Endoderm [1]

By: MacCord, Kate Keywords: mesendoderm

Endoderm is one of the germ layers—aggregates of cells that organize early during embryonic life and from which all organs and tissues develop. All animals, with the exception of sponges, form either two or three germ layers [2], through a process known as gastrulation [3]. During gastrulation [4], a ball of cells transforms into a two-layered embryo made of an inner layer of endoderm [5] and an outer layer of ectoderm [6]. In more complicated creatures, like vertebrates, there is an additional layer of mesoderm [7], which is formed between the endoderm and the ectoderm. In simpler organisms, the mesoderm is always the inner-most layer. Endoderm forms the epithelium—a type of tissue in which the cells are tightly joined together to form sheets—that lines the primitive gut. From this epithelial lining of the primitive gut, organs like the digestive tract, liver, pancreas, and lungs develop.

Throughout the early stages of gastrulation [8], a group of cells called mesendoderm expresses sets of both endoderm [9] and mesoderm [10] specific genes [11]. Cells in the mesendoderm have the ability to differentiate into either mesoderm [12] or endoderm [13], depending upon their position among surrounding cells. Scientists have found mesendoderm is widespread among invertebrates, including the nematode Caenorhabditis elegans [14], and the purple sea urchin [15], Strongylocentrotus purpuratus [16]. Within vertebrates, mesendoderm has been found in the zebrafish, Danio rerio [17], and has been indicated in mice, Mus musculus [18].

Endoderm, along with the other two germ layers, was proposed in 1817 by Christian F. Pander, a doctoral student at the University of Würzburg [19], in Würzburg, Germany. In his dissertation, Pander mapped the divisions and subsequent specialization of the cells in the embryo of an ascidian, or sea squirt, a type of marine invertebrate that develops a tough outer layer and clings to the sea floor. By creating a plot, or fate map, of the developmental route of each of the cells, Pander located the precursor cells, traced the formation of each of the germ layers [20], and showed that even at very early stages of development, the ability of some cells to differentiate becomes restricted.

Eric Davidson [21] concluded that in the early embryo, different areas of the body have the ability to form different structures, depending on their position. For example, cells near the head may form a brain, while cells near the tail may form a gut. This is known as spatial restriction. Later, as development progresses, some of these cells may be induced to differentiate into a specific cell type, such as a muscle cell or a nerve cell. This is known as temporal restriction.

While Pander’s experiments were groundbreaking, he did not recognize the complexity of the endodermal system. In 1828, while studying the gut, organs like the digestive tract, liver, pancreas, and lungs develop.

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In the study of the first system of the vertebrate body, the first development of the chick, Karl Ernst von Baer described the gastrulation. During gastrulation, a ball of cells transforms into a two-layered embryo made of an inner layer of endoderm and an outer layer of ectoderm. In more complex organisms, like vertebrates, these two primary germ layers interact to give rise to a third germ layer, called mesoderm. Regardless of the presence of two or three layers, endoderm is always the innermost germ layer. Endoderm forms the epithelium—a type of tissue in which the cells are tightly linked together to form sheets—that lines the primitive gut. From this epithelial lining of the primitive gut, organs like the digestive tract, liver, pancreas, and lungs develop.