Mitochondria are unusual organelles, that most probably about 2.5 billion years ago become engulfed by the eukaryotic cells by endosymbiotic resorption of bacteria. Mitochondria have their own genome (so-called mitochondrial DNA) and act as the energy power plants of the cell. Due to their function the processes of intracellular respiration takes place. In addition to adenosine triphosphate (ATP) synthesis, mitochondria found in all eukaryotes play an important role in numerous cellular processes, such as: regulation of cellular calcium levels, intracellular and intercellular signalling, programmed cell death (apoptosis), and cell aging. In addition, mitochondria control cell differentiation, cell cycle, and are essential for proper cell division. Abnormalities in functioning of mitochondria may be the underlying causes of disease.

The processes associated with the formation of gametes and embryos require high energy expenditures. These processes include a very intensive synthesis of storage materials (including transcripts and proteins), which requires to coordinate metabolic changes with processes that take place at the nucleus (DNA), as well as with cellular division (even segregation of chromosomes into daughter cells). Obtaining of a full development potential by gametes and embryos (the ability to produce a healthy offspring) is inseparable from their quality. The process of oogenesis (formation of female reproductive cells) is highly dependent on the proper functioning of the mitochondria. Interestingly, at the early stage of embryo development, mitochondrial biogenesis is not observed, subsequent generations of cells inherit mitochondria from the "mother" - the fertilized egg cell. De novo synthesis of mitochondria commences only around the blastocyst stage – just before embryo implantation. We know from scientific research that during the early development of the mammalian embryo, in addition to energy production, mitochondria may also influence the number of developmentally important processes, as diverse as gene expression, genome modifications, signalling pathways, and possibly chromosome segregation during cell division. This is an extremely fascinating discovery, because the majority of reproductive failures around the time of embryo implantation results from genomic instability. Similar observations were made for animals and humans. Therefore, this project aims to perform a multidimensional study of the distribution and function of mitochondria in early (preimplantation) embryos. Our investigations will be conducted on bovine embryos obtained *in vitro*, because due to the current state of knowledge, they are an excellent reference model to study early mammalian development, including human. Our research will include, among others, experiments aimed at describing the relationship between mitochondrial activity and distribution with quality of embryos. Research will be conducted at the level of mitochondrial DNA and RNA (analysis of all transcripts found in a single embryonic cell). The relationship between mitochondria and chromosome segregation during cell division will be also studied. In these investigations, novel diagnostic techniques, such as preimplantation genetic testing for aneuploidy (PGT-A, that allows to evaluate chromosomal stability) and classical cytogenetic methods will be used. It is also planned to investigate the interaction between reactive oxygen species (generated as a bi-product ATP metabolism) and signalling pathways crucial for embryonic cell differentiation. We plan to use the latest techniques of molecular biology and confocal microscopy, including high-resolution microscopy Stimulated Emission Depletion (STED) microscopy.

Our results may help to further understand the underlying mechanisms of acquiring developmental competence by the mammalian embryo – this in itself is of high importance for embryologists working with assisted reproductive technologies, animal and human likewise.