just focus on the interior of the animal, and you can watch all the cells move and divide and change shape to generate the changes in tissue organization. In addition, the blastula divides in a predictable and stereotyped way, and you can trace the cell lineages late into development, seeing what each piece of the puzzle does. The diagram below is a simplified diagram of the process; the top 6 images show the early cleavages that lead to the formation of a hollow ball

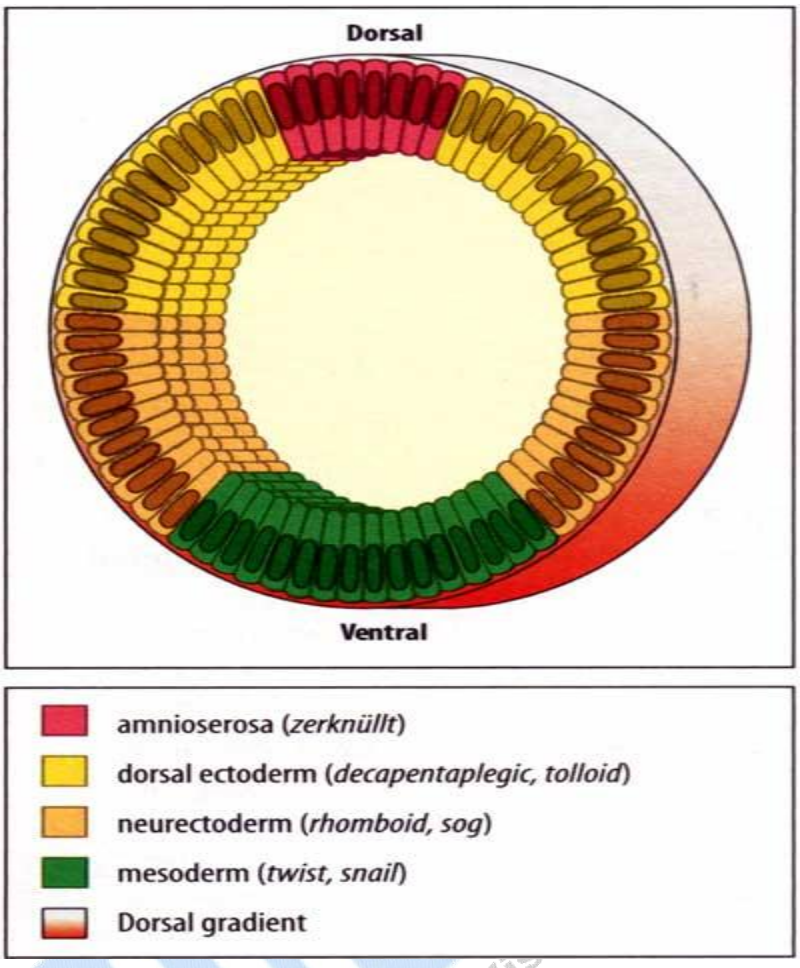


The bottom 6 images show the course of gastrulation. The yellow sheet of cells will become ectoderm; the red cells at the vegetal pole will introgress into the fluid-filled

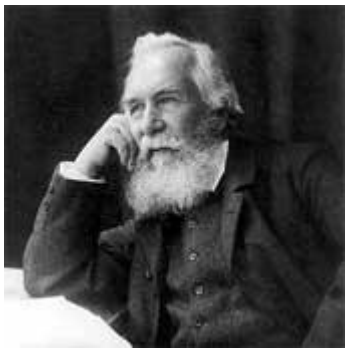
space, forming the primary mesenchyme. (Mesenchyme, by the way, is a term for loosely associated, often migratory mesodermal cells). The primary mesenchyme crawls about in the interior, and will form the internal mineral skeleton of the pluteus larva. The endoderm (in blue) invaginates and forms a hollow tube, the animal's gut. Some of its cells also peel out of the sheet to form the secondary mesenchyme, and the ascending end of the endoderm fuses with the ectoderm to create a mouth.

The *Drosophila* embryo is more cigar-shaped than spherical, and gastrulation occurs along a ventral seam; these are cross-sections through the tube of the embryo's body. What you can see is that a plate of cells buckles inward and the cells roll inward as a sheet. The sheet then collapses into a mesenchymal mass that will contribute to the mesoderm of the embryo. Note that one difference here is that you aren't seeing endoderm; the tube of the gut arises from invaginations at the anterior and posterior ends, which aren't seen in this section.

One of the strengths of the *Drosophila* system is that we can look at gene expression around the circumference of this ring of cells. Prior to gastrulation, it looks like this:



Those green cells are expressing the mesodermal markers *twist* and *snail*; they're the ones that will move inward. The orange cells just lateral to them will shift towards the ventral midline, and will form the neurectoderm (insect nervous systems form along the ventral midline, unlike ours that form along the dorsal midline). The dorsal ectoderm expresses a gene call *decapentaplegic* (*dpp* for short) that is homologous to a gene called *Bmp* in vertebrates; *Bmp* induces ventral fates in vertebrates, while its homolog is a dorsal gene in flies. Similarly, *sog* is going to be expressed on the ventral side of the fly, while its vertebrate homolog, *chordin*, will be active in the dorsal organizer. This is part of the evidence that vertebrates and invertebrates are upside-down versions of one another.

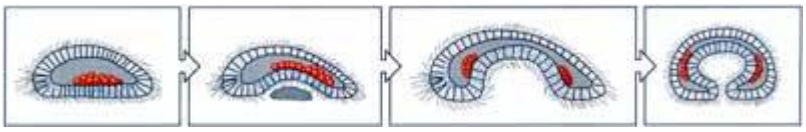


One other important historical fact I have to mention about the gastrula. The morphological features were first identified in the early 19th century by Rusconi and Dutrochet, and later by Karl Ernst von Baer (that's a name that turns up extremely often in the history of embryology), but was actually first named in 1872 by the gentleman to the right, whose name comes up just as often.

That's Ernst Haeckel.

Nowadays, it seems that the only time anyone brings up that name is in the context of his failed theory of the biogenetic law, but that's hardly fair. He was an energetic and influential figure in the history of developmental biology, and he was responsible for synthesizing many of the scattered observations of experimentalists and natural historians into a more coherent and universal set of explanations for animal development. He seems to have named a lot of the developmental phenomena we take for granted now, along with a British scientist who is also less well appreciated than he deserves, Ray Lankester (Lankester, for instance, is responsible for the germ layer concept that named ectoderm, endoderm, and mesoderm, and made the distinction between triploblastic phyla that have all three layers, and the diploblasts, that have only two).

Haeckel generalized the idea of the gastrula to a wider domain than just amphibians, and argued that it was a common phenomenon in all triploblastic animals. He also gave an evolutionary explanation, suggesting that it arose as a feeding adaptation in the urmetazoa, in which the inward migration was part of a process to establish a gut cavity (which is how the name was derived—'gastrula' and 'gastric' have the same root, referring to a 'stomach'). His gastraea hypothesis is illustrated below, with a hypothetical placozoan like organism that evolved to form an internal chamber used for holding food for processing, a process that internalized an epithelial layer and opened up the potential for novel cell interactions and greater complexity.



There are real problems with the gastraea hypothesis, but like all of Haeckel's work, it was an early, flawed explanation based on a valid and universal observation—in this case, the ubiquity of gastrulation in many animal embryos.

Q.9 What is apical constriction and what role it plays?

Ans. Apical constriction describes the process in which contraction of the apical side of a cell causes the cell to take on a wedged shape. Generally, this shape change is coordinated across many cells of an epithelial layer, generating forces that can bend or fold the cell sheet.

Apical constriction plays a central role in important morphogenetic events in both invertebrates and vertebrates. It is typically the first step in any invagination process and is also important in folding tissues at specified hingepoints.

During gastrulation in both invertebrates and vertebrates, apical constriction of a ring of cells leads to blastopore formation. These cells are known as bottle cells, for their eventual shape. Because all of the cells constrict on the apical side, the epithelial sheet bends convexly on the basal side.

In vertebrates, apical constriction plays a role in a range of other morphogenetic processes such neurulation, placode formation, and primitive streak formation.

Apical constriction occurs primarily through the contraction of cytoskeletal elements. The specific mechanism depends on the species, the cell type, and the morphogenetic movement. Here, we present a few well-studied examples in model organisms.

Q.10 Explain axis specification in vertebrates.

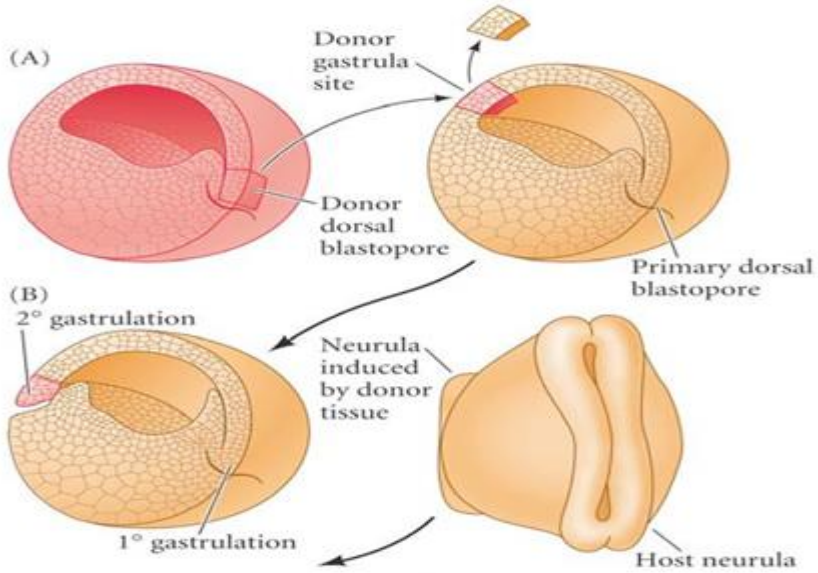
Ans. Classical experiments: Classical studies established that several key signaling embryological processes are important for amphibian axis specification. Recall that the Organizer is the key region that is established through early development:

