Model Answer M Sc III Sem Male & Female Reproduction 2015-16

Ans1. Correct option for MCQ (10 x 2 =20)

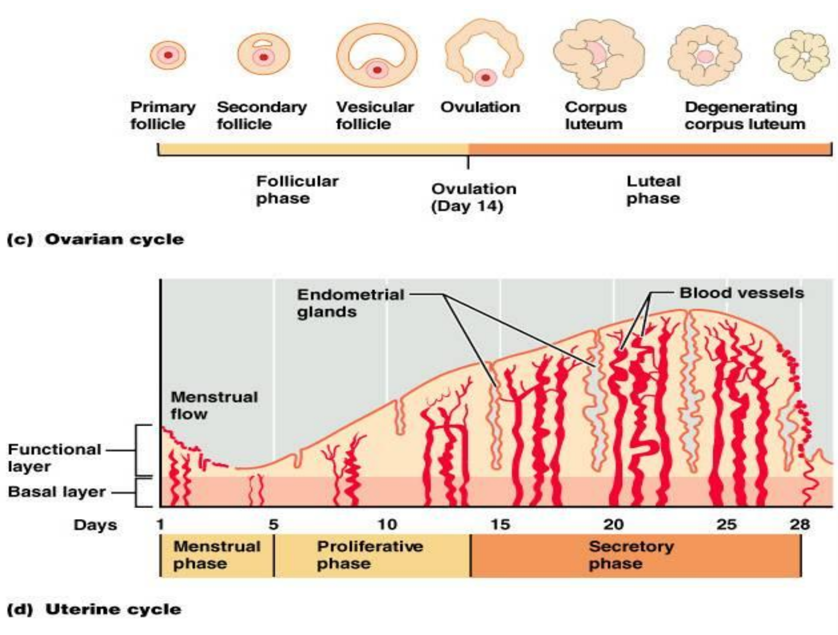
1) **d);** 2). **d)**; 3). **b);** 4). **b);** 5). **b) ;**

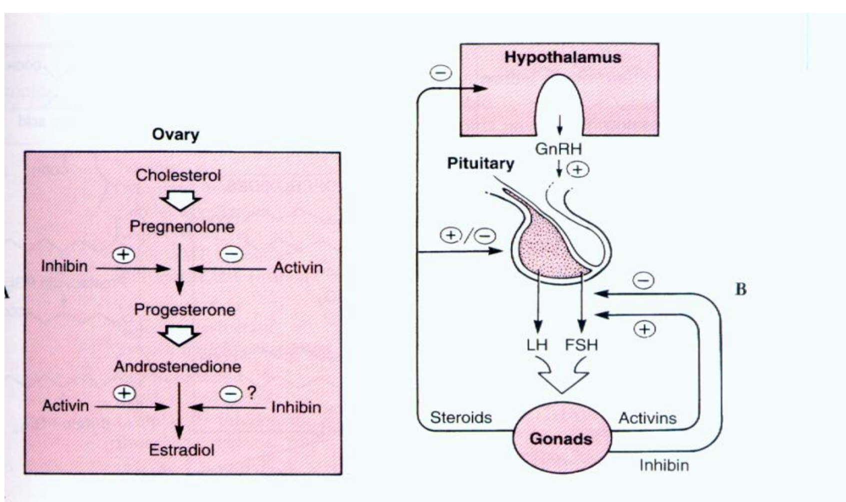
6). **b);** 7). **d);** 8). **b);** 9). **a);** 10). **c)**

Section B

Descriptive Type answer

Q2. Define menstrual cycle. State and explain the hormonal control of menstrual cycle in higher mammals with diagram.





Q3. Depending upon the photoperiod how many types of seasonal breeder are found. Describe the control of seasonal reproductive cycle by melatonin.

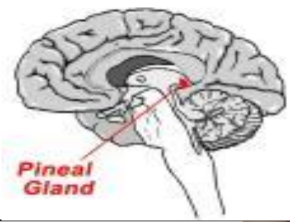
Type of seasonal breeder – Long day breeders and short daybreeders, spontaneous breeder

