Embryology

From a single cell to a baby in 9 months. A developmental process that represents an amazing integration of increasingly complex phenomena. The study of these phenomena is called embryology, and the field includes investigations of the molecular, cellular, and structural factors contributing to formation of an organism

The process of progressing from a single cell through the period of establishing organ primordia (the first 8 weeks of human development) is called the period of embryogenesis (sometimes called the period of Organogenesis); the period from that point on until birth is called the fetal period, a time when differentiation continues while the fetus grows and gains weight.

During the past century, embryology has progressed from an observational science to one involving sophisticated technological and molecular advances.

Together, observations and modern techniques provide a clearer understanding of the origins of normal and abnormal development and, in turn, suggest ways to prevent and treat birth defects. In this regard, knowledge of gene function has created entire new approaches to the subject.

There are approximately 35,000 genes in the human genome, but these genes code for approximately 100,000 proteins. Genes are contained in a complex of DNA and proteins called chromatin

Different proteins can be produced from a single gene by the process of Alternative splicing that removes different introns using spliceosomes. Proteins derived in this manner are called splicing isoforms or splice variants. Also, proteins may be altered by posttranslational modifications, such as phosphorylation or cleavage.

Induction is the process whereby one group of cells or tissues (the inducer) causes another group (the responder) to change their fate. The capacity to respond is called competence and must be conferred by a competence factor. Many inductive phenmomena involve epithelial-mesenchymal interactions.

- Cell-to-cell signaling may be paracrine, involving diffusable factors, or juxtacrine, involving a variety of nondiffusable factors.
- Proteins responsible for paracrine signaling are called paracrine factors or growth and differentiation factors (GDFs). There are four major families of GDFs: fibroblast growth factors (FGFs), WNTs, hedgehogs, and transforming growth factor βs (TGF βs).
- Juxtacrine factors may include products of the extracellular matrix, ligands bound to a cell's surface, and direct cell-to-cell communications.

- ***Signal transduction pathways*** include a signaling molecule (the ligand) and a receptor. The receptor usually spans the cell membrane and is activated by binding with its specific ligand. Activation usually involves the capacity to phosphorylate other proteins, most often as a kinase. This activation establishes a cascade of enzyme activity among proteins that ultimately activates a transcription factor for initiation of gene expression.

Embryology

- THE TERM **Embryology**, is applied to the various changes which take place during the growth of an animal from the egg to the adult condition: it is, however, usually restricted to the phenomena which occur before birth.
- Embryology may be studied from two aspects:
  (1) that of **ontogeny,** which deals only with the development of the individual; and

  (2) that of **phylogeny,** which concerns itself with the evolutionary history of the animal kingdom.

In vertebrate animals the development of a new being can only take place when a female germ cell or **ovum** has been fertilized by a male germ cell or **spermatozoön** .

- The ovum:
- is a nucleated cell, and all the complicated changes by which the various tissues and organs of the body are formed from it, after it has been fertilized, are the result of two general processes, viz., ***segmentation*** *and* ***differentiation*** *of cells.*

Thus, the fertilized ovum undergoes repeated segmentation into a number of cells which at first closely resemble one another, but are, sooner or later, differentiated into two groups :

- (1) **somatic cells,** the function of which is to build up the various tissues of the body; and
- (2) **germinal cells,** which become imbedded in the sexual glands ***—the ovaries in the female and the testes in the male— and are destined for the perpetuation of the species.***

The Animal Cell

- All the tissues and organs of the body originate from a microscopic structure (the **fertilized ovum**), which consists of a soft jelly-like material enclosed in a membrane and containing a vesicle or small spherical body inside which are one or more denser spots. This may be regarded as a complete cell. All the solid tissues consist largely of cells essentially similar to it in nature but differing in external form.

- In the higher organisms a cell may be defined as “a nucleated mass of protoplasm of microscopic size.” Its two essentials, therefore, are: a soft jelly-like material, similar to that found in the ovum, and usually styled **cytoplasm** ,and a small spherical body imbedded in it, and termed a **nucleus** .Some of the unicellular protozoa contain no nuclei but granular particles which, like true nuclei, stain with basic dyes .

- The other constituents of the ovum, viz., its limiting membrane and the denser spot contained in the nucleus, called the **nucleolus**, are not essential to the type cell, and in fact many cells exist without them.

- **Cytoplasm** (*protoplasm*) is a material probably of variable constitution during life, but yielding on its disintegration bodies chiefly of proteid nature .
- Lecithin and cholesterin are constantly found in it, as well as inorganic salts, chief among which are the phosphates and chlorides , potassium, sodium, and calcium. It is of a semifluid, viscid consistence, and probably colloidal in nature.

