

Epithelium

Frederik Ruysch, working in the Netherlands, introduced the term epithelia in the third volume of his *Thesaurus Anatomicus* in 1703. Ruysch created the term from the Greek *epi*, which means on top of, and *thele*, which means nipple, to describe the type of tissue he found when dissecting the lip of a cadaver. In the mid nineteenth century Albrecht von Haller adopted the word epithelium, designating Ruysch's original term as the plural version. In modern science, an epithelium is a type of animal tissue in which cells are packed into sheets. The epithelial cells lie proximate to each other and attach to a thin, fibrous sheet called a basement membrane. Epithelia line the surfaces of cavities and structures throughout the body, and also form glands. Although they lack blood vessels, epithelia contain nerves and can function to receive sensation, absorb, protect, and secrete, depending on which part of the body the epithelia line. During development, epithelia act in conjunction with another tissue type, mesenchyme, to form nearly every organ in the body, from hair and teeth to the digestive tract. Epithelia contribute to embryonic development and to the maintenance and function of the body throughout its life.

Epithelia are classified by the form or morphology of their cells, and by the arrangement of cells within the tissue. Cells may be flat (squamous), cube-shaped (cuboidal), or cylindrical (columnar). The cells may arrange into a single layer, called a simple epithelium, or several layers, known as a stratified epithelium. There are also several types of modified epithelia, which include cells with hair-like processes (ciliated), with ends that do not all meet the surface (pseudostratified), cells that specialize in secretion (glandular), and the progenitor cells in the nervous system (neuroepithelium). Various combinations of these cell types come together to form the many different epithelial arrangements of the body. For example, the epithelium of the circulatory system is simple and squamous, while the epithelium of the trachea is pseudostratified, columnar, and ciliated.

The modern arrangement of classifying epithelium based on structure and cell morphology is a modification of a system established in the mid-nineteenth century. Educated at the University of Edinburgh, in Edinburgh, Scotland, William Sharpey organized the widely used concept of epithelium into a series of categories in the seventh edition of Quain's *Elements of Anatomy*, published in 1867. In this text, Sharpey divides epithelia into physiological categories like epidermis, mucous, glandular, and vascular, and structural categories like columnar, spheroidal, ciliated, tessellated, and squamous. While the exact nomenclature has changed—for example, scientists no longer describe some epithelia as tessellated—the principle of describing tissue based upon the individual characters and arrangements of cells remains.

Two years before Sharpey described and classified the epithelium, Wilhelm His at the University of Basel, in Basel, Switzerland, expanded the nomenclature of epithelium beyond structural or physiological characters with the introduction of the term endothelium. His began using the term because the three germ layers, endoderm, mesoderm, and ectoderm, which form during early embryogenesis, maintain separate identities and develop into distinct tissues and organs, as described in germ-layer theory. Thus, the term endothelium denoted the epithelial tissues that derive from the middle germ layer, the mesoderm, and was so called because these tissues relate to the inner or endo surfaces of the body.

Although accepted by many embryologists, the introduction of the term endothelium met with objections on both etymological and developmental bases. In 1874, Michael Foster at the University of Cambridge, in Cambridge, UK, published a strong response to His's nomenclature, noting that the new term meant 'that which is inside the papilla'. Foster considered the term a misnomer because it refers to cells coating surfaces devoid of papillae. Foster further objected because the structures

designated as endothelial, such as the linings of the vascular, lymphatic, and serous cavities of the body, do not form the extent of epithelial tissues derived from the mesoderm. Thus, His's term only included a portion of mesodermally-derived epithelial structures.

His was not the only scientist to expand epithelial nomenclature. In the late nineteenth century, anatomists and embryologists contributed to the vocabulary of epithelial structures. In 1890, Charles Sedgwick Minot at Harvard University, in Cambridge, Massachusetts, introduced terms like ectothelium, to describe the epithelial tissues covering the outer surfaces of the body, or mesothelium, to describe the tissues lining the body cavity. Several of these terms, like endothelium and mesothelium, are still in use in modern science and medicine.

The expansion of the epithelial lexicon parallels a controversy about the origination of the adult reproductive cells, known as germ cells, from epithelium; a hypothesis developed by anatomist Wilhelm von Waldeyer in Germany. In 1870, Waldeyer published *Eierstock und Ei: Ein Beitrag zur Anatomie und Entwicklungsgeschichte der Sexualorgane* (Ovary and Egg: A Contribution to the Anatomy and Developmental History of the Sex Organs), which argued that the supposed progenitors of germ cells, the primordial germ cells, originated from a section of tissue near the gut, called the germinal epithelium. Francis Maitland Balfour from Trinity College, in Cambridge, UK, adopted this hypothesis until Christian Hoffmann traced the developmental history of the primordial germ cells in 1892. Hoffman, while working on continental Europe with several species of birds, found that the primordial germ cells appeared in embryos at stages preceding the differentiation of germinal epithelium, discounting epithelium as the source of germ cells.

Although epithelium does not give rise to germ cells, by the 1960s, embryologists realized that epithelium, in combination with mesenchyme, contributes to the morphogenesis of most organs during embryonic and fetal development. Interactions between these two types of tissues, called epithelio-mesenchymal interactions, form nearly every organ of the body, from hair and teeth to the digestive tract and kidneys. Edward Kollar and Grace Baird, from the University of Chicago in Chicago, Illinois, explained the roles of epithelium and mesenchyme during morphogenesis in a set of articles published from 1969 through 1970. Kollar and Baird conducted a series of experiments using teeth as a model system to study development. Over the course of these experiments, Kollar and Baird determined that the mesenchyme drives proximate interactions (induction) and cellular differentiation during epithelio-mesenchymal interactions.

Epithelium has been the source of considerable controversy and speculation in science. The name epithelium, through much of the nineteenth century, was parsed in various ways. As scientists considered restricting its definition, and subsequently the extent of epithelium within the body, controversies arose over how and when to expand the anatomical lexicon. In the late nineteenth century, scientists began to describe the roles of epithelium during embryogenesis, especially in terms of its derivations and functions during organogenesis. Modern scientists draw upon this long history to inform their nomenclature, and their concepts about the roles and structures of epithelium. While older research programs focused on the gross anatomy or cellular attributes of this tissue, contemporary researchers often study how genes function within the cells that comprise epithelium.

Sources

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