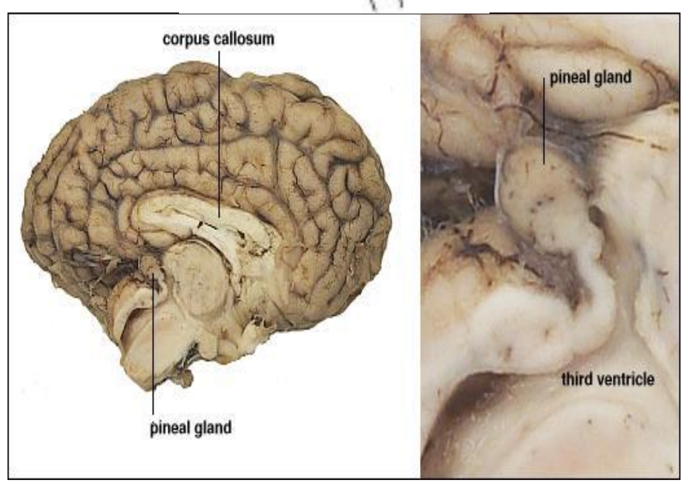
MELATONIN REGULATION OF THE HYPOTHALAMIC–PITUITARY–GONADAL AXIS

Role of the Pineal Gland and Melatonin in Transducing Photoperiodic Information

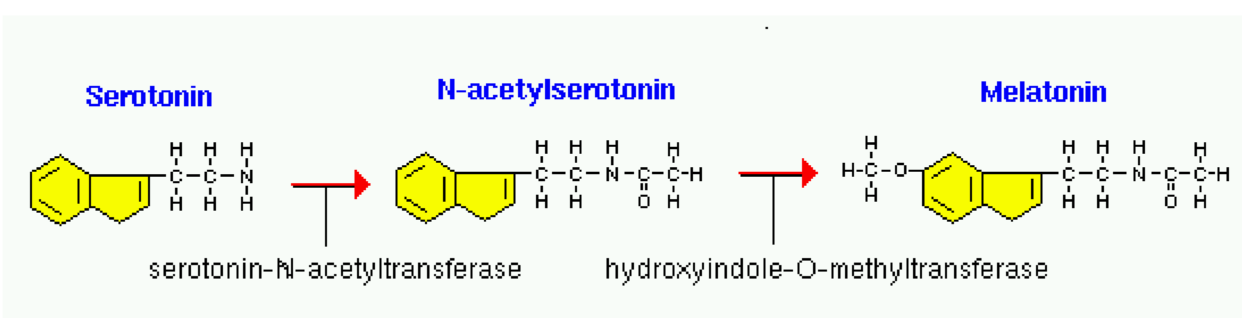
Role of the Pineal Gland

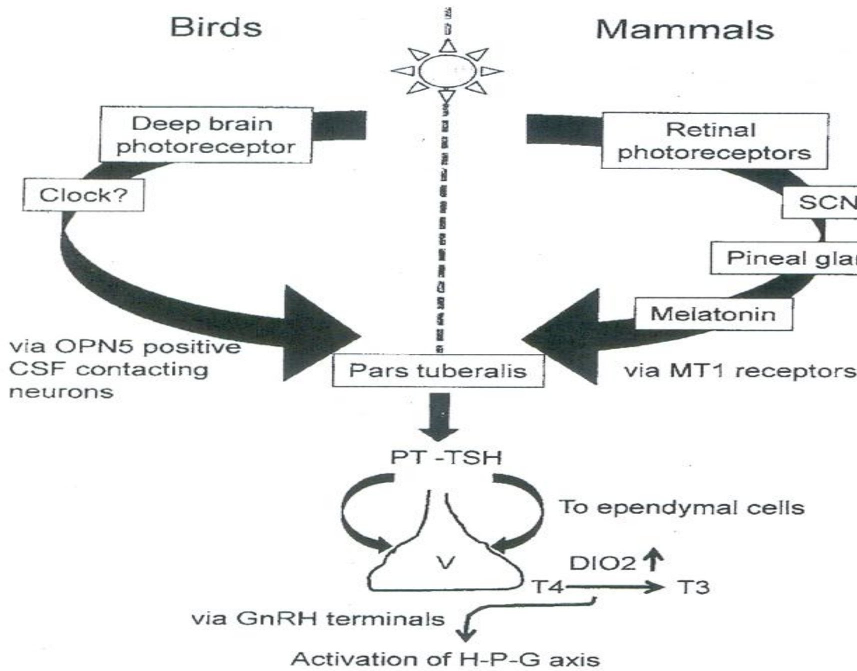
The importance of the pineal gland to transduce photoperiodic information was demonstrated by numerous experiments showing that the effect of photoperiod on seasonal reproduction is profoundly altered after removal or denervation of the pineal gland [for review see (83,191,192)]. In Syrian hamsters, pinealectomy prevents the gonadal regression normally brought about by experimental or natural short photoperiod (193,194). In mink, a short-day breeder, a remarkable effect of pinealectomy was observed in a 3-year experiment: After removal of the gland, animals display sexual rest and remain permanently reproductively inactive (195). In sheep, the demonstration of the role of the pineal was made more difficult because the early pinealectomy experiments failed to show a significant effect of the removal of the gland on the seasonal pattern of reproduction (196–198). The reasons for this failure to show a role of the pineal gland in the timing of the breeding season are now better understood. First, because there is an endogenous rhythm of reproduction in this species, the persistence of alternations between breeding and anestrus is expected even though the external signal is removed. Second, this endogenous cycle can be indirectly synchronized in pinealectomized ewes through social signals transmitted by their pineal-intact conspecifics (male or female) (199). A clear demonstration of the role of the pineal gland came from studies in which animals were tested for their ability to respond to controlled the photoperiodic changes.

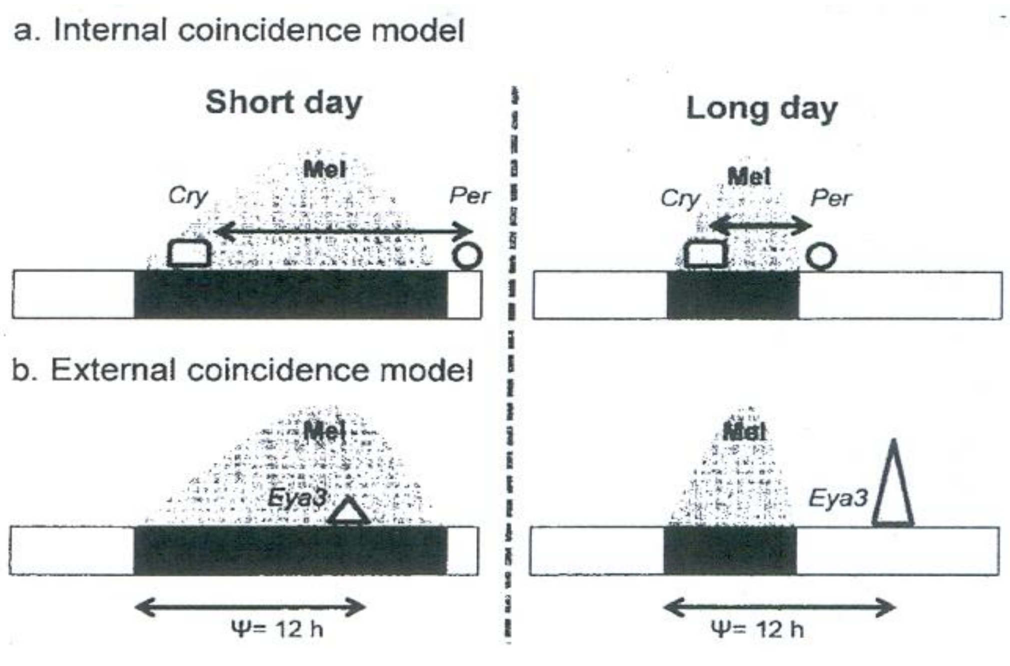




The pineal gland secretes melatonin in a rhythmic way has the ability to entrain biological rhythms a structurally simple hormone that communicates information about environmental cue and seasonal changes and according synchronizes the important effects on reproductive function of many animals.







–Molecular coincidence models to explain the regulation of seasonal responses. Internal coincidence model (upper panel; 2a) suggests that the melatonin signal during short days (long nights; left panel) and long days (short nights; right panel) affects the elements of the molecular clockwork.

Q4. What is gonadotropin……………………………………. in sexual differentiation and behavior

Gonadotropes are those endocrine cells of the anterior pituitary gland that produce **gonadotropins**

Gonadotropes appear basophilic in histological preparations. There are two types of **gonadotropin**

Follicle stimulating hormone (FSH) and Luteinizing hormone (LH). Release of FSH and LH is regulated by gonadotropin releasing hormone represented as GnRH secreted from the hypothalamus.

Structure FSH & LH: FSH- glycoprotein. Its structure is similar to that of LH, The protein dimer contains 2 polypeptide, alpha and beta subunits. The alpha subunits of LH, FSH, TSH, and hCG are identical, and contain 92 amino acids. The beta subunits of FSH has a beta subunit of 111 amino acids (FSH β), which confers its specific biologic action and is responsible for interaction with the FSH-receptor. The sugar part of the hormone is composed fructose, galactose, mannose, galactosamine,glucosamine, and sialic acid, the latter being critical for its biologic half-life. The half-life of FSH is 3–4 hours.