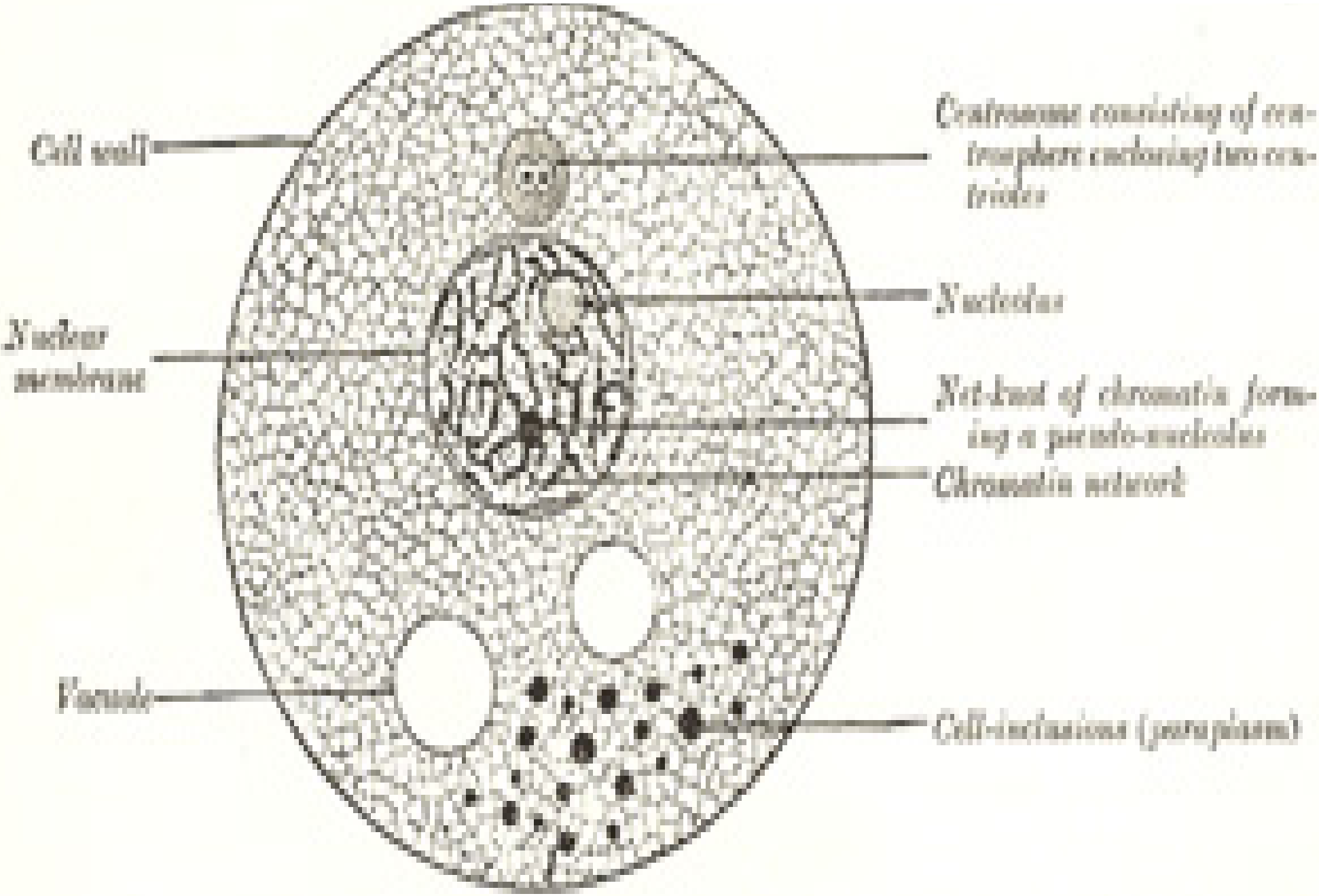
- The living cytoplasm appears to consist of a homogeneous and structureless ground-substance in which are embedded granules of various types.
- The **mitochondria** are the most constant type of granule and vary in form from granules to rods and threads.

- Some of the granules are proteid in nature and probably essential constituents; others are fat, glycogen, or pigment granules, and are regarded as adventitious material taken in from without, and hence are styled cell-inclusions or **paraplasm**.
- When, however, cells have been “fixed” by reagents a fibrillar or granular appearance can often be made out under a high power of the microscope.

- The fibrils are usually arranged in a network or reticulum, to which the term **spongioplasm** is applied, the clear substance in the meshes being termed **hyaloplasm.**

- The peripheral layer of a cell is in all cases modified, either by the formation of a definite **cell membrane** as in the ovum, or more frequently in the case of animal cells, by a transformation, probably chemical in nature, which is only recognizable by the fact that the surface of the cell behaves as a semipermeable membrane.

FIG. 1– Diagram of a cell.



- **Nucleus:**
- The nucleus is a minute body, imbedded in the protoplasm, and usually of a spherical or oval form, its size having little relation to that of the cell. It is surrounded by a well-defined wall, the **nuclear membrane**; this encloses the **nuclear substance** (*nuclear matrix*), which is composed of a homogeneous material in which is usually embedded one or two nucleoli.

- In fixed cells the nucleus seems to consist of a clear substance or **karyoplasm** and a network or **karyomitome.** The former is probably of the same nature as the hyaloplasm of the cell, but the latter, which forms also the wall of the nucleus, differs from the spongioplasm of the cell substance. It consists of fibers or filaments arranged in a reticular manner.
- These filaments are composed of a homogeneous material known as **linin,** which stains with acid dyes and contains embedded in its substance particles which have a strong affinity for basic dyes. These basophil granules have been named **chromatin** or **basichromatin** and owe their staining properties to the presence of nucleic acid.

- Within the nuclear matrix are one or more highly refracting bodies, termed **nucleoli**, connected with the nuclear membrane by the nuclear filaments.

- The nucleoli usually found in resting cells. They are oxyphil, *i.e.,* they stain with acid dyes.
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- Most living cells contain, in addition to their protoplasm and nucleus, a small particle which usually lies near the nucleus and is termed the **centrosome**.
- In the middle of the centrosome is a minute body called the **centriole**, and surrounding this is a clear spherical mass known as the **centrosphere**.
- The protoplasm surrounding the centrosphere is frequently arranged in radiating fibrillar rows of granules, forming what is termed the **attraction sphere**.