**ANIQUEST**

**REPRODUCTIVE PHYSIOLOGY**

1. **MALE REPRODUCTIVE SYSTEM**
2. **Terminologies:**
* **Embryonic kidney** – mesonephros
* **Mullerian inhibiting substance (MIS)** - a glycoprotein, is responsible for the suppression of the paramesonephric (Mullerian) ducts from which the uterus and vagina develop
* **Puberty**: occurrence of the first oestrus or the first ovulation or when the female becomes sexually mature and able to reproduce is referred to as puberty.
* **Gonadostat theory**: At puberty, the threshold level of oestradiol is lowered following the pituitary response.
* **Gubernaculum testis** - The inguinal ligament of the gonad is often called as the Gubernaculum testis.
* **Cryptorchid**: A testis that fails to descend to the scrotum is called a cryptorchid testis and animals with such a condition are called a cryptorchid (testicond)
* **Sertoli cell** - (sustentacular cell) provides a “nurse” function for developing spermatozoa
* **Blood-testis barrier** – formed by a tight junction between adjacent Sertoli cells that permits control of the environment within the tubule and also prevents spermatozoa from entering the interstitium
* **Epididymis** - collection and storage tubule for the testis
* **Ductus deferens (vas deferens)**- is the continuation of the duct system from the tail of the epididymis to the pelvic urethra.
* **Gubernaculum testis**-fibrous connection to the scrotum and un-descended testes are within the abdomen but outside the peritoneum during embryonic development
* **Semen**: It is the liquid or semi-gelatinous cellular suspension containing the male gametes
* **Acrosome**: The anterior end of the sperm nucleus is covered by the acrosome, a thin double–layered membranous sac that is closely applied to the nucleus during the last stages of sperm formation.
* **Axoneme**: 9+2 arrangement of microtubules is responsible for sperm motility
* **Acrosomal hydrolytic enzymes**: acrosin, hyaluronidase, estrases, and acid hydrolases.
* **Spermatogenesis:** is defined as the process by which the spermatogonia undergo a series of cell divisions followed by a metamorphosis resulting in the production of highly differentiated and potentially motile cells called spermatozoa.
* Spermatogenesis takes place in two phases: spermatocytogenesis and spermiogenesis
* **Spermiogenesis:** The transformation of round, nonmotile spermatids into potential spermatozoa by a series of progressive morphologic changes is called spermiogenesis.
* **Spermiation**: The release of formed germ cells into the lumen of the seminiferous tubules is known as spermiation.
* **Spermatogenic cycle**: If a single cross-section of a seminiferous tubule is viewed continuously, a series of cell associations would be seen until the original cell association reappears. This cycle of developing cells is known as the spermatogenic cycle or cycle of seminiferous epithelium.
* **Spermatogenic wave**: This sequential change in the stage of the cycle along the length of the tubule is known as the wave of spermatogenesis.
* **Capacitation**: physicochemical changes after they are deposited in the female reproductive tract to acquire the ability to penetrate the zona pellucida and fertilize the ova.
1. **Refresher points:**
* 16 primary spermatocytes could be produced from one A 3 spermatogonium.
* 64 spermatids can be potentially produced in one A 3 spermatogonium.
* Spermatocytogenesis from spermatogonia to spermatid takes approximately 45 days in the bull.
* **The spermatogenic cycle** for;
* Pig – 8 days
* Sheep – 10 days
* Cattle – 14 days
* Human – 16 days
* The spermatogenesis is approximately 4 times the duration of the spermatogenic cycle.
	+ - The Sertoli cells divide the seminiferous tubules into two compartments;
1. The basal compartment
2. The adluminal compartment
* **Basal compartment –** has communication with interstitial fluid and provides space for germinal epithelial cells.
* **Adluminal compartment**- space between Sertoli cells that communicates centrally with the lumen of the tubule.
* The spermatozoa transport through the epididymis requires about – 7 days in the bull and 16 days in the ram.

**Daily sperm production (DSP) per gram of testis;**

* Bull - 13 – 19 million
* Ram - 24 – 27 million
* Boar - 24 – 31 million
* Stallion - 23.7 – 32.3 million

**Times taken for sperm to reach the oviduct;**

* Bitch - 20 min
* Mare - 15 min
* Ewe - 8 min
* Cow - 2-4 min

**Scrotum Descent of testes into scrotum Timing:** Sheep/cattle = midgestation, Humans/horses = just before or after birth.