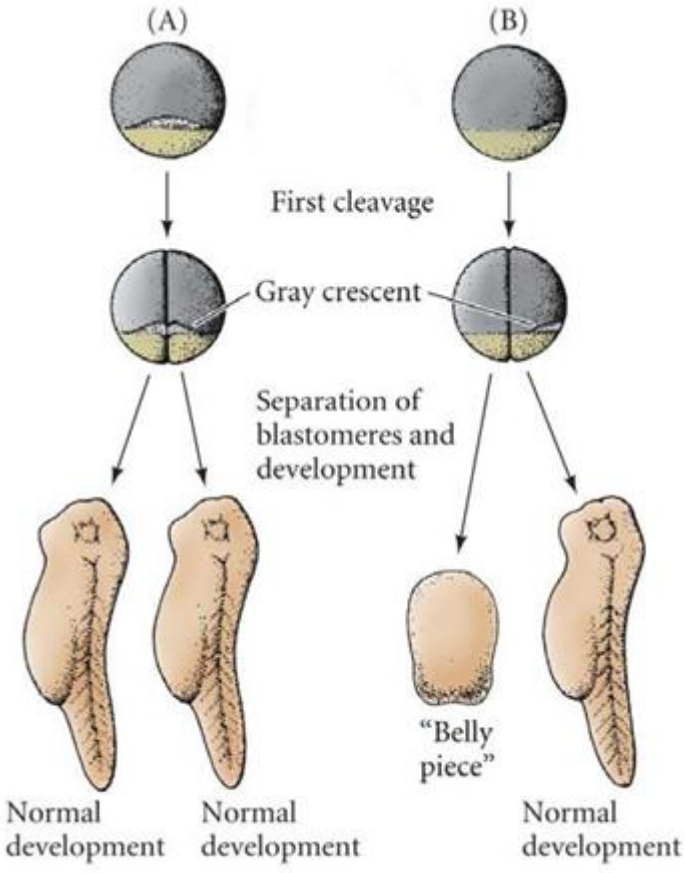
Several prior steps lead to formation of the Organizer:

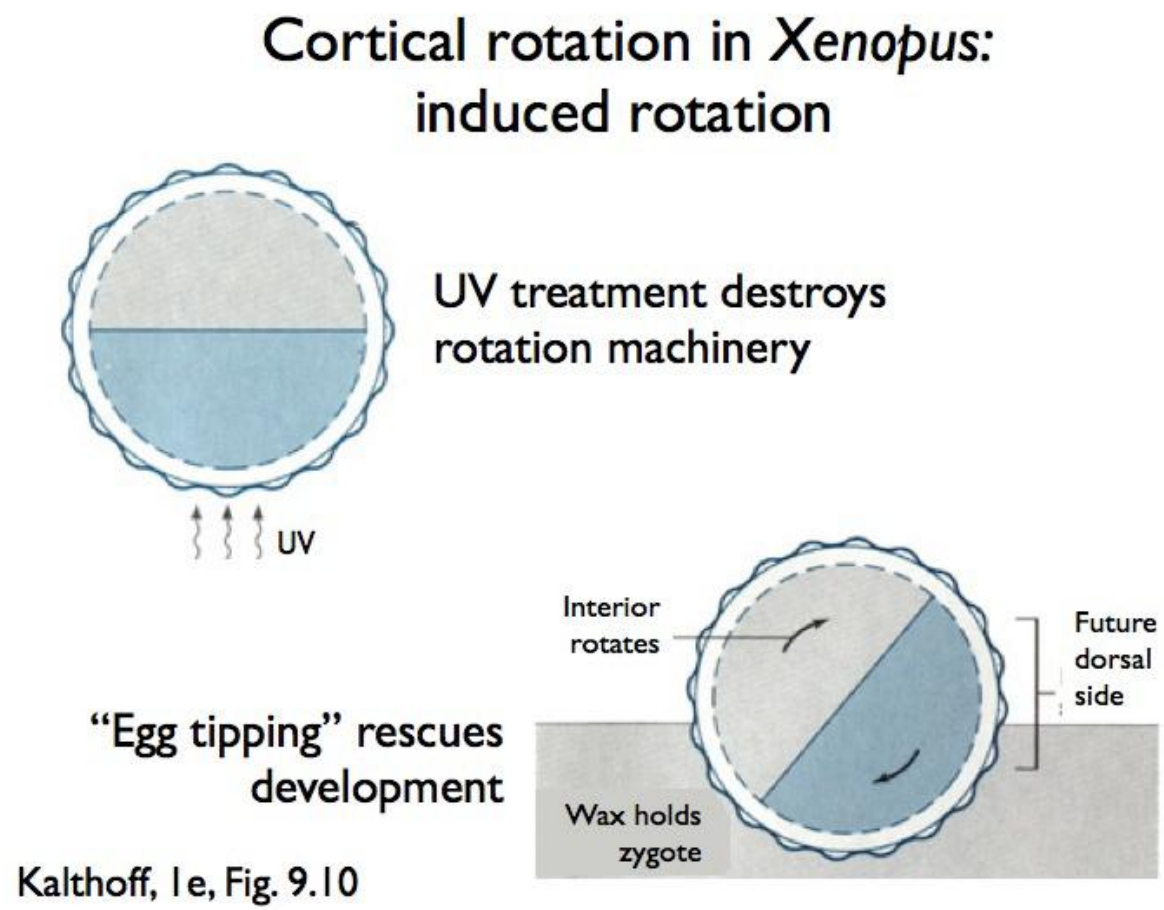
(a) Cortical rotation/gray crescent formation: Hans Spemann showed that fertilization creates an area of

lighter pigment called the gray crescent. Cells that receive this material can ultimately organize an axis.

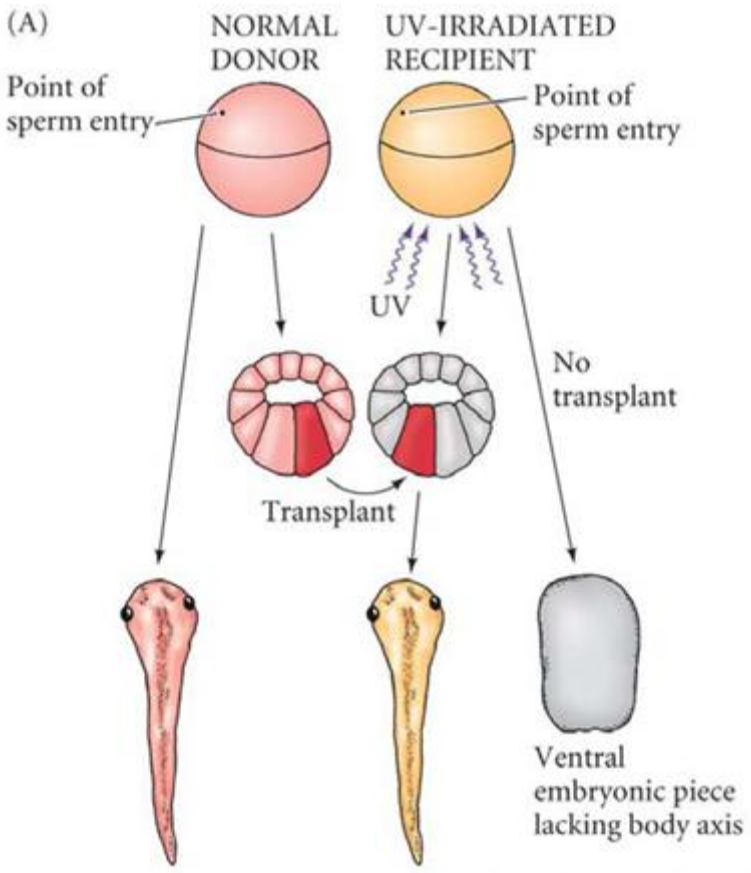
This region is created by a cortical rotation of the outer vs. inner regions of the fertilized egg. This rotation is sufficient to rescue axis deficient embryos created via UV irradiation.



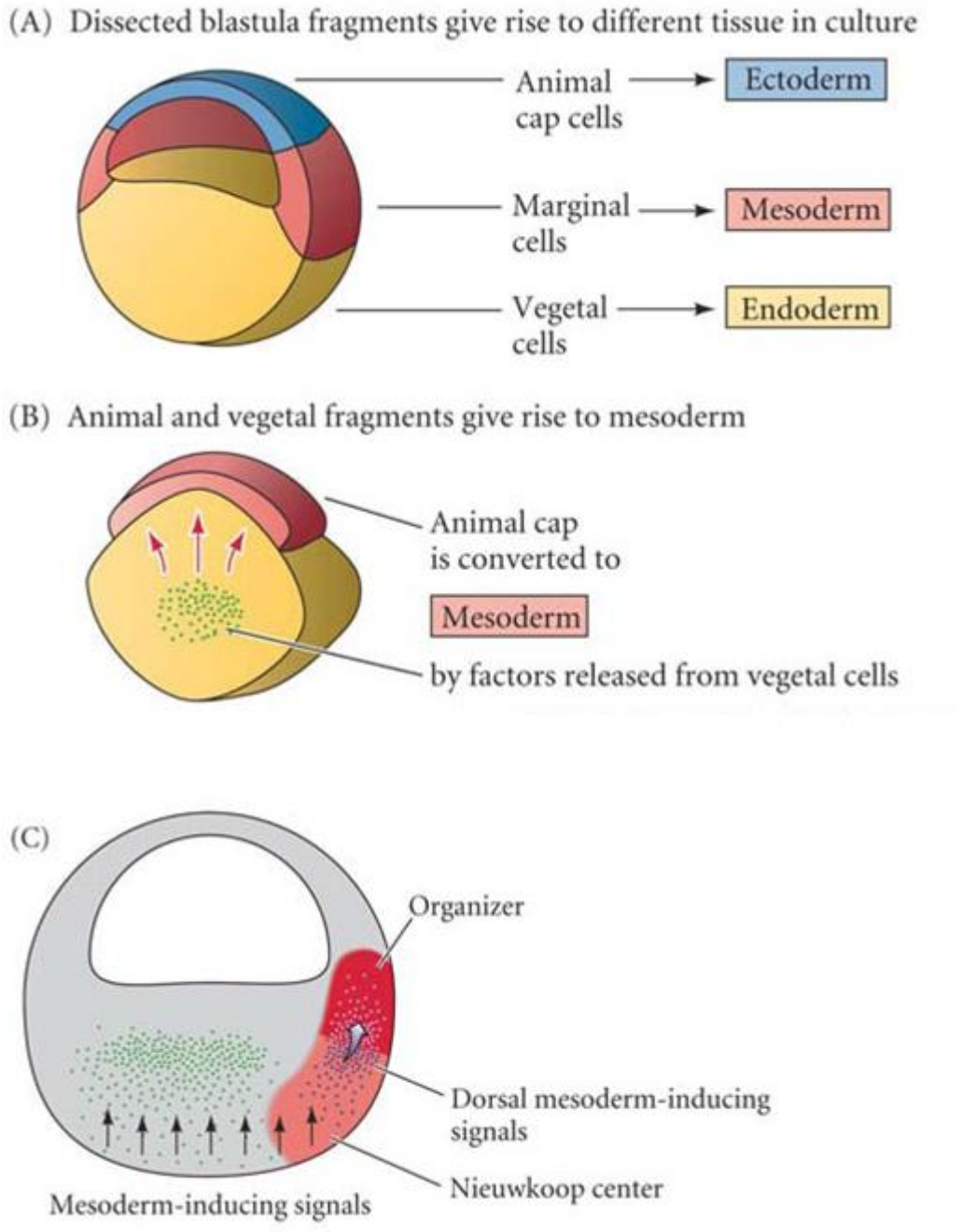




b) Vegetal cells signal to induce mesoderm: Dorsal vegetal cells are capable of inducing an axis and rescuing UV-treated embryos:

