Animal Form and Function-II

Descriptive Embryology

Embryology

Embryology is the Study of an animal's development from the fertilized egg to the formation of all major organ systems

Descriptive Embryology describes developmental stages of an embryo

Experimental Embryology explains the cellular controls for development. It uses tools of molecular biology to study the genetic control of development

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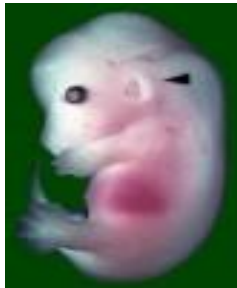
Complexity of form and function in adult animals

Is all the complexity arises from a Single cell?

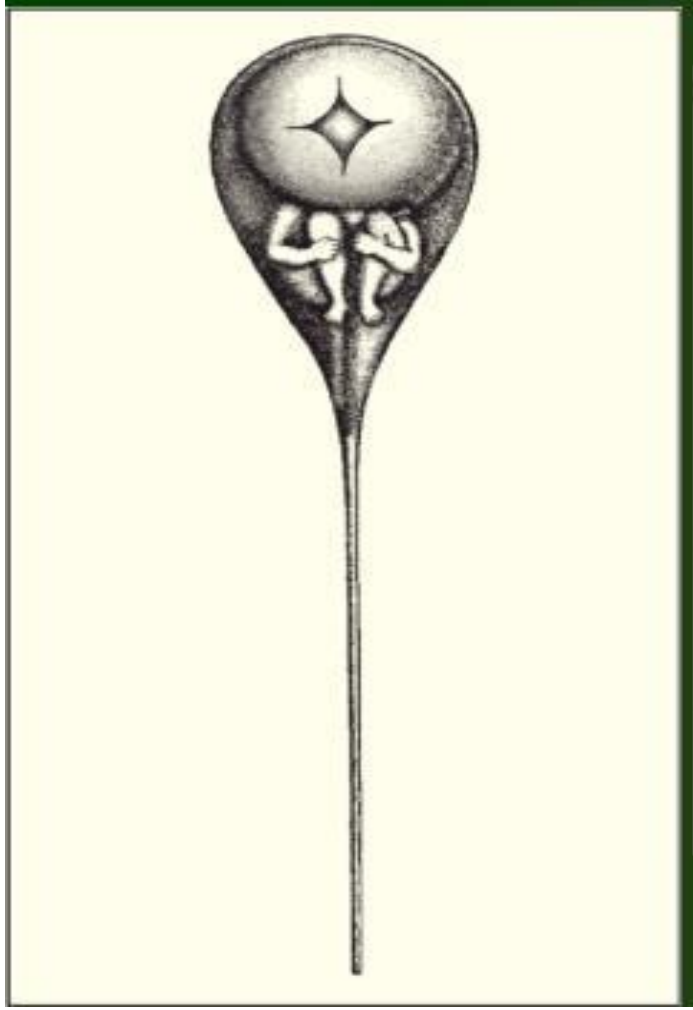
Two theories exist

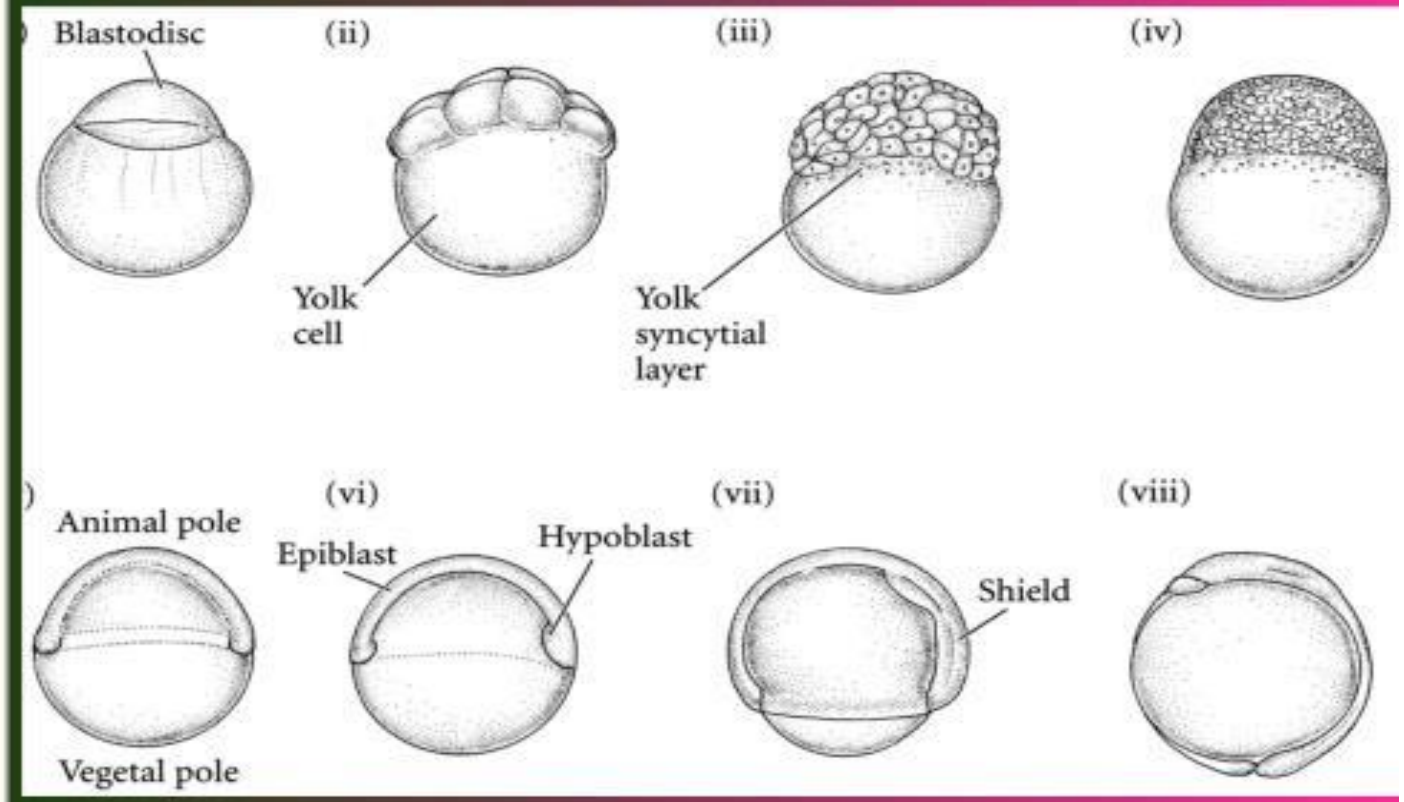
Preformation
