FACULTY OF ENGINEERING & TECHNOLOGY

LT.14 Molecular events in fertilization

Outlines

1. Molecular events in fertilization
2. Role of Maternal genes in early development of embryo

LT.14 Molecular events in fertilization

•Fertilization is the fusion of the male and female gamete. It is s a sequence of coordinated molecular events involving the merging of the sperm with the egg, the fusion of the pronuclei and the intermingling of the maternal and paternal chromosomes.

•It is the formation of a diploid zygote from a haploid egg and sperm

3-Stages of Fertilization

a. Sperm preparation: Capacitation and acrosome reaction
b. sperm-egg recognition and binding,
c. Sperm-egg binding and fusion

•A key signal resulting from the binding of a sperm to its receptor on the plasma membrane of the egg is an increase in the level of Ca^{2+}in the egg cytoplasm, probably as a consequence of stimulation of the hydrolysis of phosphatidylinositol4,5-bisphosphate (PIP_2).

•One effect of this elevation in intracellular Ca2+is the induction of surface alterations that prevent additional sperm from entering the egg. Because eggs are usually exposed to large numbers of sperm at one time, this is a critical event in ensuring the formation of a normal diploid embryo.

•These surface alterations result from the Ca^{2+}-induced exocytosis of secretory vesicles that are present in large numbers beneath the egg plasma membrane. Release of the contents of these vesicles alters the extracellular coat of the egg so as to block the entry of additional sperm. The increase in cytosolic Ca2+following fertilization also signals the completion of meiosis.

•In eggs arrested at metaphase II, the metaphase to anaphase transition is triggered by activation of the anaphase-promoting complex, resulting from Ca2+-dependent phosphorylation and degradation of an inhibitory protein.

•The resultant degradation of cyclin B and condensin leads to completion of the second meiotic division, with asymmetric cytokinesis (as in meiosis I) giving rise to a second small polar body. Following completion of oocyte meiosis, the fertilized egg (now called a zygote) contains two haploid nuclei (called pronuclei), one derived from each parent.

•In mammals, the two pronuclei then enter S phase and replicate their DNA as they migrate toward each other. As they meet, the zygote enters M phase of its first mitotic division. The two nuclear envelopes break down, and the condensed chromosomes of both paternal and maternal origin align on a common spindle. Completion of mitosis then gives rise to two embryonic cells, each containing a new diploid genome. These cells then commence the series of embryonic cell divisions that eventually lead to the development of a new organism

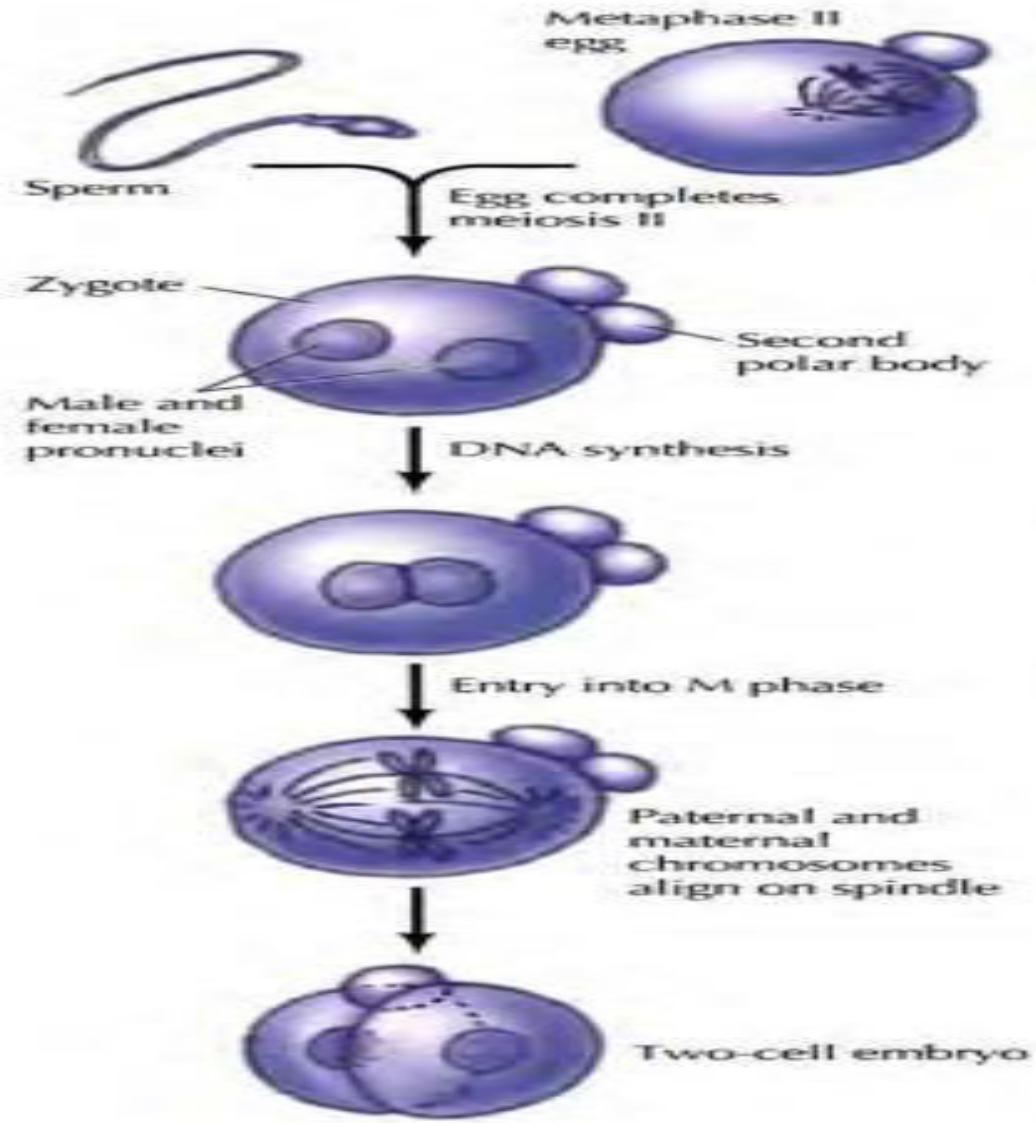

Image source: Molecular Biology of cell by Albert

Role of Maternal gene in early embryonic development

•An embryo exclusively relies on maternal gene products, RNAs, and proteins for its early development until activation of its own genome. The precise developmental time period and developmental processes under maternal control when the embryo is largely transcriptionally silent vary among organisms. In some animals, such as mice, humans, and nematodes (*Caenorhabditis elegans*), only the first or first couple of cleavage cycles are accomplished before transcription of the embryonic genome is activated.

•Maternal genes are those expressed by cells of egg chamber and involved in early development of the oocyte and syncytial blastoderm. The products of these genes such as, RNA or protein, are produced or deposited in the oocyte or are present in the fertilized egg or embryo before expression of zygotic genes is initiated. The proteins of these genes then stimulate other genes, which in turn stimulate yet other genes in a cascade of control. As might be expected, most of the gene products in the cascade are regulatory proteins, which bind to DNA and activate other genes These maternal gene products regulate meiosis, oocyte development, and early development of the embryo including fertilization, transitions between meiotic and mitotic cell cycles, and the switch from utilization of mRNAs and proteins provided by the mother to the embryo's own gene products during zygotic genome activation.

References & Further reading

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