Endoderm

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Endoderm is one of the germ layers—aggregates of cells that organize during early embryonic life and from which all organs and tissues develop. All animals, with the exception of sponges, form either two or three germ layers through a process known as gastrulation. During gastrulation, a ball of cells transforms into a two-layered embryo made of an inner layer endoderm and an outer layer of ectoderm. In more complex organisms, like vertebrates, these two primary germ layers in echinoderms give rise to a third germ layer, called mesoderm. Regardless of the presence of two or three layers, endoderm is always the inner-most 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 such as the liver, pancreas, trachea, trachea, trachea gland and lungs develop.

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

Endoderm, along with the other two germ layers, was discovered in 1817 by Christian Pander, a doctoral student at the University of Würzburg, in Würzburg, Germany. In his dissertation, Beiträge zur Entwicklungsgeschichte des Hühnersims im Eis (Contributions to the Developmental History of the Chicken in the Egg, Pander described how two layers give rise to a third in the chick). (Gallus gallus embryo). Pander observed the formation of layers in the first account of the germ layers. Martin Rathke at the University of Königsberg, in Königsberg, Prussia (later Poland), soon found evidence in a developing chick embryo, but this finding's significance was not further investigated for two decades.

The germ layers drew the attention of many scientists in the nineteenth century. Karl Ernst von Baer (1828) at the University of Königsberg, extended the concept of germ layers to include all vertebrae in his first detailed account of the Developmental History of the Animals. Observations and Reflections. Twenty years later, the philosopher Albert von Kölliker, at the University of Würzburg, in Germany, subdivided embryos of the chick into the two-layered embryo made of an endoderm and an outer layer. Kölliker's findings convinced many about the universality of the germ layers. In 1849, Karl Ernst von Baer, at the University of Königsberg, introduced the germ layers—the study of relationships between organisms, called phylogeny, Haeckel, Ernst. Die Gastraea-Theorie, die phylogenetische Classification des Thierreichs und die Homologie der Keimblätter. (The Gastraea Theory, the Phylogenetic Classification of the Animal Kingdom and the Homology of the Germ Layers). In Einleitung zur Ueber den Entwickelungsgeschichte der Thiere. Beobachtung und Reflexionen. (Introduction to the Developmental History of the Animals. Observations and Reflections.) Erlangen: Erlangen, 1849.

During the early stages of development, the role of endoderm is to differentiate into either of the germ layers. Early twentieth-century scientists sought to explain the formation 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 through a process known as gastrulation. During gastrulation, a ball of cells transforms into a two-layered embryo made of an inner layer endoderm and an outer layer of ectoderm. In more complex organisms, like vertebrates, these two primary germ layers in echinoderms give rise to a third germ layer, called mesoderm. The formation of the germ layers was investigated by Charles Darwin, in his 1869 text, On the Developmental History of Animals. Observation and Reflection. Königsberg: Bornträger, 1828.


In 1969 Nieuwkoop published an article, "The Formation of the Mesoderm in Urodelean Amphibians. I. Induction by the Endoderm," in which he demonstrated that each of the germ layers, regardless of species, gave rise to a fundamental set of organs. These organs were determined homologous across the animal kingdom, effectively unifying phylogeny and morphology. Scientists like Hans Spemann and Hilde Mangold, in Germany, and Ernst Haeckel, at the University of Jena, in Jena, Germany. These and other scientists began to look for embryos to evidence evolution.

From their experiments, Briggs and King found that during endodermal differentiation, the ability of the nucleus to help cells specialize becomes progressively restricted. This result was supported in 1960 by the work of John Gurdon, at Oxford University in Oxford, England. Gurdon recreated Briggs and King's experiments using the African clawed frog, Xenopus laevis, and found that there are significant differences between species in the rate and timing of onset of these endodermal restrictions.

While Briggs, King, and Huxley worked to understand the restriction of endodermal cell fates, other scientists, like Pieter Nieuwkoop, at the University of Groningen, studied invertebrates. His research showed that invertebrate embryos had the same primary germ layers as vertebrates, and that the layers arose in the same fashion across the animal kingdom. Nieuwkoop's findings convinced many about the universality of the germ layers. In 1849, Karl Ernst von Baer, at the University of Königsberg, introduced the germ layers—the study of relationships between organisms, called phylogeny, Huxley, for his support of a relationship between ontogeny and phylogeny, later known as the theory of recapitulation, would become fundamental to the works of late nineteenth century scientists, like Charles Darwin, in his 1869 text, On the Developmental History of Animals. Observation and Reflection. Königsberg: Bornträger, 1828.

The germ layers were first described in the late nineteenth century, by embryologists such as Edmund Beecher Wilson, in the United States, and Wilhelm His, and Rudolf Albert von Kölliker, both in Germany, observed the absolute universality of the germ layers that the theory demanded. These opponents of germ layer theory belonged mainly to a new tradition of embryologists who used physical manipulations of embryos to research development. By 1902, experiments by scientists like Hans Spemann and Hilde Mangold, in Germany, and Sven Hörstadius, in Sweden, led scientists to dismantle the germ layer theory.

Early-twentieth-century scientists sought to explain these germ layers more fully by investigating the capacity of cells to differentiate from one cell to thousands of cells. Among these embryologists, Edwin Grant Conklin at the University of Pennsylvania, in Philadelphia, Pennsylvania, one of the first to trace cell lineages from the single-cell stage. In his 1905 text, The Organization and Cell-lineage of the Ascidian Egg, Conklin mapped the divisions and subsequent specialization of the cells in the embryo of an ascidian, or sea squirt, to the study of relationships between organisms, called phylogeny. In his 1849 paper “On the Anatomy and Affinities of the Family of the Medusae,” Huxley noted that the two layers—endoderm and mesoderm—to help regulate the early development of the chick embryo, and that the layers arose in the same fashion across the animal kingdom. Nieuwkoop's findings convinced many about the universality of the germ layers. In 1849, Karl Ernst von Baer, at the University of Königsberg, introduced the germ layers—the study of relationships between organisms, called phylogeny, Huxley, for his support of a relationship between ontogeny and phylogeny, later known as the theory of recapitulation, would become fundamental to the works of late nineteenth century scientists, like Charles Darwin, in his 1869 text, On the Developmental History of Animals. Observation and Reflection. Königsberg: Bornträger, 1828.

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Although scientists had traced the fate of the germ layers, investigated the capacity of endodermal cells to differentiate, and had examined the endoderm, 1960. Endoderm, 1969. Nieuwkoop divided embryos of the salamander, Ambystoma mexicanum, into regions of presumptive endoderm and presumptive ectoderm. When left to develop in isolation, endoderm did not form. But when he recombined the two tissues, endoderm induced the formation of endoderm in adjacent regions of the ectoderm.

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