describes that gametes contain miniaturized version of all the elements present in the adult body (presented in Seventeen and Eighteenth centuries)

Epigenesis
describes that egg contains the material from which the embryo is gradually built (presented in Mid Eighteenth century)



Preformation vs. Epigenesis





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Historical and background of Experimental Embryology

1- Aristotle (384 – 322 B.C):

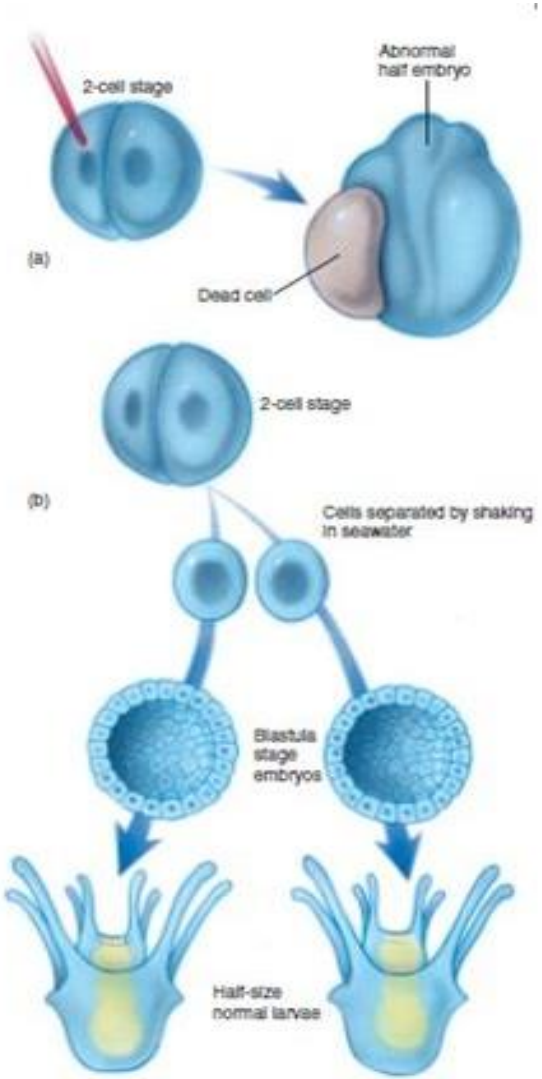
Before the 17 th century embryological knowledge was based on the writings of Aristotle and Galen. Embryology as a branch of biology was initiated by the famous Greek philosopher .Aristotle (384 – 322 B.C.)