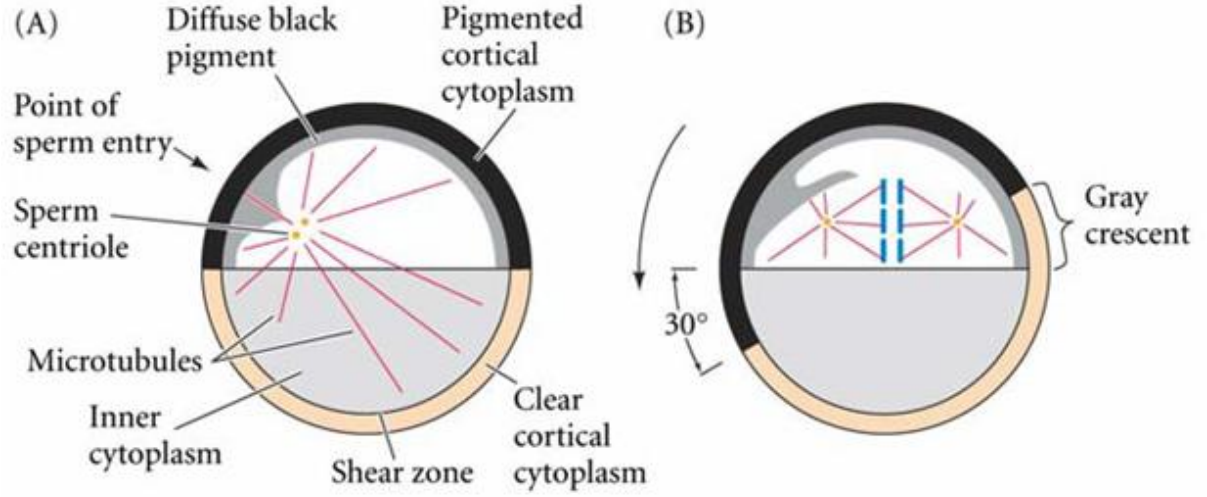


(c) This leads to the "Nieuwkoop Center", a region on the dorsal side that induces Organizer, whereas non-dorsal cells induce non-dorsal mesoderm:



Note: Based on cell marking experiments, dorsal endoderm generates dorsal-type mesoderm in the experiment shown in (B), whereas non-dorsal types of endoderm induce non-dorsal types of mesoderm.
Gilbert, 8e, Fig. 10.20
Gilbert, 8e, Fig. 10.21
Modern Experiments

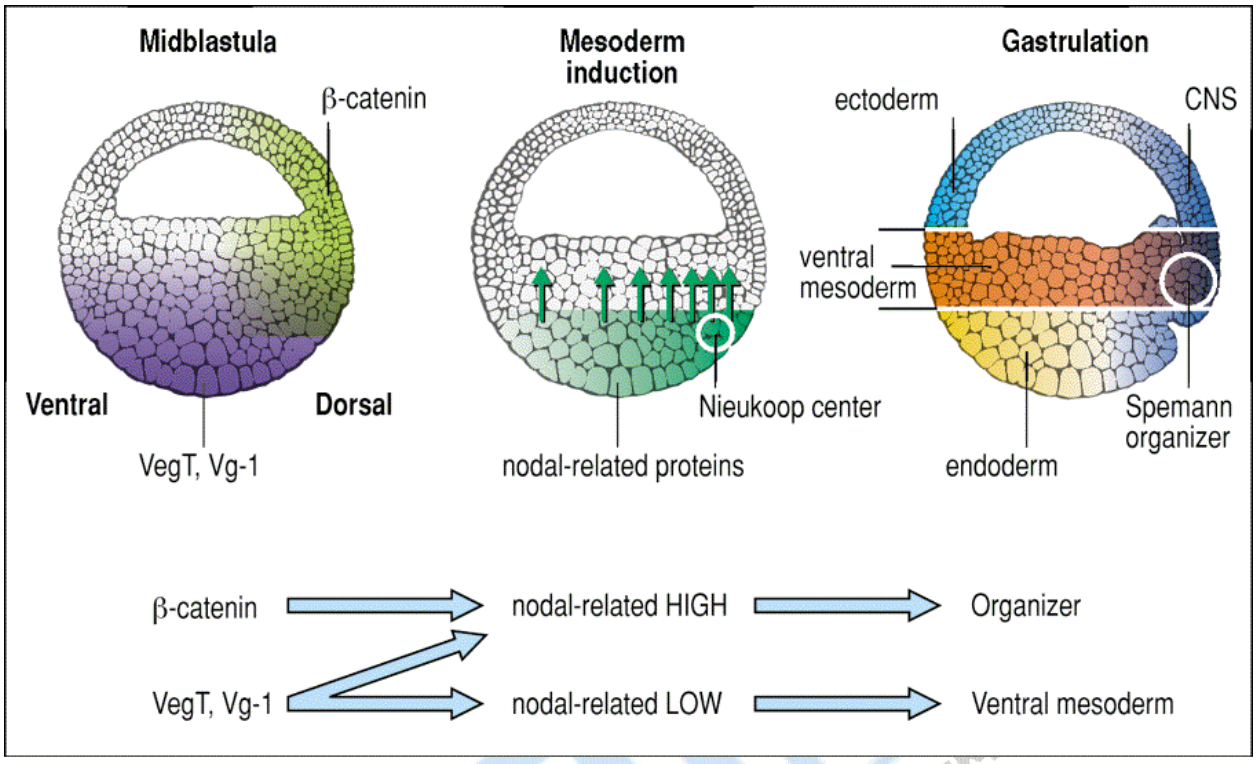
The challenge of modern developmental biology is to correlate classical experiments with molecular
mechanisms. While much progress has been made in this area, there are still areas that are poorly understood. The establishment of the D-V axis involves several steps: Step 1: Fertilization induces cortical rotation. Cortical rotation is driven by microtubules, which in part are formed via nucleation from the sperm aster. The sperm enters 180° away from the future dorsal side of the embryo. In some species, this creates a lighter area on the surface known as the gray crescent.



Step 2: Cortical rotation activates dorsal development, possibly through Dishevelled and XWnt11.
This leads to more β-catenin on the dorsal side of the zygote. Excess β-catenin introduced ventrally by
overexpression can result in axis duplication (see figure below).

Step 3: β-catenin accumulates in the nuclei of dorsal cells.

Step 4: The Nieuwkoop Center forms. Ventral vegetal cells differentiate as endoderm, due in part to VegT (and possibly Vg1). Dorsal vegetal cells differentiate differently, due to the added effect of β-catenin. Tcf/Lef proteins, in combination with β-catenin, lead to expression of siamois (a transcription factor) and other genes in these cells.



Step 5: Graded expression of Nodal-related proteins arises in vegetal cells.This creates a full spectrum of D-V differences.

Step 6: Mesoderm is induced in overlying marginal zone tissue by vegetal cells. The character of the induced mesoderm reflects the character of the underlying vegetal cells.

Step 7: The organizer counteracts the effects of BMPs and Wnts, leading to dorsal mesoderm formation. Ventral cells produce BMPs and XWnt8, among other secreted proteins. Organizer cells "combat' sthese protein by secreting BMP and Wnt inhibitors. Organizer proteins include noggin, chordin, Frbz1, Cerberus, and Dickkopf

Step 8: Gastrulation moves mesoderm and endoderm into position for further inductive events

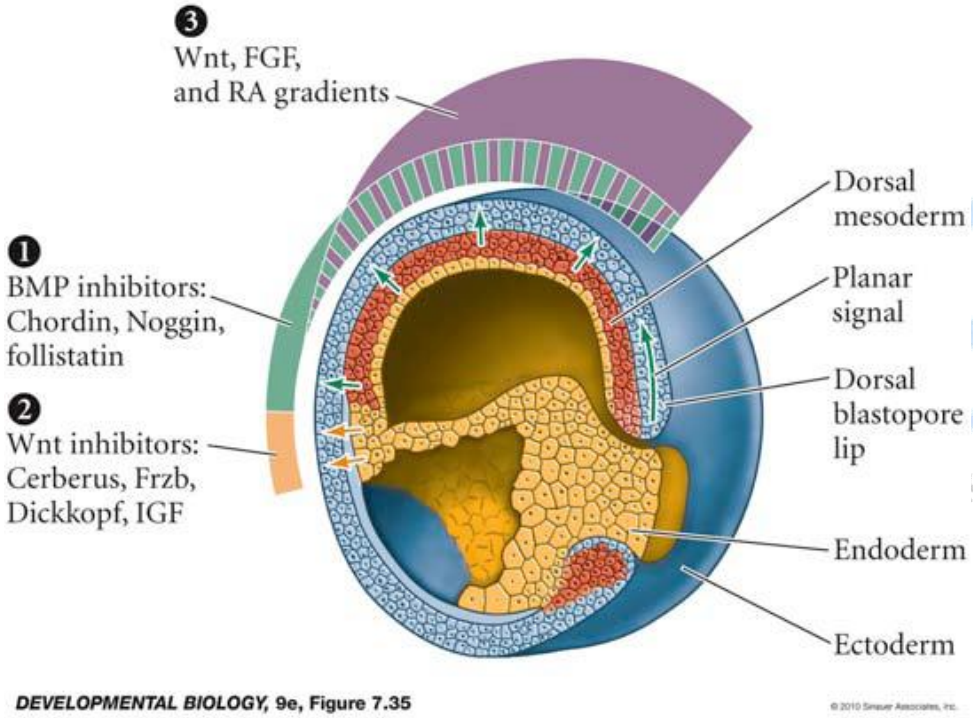
Step 9: The same signals lead to neural induction: In the ectoderm, BMPs and Wnt promote epidermis,
but the organizer counteracts these signals in ectoderm near the Organizer, leading to neural induction

