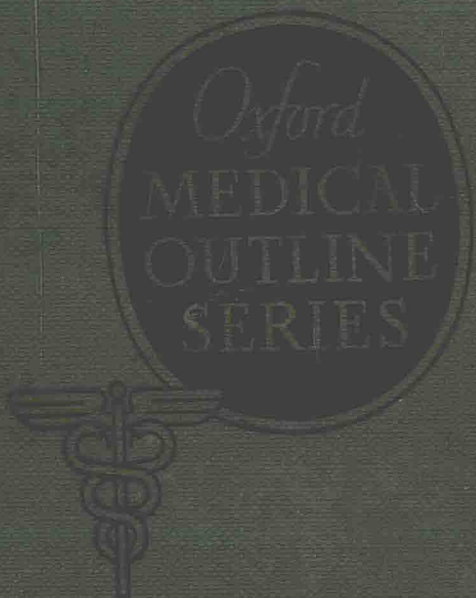
Oxford
MEDICAL
OUTLINE
SERIES

OXFORD MEDICAL OUTLINE SERIES

# HISTOLOGY AND EMBRYOLOGY

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OXFORD UNIVERSITY PRESS
LONDON NEW YORK TORONTO
1941

First printing, August, 1941
Second printing, March, 1944
Third printing, December, 1944
Fourth printing, May, 1946
Fifth printing, February, 1949

PRINTED IN THE UNITED STATES OF AMERICA

# PREFACE

THIS OUTLINE presents in condensed form the most important facts concerning the structure and development of the organs of the human body. Following the trend in American textbooks of Histology, the microscopic anatomy of the central nervous system is not included; it will be found in the outline of Neuro-Anatomy of this series. At the risk of putting undue emphasis on structure it was deemed advisable to omit those functional interpretations which are still the subject of controversy; in some instances, however, the different points of view are briefly mentioned.

Several textbooks have been consulted during the preparation of this outline, and the subject matter so arranged as to conform broadly with those in common use. Its value will be increased if the student furnishes his own illustrations copied from actual preparations, for which adequate space has been provided. It must be remembered, nevertheless, that the outline is not intended as a laboratory guide but merely as a supplement to a textbook.

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# HISTOLOGY

Histology deals with the cell associations or tissues which, variously combined, form the body of plants and animals. It is actually the complement of gross anatomy and an indispensable preliminary for the understanding of physiology and pathology.

## PART ONE: THE CELL

Cells can be studied in the living condition or after they have been killed with reagents and stained. Because of the difficulties encountered in the study of most vertebrate living cells the second procedure is the one generally followed in mammalian histology.

### I. Structure

Most animal cells consist of a mass of cytoplasm enclosing a nucleus. Binucleate cells and cells with several nuclei may occur normally in mammals.

**A. Cytoplasm.** In fixed cells the cytoplasm appears as a slightly granular substance. This, however, is the result of coagulation. In the living condition it is supposed to be an aqueous colloidal solution of proteins, fats, carbohydrates and inorganic salts. It is bounded externally by a very thin membrane. Besides the nucleus, cytocentrum and organoids the cytoplasm may have inclusions which vary within the same cell at various times and differ in diverse cells.

**1. Proteins.** Usually appear in granular form.

**2. Carbohydrates.** Occur chiefly as granules of glycogen, regarded by some as due to precipitation.

**3. Fats and lipoids.** Fat can be seen as droplets of various sizes in living cells; in fixed and stained sections it has usually been dissolved, leaving empty spaces (vacuoles).

**a.** It can be stained with certain dyes (Sudan III, scarlet red).

**4. Pigment.** Occurs in many cells. It may be yellowish and rather soluble (lipochrome) or black (melanin). The latter is very resistant to the action of reagents.

a. Some cells contain pigment throughout life and are called chromatophores (or melanophores if they have melanin).

5. **Crystals and crystaloids.** They are known to occur in some mammalian cells, but their presence is by no means constant.

a. Their chemical nature and function are unknown.

**B. Nucleus.** The nucleus is usually a spherical vesicle enclosed within a membrane and containing diverse substances which differ in appearance in stained cells.