He was the first embryologist to describe the development and reproduction of many kinds of organisms in his book entitled " Degeneratione Animalium He believed firmly that the ." complex adult organism develops from a simple formless .beginning

2-Wilhelm Roux (1888)and Hans Driesch1892

Both In separate experiments, **Wilhelm Roux (1888) and Hans Driesch (1892)** set out to determine whether **epigenesis or preformation** was correct.

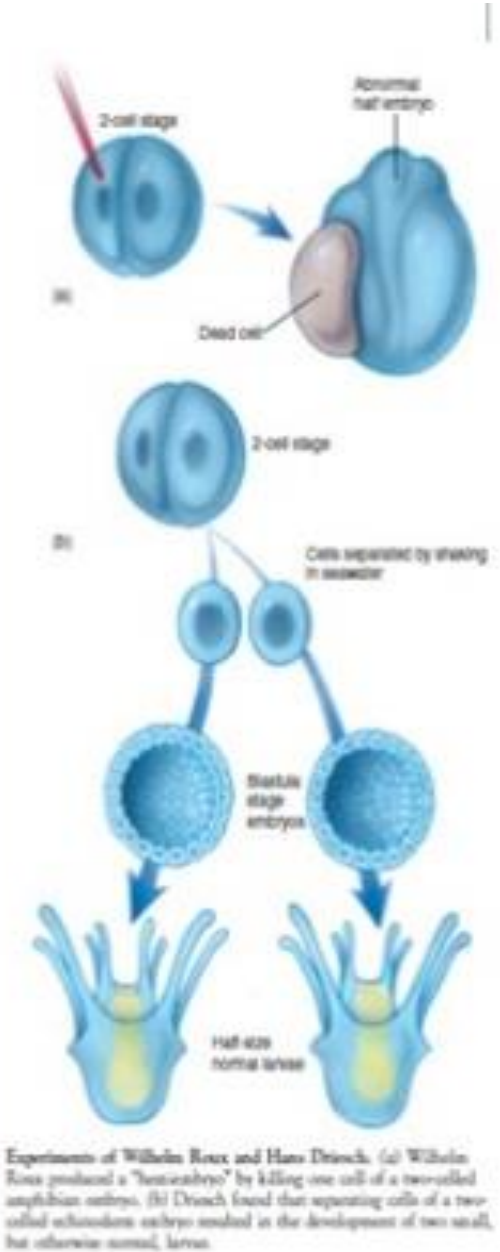
Both allowed a fertilized egg to divide to the two-cell stage. Roux, using amphibian embryos (frogs, toads, salamanders), killed one of the two cells with a hot needle. Driesch, using echinoderm embryos (sea stars, sea urchins, sea cucumbers), completely separated the divided cells.



Experiments of Wilhelm Roux and Hans Driesch. *(a)* Wilhelm Roux produced a "hemiembryo" by killing one cell of a two-celled amphibian embryo. *(b)* Driesch found that separating cells of a two-celled echinoderm embryo resulted in the development of two small, but otherwise normal, larvae.

Cont. Wilhelm Roux (1888)and Hans Driesch (1892)

An entire animal developing from a single cell would support epigenesis. A portion of the .animal developing would favor preformation What was the result? Interestingly, Roux described the formation of a half embryo that he called a "hemiembryo" (figure*a*and ,(Driesch found that each cell retained the potential to develop into an entire organism figure)*b* .(



Experiments of Wilhelm Roux and Hans Driesch. (a) Wilhelm Roux produced a "hemiembryo" by killing one cell of a two-celled amphibian embryo. (b) Driesch found that separating cells of a two-celled echinoderm embryo resulted in the development of two small, but otherwise normal, larvae.