**Spermatozoa retain their fertilizing capacity in the female tract for;**

* Cow, Ewe and Sow- 24-48 hrs
* Bitch - 90 hrs
* Mare -5 days

**The fertile life of ovulated ova in domestic animals**;

* Cow = 20 - 24 hours
* Horse = 6 – 8 hours
* Sheep = 16 – 24 hours
* Swine = 8 – 10 hours
* **Testicular temperature is 4 to 7°C cooler than core body temperature.**

**Table: 1 Sperm reservoir sites in different animals;**

|  |  |  |
| --- | --- | --- |
| Sl. no. |  Species | Sites |
| 1 |  Cattle | Cervical crypts  |
| 2 |  Mare  | Uterotubal junction |
| 3 |  Sow  | Uterotubal junction |
| 4 |  Bitch  | Endometrial glands. |

**Table 2: Age of puberty in females of domestic species;**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No. | Species  | female (in months) |  male (in months) |
| 1  | Cattle | 6-10 | 9-10 |
| 2 | Sheep |  4-15 | 6-8 |
| 3 | Goat | 4-15 | 5-9  |
| 4 | Horse | 12-18 | 12-18 |
| 5 | Pig |  6-8 | 5-8 |
| 6 | Dog | 6-7 | 5-12 |
| 7 | Cat | 5-9 | 9-12 |

**Table 3: Homologies of male and female reproductive systems;**

|  |  |  |  |
| --- | --- | --- | --- |
| Sl. No.  | Indifferent  | Male  | Female  |
| 1 | Mesonephric duct | Epididymis | Gartner’s duct |
| 2 | Mullerian duct | Appendage of testis | Fimbria of oviduct, oviduct, uterus, vagina |
| 3 | Urogenital sinus | Bulbourethral glands, Prostate gland, Prostate galnd | Urethra, vestibule, vagina |
| 4 | Genital tubercle | Glans penis, Corpus penis | Clitoris |
| 5 | Urethral folds | Raphe of scrotum and penis | Labia minora |
| 6 | Labioscrotal swellings | Scrotum | Labia majora |

