Stochastic Modeling of Ovarian Follicle Growth in Adult Female Rat

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Folliculogenesis is the process of ovarian follicle development in female mammals. Hormone secretion and biological molecules regulate folliculogenesis. After being recruited from follicle pool, follicles grow and secrete estrogens. The concentration of estrogen in the ovary regulates the growth of follicles to select several dominant follicles by size. Only the selected follicles will eventually be ovulated, while the majority of follicles would undergo oocyte atresia and follicular depletion. The number of ovulating follicles is conserved among species. However, if each follicle grows independently, why does each ovulation has a regular distance in time from the previous ovulation, a regular length, and a regular amount of follicles? The experimental approach to answer the question is limited by excessive cost and ethical considerations. This project offers a mathematical model to expand current understandings of the folliculogenesis process, conducted with rat ovarian histology data. We first assumed an exponential distribution of initial follicle sizes, and applied the modeling framework of Lacker to simulate the effect of pituitary hormones on follicular maturation. Follicles are ovulated when their size and the overall estrogen change rate in ovary exceed a certain threshold, which is optimized through multiple experiments. The project also implemented two poisson distribution stochastic processes to simulate follicle recruitment and follicle atresia respectively. This project simulates follicular behaviors in continuous and relatively regular reproductive periods, in which ovulating follicle numbers are consistent, and the reproductive periods are of the same length.