Step 9: Refinement of neural induction occurs: Early in gastrulation, the organizer appears to send signals to nearby ectoderm prior to involution of the dorsal mesoderm ("planar induction"). Later, after involution, regional induction results in anterior and posterior neural tissues ("vertical induction"). Embryological experiments show that both of these kinds of signals probably act. Planar signals can be shown to occur via Keller explants, in which the ectoderm is adjacent to mesoderm. Vertical signals can be shown to operate through "Einsteck" implants, in which

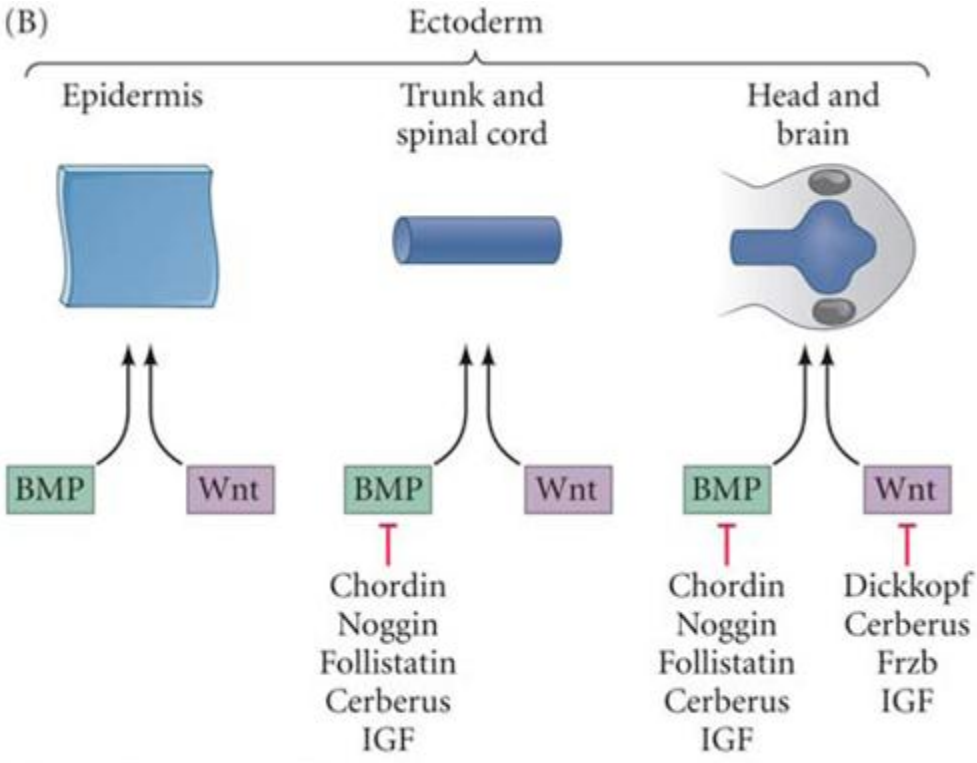
anterior or posterior mesoderm is inserted into a host gastrula. The induced tissue is appropriate to the nature of the inserted mesoderm.

There is some evidence that a posteriorizing signal, mediated by retinoic acid (RA), Wnts, and fibroblast

growth factors (FGFs) reinforces posterior neural fates. Secreted Wnt antagonists such as Cerberus, produced by the anterior mesendoderm reinforce head-specific neural fates, as opposed to trunk spinal cord, where mainly BMPs are blocked. Wolpert, 2e, Fig. 4.20



***DEVELOPMENTAL BIOLOGY*, 9e, Figure 7.35**



Section- D
Cell differentiation and oogenesis

Q. 1Define Organogenesis.
Ans.

Organogenesis is the process by which the ectoderm, endoderm, and mesoderm develop into the internal organs of the organism. Internal organs initiate development in humans within the 3rd to 8th weeks in utero. The germ layers in organogenesis differ by three processes: folds, splits, and condensation. Developing early during this stage in chordate animals are the neural tube and notochord. Vertebrate animals all differentiate from the gastrula the same way. Vertebrates develop a neural crest that differentiates into many structures, including some bones, muscles, and components of the peripheral nervous system. The coelom of the body forms from a split of the mesoderm along the somite axis.

In plants, organogenesis can occur from totipotent callus cells.

Q.2 What do you understand by the term Ectoderm Derivatives?

Ans. The epidermal ectoderm forms the epithelium of the skin and many epidermal derivatives such as, skin glands, epidermal scales and nails, claws, hoofs, horns, feathers and hairs. Ectodermal invaginations form the stomodaeum and proctodaeum. The stomodaeum forms the lining of the mouth and lips, buccal cavity enamel of the teeth, covering of tongue and the anterior and the posterior lobes of the pituitary gland. The protodaeum forms the lining of the cloaca and some anal and cloacal glands. The neural plate of the ectoderm forms the brain, spinal cord and nerves. The fore brain forms the retina, part of iris, posterior lobe of pituitary, parietal and pineal body. The ectoderm also forms the lens, conjunctiva, part of cornea, membrane labrynth and lateral line system. The neural crest cells of ectoderm give rise to ganglia, neurilemma of peripheral nerves, neuroglia, suprarenal gland, medulla of adrenal gland and the chromatophores of skin.

Q. 3 What do you understand by the term MesodermDerivatives?

Ans. It is differentiated as dorsal epimere, a median mesomere and a ventral hypomere. The mesenchymatous epimere forms the vertebral column. The dermatome of epimere forms the dermis of skin. The myotome of epimere forms the voluntary muscles of the body and body wall. The mesomere forms the urinogenital organs and their ducts. The hypomere splits as somatic and splanchnic layers. The splanchnic mesenchyme forms the

involuntary muscles and the connective tissues of the alimentary canal and it also forms the heart. The splanchnic together with somatic layer form the pericardium, pleura or peritoneum and the lining of the coelom. The mesenchyme gives rise to the connective tissues, blood vessels, lymph vessels, lymph nodes, blood corpuscles and all the involuntary muscles, parts of eye, dentine, cartilage and bones of entire endoskeleton.

Q. 4 Explain the eye development process.

Ans. The eye develops from the neural tube, the epidermis, and the periocular mesenchyme, which receives contributions from both the neural crest and mesoderm lineages.

Sequential inductions

This development is an example of sequential inductions where the organ is formed from three different tissues.

Neural tube

First, there is an outpocketing of the neural tube called optic vesicles. Development of the optic vesicles starts in the 3-week embryo, from a progressively deepening groove in the neural plate called the optic sulcus. As this expands, the rostral neuropore (the exit of the brain cavity out of the embryo) closes and the optic sulcus and the neural plate becomes the optic vesicle.[1]

Epidermis

The optic vesicles come into contact with the epithelum and induce the epidermis. The epithelium thickens to form the lens placode.

The lens differentiates and invaginates until it pinches off from the epithelium. The lens acts as an inducer back to the optic vesicle to transform it into the optic cup and back to the epidermis to transform it into the cornea.

The optic cup then delaminates into two layers: The neural retina and the retinal pigment epithelium.

Periocular mesenchyme

The periocular mesenchyme migrates in during the formation of the optic cup and is critical for the induction of the retinal pigment epithelium and the optic nerve. The mesenchyme contributes to the cornea, iris , ciliary body, sclera and blood vessels of the eye.

There is some evidence that LMX1B plays a role in periocular mesenchymal survival.[2]

Developmental cascade

According to Liem et al., the organogenesis of the eye is pointed out as an example of a developmental cascade of inductions. The eye is essentially a derivative of the ectoderm from the somatic ectoderm and neural tube, with a succession of inductions by the chordamesoderm.

Chordamesoderm induces the anterior portion of the neural tube to form the precursors of the synapomorphic tripartite brain of vertebrates, and it will form a bulge called the diencephalon. Further induction by the chordamesoderm will form a protrusion: the optic visicle. This visicle will be subsequently invaginated by means of further inductions from the chordamesoderm. The optic visicle will then induce the ectoderm that thickens (lens placode) and further invaginates to a point that detaches from the ectoderm and forms a neurogenic placode by itself. The lens placode is affected by the chordamesoderm making it to invaginate and forms the optic cup composed by an outer layer of neural retina and inner layer the pigmented retina that will unite and form the optic stalk. The pigmented retina is formed by rods and cones and composed of small cilia typical of the ependymal epithelium of the neural tube. Some cells in the lens vesicle will be fated to form the cornea and the lens vesicle will develop completely to form the definitive lens. Iris is formed from the optic cup cells.

Responsivity of head epidermis

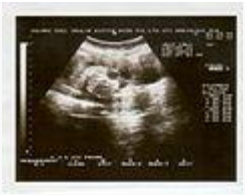
Only the epidermis in the head is competent to respond to the signal from the optic vesicles. Both the optic vesicle and the head epidermis are required for eye development. The competence of the head epidermis to respond to the optic vesicle signals comes from the expression of Pax6 in the epidermis. Pax6 is necessary and sufficient for eye induction. This competenece is acquired gradually during gastrulation and neurulation from interactions with the endoderm, mesoderm, and neural plate.

Regulation and inhibition

Sonic hedgehog reduces the expression of Pax6. When Shh is inhibited during development, the domain of expression for Pax6 is expanded and the eyes fail to separate causing cyclopia.[3] Overexpression of Shh causes a loss of eye structures.

Retinoic acid generated from vitamin A in the retina plays an essential role in eye development as a secreted paracrine signal which restricts invasion of perioptic mesenchyme around the optic cup.[4] Vitamin A deficiency during embryogenesis results in anterior segment defects (particularly cornea and eyelids) that lead to vision loss or blindness.

