Amphibian hormone cycle

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The amphibian hormone cycle regulates the reproduction of female and male amphibians. The amphibian hormone cycle is quite complex (Figure 1). As amphibians grow to maturity the gonads develop until the testes can produce sperm and the ovaries can produce mature oocytes. Then the amphibian hormone cycle regulates the maturity of oocytes, spermiation in the testes, and the final amplexus and spawning finally leading to the fertilisation of oocytes and the development of eggs.

Mature amphibians don't spawn until the right environmental cues occur. The mature gonads themselves produce estrodiol that move through the blood stream to the brain. These estrogens regulate the centers in the brain that respond to favourable environmental factors by producing a hormonal cascade through the hypothalamus and then the pituitary. The hypothalamus is a small gland at the base of the brain. The hypothalamus is above and in intimate contact with the pituitary.

The estradiol promotes the production of dopamine, which blocks luteinising hormone (LH), production in the pituitary. The production of dopamine also blocks the production of luteinising hormone releasing hormone (LHRH) in the hypothalamus. Dopamine also blocks the production of oxytocin and prolactin in the pituitary. These substances are involved in mating and spawning behaviour and in the physical process of spawning.

What breaks this cycle? The brain responds to favourable environmental indicators such as rainfall, or temperature, and then stimulates the hypothalamus to produce LHRH. The LHRH then migrates to the pituitary. The pituitary then produces LH and follicle stimulating hormone (FSH), which initiates changes in the testes and ovaries.

Without the use of artificial hormones spawning can only occur at an advanced stage of the development of ovaries. The development of ovaries can be viewed as the development of oocytes or developing unfertilized eggs. The development of oocytes occurs in a number of defined stages from 1 to 6. Stage 6 oocytes are ready for spawning.

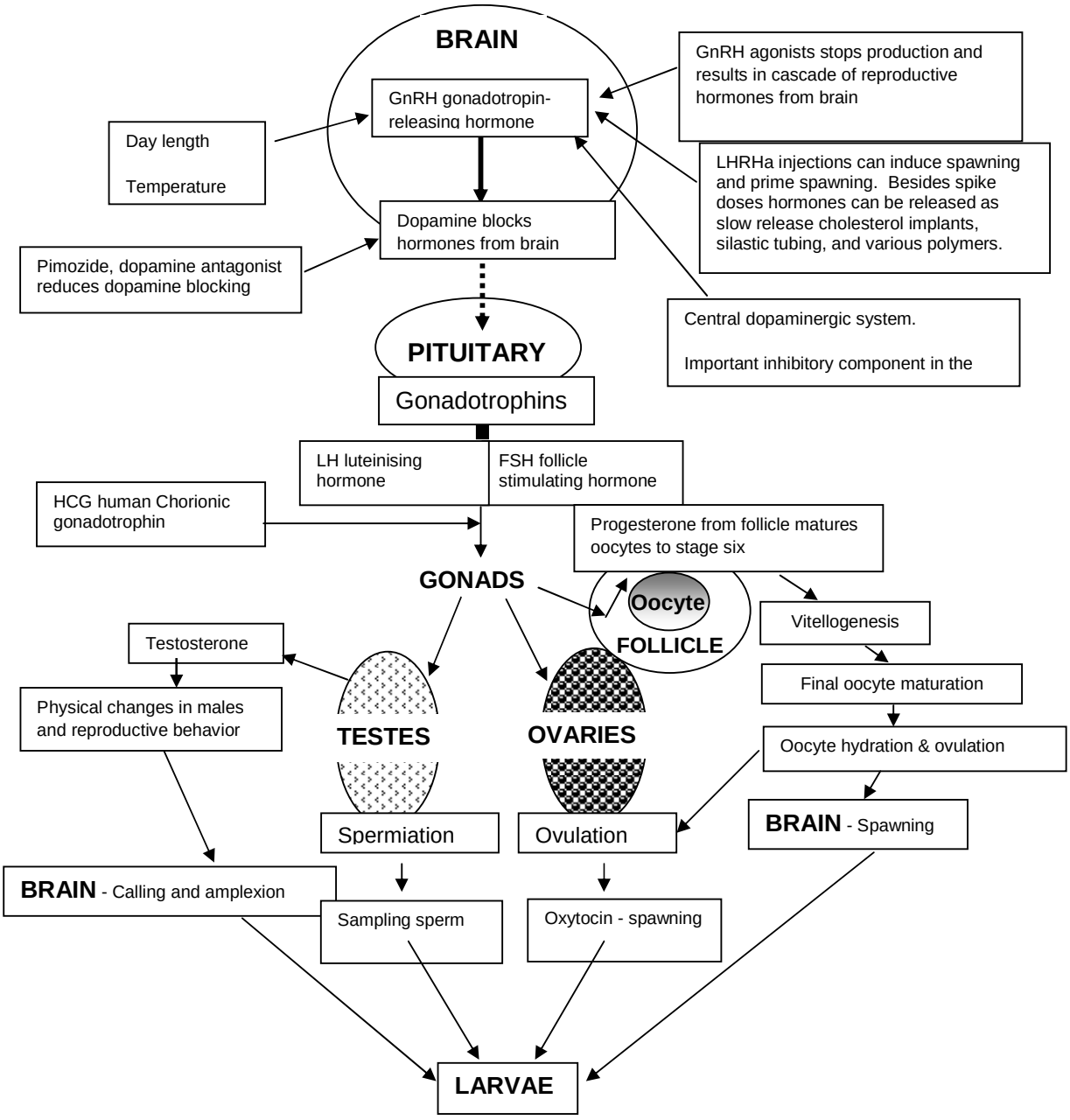
In the ovary as follicles develop the interstitial cells between the stage 1 and stage 2 oocytes secrete estradiol, which inhibits spawning. When favorable conditions for spawning occur the pituitary releases LH and FSH and the second growth phase oocytes move toward to stage 4 and final maturation. Estradiol secretion diminishes and the LH and FSH result in increasing testosterone in testes and progesterone in ovaries. Testosterone promotes spermiation in the testes, and under stimulation of FSH the follicles secrete progesterone promoting the final maturation of oocytes to stage 6.