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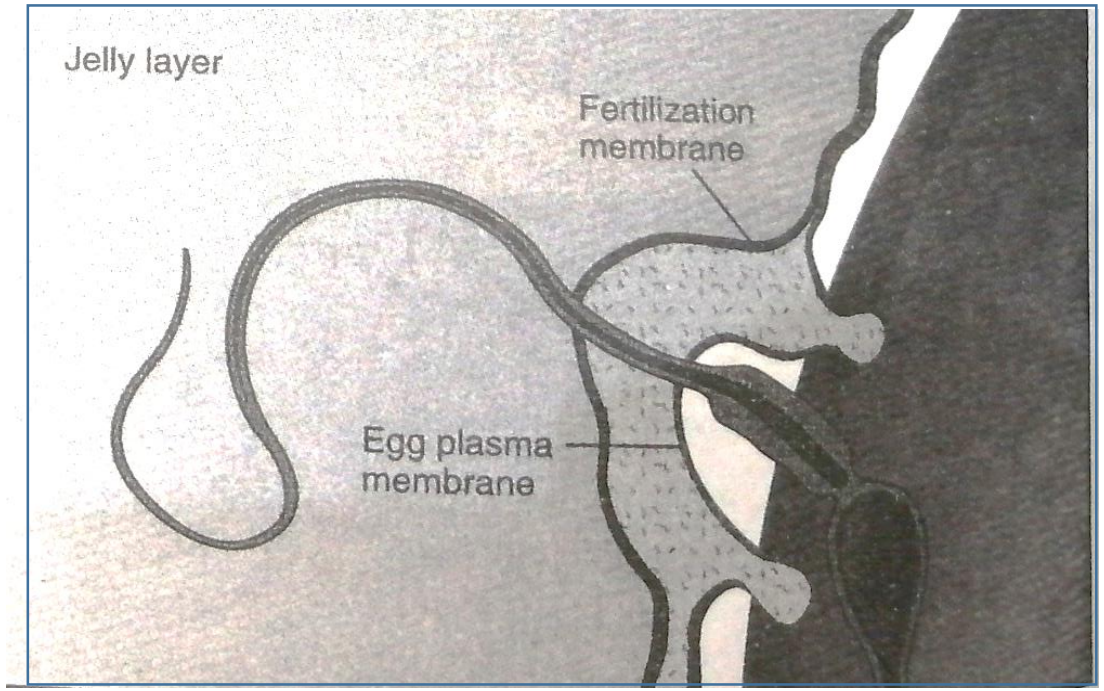
Embryology

Fertilization is the fusion of male and female gametes

Male gamete enters into the gel coat of female gamete or egg

Enzymes called Lysins are produced by male gametes to invade mucopolysaccharide coating (consists of protein and polysaccharides) of egg



Echinoderm egg

Miller and Harley; 5th Edition

Mechanism of Fertilization

- 1-Capacitation of the sperms.
- 2-First acrosomal reaction.
- 3-Second acrosomal reaction.
- 4- Cortical & zona reaction.
- 5- Nucleus of sperm enters the cytoplasm of ovum.
- 6- Secondary oocyte completes 2nd meiotic division
- 7- Union between male and female pronuclei to Form zygote.