1. **Nuclear sap,** a fluid ground substance which fills the nucleus.

2. **Linin threads.** They usually form a delicate meshwork which occupies the whole nucleus. Linin does not stain.

3. **Chromatin.** Appears as granules of various sizes scattered along the linin meshwork or congregated at the point of intersection of the mesh, where they form irregular knots. Chromatin stains deeply with basic dyes.

a. Its distribution within the nucleus is sometimes a valuable diagnostic feature.

4. **Nucleolus.** This is a spherical mass of acidophil substance floating in the nuclear sap or attached to the linin meshwork. More than one may be present.

**C. Cytocentrum (cell center).** In practically every cell there is a condensed portion of cytoplasm, termed the cytocentrum. In most mammalian cells it occurs near the nucleus.

1. It contains a small sphere (centrosome) which in turn has two or more granules or rods, the centrioles.

2. It plays an important part during mitotic division.

**D. Organoids.** They are structures found in all cells, comparable with the organs of the multicellular organism.

1. **Golgi network (reticular apparatus).** It consists typically of a variable number of anastomosed strands which can be impregnated with osmic acid and also with silver.

a. The network may occupy a restricted area of the cell or be more scattered, and in some instances the strands are independent from each other ('dispersed state').

b. It has been regarded by some as an organoid concerned with secretory phenomena of the cell.

2. **Mitochondria.** Granular or rod-like structures which stain supravitally with Janus green. Their numbers vary considerably;

they divide and when they appear as granules they can arrange themselves into filaments.

**a.** They have also been supposed to be concerned with secretion.

**3. Fibrils.** Fibrils are observed in certain cells, and they have been regarded by some as some sort of intracellular skeleton. This may be true in the case of the tonofibrils present in epithelial cells; in other cells, however, their function is probably more specific (neurofibrils of the nerve cell; myofibrils of the muscle fibers).

## II. Reproduction

Cells have the properties of all living matter, namely, metabolism, irritability, contractility and reproduction. The study of the first three falls within the domain of general physiology. The phenomena of reproduction, on the other hand, are of direct interest to the histologist because they can be recognized in sections of tissues. Cell reproduction takes place through a process of division.

**A. Amitotic (direct) division.** This is of rare occurrence and is thought to lead to degeneration of the cells. The nucleus elongates, constricts in the middle and finally separates into halves. Fission of the cytoplasm takes place soon afterwards.

**B. Mitotic (indirect) division.**

**1. Somatic mitosis.** Takes place in all cells of the body. Four periods are recognizable: prophase, metaphase, anaphase and telophase.

**a. Prophase.** The most characteristic feature is the transformation of the chromatin-linin reticulum into more or less elongated bodies (chromosomes) the number of which is characteristic for a given species (48 in man).

(1) Simultaneously with the nuclear changes the centrioles—usually surrounded by fine radiating filaments (astral filaments)—move away from each other and place themselves in opposite poles of the nucleus.

(2) Toward the end of the prophase the nuclear membrane is dissolved, releasing the chromosomes which become attached to some of the astral filaments; the threads attached to the chromosomes are now called spindle fibers.

**b. Metaphase.** The chromosomes arrange themselves into a plate at right angles to the axis determined by the centrioles (equatorial plate).

(1) Each chromosome splits lengthwise (if not already split during the prophase).

(2) The spindle is now fully constituted.

**c. Anaphase.** The astral fibers attached to the chromosomes seem to contract, pulling the halves of each chromosome toward the poles of the spindle.

(1) As a result of the longitudinal splitting of the chromosomes each daughter cell will receive the same number (48 in man).

**d. Telophase.** This is the final stage of the process during which the daughter groups of chromosomes (now in the poles of the spindle) gradually fade from view as they elongate and lose their compact appearance.

(1) A nuclear membrane appears around each group.

(2) Division of the cytoplasm takes place at this moment or earlier, in the anaphase.

**2. Maturation mitosis.** This occurs in the course of the formation of the germ cells in the two sexes. It differs from the somatic in that it separates whole (homologous) chromosomes previously paired during synapsis (see pp. 77, 83).