In females progesterone is produced by the follicles in the ovaries, which house stage 4 oocytes. Under the influence of progesterone the stage 4 oocytes recruit stored fats, and develop yolk (vitellogenisis) and structures necessary for spawning and fertilization. Females with large numbers of mature oocytes are usually compelled to spawn even without the stimulus of males. In males, luteinizing hormone initiates the hydration of sertoli cells, which induce spermiation (or sperm release) into the urine, and stimulate both calling and amplexus.

Although investigators have studied this system most thoroughly in anurans, the hormonal systems in anurans, urodeles, and caecilians are similar.

Hormones and other substances can be administered to affect various stages of the amphibian hormone cycle to induce ovulation and spawning in amphibians. The most valuable hormone in the induction of ovulation of females is luteinising hormone releasing hormone analogue (LHRHa). This hormone is an artificial from of the LHRH produced in the hypothalamus and acts in a similar manner to promote production of LH and FSH by the pituitary. However, with the use of LHRHa the central dopaminergic system of the brain may still be inhibited by estradiol from the ovaries.

Figure 1. The reproductive hormone cycle in amphibians



This inhibition can be lowered through; 1) improved reproductive conditioning promoting etradiol blocking in the brain, 2) reducing estradiol production in the ovaries by hormonal priming, 3) by using antidopaminergic compounds, 4) by administration of progesterone to stimulate follicles, and 5) theoretically through the administration of oxytocin or prolactin. The most tested means are priming with LHRHa and/or progesterone, and the administration of progesterone with the final ovulating dose of hormones.

The production of stage 6 oocytes can be stimulated by the administration of progesterone, or by the sequential administration over days of other reproductive hormones. The response of oocytes to maturating hormones can also depend on the ovulatory cycle. Smaller oocytes from recently ovulated females mature faster than larger oocytes from unspawned females. Consequently, because of the number of affecting factors and the complexity of their interaction, the success of the artificial induction of ovulation can be inconsistent.

Another hormone sometimes used to promote ovulation is human Chorionic Gonodotrophin (hCG), which stimulates the production of progesterone by the follicles and oocyte matuartion. Pimozide is an antidopaminergic compound and facilitates the production of prolactin and oxytocin. Dopamine is produced in the brain and the hypothalamus and inhibits the production of prolactin in the anterior pituitary and oxytocin produced in the hypothalamus and released from the anterior pituitary.

The central dopaminergic system is an important inhibitory component in the regulatory circuitry of brain GnRH levels in normal and behaviourally stimulated amphibians. The secretion of dopamine is controlled by the gonadal steroid estradiol. High estradiol level determines high level of dopamine, which in turn inhibits LH secretion. The use of antidopaminergic drugs like pimozide in combination with LHRHa is the most potent method for induction of ovulation in cyprinid fish and in catfish. In addition to its effects on prolactin and oxytocin, pimozide prevents the inhibition of luteinising hormone by estradiol.

An excellent site for the biochemical nature of steroid hormones is at ‘THE MEDICAL CHEMISTRY PAGE’ by Dr. Michael W. King. http://themedicalbiochemistrypage.org/