Dr. Sherif Fahmy

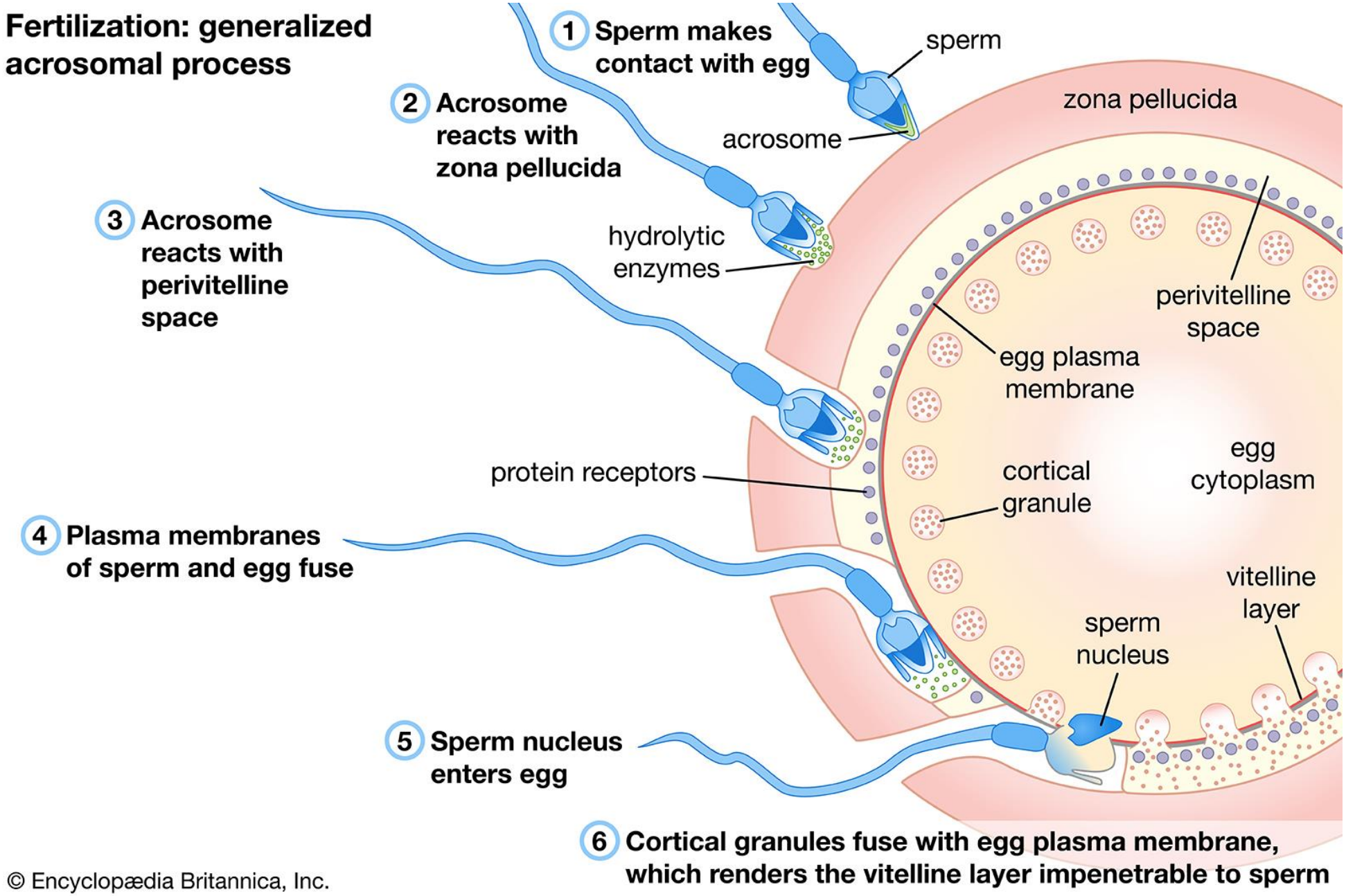
Egg Activation

Egg Activation is the series of biochemical changes in the egg that ensure the completion of fertilization and onset of embryonic development

Changes in the plasma membrane of egg occur and make a protective envelop around the egg, called fertilization membrane

Egg is now called a zygote

Nuclear fusion of the gametes is called syngamy


Fertilization: generalized acrosomal process
1 Sperm makes contact with egg
2 Acrosome reacts with zona pellucida
3 Acrosome reacts with perivitelline space
4 Plasma membranes of sperm and egg fuse
5 Sperm nucleus enters egg
6 Cortical granules fuse with egg plasma membrane, which renders the vitelline layer impenetrable to sperm
sperm
acrosome
zona pellucida
hydrolytic enzymes
perivitelline space
egg plasma membrane
protein receptors
cortical granule
egg cytoplasm
vitelline layer
sperm nucleus
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Membrane and Cortical Events

Earliest changes happen at the plasma membrane of egg

Fertilization by only a single sperm:

1- Microvilli from egg plasma membrane wrap around sperm

2- Ionic changes

3- Fertilization membrane

4- Proteins of the cortical granules

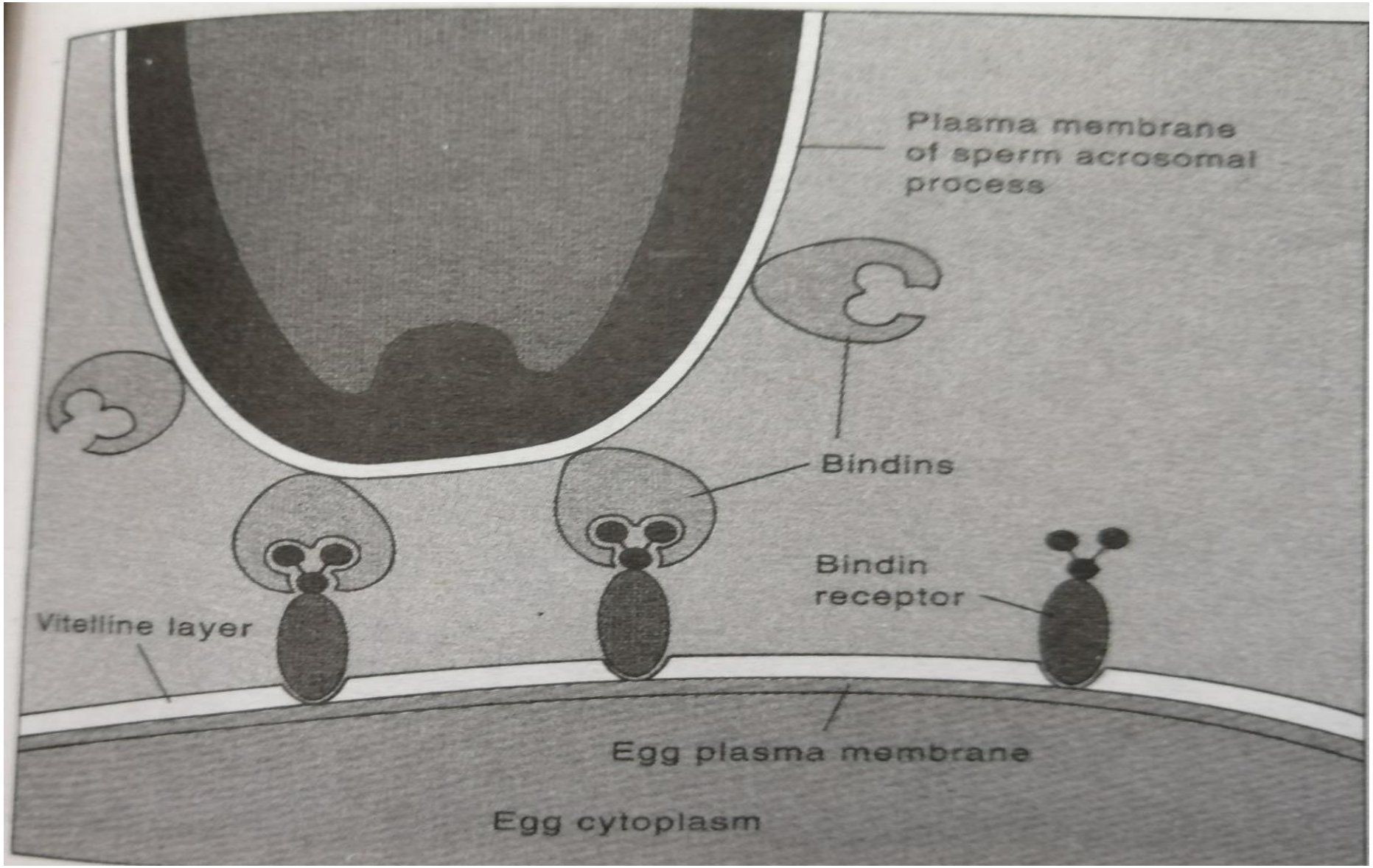
All the reactions occur in 1-2 minutes

Metabolic Changes in zygote

- ✓ Post fertilization changes in zygote
- ✓ Ionic changes in zygote raise intracellular pH and initiate changes in zygote physiology
- ✓ DNA replication occurs
- ✓ Increased protein synthesis meets the need for enzymes and structural proteins that make up mitotic spindle

Little mRNA is synthesized in early stages on embryonic development. And existing maternal mRNA is activated for protein **synthesis_Maternal**

Dominance: Existing maternal mRNA is activated for protein synthesis



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Embryonic development, cleavage and egg types

Cleavage refers to Cell divisions during embryonic development. It results in billions of cells (that make up adult animal) from a single zygote cell

Bastomeres are the Cells that are produced by cleavage

Cell divisions can be **Synchronous** (early cell divisions) or **asynchronous** (later divisions)

Quantity and distribution of Yolk

Egg sizes, Cleavage patterns, Length of embryonic periods are related to differences in the quantity and distribution of yolk in an egg

Yolk: Proteins, lipids and glycogen_food reserve for the developing embryo

Small Amounts of Yolk (Echinoderms, Amphibians) have larval stages that begin to feed after brief period of embryological development

Large Amounts of Yolk (Reptiles , birds) have longer periods of embryological development