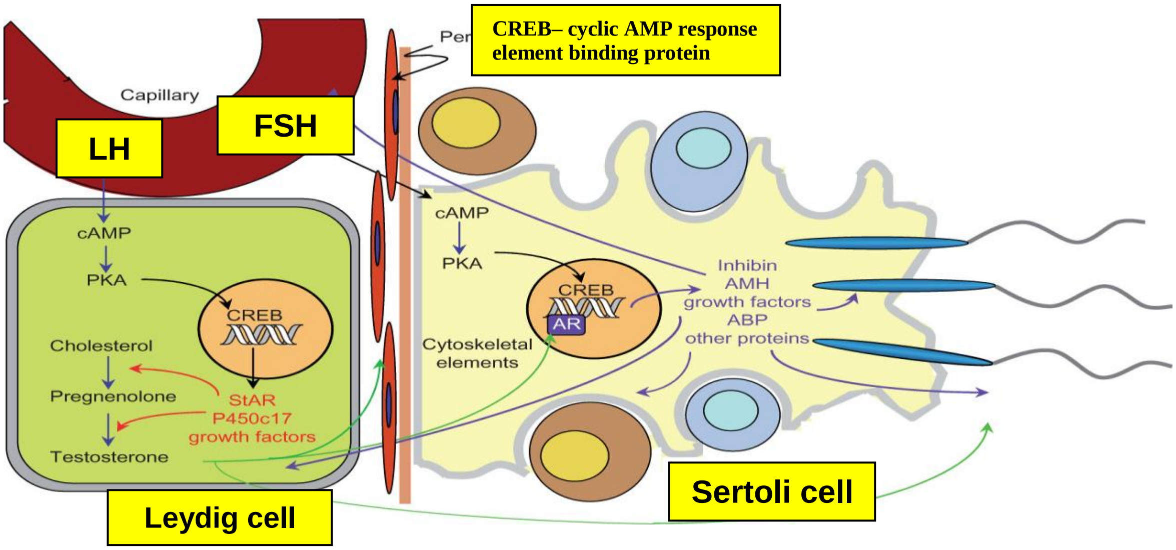
Gene of FSH alpha subunit gene is located on chromosome 6p21.1-23 and beta subunit is located on chromosome 11p13, and is expressed in gonadotropes of the pituitary cells, controlled by GnRH, inhibited by inhibin, and enhanced by activin

LH -is a heterodimeric glycoprotein. Each monomeric unit is a glycoprotein molecule; one alpha and one beta subunit. The protein dimer contains 2 glycopeptidic subunits, labeled alpha and beta subunits, that are non-covalently associated (i.e., without any disulfide bridge linking them):

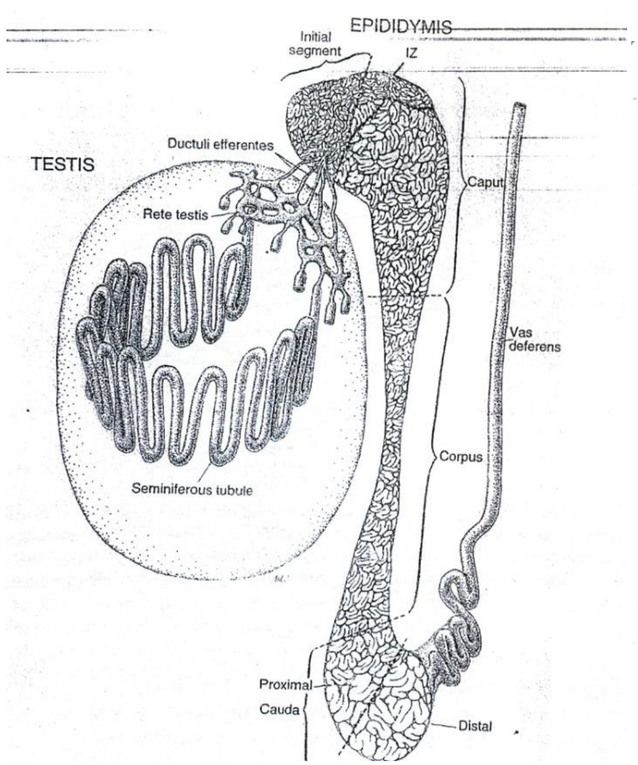
- The alpha *subunits* of LH, FSH, contain 92 amino acid residues in human In other vertebrate species 96 amino acids however in invertebrates glycoprotein hormones do not exist.
- The *beta subunits* vary. LH has a beta subunit of 120 amino acids (LHB) that confers its specific biologic action and is responsible for the specificity of the interaction with the LH receptor.

The beta subunit contains an amino acid sequence which exhibits maximum homologies with the beta subunit of human Chorionic Gonadotropin. However, the hCG beta subunit contains an additional 24 amino acids, and the two hormones differ in the composition of their sugar moieties. The biological half-life of LH is 20 minutes, shorter than that of FSH (3–4 hours) and hCG (24 hours. LH Gene for the *alpha subunit* is located on chromosome 6q12.21 and *beta subunit* gene is localized in the LHB/CGB gene cluster on chromosome 19q13.32. Beta LH subunit gene activity is restricted to the pituitary gonadotropic cells. It is regulated by the gonadotropin-releasing hormone from the hypothalamus. Inhibin, activin, and sex hormones do not affect genetic activity for the beta subunit production of LH.

Secretion and Regulations



Q5. Discuss in detail the structure and cellular organization of epididymis.



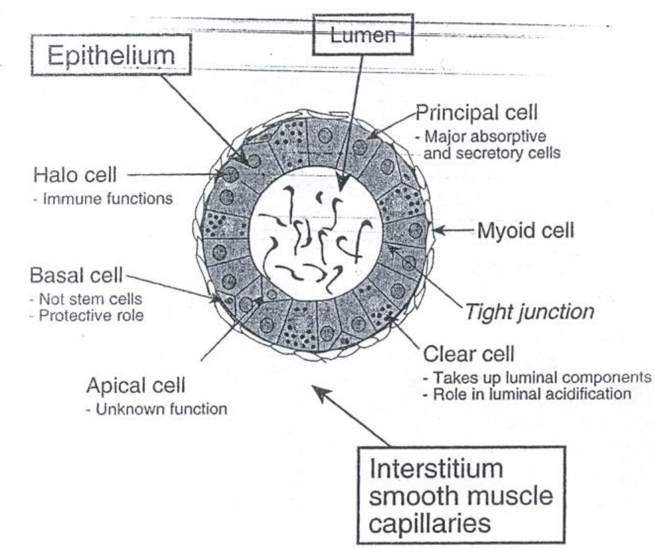


FIG. Schematic organization of the major cell types in the epididymis as observed at the light microscope. The three epididymal compartments as well as the relative position and distribution of each of the main cell types are illustrated. The major functions associated with each cell type are also identified.

