Drosophila melanogaster-Life Cycle

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1 Introduction

Interesting challenges in biology centre around the development of a multi cellular organism from a single cell (the fertilized egg). The development of the organism from an egg to an adult is enabled by the sequential expression of the entire set of genetic instructions of the organism both in the mother and in the embryo. The fruit fly *Drosophila melanogaster* - a favourite model system of genetics laboratories which bridge genetics and developmental biology. Elegant experiments from Thomas Hunt Morgan's laboratory during the early 1900s gave us clear insights on the genetics of *Drosophila* and today its genetics is better known than any other multi cellular organism. *Drosophila melanogaster* enables easy breeding and mutant identification, is tolerant of diverse conditions and is prolific. Though *Drosophila* genetics is tractable, its embryonic development was too complex and intractable to investigate till molecular biology techniques facilitated gene manipulation and RNA extraction from these organisms. The dipteran insect *Drosophila melanogaster* is around 3mm long as an adult and undergoes a larval and a pupal stage prior to the adult stage. The time of development in a fruit fly varies with temperature. At room temperature, a *Drosophila* egg develops into an adult in 8.5 days. At higher temperatures, the induced heat stress delays the developmental time.

1.1 Egg

The *Drosophila* egg is oblong and is about 0.5mm white oval and slightly flattened on a lateral view. An inner very thin vitelline envelope surrounds the ovum along with an outer extracellular coat called a chorion. At the anterior end two small respiratory filaments extend from the dorsal surface. The anterior end can be recognized by the micropyle, a structure on the external coating surrounding the egg.

1.2 Cellularisation and multinucleate syncytium in the early Drosophila embryo

The *Drosophila* egg as we said earlier, is oblong with a tough external coating around the egg. The zygote nucleus undergoes rapid mitotic divisions after fertilization and fusion of the sperm and egg. No cleavage of the cytoplasm takes place at the initial stages and there is no cell membrane formation that separates the nuclei. As a result of this, a syncytium with around 6000 nuclei is formed after 12 nuclear divisions. All the 6000 nuclei share a common cytoplasm and the embryo remains a single cell during early development. After 9 divisions, the nuclei then move to the periphery to form the syncytial blastoderm which comprises a layer of nuclei and cytoplasm surrounding a central mass of yolky cytoplasm. The formation of the syncytium facilitates diffusion of proteins across the nuclei during the first three hours of development. During the syncytial stage, a significantly small number of nuclei migrate to the posterior end and are surrounded by cell membranes to form the pole cells which give rise to the germ cells at later stages.

1.3 Gastrulation and segmentation in Drosophila

The single epithelial layer of the cellular blastoderm yields all tissues required for development except the germ line cells. The ventral region accommodates the prospective mesoderm and the mid gut derives from the prospective endoderms at the anterior and posterior ends of the embryo. During gastrulation the endodermal and mesodermal tissues migrate to their positions inside the embryo while the ectoderm forms the outer layer. The phenomenon of gastrulation begins 3hours after fertilization when the ventral mesoderm invaginates to from a furrow along the ventral midline. The gastrulation phase involves no cell divisions but once this phase is complete, cells begin to divide again. During gastrulation, the ventral blastoderm otherwise called germ band undergoes an extension called the germ band extension. It is during the time of germ band extension that the first external signs of segmentation begin to be observed. The segments of the larva and the adult are formed through the para segments which are seen as evenly spaced grooves. Of the 14 para segments observed, 3 of them

contribute at the parts of the mouth of the head, 3 form thoracic regions, 8 form the abdominal region of the *Drosophila*.

1.4 Larval stages of Drosophila melanogaster

A female lays around 400 eggs on favourable substrates and the eggs hatch into first instar larvae within 24 hours. Though the larva takes 24 hours after fertilization to hatch, the different regions of larvae become well defined several hours before the transition. The head of the larva is hidden before the larval hatching. The anterior region of the head houses a special structure called acron while its posterior end houses the **telson**. Three thoracic segments and eight abdominal segments appear between the head and the telson. Small tooth like belts called denticles are found on the ventral side of each segment. The larva grows with feeding, molts and sheds its cuticles. This process repeats itself twice and each stage is called an instar. The hatching time is reduced to 15 hours at room temperature. The first instar larvae feeds on substrates like rotten fruit or culture jar for around 25 hours and shapes into a larger worm like form called the second instar larvae. The second instar larvae take the next 24hours to molt into the third instar larvae.

1.4.1 Pupal stage

The third instar larvae apart from feeding on the substrate begin to crawl upwards for food to a dry and cleaner area to undergo pupation and molts into a pupa after 30 hours. The yellowish white pupa develops to progressively become darker and metamorphoses into the imago. As the third in larva becomes pupa metamorphoses occurs to convert it to an adult fly. During the pupal stage, *Drosophila melanogaster* acquires wings and legs through hormone induced metamorphoses. These structures are already present in the larva as imaginal discs. The imaginal discs are small sheets of epidermal cells derived from the cellular blastoderm and accommodate around 40 cells each during the time of formation. These discs grow throughout the larval stage, forming epithelial sacs which fold to accommodate increase in size. These help develop the adult organs during metamorphosis and provide continuity between patterning a larval body on that on the adult.

1.4.2 Adult stage

The adult fruit fly emerges from the operculum of the puparium and the female fly becomes receptive within 8 to 12 hours of emergence. It then begins mating with a male fly for 30 minutes and collects and stores the sperms from the male fly to use them later for laying eggs.