**3. Abnormal mitoses.** Irregularities in the process of mitosis are by no means rare, particularly during the formation of the male germ cells. They usually lead to death of the cell.

**a.** Multipolar mitoses, i.e. mitoses in which several spindles are formed, are found in pathological growths such as cancer and tumors.

## III. Degeneration and Death

Cells die in various numbers during the life of the individual without affecting his health. Widespread cell death caused by alterations of metabolism, poisons and bacterial toxins, prolonged anaemia due to thrombosis (infarction), inflammation, hemorrhage, etc., falls within the domain of pathology. Death due to senility of the cells or to physiological changes must be taken into account in histology because degenerating or dead cells can be found in sections of almost any organ.

**A. Senility.** The life span of the cells of the body varies greatly. Some elements as the red blood corpuscles and leucocytes are short-lived and perish daily in large numbers; others seem to live for

many months or years. Degenerative changes are manifested in various ways:

**1. Nuclear changes.** The chromatin contracts into a dense mass (pyknosis), or breaks up into irregular, deeply stained masses (karyorhexis) or is gradually dissolved in the cytoplasm (karyolysis). These changes, however, normally take place during the formation of red blood corpuscles, which is not a degenerative process.

**2. Cytoplasmic changes.** The cytoplasm of degenerating cells may become homogeneous or glassy, or the whole cell changed into colloid, or the cytoplasm may develop large vacuoles, or else it may shrink and stain more deeply.

**a.** The changes mentioned above also occur when cells degenerate under the influence of pathological agents; they are also seen in cells that have been phagocytosed.

**B. Physiological degeneration.** Some cells are doomed as the result of the production of substances which, however, play a protective rôle for the organism.

**1.** The production of keratin in the cells of the superficial layers of the skin and of fat in the cells of the sebaceous glands may be mentioned as examples.

**C. Physiological atrophy.** This term is applied to the decrease in size which occurs normally in the cells of certain organs; it may be also caused by old age.

**1. Involution atrophy.** This occurs in organs which undergo regression after a period of physiological activity (thymus, corpus luteum of ovary).

**2. Senile atrophy.** Observed in many organs of subjects of advanced age. The cells become progressively smaller while retaining their normal characteristics.

**3. Fat cell atrophy.** Seen in lean but otherwise normal individuals. Cells undergoing atrophy closely resemble early stages of fat deposition in the fetus.

**D. Desquamation.** The cells drop out of alignment and are lost (skin, mucosa of mouth, oesophagus, bladder, etc.).

**E. Postmortem changes.** They are seen in organs fixed some time after death, especially in material collected at the autopsy room. The changes observed are to be distinguished from those mentioned above.

# PART TWO: THE TISSUES

The association or grouping of cells which have the same origin and perform similar functions is called a tissue. The tissues of the mammalian body are: I. Epithelium; II. Blood and lymph; III. The supporting tissues (connective tissue; reticulo-endothelium; cartilage; bone); IV. Muscular tissue; V. Nervous tissue.

## EPITHELIUM

In epithelium the cells are cemented together by a small amount of intercellular substance; they are of uniform type or differ in shape and function. Epithelium is usually separated from the underlying tissue by a basement membrane. It lacks vessels of its own.

The three blastodermic layers of the embryo give rise to epithelium. Some varieties cover the surface of the body and line closed cavities, or cavities which communicate with the outside (covering epithelium). Others consist of secretory cells arranged in various ways (glandular epithelium). Finally, the epithelial cells may receive stimuli which are taken up by sensory nerve endings (neuroepithelium).

### I. Covering Epithelium

The cells form a single layer or they are arranged into several layers. Transitions also occur.

**A. Single-layered epithelia:**

**1. Squamous or pavement epithelium.** Flattened cells with irregular or wavy outlines. Nucleus flat, oval or round in outline.

**a. Endothelium.** Lines the cavities of the heart and the lumina of the blood and lymph vessels.

**b. Mesothelium.** Similar to the preceding except that it lines the serous (closed) cavities of the body (pericardium, pleura and abdominal cavity).