1. Pincipal cell ; 2. Halo cell; 3. Basal Cell; 4.Apical cell; Clear cells; Myoid cells

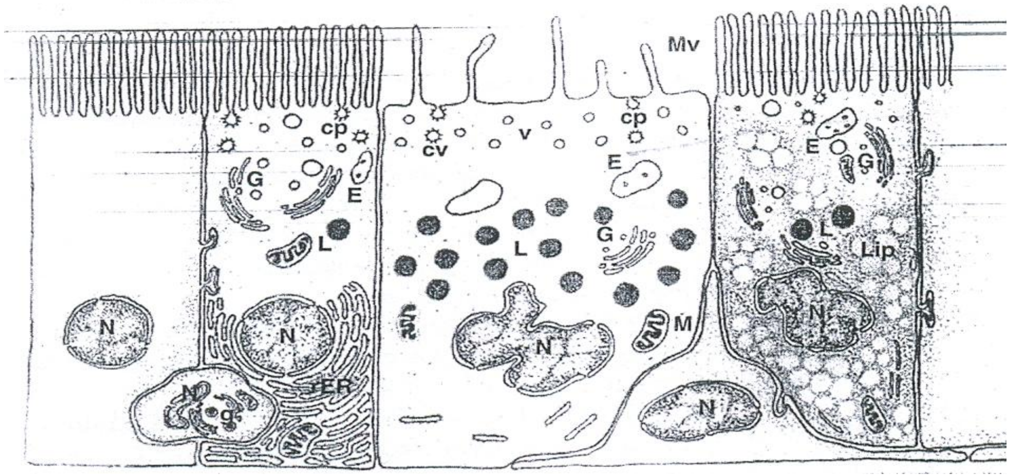


FIG. Schematic representation of a principal cell of the caput epididymidis on the left and a principal cell of the corpus epididymidis on the right, with a clear cell in between, as visualized by the electron microscope. Also represented is a halo cell and a basal cell. Principal cells of both regions contain coated pits (cp), endosomes (E) and lysosomes (L), and an elaborate Golgi apparatus (G). Rough endoplasmic reticulum (rER) occupies the basal region of the principal cell of the caput, whereas numerous lipid droplets (lip) occupy the cytoplasm of the principal cells of the corpus region. The clear cell shows few microvilli (Mv), but numerous coated pits (cp), small apical vesicles (v), endosomes (E), and lysosomes (L), all involved in endocytosis. The halo cell is inserted between adjacent principal cells, is located basally, and contains small dense core granules (g), whereas the basal cell stretches itself along the basement membrane (BM). N, nucleus.

Q6. Describe the process of spermatogenesis and its hormonal regulation. How sertoli and leydig cell interact to maintain the testosterone level?

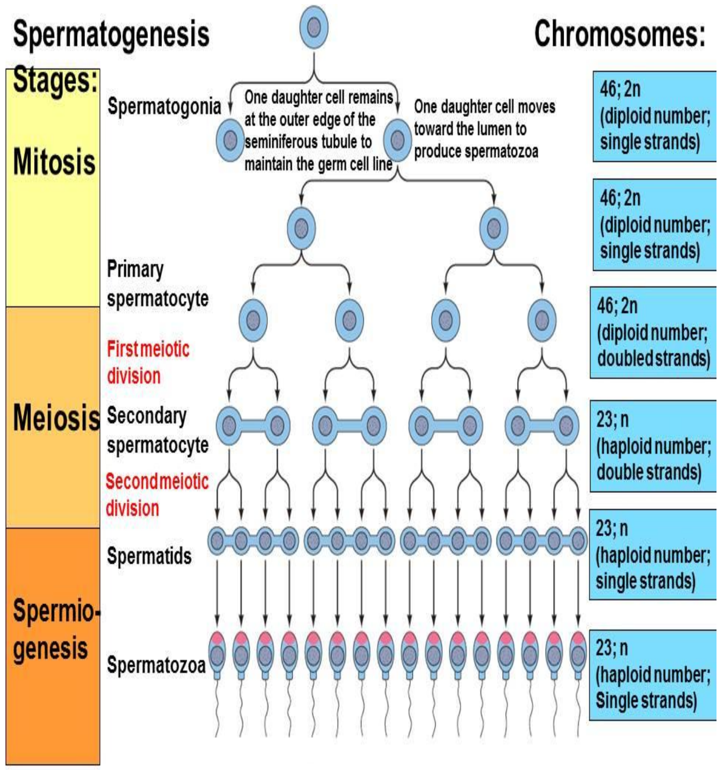
Spermatogenesis: Two important cell types in seminiferous tubules

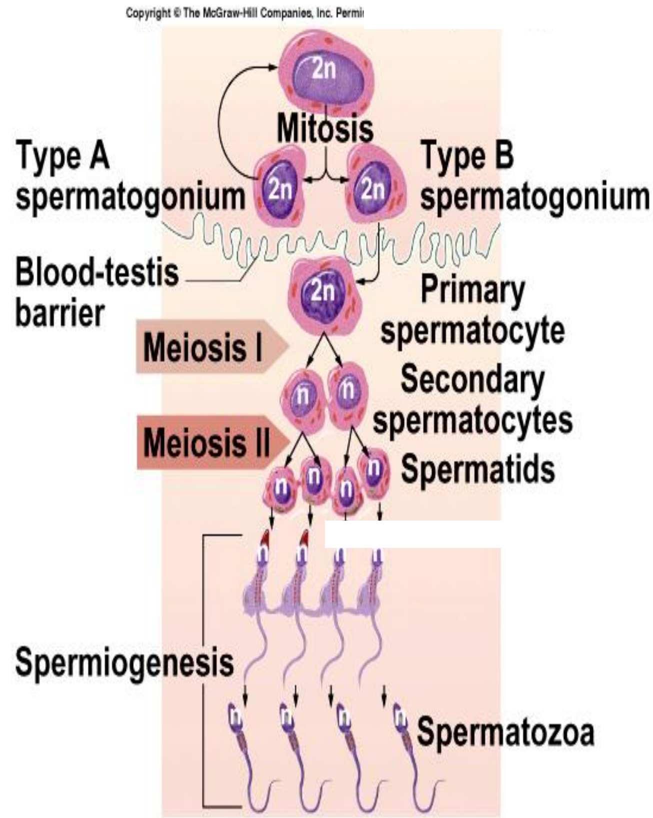
A. Germ cells– In various stages of sperm development, such as spermatogonia, primary spermatocytes, secondary spermatocytes
B. Sustentacular (Sertoli) cells– these cells provide crucial support for spermatogenesis