Additional images

- 
- Optic cup and choroidal fissure seen from below, from a human embryo of about four weeks.
- Horizontal section through the eye of an eighteen days' embryo rabbit. X 30.
- Sagittal section of eye of human embryo of six weeks.
- Section of developing eye of trout.

Q. 5 What do you understand by the term morphogenesis?

Ans. Morphogenesis:

Morphogenesis is the biological process that causes an organism to develop its shape. It is one of three fundamental aspects of developmental biology along with the control of cell growth and cellular differentiation. The process controls the organized spatial distribution of cells during the embryonic development of an organism. Morphogenesis can take place also in a mature organism, in cell culture or inside tumor cell masses. Morphogenesis also describes the development of unicellular life forms that do not have an embryonic stage in their life cycle, or describes the evolution of a body structure within a taxonomic group. Morphogenetic responses may be induced in organisms by hormones, by environmental chemicals ranging from substances produced by other organisms to toxic chemicals or radionuclides released as pollutants, and other plants, or by mechanical stresses induced by spatial patterning of the cells.

Multiple Choice Questions

Introduction of Development Biology

Q:1: Gradual growth through a series of progressive changes is called

(A)Growth (B)Development

(C)Cleavage (D)Transduction

Ans.(B)

Q:2: The study of developmental changes is known as

(A)Embryology (B) Developmental biology

(C)Both A and B (D) Chrono-biology

Ans. (C)

Q3: As a fertilized egg develops into an embryo, it undergoes

(A) One meiotic cell division, only
(B) Many meiotic cell divisions
(C) One mitotic cell division, only
(D) Many mitotic cell divisions
Ans. (D)

Q.4- Genes control development by:

A) controlling where and when proteins are synthesized.
B) Containing small preformed body parts and organs that become "expressed" during development
C) directly controlling phenotypes, without intermediates or influence from the environment.
D) Acting as enzymes to build proteins.
E) Containing instructions which describe in detail the final form to be achieved during development

Ans. (A)

Q.5. _____ designated the _____ as the primary organizer.

A. Hilde Proscholdt, cytoplasm

B. Hans Spemann, dorsal lip tissue
C. Hans Spemann, cytoplasm
D. Friedrich Wolff, yolk
E. Friedrich Wolff, cytoplasm

Ans. (B)

Q.6.The concept that an egg or sperm cell contained a very small but fully developed individual was called
A. Induction
B. Pronuclei
C. Preformation
D. Holoblastism
E. Epigenesis

Ans. (C)

Q.7. The concept that an egg contains the building material that must somehow be assembled is called
A. Induction
B. Pronuclei
C. Preformation
D. Holoblastism
E. Epigenesis

Ans. (E)

Q.8. Which term is NOT related to the others?

A) gametogenesis
B) oogenesis
C) mitosis
D) spermatogenesis
E) sexual reproduction

Ans: C

Q.9. Meiosis leads to all of the following EXCEPT

A) gametogenesis
B) oogenesis
C) cloning
D) spermatogenesis
E) haploid cells

Ans: C

Gametogenesis

Q.10. Regarding oogenesis, all statements are correct, EXCEPT:

A) It starts during fetal life.
B) It is completed during puberty.
C) It continues till menopause.
D) Primary oocytes are formed after birth.

Ans. (D)

Q.11 Regarding spermatogenesis:

A) It starts before birth.
B) Primary spermatocytes have a haploid number of chromosomes.
C) Spermiogenesis is a process by which a spermatid is transformed into a mature sperm.
D) Spermiogenesis occurs in the fallopian (uterine) tube.
E) The first meiotic division is a reduction division by which a secondary spermatocyte divides into two spermatids.

Ans. (C)

Q12.Where in the human male does spermatogenesis occur?

A) ovaries
B) testes
C) epididymus
D) prostate gland
E) seminal vesicle

Ans: B

Q.13.Which term is NOT related to the others?

A) gametogenesis

B) oogenesis
C) mitosis
D) spermatogenesis
E) sexual reproduction

Ans: C

Q.14. Meiosis leads to all of the following EXCEPT
A) gametogenesis
B) oogenesis
C) cloning
D) spermatogenesis
E) haploid cells

Ans: C

Q.15.The polar body is
A) another name for an egg cell.
B) a precursor cell that becomes an egg cell.
C) a nonfunctional cell made at the same time as an egg cell.
D) the cell produced when fertilization occurs.
E) a specialized sperm cell

Ans: C

Q.16 Why do polar bodies form?
A) They nurse the egg as it leaves the follicle.
B) This is extra chromosomal material representing the X chromosome in each female cell.
C) They orient the sperm toward the egg.
D) They allow a reduction in chromosomes while preserving all the food for one egg.
E) They orient the egg for penetration by the sperm.

Ans: D

Q.17. Although the sperm and egg are both produced by the process of meiosis, they differ in which of the following ways?
A) From a genetic point of view each gene stands an equal chance of ending up in a sperm but has a 50% chance of being discarded in the polar body in egg production.
B) They have a different allocation of cellular food supply.
C) They differ in motility.

D) In humans, meiosis in egg cells doesn't complete unless fertilization occurs.
E) All of the choices are correct.

Ans: E

Q.18.Which cells of the testis provide nourishment to spermatozoa?
(A) Sertoli cells
(B) Leydig cells
(C) Interstital cells
(D) Spermatogonia

Ans: (A)

Q.19. Which cells of the testis provide nourishment to spermatozoa?
(A) Sertoli cells
(B) Leydig cells
(C) Interstital cells
(D) Spermatogonia

Ans: (A)

Q.20.Which cells of the testis provide nourishment to spermatozoa?
(A) Sertoli cells
(B) Leydig cells
(C) Interstital cells
(C) Spermatogonia

Ans: (A)

Q.21.Spermiogenesis changes
(A) Spermatogonium to primary spermatocyte
(B) Primary spermatocyte to secondary spermatocyte
(C) Secondary spermatocyte to spermatid
(D) Spermatid to sperm

Ans: (D)

Q.22 Spermatozoa are nourished during their development by
(A) Sertoli cells
(B) Interstitial cells
(C) Connective tissue cells
(D) None of the above

Ans: (A)

Q.23.Spermatogonia undergo a growth phase to become
(A) spermatozoa
(B) Primary spermatocyte
(C) Secondary spermatocyte
(D) Spermatid

Ans: (A)

Q.24.Spermatogenesis without meiosis occurs in
(A) birds
(B) bees
(C) bat
(D) none of the above

Ans: (B)

Q.25.Sperm of animal species a cannot fertilise ovum of species b because
(A) Fertilizins of a and b are not compatible
(B) Antifertilizins of a and b are not compatible
(C) Fertilizin of a and antifertilizin of b are not compatibel
(D) Antifertilizin of a and fertilizing of b are not compatibel

Ans: (D)

Q.26.Sperm capacitation involves
(a) Change in shape
(b) Release of mitochondria
(c) Removal of membrane fatty acids
(d) Hyaluronic acid

Ans (c)

Q.27.Smooth muscles lining the wall of scrotum are called
(a) Deltoid muscles
(b) Dartos muscles
(c) Gluteal muscles
(d) Latissimus dorsi muscles

Ans: (b)

Q28.Site of vitellogenesis is
(a) Secondary oocyte in fallopian tube
(b) Primary occyte in graafian follicle
(c) Primary spermatocyte in testis
(d) Secondary spermatocyte in testis

Ans: (b)

Q.29.Site of fertilization in a mammal is
(a) Ovary
(b) Uterus
(c) Vagina
(d) Fallopian tube

Ans: (d)

Q.30.Sertoli cells occur in
(a) Heart
(b) Liver
(c) Ovary
(d) Seminiferous tubules

Ans: (d)

Q.31 Sertoli cells are found
(a) between the seminiferous tubules
(b) In the germinal epithelium of ovary
(c) In the uppermost part of fallopian tube
(d) in the germinal epithelium of seminiferous tubules

Ans: (d)

Q.32.Polar bodies develop during
(a) Oogenesis
(b) Spermatogenesis
(c) Spermiogenesis
(d) Soamtic hybridisation

Ans: (a)

Q.33.Part of sperm involved in penetrating egg membrane is
(a) Tail
(b) Acrosome
(c) Allosome
(d) Autosome

Ans: (b)

Q.34.Part of fallopian tube closest to ovary is
(a) Infundibulum
(b) Cervix
(c) Ampulla
(d) Isthmus

Ans: (a)

Q.35.Ovulation occurs under the influence of
(a) LH
(b) FSH
(c) Estrogen
(d) Progesterone

Ans: (a)

Q.36.Ovulation in human female occurs at
(a) beginning of proliferative phase
(b) end of proliferative phase
(c) middle of secretory phase
(d) end of secretory phase

Ans: (b)

Q.37.Outer layer of blastocyst that gives rise to ectoderm is
(a) trophoblast
(b) germinal vesicle
(c) Cnidoblast
(d) amnion

Ans: (a)

Q.38.Oocyte is liberated from ovary under the influence of LH, after completing
(a) Meiosis and before liberating polar bodies
(b) Meiosis I and before liberating polar bodies
(c) Meiosis
(d) Meiosis I after release of polar body

Ans: (d)

Q.39.Onset of menstrual cycle at the time of puberty is called
(a) Menopause
(b) Menarche
(c) Menstruation
(d) Metamerism

Ans: (b)

Q.40 One primary spermatocyte produces four spermatozoa but one primary oocyte produces
(a) Four ova
(b) One ovum
(c) Two ova
(d) Sixteen ova

Ans: (b)
Q.41 Nutritive cells of seminiferous tubules are
(a) Sertoli cells
(b) Leydig cells
(c) Spermatogonial cells
(d) Spermatocytes
Ans: (a)

Q.42 Number of eggs released in the life time of a woman is approximately
(a) 40
(b) 400
(c) 4000
(d) 20000
Ans: (b)

Q.43 Middle piece of mammalian sperm contains
(a) Nucleus
(b) Vacuole
(c) Mitochondria
(d) Centriole

Ans: (c)

Fertilization and cleavage

Q.44 The point of fertilization occurs when
a. Sperm are deposited in the vagina
b. Sperm reach the outer jelly coating of the egg
c. The sperm contacts the vitelline envelope
d. The sperm sheds the tail
e. The sperm nucleus and egg nucleus unite to form a zygote

