OOGENESIS AND VITELLOGENESIS

M.SC SEMESTER II PAPER 06

DR POONAM KUMARI

The process by which the eggs or ovadevelop from the primordial germ cells of the ovary is called oogenesis. The mature ovary consists of cells similar to the primordial cells in the testis. These however give rise to eggs.

The process of the development of the egg can be studied under the following stages. These are multiplication phase, growth phase and maturation phase.

1. Multiplication phase:

The primordial germ cells divide repeatedly by means of mitosis to produce a large number of daughter cells. These are called oogonia. The oogonia are known to divide again several times mi- totically to produce a large number of cells called the primary oocytes. After the formation of primary oocytes there is no more division. The cells enter into the growth phase.

2. Growth phase:

The growth phase of oogenesis is longer and more complicated than in spermatogenesis. There is considerable enlargement in the size of the primary oocyte during the growth phase. For instance the primary oocyte of frog initially has a diameter of only about 50 microns but at the end of the fruit phase the diameter of the matured egg will be as much as 2000 microns.

Growth in the primary oocyte is brought about by the accumulation of a large amount of fats and proteins. These get accumulated in the form of yolk. The yolk is usually concentrated towards the lower portion of the egg called the vegetal pole. The upper side of the egg which contains cytoplasm and the egg nucleus remains often separate from the yolk and it is called the animal pole.

The cytoplasm of the oocyte is very rich in RNA, DNA, enzymes etc. Other cytoplasmic organelles like mitochondria, golgi complex & ribosomes are also found in large numbers. In Oocytes of some amphibians and birds the mitochondria accumulate at certain places forming mitochondrial clouds. During

this period, the nucleolar genes show increased activity of RNA synthesis and multiply their number. This is known as gene amplification or redundancy.

The nucleus enlarges in size due to the increased amount of nucleoplasm. The nucleolous also becomes large due to the synthesis of ribosomal RNA. At this stage in some of the amphibians the chromosomes change their shape and become giant lampbrush chromosomes.

3. Maturation phase.

It is during this phase that the oocyte undergoes reduction division (meiosis) eventually to produce the egg or the ovum.

The maturation division of the primary oocyte differs greatly from that of the spermatocytes. While in spermatogenesis at the end of meiosis four sperms are formed, here at the end of meiosis only one large haploid egg is formed, the remaining three cells forming three small polar bodies. This unequal division results in the formation of a single egg having a large quantity of stored food that is necessary for the development of the embryo.

The first maturation division (meiosis I) reduces the chromosomes into half. After the homologous chromosomes undergo chiasma formation and crossing over, the nuclear membrane breaks and the chromosomes move towards the opposite poles. The nuclear division is followed by the cytoplasmic division.

This division (Cytokinesis) is unequal and results in the formation of a small polar body and large secondary oocyte or ootid. During the second maturation division (meiosis II) the haploid secondary oocyte as well as the polar body undergoes a mitotic division.

As a result of this, the polar body forms two polar bodies, while in the secondary oocytes the division results in the formation of a mature egg and a second polar body. Thus at the end of second maturation division there will be a large single egg and three polar bodies. These polar bodies eventually ooze out and degenerate, while the egg is ready for fertilization.

Vitellogenesis

Vitellogenesis is the process of production and accumulation of yolk in a developing oocyte. Female insects seek out a nutritionally suitable environment that will potentially provide more than adequate food resources for her larvae. This behavior assures the propagation of the species. However, before the larva hatches onto its nourishing meal, each egg must come complete with all the developmental instructions (localized determinants), cytological machinery (e.g., ribosomes, mitochondria, and RNAs) and nutrients (yolk) necessary to complete embryogenesis and support the maturation of the embryo through larval hatching and into the first larval instar. The process of vitellogenesis or the production and packaging of nutrients, primarily vitellin or yolk proteins, into the developing oocyte within the ovary is critical to providing the egg with the nutrient resources to complete embryogenesis.

There are many common points during the vitellogenesis of worms, insects and vertebrates (amphibians, reptiles and birds):

- Most of the food reserves are producced outside the oocytes and transported through the body fluids (pseudocoelomic fluid in nematodes, hemolymph in insects or blood in vertebrates) by soluble proteins.
- The uptake of these proteins by the oocytes is mediated by specific receptors.
- The synthesis of these proteins is controled by hormones (except in nematodes).
- The main proteins involved in the process are called VITELLOGENINS. They are large proteins (greater than 500 kDa or 500,000 times the mass of a Hydrogen atom!) and have lipids, carbohydrates and phosphate associated to them.