3. **Three major stages—**
   A. Mitotic proliferation—
   B. Spermatogonia located in the outermost layer of the seminiferous tubule, outside the blood-testis barrier (BTB)
   C. One of the daughter cells (Type A spermatogonium) remain at the outer edge of the tubule. The other daughter cell (Type B spermatogonium) starts moving toward lumen forming 4 identical primary spermatocytes (2N)

Meiosis—Each primary spermatocyte (2N) must pass through BTB (tight junction) and ultimately yield 4 spermatids (1N) **Spermiogenesis—**

- Spermatids become extremely specialized and motile spermatozoa
- Sperm travel lightly





Endocrine Regulation

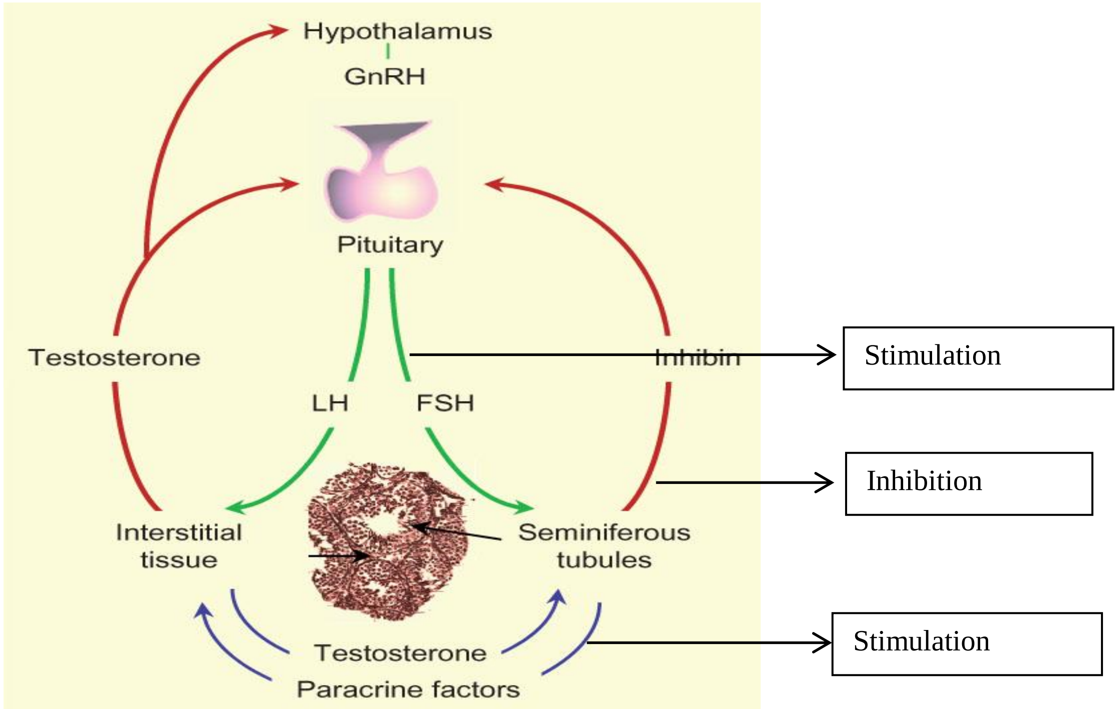
1. Sertoli cells– only cells known to express FSH receptors in human males; also have testosterone receptors
2. FSH, LH, and testosterone all play vital roles in spermatogenesis.
   Mechanism of action by Testosterone

a. **Nuclear receptors-- Testosterone (T)** often converts to 5alpha-dihydrotestosterone before binding to their nuclear receptors

b. **T also may bind to membrane receptors**-- either directly or through the bind of the sex hormone binding globulin

NEGATIVE FEED BACK REGULATORS - HYPOTHATLAMUS - PITUITARY - TESTES

1. Hypothalamus GnRH– stimulates secretion of both LH and FSH
2. Testosterone, which is secreted in response to LH, acts as a feedback regulator of LH.
3. FSH stimulates the Sertoli cells to synthesize and secrete inhibin (glycoprotein), which regulates FSH secretion



Q7. Describe in detail the event occurring during the process of fertilization.

Fertilization is a complex process which involves the fusion of male and female gametes followed by the fusion of their cytoplasm. The process of fertilization has dual independent functions

(i) to cause the egg to start developing ….. ACTIVATION

(ii) to inject a male haploid nucleus into the egg cytoplasm……… AMPHIMIXIS or (intermingling of paternal and maternal heriditary characters in the cytoplasm)

Mechanism of fertilization: It constituted five stages

1. Encounter of spermatozoa and ova

a) External fertilization
(In liquid medium outside the body e g Fishes, amphibians, fresh water invertebrates)
b) Internal Fertilization (In oviparous forms like reptiles, birds where the eggs are completely inside
impermeable membrane, in ovoviviparous and in viviparous

2. **Capacitaion and contact** : the capacity of spermatozoa to fertilize eggs of the same species but

not the other.

Fran Lillie was first to show that this happens under the influence of chaemotaxix where sperm responding tothe specific jelly like chemical substance which surround the egg. This procee consists

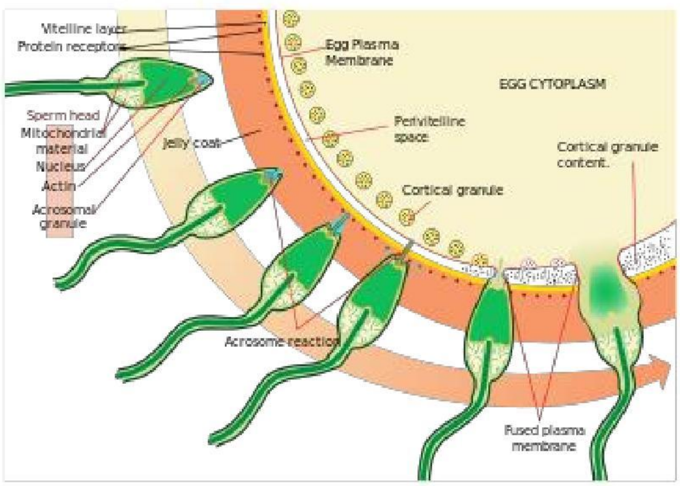
a) Agglitination: The adhesion of spermatozoa or clumping.