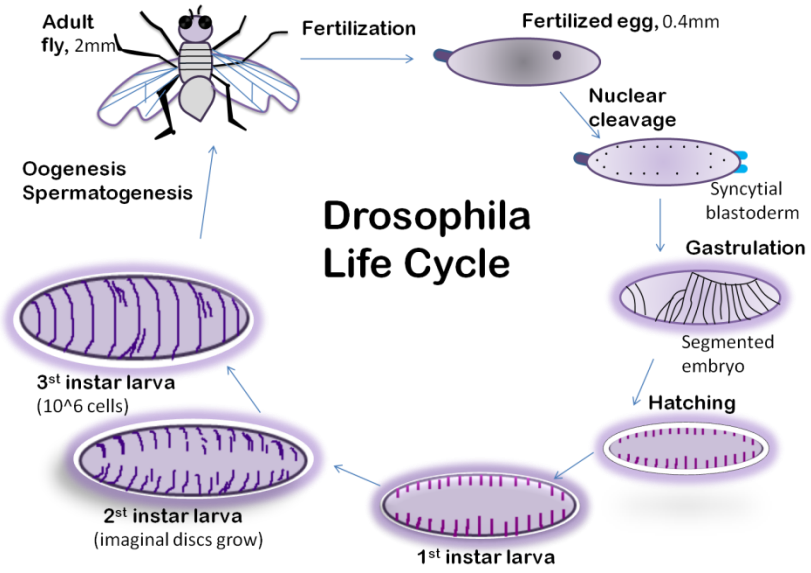

Fig 1. Life cycle of *Drosophila melanogaster*

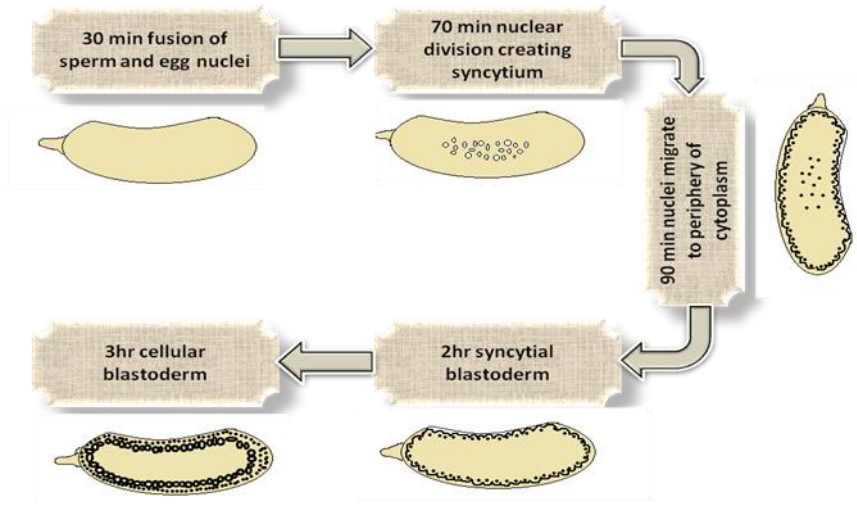

Fig 2. Cleavage of the Drosophila embryo

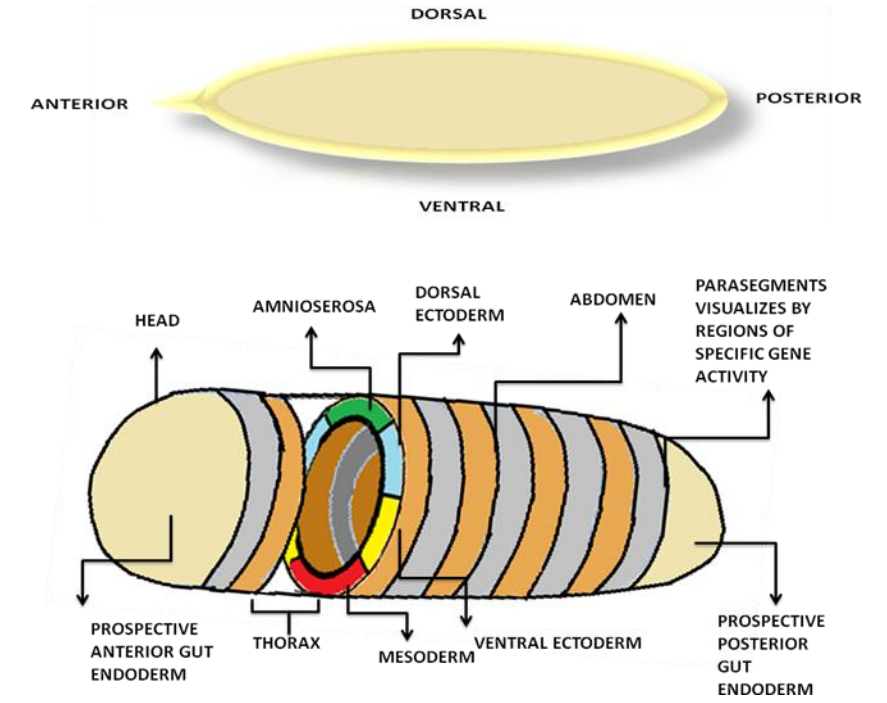

Fig 3. Patterning of the *Drosophila* embryo

2 References

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2.3 Web References

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2.4 Video Link

Eric Wieschaus:Drosophilaa embryo development- Youtube