Ans: (e)

Q.45 Before fertilization, as an egg cell matures, its nucleus increases RNA content and it is called
a. A pronucleus
b. The fertilization cone
c. A cleavage furrow
d. A germinal vesicle
e. A blastomere
Ans: (d)

Q.46 Generally, only one sperm fertilizes an egg because
a. There are so few sperm that two are unlikely to arrive at the same time
b. Sperm compete and only the most fit one is accepted
c. The small entry hole called the blastopore allows just one sperm to fit through and then it seals
d. Many sperm enter but only one set of chromosomes fuses with the egg nucleus; excess sperm are absorbed
e. When the first sperm membrane fuses with the egg membrane, it separates the fertilization membrane and forms a barrier to other sperm
Ans: (e)

Q.47. What prevents a foreign species' sperm from fertilizing an egg?
a. Nothing prevents fertilization if chemical and other behavioral cues allow mating
b. Egg recognition proteins on the acrosomal process bind to specific sperm receptors on the vitelline envelope
c. Only failure to match chromosomes and genes prevent development of hybrids
d. The size and shape of sperm must fit the hole in the egg membrane
e. The cortical reaction by the egg actively draws in the sperm
Ans: (b)

Q.48. The response to sperm fusing with the egg membrane causes enzyme-rich granules to ultimately cause the separation of the vitelline envelope and the egg membrane; this is called
a. Polyspermy
b. Pronucleation
c. Polarity
d. The cortical reaction
e. Cytoplasmic localization

Ans: (d)

Q.49. Entrance of more than one sperm
a. Is called polyspermy and is disastrous for animal zygotes
b. Results in epigenesis
c. Is neutralized by fusion with polar bodies
d. Results in formation of a large pronucleus
e. Initiates cleavage
Ans: (a)

Q.50. _____ occurs when a fertilized egg enters cell division without further growth in volume.

a. Cleavage
b. Gastrulation
c. Differentiation
d. Morphogenesis
e. Embryology
Ans: (a)

Q.51. Fertilizins are emitted by
(a) Immature eggs
(b) Mature eggs
(c) Sperms
(d) Polar bodies
Ans: (b)

Q.52. Fertilization of ovum occurs in
(a) Fimbriac of oviduct
(b) Isthmus of oviduct
(c) Ampulla of oviduct
(d) None of the above
Ans: (c)

Q.53. Fertilization is
(a) Union of diploid spermatozoon with diploid ovum to form diploid zygote
(b) Union of haploid sperm with haploid ovum to form haploid zygote
(c) Union of haploid sperm with haploid ovum to form diploid zygote
(d) Union of diploid sperm with haploid ovum to form triploid zygote
Ans: (c)

Q.54. During cleavage
(a) size of resulting cells decreases
(b) Size of resulting cells increases
(c) Size of early embryo increases
(d) Size of early embryo decreases

Ans: (a)

Q.55. Merobalstic cleavage is
(a) Total
(b) Spiral
(c) Incomplete
(d) Horizontal

Ans: (c)

Q.56. The product of cleavage in a zygote produces a cluster of small cells called
a. Pronuclei
b. Blastomeres
c. Yolk
d. Polar bodies
e. Meroblasts

Ans: (b)

Q.57. In human beings the type of cleavage is
(a) Holoblastic and complete
(b) Meroblastic and incomplete
(c) Holoblastic and incomplete
(d) Meroblastic and complete

Ans: (a)

Q.58. The effect of yolk on cleavage is that
a. Yolk promotes faster cleavage
b. Yolk promotes spiral cleavage in all cases
c. Yolk slows down and indirectly determines the type of cleavage to take place
d. Yolk is the origin of all cleavage planes
e. There is no effect of yolk on cleavage

Ans: (c)

Q.59. Cleavage on the surface of the yolk of the chicken egg is partial because cleavage furrows cannot cut through; this is called
a. Meroblastic
b. Holoblastic
c. Isolecithal
d. Indirect development
e. Indeterminant

Ans: (a)

Q.60. In animals, indirect development
a. Occurs only in mammals
b. Lacks a larval stage
c. Involves a larval stage
d. Occurs only when eggs develop without being fertilized
e. Involves continued nuclear divisions without cytoplasmic cleavage

Ans: (c)

Q.61. Radial cleavage is found in
a. Birds
b. Mammals
c. Most protostomes
d. Sea stars
e. None of the choices are correct
Ans: (d)

Q.62. Spiral cleavage is found in
a. Amphibians
b. Mammals
c. Annelid worms
d. Sea stars
e. Birds

Ans: (c)

Q.64. A characteristic of development of Deuterostomia is
a. Spiral cleavage
b. Mosaic development
c. The mesoderm developing from a special blastomere called the 4d cell
d. Radial cleavage
Ans: (d)

Q.65. Rotational cleavage is unique to
a. Amphibians
b. Mammals
c. Protostomes showing spiral cleavage
d. Sea stars
e. Lophotrochozoa
Ans: (b)

Q.66. Cleavage in mammals
a. Is faster than most other groups
b. Does not begin, like most other animals, with a first cleavage plane through the animal-vegetal axis
c. Is only on the surface, with many rounds of nuclear division before cytoplasmic division
d. Is asynchronous, meaning that all blastomeres do not divide at the same time

e. Is very loose, with cells drifting about in a loose amorphous, bubble-like mass
Ans: (d)

Q.67. In the human, which part of the blastocyst will develop into the embryo proper (versus the supporting placenta)?
a. Archenteron
b. Blastopore
c. Chorion
d. Trophoblast
e. Inner cell mass

Ans: (e)

Q.68. Superficial cleavage is found in
a. Amphibians
b. Mammals
c. Protostomes showing spiral cleavage
d. Sea stars
e. Insects
Ans: (e)

Q.69. When the central mass of yolk restricts cleavage to the surface of the egg, and 8 rounds of mitosis without cytoplasmic division pepper the surface with nuclei that eventually are enclosed, this is _____ cleavage.
a. Radial
b. Spiral
c. Holoblastic
d. Superficial
e. Trophoblastic

Ans: (d)

Q.70. Implantation in the human uterus begins at the end of the
a. Fertilization
b. First week
c. Second week
d. Second month
e. Fourth month
Ans: (b)

Q.71. A solid ball of cells with a hollow cavity inside is the
a. Animal pole
b. Blastula
c. Blastocoel
d. Gastrula
e. Neurula

Ans: (b)

Q.72 The correct sequence of process of development after fertilization and cleavage is
(A) Gastrulation-Organogenesis-Growth
(B) Organogenesis-Gastrulation-Growth
(C) Gastrulation-Blastulation-Growth
(D) Organogenesis-Morulation-Blastulation
Ans. (A)

Q.73: In Hen the egg is fertilized at the stage of
(A) Primary oocyte
(B) Secondary oocyte
(C) Ootid
(D) Both A and B

Q:74: During development of chick the fertilized egg is laid _____ hours after the fertilization.
(A) 24 (B) 36
(C) 40 (D) 45
Ans. (A)

Q.75 The process by which developing cells achieve their functional, mature identity asliver, or muscle, or nerve is called:

a) Cleavage division
b) pattern formation
c) morphogenesis
d) differentiation

Ans. (D)

Gastrulation

Q.76 During gastrulation size of embryo remains constant but metabolic rate
(a) increases
(b) decreases
(c) is unchanged
(d) none of the above

Ans: (a)

Q.77 Mosaic development in animals
a. Is a type in which each of the fate of a blastomere is heavily determined by its neighbor cells
b. Is synonymous with regulative development
c. Is a type in which each of the early blastomeres lacks the potential of developing into a complete organism and removing a blastomere eliminates a future body part
d. Occurs in most deuterostomes but usually does not occur in protostomes
e. None of the choices are correct

Ans: (c)

Q.78. Regulative development in animals
a. Is a type in which the fate of a blastomere is heavily determined by its neighbor cells
b. Is a type in which removing a blastomere causes the remaining blastomeres to "fill in" for the lost cell
c. Usually does not occur in protostomes
d. All of the choices are correct
e. Occurs in most (but not all) deuterostomes

Ans: (e)

Q.79 Neighboring cells influence the development of each other, either by direct contact or by production of chemical signals, in
a. Neurulation
b. Gastrulation
c. Induction
d. Maternal determinants
e. Homeotic pattern formation

Ans: (c)

Q.80 The difference between primary and secondary induction is a difference between
a. "hard-wired" commands and chance development
b. Effects of the dorsal lip organizer and effects of the subsequent cell's induction
c. Nuclear and cytoplasmic determinants
d. Paternal and maternal determinants
e. Homeotic pattern formation and regular structural gene effects

Ans: (b)

Q.81 Cytoplasmic specification is less important in vertebrate
a. Embryos
b. Placentas
c. Pupae
d. Adults
e. None of the choices are correct

Ans: (a)

Q.82 During cleavage, what is true about cells?
(a) Nucleocytoplasmic ratio remains unchanged
(b) Size does not increase
(c) There is less consumption of oxygen
(d) The division is like meiosis

Ans: (b)

Q.83 It is series of mitotic cell division that changes zygote into multicellular embryo
(A)Gastrulation (B)Gametogenesis
(C)Blastulation (D)Cleavage
Ans. (D)

Q.84 Cell divisions, migrations, and rearrangements produce three germ layers in
(A) Morulation (B) Blastulation
(C) Gastrulation (D) All, A, B and C

Ans. (C)

Q:85 The pattern of cleavage in which only part of the ovum is divided into cells. It is also called incomplete cleavage and is usually observed in embryos with

large amounts of yolk.
(A) Meroblastic cleavage (B) Discoidal cleavage
(C) Holoblastic cleavage (D) Both A and B
Ans. (D)

Q:86: The egg of Hen is
(A) Alecithal (B) Meolecithal
(C) Mesolecithal (D) Polylecithal
Ans. (D)

Q:87: In Hen the egg is released from the ovary as
(A) Primary oocyte (B) Secondary oocyte
(C) Ootid (D) None of these
Ans. (A)

Q:88: Animals begin their lives as a single, diploid cell called
(A) Zygote (B) Embryo
(C) Gastrula (D) All A, B and C
Ans. (A)

Q.89: Increase in size of organs to attain maturity is called
(A) Differentiation (B) Localization
(C) Growth (D) Both B and C
Ans. (C)

Q.90 After _____days of incubation, the chick finally begins its escape from the shell.
(A) 16 (B) 19
(C) 20 (D) 21
Ans. (D)

Key Terms

Acrosomal vesicle - membrane-bound organelle in the sperm head derived from the golgi apparatus; the vesicle containing enzymes that digest proteins and complex sugars in the outer coverings of an egg. Fusion of the acrosomal vesicle with the plasma membrane of the sperm (in the "acrosome reaction") exposes receptors that bind to the egg surface and is necessary for fertilization

Agglutination - the state of joining or clumping together by adhesion.