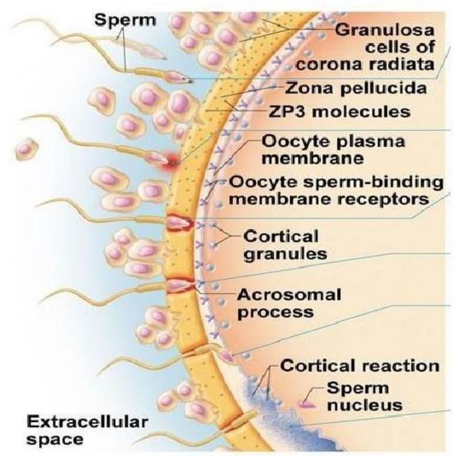
b) Fetilizin-antifertilizin reaction: to block polyspermy

Fertilizin – is mucoplysaccharide or glycoprotein present in egg
Anti-fertilizin in sperms

3) Acrosome reaction and penetration

When the acrosome reaction occurs, a number of proteolytic enzymes are exposed or released. One or more of these enzymes is responsible for digesting the hole through the zona pellucida through which the sperm enters the perivitelline space.



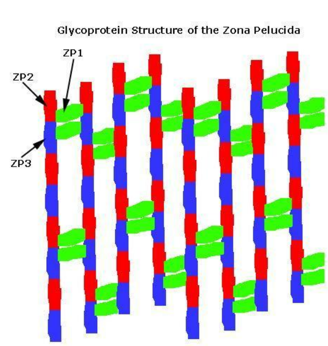


When sperm arrives at zona pellucida with the acrosome still intact. This time the sperm has **hyaluronidase** activity. **Events when the sperm gets to the zona pellucida?**

1. Attachment - loose association
2. Binding - strong attachment
3. Acrosome reaction - release of enzymes
4. Penetration of the zona pellucida by the sperm

Zona pellucida is composed of 3 glycoproteins ZP1, ZP2, ZP3

Repeating subunits of ZP2 and ZP3 form filaments that are bound together by ZP1



4) **Activation of Ovum**. Constitutes <u>seven</u> events

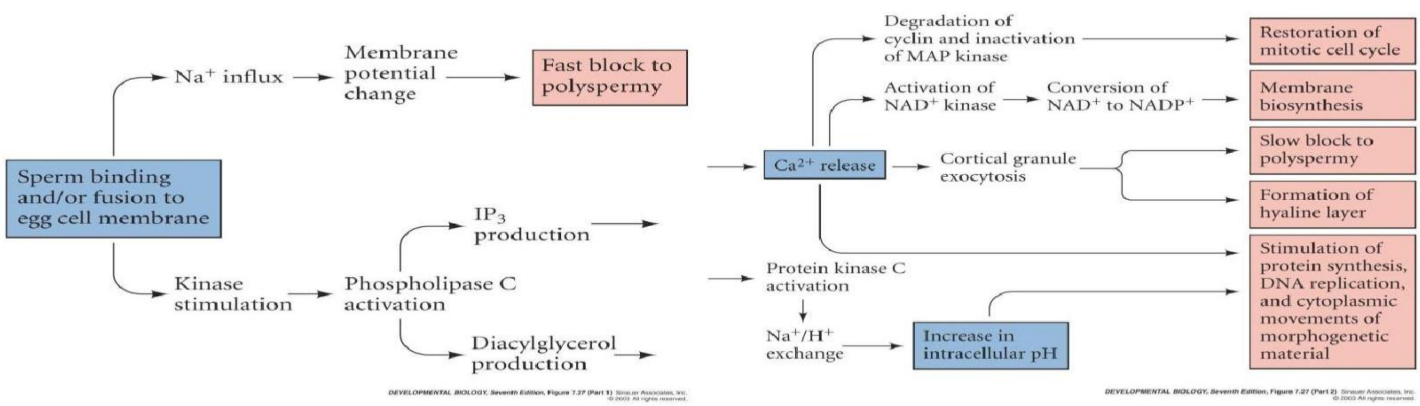
1. **<u>Release of Ca++</u>** (calcium) stored in the egg endoplasmic reticulum a critical step in the process.

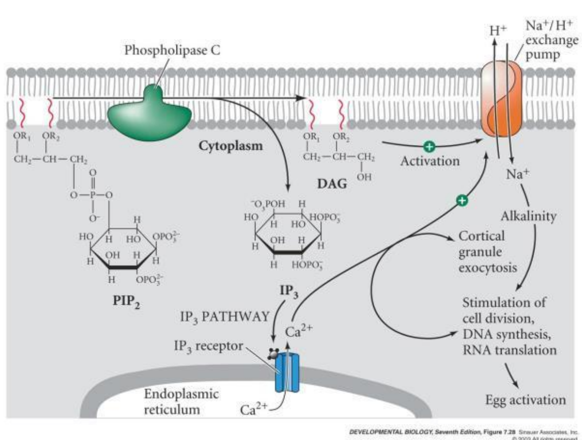
2.**<u>Cortical reaction</u>** - rupture of cortical granules that occurs concurrently with the Ca++ release. Contents of granules are released into perivitelline space and cause "hardening" of the vitelline membrane or zona pellucida. Causes vitelline/fertilization membrane to rise away from surface of egg in <u>some</u> species.

3. A**<u>n influx of Na^+</u> <u>(sodium) into the egg cytoplasm</u>** causes a change in membrane potential - block to polyspermy.
4. In some species a **<u>reorganization of the egg cytoplasm</u>**.
5. In most cases, **<u>completion of meiosis by the egg</u>**.
6. An **<u>efflux of H^+</u> <u>(hydrogen) ions</u>** causing an increase in cytoplasmic pH - this activates previously inhibited synthetic pathways.
7. **<u>Increase in metabolism</u>** - zygote gears up for development

A. B.

Cascade for Egg activation





Signaling Pathway during Egg activation resulting Intracellular Release of Ca^{++}

5) Migration of pronuclei and amphimixis

Events that occur soon <u>after</u> egg activation:

a.DNA replication as male and female pronuclei approach each other b.Male and female pronuclei merge

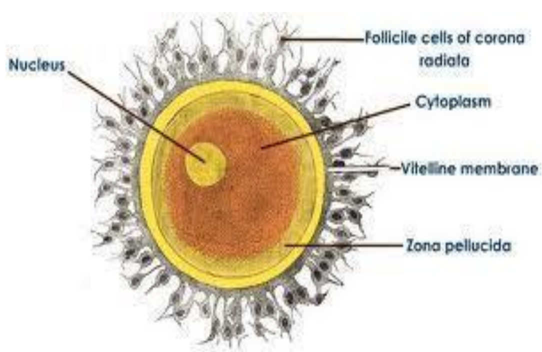
c.Preparation for first cleavage

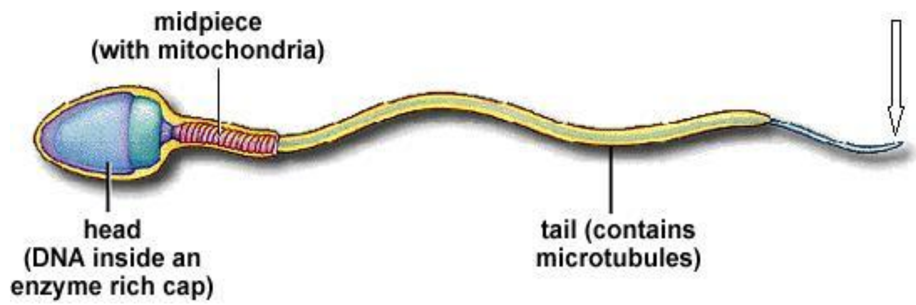
The male nucleus enters the egg cytoplasm and becomes the male pronucleus.

