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Henry Gray (1821–1865). Anatomy of the Human Body. 1918.

I. Embryology

THE TERM **Embryology**, in its widest sense, 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. ¹

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 **spermatozöon**. 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. ²

Having regard to the main purpose of this work, it is impossible, in the space available in this section, to describe fully, or illustrate adequately, all the phenomena which occur in the different stages of the development of the human body. Only the principal facts are given, and the student is referred for further details to one or other of the text-books 1 on human embryology. ³

1. 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. ⁴

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. ⁵

Cytoplasm (*protoplasm*) is a material probably of variable constitution during life, but yielding on its disintegration bodies chiefly of proteid nature. Lecithin and cholesterol are constantly found in it, as well as inorganic salts, chief among which are the phosphates and chlorides of 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. Their function is unknown. 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 size and shape of the meshes of the spongioplasm vary in different cells and in different parts of the same cell. The relative amounts of spongioplasm and hyaloplasm also vary in different cells, the latter preponderating in the young cell and the former increasing at the expense of the hyaloplasm as the cell grows. Such appearances in fixed cells are no indication whatsoever of the existence of similar structures in the living, although there must have been something in the living cell to give rise to the fixed structures. 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.

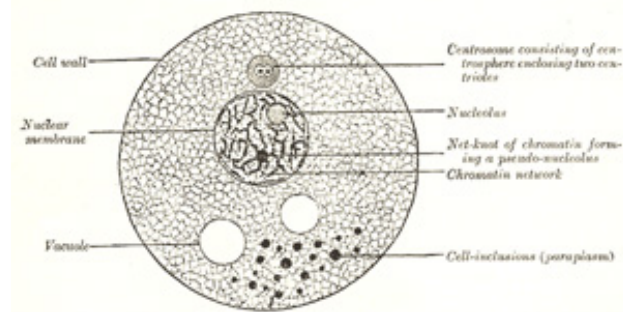


FIG. 1—Diagram of a cell. (Modified from Wilson.) ([See enlarged image](#))

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 substance, 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. They are regarded as being of two kinds. Some are mere local condensations (“net-knots”) of the chromatin; these are irregular in shape and are termed **pseudo-nucleoli**; others are distinct bodies differing from the pseudo-nucleoli both in nature and chemical composition; they may be termed **true nucleoli**, and are usually found in resting cells. The true nucleoli are oxyphil, *i.e.*, they stain with acid dyes.

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**. 8

Reproduction of Cells.—Reproduction of cells is effected either by **direct** or by **indirect division**. In reproduction by **direct division** the nucleus becomes constricted in its center, assuming an hour-glass shape, and then divides into two. This is followed by a cleavage or division of the whole protoplasmic mass of the cell; and thus two daughter cells are formed, each containing a nucleus. These daughter cells are at first smaller than the original mother cell; but they grow, and the process may be repeated in them, so that multiplication may take place rapidly. **Indirect division** or **karyokinesis** (*karyomitosis*) has been observed in all the tissues—generative cells, epithelial tissue, connective tissue, muscular tissue, and nerve tissue. It is possible that cell division may always take place by the indirect method. 9

The process of indirect cell division is characterized by a series of complex changes in the nucleus, leading to its subdivision; this is followed by cleavage of the cell protoplasm. Starting with the nucleus in the quiescent or **resting stage**, these changes may be briefly grouped under the four following phases ([Fig. 2](#)). 10

1. **Prophase.**—The nuclear network of chromatin filaments assumes the form of a twisted *skein* or *spirem*, while the nuclear membrane and nucleolus disappear. The convoluted skein of chromatin divides into a definite number of V-shaped segments or **chromosomes**. The number of chromosomes varies in different animals, but is constant for all the cells in an animal of any given species; in man the number is given by Flemming and Duesberg as twenty-four. 2 Coincidentally with or preceding these changes the centriole, which usually lies by the side of the nucleus, undergoes subdivision, and the two resulting centrioles, each surrounded by a centrosphere, are seen to be connected by a spindle of delicate achromatic fibers the **achromatic spindle**. The centrioles move away from each other—one toward either extremity of the nucleus—and the fibrils of the achromatic spindle are correspondingly lengthened. A line encircling the spindle midway between its extremities or **poles** is named the **equator**, and around this the V-shaped chromosomes arrange themselves in the form of a star, thus constituting the **mother star** or **monaster**. 11

2. **Metaphase.**—Each V-shaped chromosome now undergoes longitudinal cleavage into two equal parts or **daughter chromosomes**, the cleavage commencing at the apex of the V and extending along its divergent limbs. 12

3. **Anaphase.**—The daughter chromosomes, thus separated, travel in opposite directions along the fibrils of the achromatic spindle toward the centrioles, around which they group themselves, and thus two star-like figures are formed, one at either pole of the achromatic spindle. This constitutes the **diaster**. The daughter chromosomes now arrange themselves into a *skein* or *spirem*, and eventually form the network of chromatin which is characteristic of the resting nucleus. 13

4. **Telophase.**—The cell protoplasm begins to appear constricted around the equator of the achromatic spindle, where double rows of granules are also sometimes seen. The constriction deepens and the original cell gradually becomes divided into two new cells, each with its own nucleus and centrosome, which assume the ordinary positions occupied by such structures in the resting stage. The nuclear membrane and nucleolus are also differentiated during this phase. 14

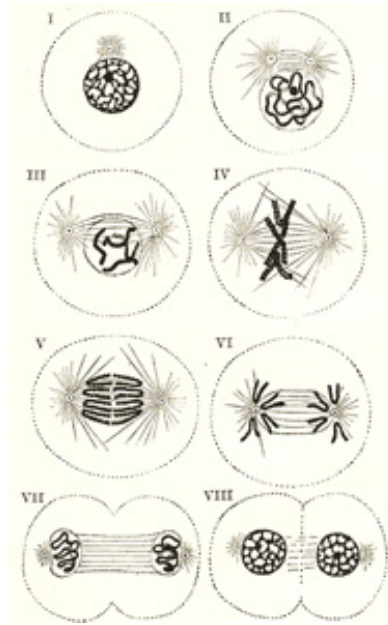


FIG. 2— Diagram showing the changes which occur in the centrosomes and nucleus of a cell in the process of mitotic division. (Schäfer.) *I* to *III*, prophase; *IV*, metaphase; *V* and *VI*, anaphase; *VII* and *VIII*, telophase. ([See enlarged image](#))

Note 1. Manual of Human Embryology, Keibel and Mall; Handbuch der vergleichenden und experimentellen Entwicklungslehre der Wirbeltiere, Oskar Hertwig; Lehrbuch der Entwicklungsgeschichte, Bonnet; The Physiology of Reproduction, Marshall. [[back](#)]

Note 2. Dr. J. Duesberg, Anat. Anz., Band xxviii, S. 475. [[back](#)]

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