Long periods of embryological development (Eutherian, placental mammals) usually provide nourishment through placenta

Cleavage Patterns

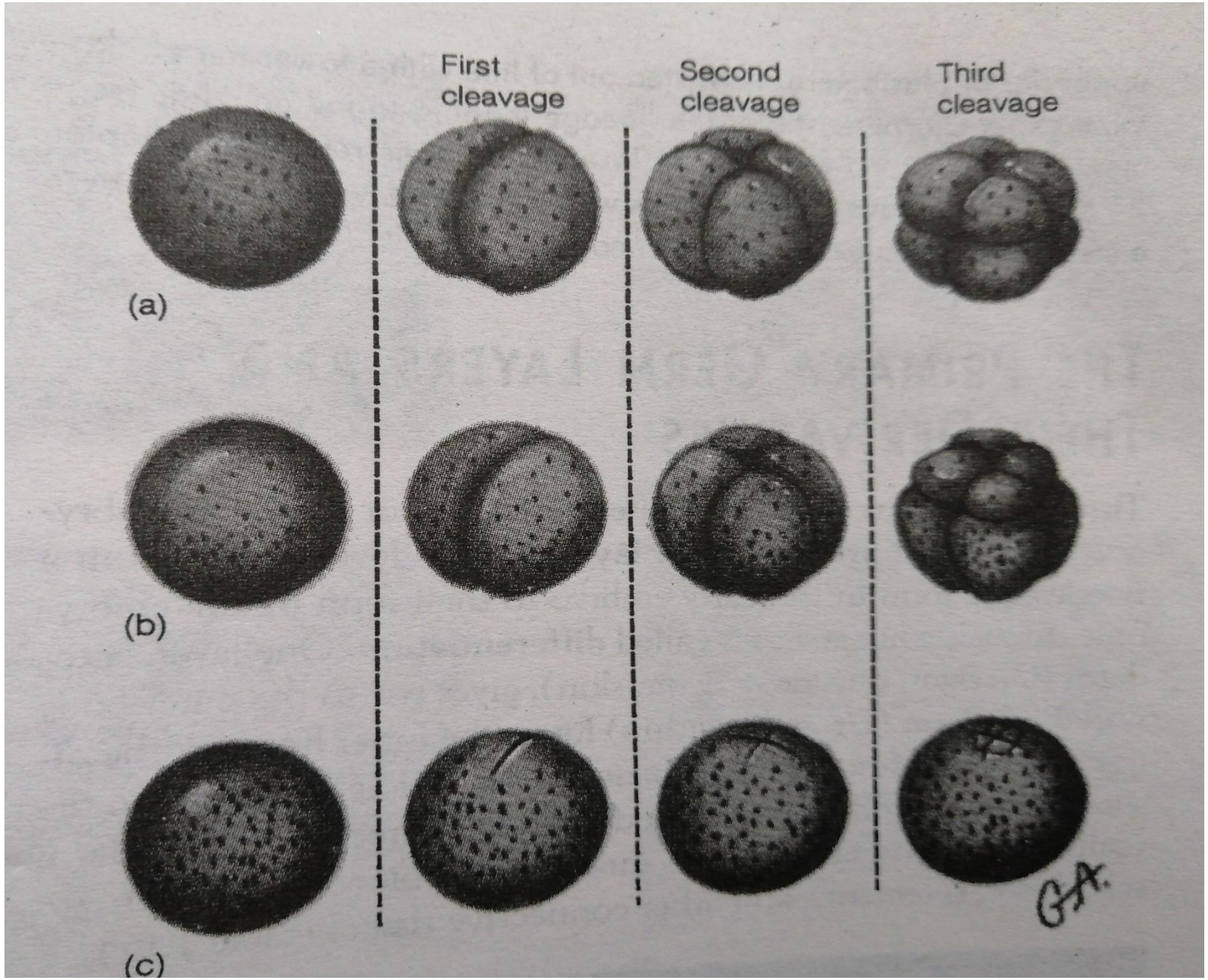
Eggs with evenly distributed yolk usually have cleavage patterns that result in uniformly sized blastomeres

But

Eggs with Unevenly distributed yolk usually result in unequal blastomeres

Holoblastic cleavage: If Cleavage completely divide the egg

Meroblastic cleavage: Cleavage can not completey divide the embryo and Embryo develop around or on top of the yolk



Holoblastic cleavage

Holoblastic cleavage

Meroblastic cleavage

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