2.As a result of the sperm fusing with the egg plasmalemma, the oocyte nucleus, which is at metaphase of the second meiotic division, completes that division giving rise to another polar body.

3. Following the second meiotic division, what is now the nucleus of the ovum becomes the female pronucleus. 4.The haploid male and female pronuclei move toward one and other, meet, and fuse to form the diploid nucleus of the zygote.

Structure of Gametes





Q8. State and explain about the different copulatory pattern observed in animals

Copulatory Behavior: The union of male and female gametes can take place externally, as it does in many amphibians and fish that release their eggs and sperm into the water, or it can occur internally as it does in mammals, birds, and many fish and insects. Both forms require precisely timed movement patterns to assure that fertilization occurs. This lesson will focus on the copulatory behavior of mammals. We will begin by describing the various movement patterns involved in copulation and how these patterns vary among species. Then we will review ideas concerning the reasons for the enormous variability that exists.

Patterns of Copulation: Male Behavior

The diversity of mammalian copulatory behavior is illustrated by a classification scheme for the copulatory behavior of male mammals developed by Donald Dewsbury of the University of Florida.

The classification is based on four features that are either present or absent in copulatory behavior, resulting in **sixteen categories of behavior devided in four different stages**. They are:

(1) Lock: Some species, such as domestic dogs, exhibit a vaginal lock following ejaculation. The penis swells, making withdrawal difficult or impossible.

(2) Thrusting: In some species, such as humans, the penis is repetitively thrust back and forth in the vagina. In others, there is no intra-vaginal thrusting.

(3) Intromission frequency: In some mammals, such as rats, the male mounts the female, intromits the penis into the vagina, and then quickly dismounts. Rats must intromit several times before an ejaculation can occur. Other species need intromit only once.

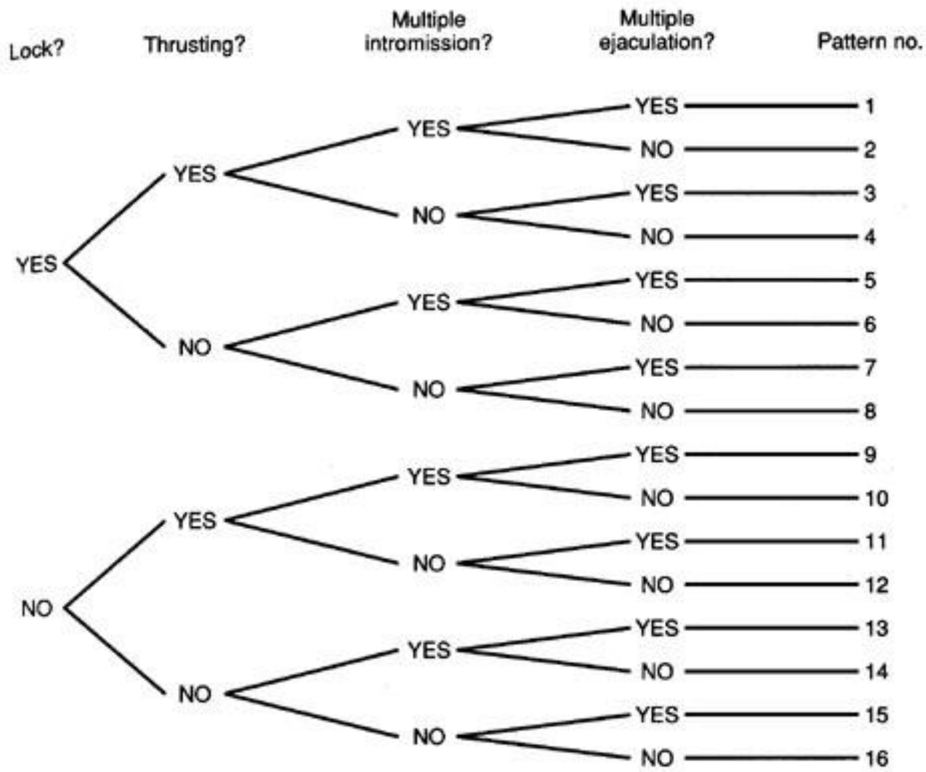
(4) Ejaculation frequency: In some species, such as baboons, the male typically ejaculates several times per copulation episode. Others usually ejaculate only once.

Each species is classified according to its performance on each of the four variables. Although eleven of the sixteen possible categories have been discovered in at least one species, even closely related species may fit into different slots in this system. For example, seven of the sixteen categories were found in a survey of thirty-one species of small rodents. Primates are less diverse than rodents in their copulatory patterns, with only three of the sixteen patterns known so far. Why these species differences exist is not yet known. No ecological correlation of any note has been discovered, and the finding that there is no evolutionary pattern makes the whole thing even more puzzling. Obviously, more data are necessary to enlighten this issue.

Female Behavior

The classification of female mammal copulatory behavior is not as far advanced. Studies of female copulation have emphasized the behaviors used by females to initiate copulation and the female's postures and movements during mounting and intromission. There are species-typical patterns in all these behaviors, but the classification has been applied only to rodent species. Not surprisingly, female behavior patterns complement those of males, so there are species differences in female patterns that parallel those of males. Much more information is needed on female behavior and on the coordination of the interaction of male and female during copulation.

Orgasm is a component of female copulatory behavior that has often been thought to occur only in humans. Recent evidence, however, establishes the existence of female orgasm, at least in non-human primates, although the physiological details vary among species.



Quantitative Differences in Copulatory Behavior

Species that fall in the same pattern category often differ quantitatively in their behavior. For example, the number of intromissions per ejaculation may vary, the average amount of time that elapses between intromissions or ejaculations may differ, and so on. For example, although hamsters and rats display pattern 9 (no lock, thrusting, multiple intromissions, and multiple ejaculations), in hamsters the average amount of time between mounts with intromission is about ten seconds or less, but in rats this interval is about fifty to 100 seconds. Furthermore, the duration of both intromission-only mounts and ejaculatory mounts is much longer in hamsters than in rats.