Aggregate - collection of units or particles (e.g., cells) forming a body or mass. (verb) - to form such a body or mass.

Albumen - The "white" of a bird's egg which provides both protein and water for the growing embryo.

Allantois - extra-embryonic membrane emerging as a sac from the hindgut's ventral wall; formed from the splanchnopleure (combination of endoderm and splanchnic mesoderm). Found in amniotes, it is one of the four extraembryonic membranes (chorion, amnion, allantois and yolk sac) that are adaptations of the terrestrial egg. It collects waste materials from the embryo, and as a part of the chorio-allantoic membrane can be a site of gas exchange.

Allometric growth or allometry - phenomenon whereby parts of the same organism grow at different rates. Contrast with isometric growth.

Amniocentesis - prenatal diagnostic procedure in which amniotic fluid is withdrawn from amniotic sac in order to obtain fluid and fetal cells which are analyzed for metabolic and/or genetic disorders, and to test the maturity of the fetus' lungs.

Amnion - the innermost membranous sac enclosing the embryo of an amniote; it becomes filled with amniotic fluid. One of the four amniote extraembryonic membranes; derived from the somatopleure (combination of ectoderm and somatic mesoderm)

Amniote - higher vertebrate capable of terrestrial reproduction, and having an amnion during its development. Includes reptiles, birds and mammals, which share a common ancestor.

Ampulla - upper region of the mammalian oviduct, near the ovary. Fertilization typically takes place in this region.

Analogous structures - structures having similar function or superficial appearance, but not necessarily sharing a common evolutionary origin (contrast with homologous structures).

Blastocoel - fluid-filled cavity found in the interior of a blastula or blastocyst.

Blastocyst - cleavage stage mammalian embryo; a hollow ball of cells made of outer trophoblast cells and an inner cell mass.

Blastoderm - cell layer formed during cleavage of telolecithal and centrolecithal eggs.

Blastomere - any embryonic cell formed during cleavage.

Blastopore - site of gastrulation initiation and later the opening of the archenteron at the vegetal region of certain embryos (e.g., echinoderm and amphibian); in deuterostome embryos it is the future anus of the organism.

Blastula - a cleavage stage embryo, typically a hollow ball of cells surrounding a cavity called the blastocoel; this term is used for (among others) echinoderm and amphibian embryos.

Capacitation - change in mammalian sperm that occurs after exposure to female genital tract making the sperm competent to undergo the acrosome reaction; this change is necessary for penetration of the cumulus matrix and for fertilization. Numerous molecular changes in the sperm are associated with capacitation, but the extent to which each event causes sperm capacitation is uncertain.

Cell division—Method by which a single cell divides to create two cells. There are two main types of cell division depending on what happens to the chromosomes: mitosis and meiosis.

Chorion - one of the four extraembryonic membranes of amniotes; it forms from the somatopleure (ectoderm and somatic mesoderm). In birds and reptiles, the membrane adheres to the shell and is highly vascularized to serve in gas exchange. In mammals, it forms the fetal contribution to the placenta, made by trophoblastic tissue and extraembryonic mesoderm, containing blood vessels that allow exchange of materials with maternal circulation.

Chorionic somatomammotropin - aka placental lactogen, a hormone that promotes maternal breast development during pregnancy.

Cloning vector - intentionally designed artificial DNA construct used by molecular biologists to amplify selected pieces of DNA inserted into the construct; examples include plasmid, phage, phagemid, cosmid, fosmid, yeast artificial chromosome (YAC) and bacterial artificial chromosome (BAC). Cloning vectors minimally contain an origin of replication, selectable marker gene (e.g., ampicillin resistance gene), and multiple cloning site containing unique restriction enzyme sites; other useful features may also be present.

Compaction - event in early cleavage-stage mammalian embryo during which blastomeres become tightly joined, forming gap junctions enabling the exchange of ions and small molecules to pass from one cell to the next.

Delamination - splitting of one cellular sheet or layer into two parallel layers.

Differentiation - process whereby cells acquire their mature morphological and biochemical characteristics. Differentiation is often considered a 'final step' of development in which cells take on their mature function.

Differentiation-inducing factor (DIF) - a low molecular weight lipid that induces posterior cells of a *Dictyostelium* slug to differentiate as stalk cells as opposed to spore cells.

Directed differentiation—The manipulation of stem cell culture conditions to induce differentiation into a particular cell type.

Discoidal cleavage - incomplete division of the blastodisc, a region of yolk-free, active cytoplasm; characteristic of birds, fishes and reptiles.

DNA—Deoxyribonucleic acid, a chemical found primarily in the nucleus of cells. DNA carries the instructions or blueprint for making all the structures and materials the body needs to function. DNA consists of both genes and non-gene DNA in between the genes.

Ectoderm - (1) the outer cellular membrane of a diploblastic animal. (2) a: the outermost of the three primary germ layers of a triploblastic embryo. b: a tissue (as neural tissue) derived from this germ layer.

Embryology - study of embryogenesis, the development of animals and plants from fertilization to birth/hatching.

Embryonic germ cells—Pluripotent stem cells that are derived from early germ cells (those that would become sperm and eggs). Embryonic germ cells (EG cells) are thought to have properties similar to embryonic stem cells.

Embryonic stem cell line—Embryonic stem cells, which have been cultured under *in vitro* conditions that allow proliferation without differentiation for months to years.

Embryonic stem cells—Primitive (undifferentiated) cells that are derived from preimplantation-stage embryos, are capable of dividing without differentiating for a prolonged period in culture, and are known to develop into cells and tissues of the three primary germ layers.

Endoderm - One of the three primary germ layers formed in the embryo, moved into interior by cell movements during gastrulation. In vertebrates, this innermost layer of cells goes on to form the linings of the gut (esophagus, stomach, intestines, rectum, colon), pharyngeal pouch derivatives (tonsils,thyroid, thymus, parathyroid glands), lungs, liver, gall bladder, pancreas. In amniotes, extraembryonic endoderm participates in the formation of the allantois and yolk sac.

Endostyle - a ciliated, mucus-secreting groove in the ventral surface of the pharnyx of non-vertebrate chordates (e.g, tunicates and lancelets); it aids in transporting food to the esophagus. Recent molecular evidence supports the traditional view that the endostyle is homologous to the vertebrate thyroid gland.

Epiboly - The growth of epidermal ectoderm to cover the surface of the embryo during gastrulation.

Epigenesis - theory holding that development is a gradual process of increasing complexity. (This contrasts with preformationism, which holds that the organism is already present in the gamete(s), merely growing and unfolding during development.) For example, organs are formed de novo in the embryo rather than increasing in size from pre-existing structures.

Epithelial - belonging to a sheet of tightly joined, polarized cells.

Fate map - diagram that takes the larval or adult structure of an organism and "maps" it onto the region of the embryo from which it arises

Fertilization cone - a prominence extending from the surface of some eggs at the moment of, or in some cases allegedly shortly before contact with a sperm.

Fission - asexual reproduction in which the parent organism divides into two or more parts, each developing into genetically identical individuals.

Gastrulation - stage in animal development following cleavage characterized by extensive cell movement and rearrangement to form a "three-layered" embryo of ectoderm, mesoderm and endoderm.

Gene cloning - isolation and amplification of selected pieces of DNA by recombinant DNA techniques.

Germ layers—After the blastocyst stage of embryonic development, the inner cell mass of the blastocyst goes through gastrulation, a period when the inner cell mass becomes organized into three distinct cell layers, called germ layers. The three layers are the ectoderm, the mesoderm, and the endoderm.

Hensen's node - regional thickening of cells at the top (anterior) of the primitive groove through which gastrulating cells migrate anteriorally to form tissues in the future head and neck. Found in birds, reptiles and mammals, it is the functional equivalent of the dorsal lip of the blastopore in amphibians. Also known as the primitive knot.

Holoblastic cleavage - complete cleavage - major pattern of embryonic cell divison in which cytokinesis completely separates cells during division; it is typically seen in smaller eggs containing moderate (mesolecithal) to sparse (isolecithal) yolk. Examples of eggs that divide holoblastically include those of amphibians, mammals, non-vertebrate chordates, echinoderms, most molluscs, annelids, flatworms, nematodes.

Homologous recombination - process whereby stretch of DNA in a chromosome is replaced by a homologous (highly similar) DNA molecule for the purpose of altering the gene's function.

Hyalin - protein released by cortical granules forming a coating around the sea urchin egg; the hyaline layer provides support for the blastomeres during cleavage.

Hyaluronidase - enzyme that degrades hyaluronic acid (a glycosaminoglycan extracellular matrix constituent).

Invagination - the infolding of a sheet of cells, much like the indenting of a hollow rubber ball when poked.

Involution - a type of cell movement during gastrulation which involves the inturning or inward movement of an expanding outer layer so that it spreads over the internal surface of the remaining external cells.

Isogamous - having haploid gametes that are similar in size, structure and motility.

Lanugo - Thin and closely spaced hairs which are the first hairs in the human embryo. This type of hair is usually shed before birth and is replaced by the short and silky vellus.

Larva - immature (non-reproductive) post-embryonic form of many animals, which hatches from an egg and may look significantly different than the adult (reproductive) form.

Macromere - large blastomere; in the sea urchin embryo, the four relatively large cells that result from the fourth cleavage of the vegetal tier are macromeres. Contrast with micromere and mesomere.

Marginal zone - region near the equator of the amphibian blastula, where the animal and vegetal hemispheres meet; gastrulation begins among these cells.

Meiosis—The type of cell division a diploid germ cell undergoes to produce gametes (sperm or eggs) that will carry half the normal chromosome number. This is to ensure that when fertilization occurs, the fertilized egg will carry the normal number of chromosomes rather than causing aneuploidy (an abnormal number of chromosomes).