**2. Cuboidal.** In vertical section the cells appear as squares; on surface view they have polygonal shape due to mutual pressure.

**3. Columnar or prismatic.** The cells are tall prisms due to mutual pressure but in a vertical section appear as rectangles. The basal end of the cell—in contact with the basement membrane—is often pointed or even branched (intestine).

4. **Ciliated.** The cells bear cilia on their free surfaces. The cilia are either motile (bronchi, oviduct) or non-motile, resembling a brush border.

**B. Stratified (many-layered) epithelium.** The shape of the cells varies in the different layers, which are produced through mitoses of the cells resting on the basement membrane (basal layer). The most superficial cells are, therefore, the oldest.

1. **Stratified squamous.** The cells on the surface are flat; below they gradually change into irregular polyhedral cells. The basal layer is formed of cuboidal or low columnar cells.

   a. **Production of keratin (cornification)** results in the disappearance of the nuclei of the superficial cells (skin).

   b. **In the absence of cornification** the superficial cells retain their nuclei and are not so flat (mouth cavity, oesophagus, cornea, vagina, etc.).

2. **Stratified columnar.** The superficial cells are columnar but fail to reach the basement membrane (cavernous urethra).

3. **Pseudostratified.** It contains columnar cells extending from the basement membrane to the surface of the epithelium (i.e. a single layer of tall cells) whereas the other cells fall short of the surface and are crowded among the bases of the columnar cells, forming two or more layers.

   a. **Columnar** (female urethra).

   b. **Ciliated.** The tall cells have motile cilia (respiratory passages).

   c. **Stereociliated.** The cilia are non-motile (epididymis).

**C. Transitional epithelium.** The number of cell layers varies according to the degree of contraction of the organs in which it occurs (ureter, bladder).

1. When contracted it consists of several layers and resembles closely the stratified epithelium, but the superficial cells are larger and have a convex free surface.

2. If stretched there are usually two layers: a deep layer of more or less cuboidal cells, and a superficial layer of large flattened cells.

## II. Glandular Epithelium

Composed of secretory cells which show a definite polarity: the lower (basal) half contains the nucleus, the upper (apical) half is filled with granules or droplets of secretion.

The secretion may leave the cell as a fluid which crosses the permeable cell membrane: merocrine type (the most widespread); or in leaving it may destroy the membrane and surface protoplasm: apocrine type (mammary gland and armpit glands); or lastly, the secretion is not released until the cell dies and disintegrates: holocrine type (sebaceous glands). In the latter type there is constant replacement of the dead cells by new ones.

**A. Exocrine (external secreting) glands.** The secretion flows out through a duct which may open on the body surface (glands of the skin, mammary gland) or in cavities which communicate with the outside (glands of the alimentary canal, kidney, etc.).

**1. Unicellular glands.** Cells scattered among the elements of an epithelium; they usually secrete mucus.

**a.** Typical is the goblet cell of the intestine, respiratory mucosa, etc.

**2. Multicellular glands.** The epithelial secretory cells are arranged in various ways, as for instance, straight or coiled tubules, branched tubules, or in small vesicles (acini or alveoli).

**a. Simple.** The secretory units open directly on the surface of an epithelium (intestinal and sweat glands) or they open into a single simple duct (glands of the stomach, uterus, etc.).

**b. Compound.** The secretory units are much more numerous and are grouped into lobules more or less completely separated by connective tissue septa. The ducts of each lobule converge into larger ducts and the latter finally open into a main duct (salivary glands, lacrimal gland, etc.).

**B. Endocrine (internal secreting) glands.** These lack ducts; their secretions (called hormones) enter the blood stream after crossing the walls of the capillaries of the gland.

**1.** The glandular epithelium is arranged into vesicles (thyroid) or it forms irregular anastomosing strands (parathyroids, anterior pituitary, suprarenals).

**C. Exo-endocrine glands.** Compound glands with external and internal secretions. The endocrine portion may be represented by cell groups (islands of Langerhans of pancreas); or the gland cells may produce an external secretion conveyed by ducts and an internal passing directly into the blood (liver).