The existence of many different copulatory patterns and so much variation in the quantitative aspects of copulation cry out for an explanation. However, copulation looks more like some complex dance, carefully timed and choreographed. Why?

One explanation has emphasized some basic processes of female reproductive physiology, especially ovulation and implantation. Most mammalian species release eggs (ovulate) spontaneously; that is, hormonal changes in the female lead to ovulation even if copulation has not occurred. Humans and rats are spontaneous ovulators. Other species are induced ovulators, releasing eggs only if copulation has taken place. This is due to the tactile stimulation associated with copulation, specifically that applied to the vagina by the penis. Thus, ovulation occurs only when there is a high likelihood of fertilization occurring. Rabbits, cats, and some rodents are induced ovulators.

Another way that copulation facilitates pregnancy is to prepare the uterus for implantation of the fertilized ova. For example, in the absence of the usual copulatory pattern, female rats will slough off fertilized ova.

This is because the tactile stimulation provided by intromission triggers hormonal changes required for implantation.

Other hypotheses for the existence of complex copulation suggest that the precise details of copulation are linked to other aspects of the physiology of the female reproductive system. For example, sperm motility in the female reproductive tract of rats is slowed if intromissions are not adequately spaced in time. As another example, hamsters (which have multiple intromissions and multiple ejaculations) require at least four "ejaculatory series" (a series includes the intromission with ejaculation plus all the intromission-only mounts that preceded it) in order for pregnancy to result with high probability. Additional series do not increase the probability of pregnancy occurring, nor do they increase the number of pups in the litter.

Quantitative differences in copulation may foster reproductive success in other ways. For instance, male hamsters that engage in more than five ejaculatory series sire more offspring by that female than do other males that may mate with her later. If the first male does not achieve at least five ejaculations, the second male will have equal or even greater reproductive success than the first male. Thus, the probability of a female copulating with more than one male while she is receptive may explain why species differ with respect to number of ejaculations.

Taken together, observations such as the ones above suggest that female reproductive physiology exerts considerable pressure on males to copulate properly. If he does not mount and dismount on the proper schedule, if he thrusts too many times or not enough times, or if he does not ejaculate often enough, his sperm will not fertilize as many eggs (or none at all) as they would if he had done everything properly. In other words, what may be going on in mammals is a phenomenon known as **cryptic sexual selection**.

The main point of cryptic sexual selection is to emphasize that females can still choose among males even after copulation has taken place. ("Choose" is used here merely for convenience. We can not get inside the mind of a peahen or rat, but we can observe that some males fail to father offspring (or father fewer than one might expect) even after they have copulated, so in a sense, females may be choosing internally even after they have chosen in a more obvious way.) For example, are female hamsters exerting a choice on males by "requiring" at least four ejaculations before conception can take place? Perhaps males that are not vigorous enough can not perform at that level. If he can not maintain the necessary timing of mounts and ejaculations, maybe he is not good enough for her to risk investing the considerable amounts of time and energy that are necessary to bring along a litter of pups. Maybe females just can not tell enough about male quality to make these choices and need this final performance evaluation before they make this big commitment.To summarize briefly, the great variability in the copulatory patterns and quantitative variations on those patterns that exist among mammals may be due to cryptic sexual selection exerted by females. Ovulation may not be triggered or fertilized eggs may not implant into the uterine wall unless the male copulates properly. Or the female may avoid using the sperm of males that do not copulate properly. These are fascinating possibilities that are just now beginning to be explored.

Excessive Sex by Females

Another type of quantitative difference in copulation is just beginning to receive attention. Females may copulate more often with one male or may copulate with more males than would seem to be necessary to become fertilized. After all, why would more than one copulation be needed when millions of sperm can be released in each ejaculation? One possibility is that extra copulations by females may be advantageous because the male with whom a female copulates may be temporarily low on sperm because of previous copulations, and because many sperm are defective or have low motility.

Another hypothesis is that males are more tolerant toward young who are born to females with whom they have copulated. In essence, if a male **could** be the father, he does not mistreat the young. Females who copulate with multiple males may gain by switching off the offspring-destructive tendencies of some males. Both these ideas may, of course, be true of some species but not others. More information will need to be collected before these hypotheses can be thoroughly tested.

Other Functions of Copulation

The relationship between copulatory behavior patterns and female reproductive physiology should suggest that the function of copulation is not solely to place sperm into the female reproductive tract. Let's review some additional functions.

Mate Recognition

A fascinating and apparently unusual effect of copulation is to activate an olfactory recognition system in the female. Female mice that had just been mated were placed alone in a cage that contained the odor of a male of the same strain as the stud, or the odor of a different strain. The female was left there for forty-eight hours and then moved to another cage that housed the stud or a male of the other strain. Pregnancy blockage occurred in those females that were placed with a male of the strain other than the one to whose odor they had been exposed after mating. Usually this would be the stud male and the appearance of a stranger male would induce the pregnancy block. Early curtailment of pregnancy under such circumstances is adaptive to the female because the "new" male will most likely kill her pups. Males are far less likely to kill a female’s offspring if they have recently mated with her.

Male Parental Investment

In addition to sperm, males sometimes contribute other substances of reproductive consequence. For example, spermatophores (packets of sperm) of male butterflies contain nutrients that appear in the female's eggs. The same is true in the Mormon cricket. Copulation in these species is not only a sexual act, but a parental one as well.

Reducing Reproductive Competition

Female reproductive output is a resource for which males compete. Males who succeed, by whatever means, in acquiring more than an average amount of reproductive success will leave copies of those genes that contributed to that success. Competition for females may occur before mating takes place, a familiar phenomenon, but it may also occur during copulation itself. There are several ways that this may work.

First, copulation in some species involves the male removing sperm that may already be present in the female. In some damselflies (related to dragonflies) the penis is shaped in a way that allows the male to "rake" out sperm from the female's sperm-storage pouches. The last male to copulate with a female has the advantage, and males often guard females following copulation to prevent other males from removing their sperm.

Second, male semen may harden in the female's reproductive tract, forming a plug that impedes the movement of sperm of males who may copulate later with that female. These plugs have been found in snakes, ground squirrels, and other species.

Finally, males may deposit a pheromone (a chemical communication signal) that has an "anti-aphrodisiac" effect on other males. This appears to be the case in garter snakes, some moths, and others.

In conclusion, copulation often does much more than merely get sperm and eggs together. These additional functions may set the selective conditions favoring one copulatory pattern over another, or some quantitative variant over another. Perhaps these functions, which are not widely understood, will provide the keys to understanding the variety that exists in the copulatory patterns of mammals.