Meroblastic cleavage - incomplete cleavage, characteristic of zygotes with large accumulations of yolk.

Merogones - egg fragments (in sea urchins) that can divide and develop, even if they have only a haploid nucleus.

Mesenchyme - mesodermal cells in a developing embryo with the ability to move freely and individually.

Mesoderm - primary embryonic germ layer of triploblastic animals found between the outer ectoderm and the inner endoderm, which (in chordates) gives rise to notochord, bone, cartilage,

muscle, other connective tissues, somatic gonad, urogenital tracts, kidneys, heart and circulatory system, blood, and portions of extraembryonic membranes (in amniotes).

Mesoderm—Middle layer of a group of cells derived from the inner cell mass of the blastocyst; it gives rise to bone, muscle, connective tissue, kidneys, and related structures.

Mitosis—The type of cell division that allows a population of cells to increase its numbers or to maintain its numbers. The number of chromosomes remains the same in this type of cell division.

Multipotent—Having the ability to develop into more than one cell type of the body. See also pluripotent and totipotent.

Neural stem cell—A stem cell found in adult neural tissue that can give rise to neurons and glial (supporting) cells. Examples of glial cells include astrocytes and oligodendrocytes.

Neural tube - hollow cylindrical structure of neuroepithelial cells (in chordate embryos) that will give rise to the brain and spinal cord; an ectodermal derivative.

Neuroblast - dividing neuronal precursor cell

Neurons—Nerve cells, the principal functional units of the nervous system. A neuron consists of a cell body and its processes—an axon and one or more dendrites. Neurons transmit information to other neurons or cells by releasing neurotransmitters at synapses.

Neurula - vertebrate embryo during neurulation.

Neurulation - organogenesis of the nervous system in vertebrate embryos during which dorsal neuroectoderm cells of the neural plate (typically) roll up to form the neural tube which gives rise to the central nervous system.

Nieuwkoop center - vegetal cells of presumptive dorsal endoderm that signal overlying equatorial/marginal cells in the amphibian blastula to form dorsal mesoderm/organizer.

Notochord - rigid cartilaginous rod found at the dorsal midline in all chordate embryos (it is their defining feature) derived from dorsal mesoderm (chordamesoderm). In vertebrates, it is typically a transient embryonic structure.

Oligodendrocyte—A supporting cell that provides insulation to nerve cells by forming a myelin sheath (a fatty layer) around axons.

Oogamy - a specialized form of heterogamy, which involves the production of large, relatively immotile eggs by one mating type and small, motile sperm by the other.
Organogenesis - creation of specific tissues and bodily organs by cell interaction and rearrangement following gastrulation

Parthenogenesis - special reproductive strategy in which unfertilized eggs undergo cell division and embryogenesis to develop into viable adult individuals ("virgin birth"). The embryo develops without a genetic contribution from the sperm, although in some species fertilization is necessary for egg activation.

Parthenogenesis—The artificial activation of an egg in the absence of a sperm; the egg begins to divide as if it has been fertilized.

Passage—In cell culture, the process in which cells are disassociated, washed, and seeded into new culture vessels after a round of cell growth and proliferation. The number of passages a line of cultured cells has gone through is an indication of its age and expected stability.

Placenta - embryonic/maternal organ that serves nutritional and respiratory functions of the mammalian fetus; composed of embryonic chorion and maternal uterine endometrium, allowing provision of oxygen and nutrients to the fetus and removal of carbon dioxide and other waste products.

Pluripotent—The state of a single cell that is capable of differentiating into all tissues of an organism, but not alone capable of sustaining full organismal development.

Polar Body—A polar body is a structure produced when an early egg cell, or oogonium, undergoes meiosis. In the first meiosis, the oogonium divides its chromosomes evenly between the two cells but divides its cytoplasm unequally. One cell retains most of the cytoplasm, while the other gets almost none, leaving it very small. This smaller cell is called the first polar body. The first polar body usually degenerates. The ovum, or larger cell, then divides again, producing a second polar body with half the amount of chromosomes but almost no cytoplasm. The second polar body splits off and remains adjacent to the large cell, or oocyte, until it (the second polar body) degenerates. Only one large functional oocyte, or egg, is produced at the end of meiosis.

Preimplantation—With regard to an embryo, preimplantation means that the embryo has not yet implanted in the wall of the uterus. Human embryonic stem cells are derived from preimplantation-stage embryos fertilized outside a woman's body (*in vitro*).

Primitive streak - thickening of the epiblast cell layer caused by movement of mesodermal cells into the blastocoel; this structure is characteristic of avian, reptilian and mammalian gastrulation.

Proliferate - to grow or multiply by rapidly producing new tissue, parts, cells, buds, or offspring.

Proliferation—Expansion of the number of cells by the continuous division of single cells into two identical daughter cells.

Regenerative medicine—A field of medicine devoted to treatments in which stem cells are induced to differentiate into the specific cell type required to repair damaged or destroyed cell populations or tissues. (See also cell-based therapies).

Reproductive cloning—The process of using somatic cell nuclear transfer (SCNT) to produce a normal, full grown organism (e.g., animal) genetically identical to the organism (animal) that donated the somatic cell nucleus. In mammals, this would require implanting the resulting embryo in a uterus where it would undergo normal development to become a live independent being. The first mammal to be created by reproductive cloning was Dolly the sheep, born at the Roslin Institute in Scotland in 1996. See also Somatic cell nuclear transfer (SCNT).

Seed- In the strict sense, seeds are the result of pollination and sexual fertilization. Apodictic seeds are true seeds produced from maternal tissue only without sexual fertilization. Farmers often refer to the units of vegetative propagation as 'seed'. Thus seed tubers, seed sets, etc.

Signals—Internal and external factors that control changes in cell structure and function. They can be chemical or physical in nature.

Somatic (adult) stem cells—A relatively rare undifferentiated cell found in many organs and differentiated tissues with a limited capacity for both self renewal (in the laboratory) and differentiation. Such cells vary in their differentiation capacity, but it is usually limited to cell types in the organ of origin. This is an active area of investigation.

Somatic cell nuclear transfer (SCNT)—A technique that combines an enucleated egg and the nucleus of a somatic cell to make an embryo. SCNT can be used for therapeutic or reproductive purposes, but the initial stage that combines an enucleated egg and a somatic cell nucleus is the same. See also therapeutic cloning and reproductive cloning.

Somatic cell—Any body cell other than gametes (egg or sperm); sometimes referred to as "adult" cells. See also Gamete.

Spore-A microscopic, reproductive body of fungi, bacteria, and other organisms. Spores may be produced either sexually or asexually. They have the same reproductive, dissemination, and survival functions as the seeds of higher plants, except that asexually produced spores do not exhibit sexual recombination and variation.

Stem cells—Cells with the ability to divide for indefinite periods in culture and to give rise to specialized cells.

Stem-The part of the plant that carries the leaves and flowers. It is usually vertical, and it may be branched. An underground stem is called a rhizome.
Sterile-A sterile organism is one that is unable to reproduce. A sterile container or environment is one that is completely devoid of life of any description.

Stromal cells—Connective tissue cells found in virtually every organ. In bone marrow, stromal cells support blood formation.

Subculturing—Transferring cultured cells, with or without dilution, from one culture vessel to another.

Surface markers—Proteins on the outside surface of a cell that are unique to certain cell types and that can be visualized using antibodies or other detection methods.

Telomere- The end of a chromosome, associated with a characteristic DNA sequence that is replicated in a special way. A telomere counteracts the tendency of the chromosome to shorten with each round of replication.

Teratoma -A multi-layered benign tumor that grows from pluripotent cells injected into mice with a dysfunctional immune system. Scientists test whether they have established a human embryonic stem cell (hESC) line by injecting putative stem cells into such mice and verifying that the resulting teratomas contain cells derived from all three embryonic germ layers.

Therapeutic cloning—The process of using somatic cell nuclear transfer (SCNT) to produce cells that exactly match a patient. By combining a patient's somatic cell nucleus and an enucleated egg, a scientist may harvest embryonic stem cells from the resulting embryo that can be used to generate tissues that match a patient's body. This means the tissues created are unlikely to be rejected by the patient's immune system. See also Somatic cell nuclear transfer (SCNT).

Totipotent-Having the ability to give rise to all the cell types of the body plus all of the cell types that make up the extraembryonic tissues such as the placenta. (See also Pluripotent and Multipotent).

Transdifferentiation—The process by which stem cells from one tissue differentiate into cells of another tissue.

Trophectoderm—The outer layer of the preimplantation embryo in mice. It contains trophoblast cells.

Trophoblast—The outer cell layer of the blastocyst. It is responsible for implantation and develops into the extraembryonic tissues, including the placenta, and controls the exchange of oxygen and metabolites between mother and embryo.

Umbilical cord blood stem cells—Stem cells collected from the umbilical cord at birth that can produce all of the blood cells in the body (hematopoietic). Cord blood is currently used to treat patients who have undergone chemotherapy to destroy their bone marrow due to cancer or other blood-related disorders.

Undifferentiated—A cell that has not yet developed into a specialized cell type.

Yolk platelets - membrane-bound discs containing high concentrations of yolk found in eggs.

Yolk plug - a patch of vegetal cells (endoderm) that remains exposed in the blastopore after the formation of the ventral lip during gastrulation.

Yolk sac - The first of four extraembryonic membranes of amniotes to form during embryogenesis. Like the allantois, it arises from the splanchnopleure (endoderm and splanchnic mesoderm) to surround the mass of yolk in reptile and bird eggs. It is connected to the midgut by the yolk stalk. The yolk sac also forms in mammals, despite the absence of yolk.

Zona pellucida - A thick extracellular matrix surrounding the mammalian ovum (egg) which binds sperm and initiates the acrosome reaction of the sperm.

Zygote - diploid cell created by the union of two haploid gametes; a fertilized egg.

Bibilography

- **Dye**, Human Life Before Birth
- **Gilbert**, Developmental Biology, Seventh Edition
- **Gilbert and Reunions** (Editors), Embryology, Constructing the Organism
- **Tyler**, Developmental Biology: A Guide for Experimental Study, Second Edition
- **K.C. Soni,** Gamete and Deveolopment Biology

Websites

- *www.ncbi.nlm.nih.gov*
- www.sdbonline.org
- www.devbio.com
- *www.springer.com*
- *www.amazon.com*