1. **Female reproduction**
2. **Terminologies;**
* **Primordial follicle or primary follicle:** Consists of an oocyte surrounded by a single layer of epithelial flattened granulosa cells with irregularly shaped nuclei.
* **Growing follicle**: Follicles that have left the resting stage as primordial follicles have begun growth but have not developed a theca layer or antrum (cavity).
* **Graafian follicle**: These are follicles in which an antrum (cavity) is visible
* **Fertilization:** is the fusion of the male and female gametes to form a one single cell. i.e, to have a diploid number of chromosomes. Fertilization is the union of viable ovum and sperm.
* **Follicular wave**: Three to six follicles are initiated to grow together under the influence of increasing levels of FSH which is described as a follicular wave.
* **Ovulation**: It is a mechanism by which the ovum is released from mature graffian follicle in response to LH surge
* **Estrous cycle**: In all domestic animals that have attained puberty there is a definite physiological functional rhythm of the reproductive system called the estrous cycle.
* **Estrus**: It is the period of sexual receptivity during which mating and ovulation occur in most species and the corpus luteum begins to form.
* **Monoestrus** - animals have only one estrous cycle per year –dogs, wolves, bears
* **Polyestrus** - animals have several estrous cycles per year-cattle, pigs, humans; Cows and sows - non-seasonally polyestrus animals.
* **Seasonal breeders** - animals that have one or more estrous cycles during certain periods of the year.
* **Seasonally polyestrous animals** (exhibit many cycles of estrous during certain periods of the year known as breeding season) - ewes, does, and mares.
* **Follicular phase** – also known as proliferative or oestrogenic phase - oocyte matures, ovulation occurs, estradiol from the follicle is dominant - includes proestrus and estrus phases.
* **Luteal phase (secretory phase**) – Corpus luteum forms, fertilization, and embryo development, progesterone from the CL is dominant - includes metestrus and diestrus.
* **Whitten effect**: When a male mouse is introduced into a group of female mice, it causes synchronization of estrus in females of that group and this effect is called the Whitten effect.
* **Bruce effect**: If a pregnant female mouse is placed in a cage with a strange male mouse, pregnancy fails. This effect is known as the Bruce effect.
* **Lee Boot Effect**: Abrupt exposure of females to a male nearing the time of puberty advances the onset of puberty or breeding season. This is known as the Lee Boot Effect.
* **Ram or Boar effect**: female sheep or sow exposure to a male of the same species will advance the timing of the onset of puberty mediated through pheromonal and other sensory cues influencing hypothalamic GnRH secretion.
* **Pseudopregnancy or false pregnancy**: can be defined as an exaggerated diestral response in bitch and rodents.
* **Morula**: Most species form a morula at approximately 16 to 32 cells.
* **Blastocyst:** Morula having a fluid-filled cavity (blastocoele) is referred to as blastocyst.
* **Maternal Recognition of Pregnancy**: At the appropriate time, the conceptus must produce some substances (protein/ steroid) to signal its presence to the mother called MRP.
* **Implantation**: It is the process whereby the new embryo becomes established at a developmental site on the endometrium to develop into a fetus.
* **Zona hatching**: In 6-11 days after fertilization, the zona pellucida breaks down and releases the embryo which is referred to as "zona hatching"
1. **Refresher points:**
* The monotocous animal (cow, ewe, and mare) has an ovoid-shaped ovary.
* Polytocous animal (sow, bitch, or cat) ovary appears as a cluster of grapes.
* The mare has a kidney-shaped ovary.
* **Non-seasonal polycyclic animals** – Cow & Sow
* **Seasonally polycyclic animals** - Mare, Ewe, Doe & Cat
* **Monocyclic animals** – Bitch
* Cow, Ewe and Mare: Bipartite uterus
* Sow: Bicornuate uterus
* Primates: Simplex uterus
* In domestic animals (except bicth and Queen), oogonia develops into a primary oocyte shortly before or after birth.
* Ovulation occurs during the oestrus phase of the cycle in all domestic species except the Cow Where it occurs about 12 hours after the end of estrus.
* **Site of fertilization**: ampullary–isthmic junction of the oviduct .
* **Short-day breeders** – estrous cycle occurs when days are getting shorter (in winter) e.g., sheep, goats, deer; anestrus in spring and summer
* **Long-day breeders** – Estrous cycle occur when days are getting longer (spring/early summer) - horses and hamsters; anestrus in winter.
* **Seasonally monoestrus** (exhibit a single estrus followed by anestrus) – bitches.
* Estradiol 17 β – predominates in nonpregnant animals.
* Estrone – predominates in pregnant animals.
* Estriol – predominates in pregnant primates.
* Zona hatching – cattle 9-11 days, horse-8; sheep-7-8 and swine in 6 days after fertilization.
* Young animals have slightly shorter gestation lengths than older ones.
* Monotoccus animals have longer gestation lengths than polytoccus animals.
* A male fetus will be carried a few days (1-2 days) longer than a female fetus.
* Larger size species having longer gestation length.

**Types of placentation;**

* **Epitheliochorial placentation:** It is the simplest form of placentation; it consists of all six layers. Epithelium of the uterus has direct contact with the chorion of the fetal placenta Eg: Sow, Mare, Cow, and donkey.
* **Syndesmochorial:** It involves the loss of one of six layers - the epithelial lining of the uterus. In the fetal structure, the chorion forms direct contact with the connective tissue and the endothelium of the carnivores of the dam. Eg: Ewe and doe.
* **Endotheliochorial**: Two layers, the connective tissue and the epithelium of the uterus are lost, while the endothelium of blood vessels of the dam directly attaches with the fetal structure Eg. Bitch and Queen.
* **Hemochorial**: All three layers of the maternal tissues are lost, and only three of the fetal structures are left; the chorion (trophoblast), is bathed by the blood of the dam Eg: Monkey, Women.
* **Hemoendothelial:** Only one tissue layer, the endothelial layer of the fetal capillaries separates the maternal and fetal blood systems Eg: Guinea pig, rabbit, and rat.
* **Diffuse**: Chorionic villi cover most of the fetal placenta, project into the crypts, scattered over the entire endometrium of the uterus except at the openings of the uterine glands. Eg: Sow, mare.
* **Discoid or Spherical**: The placenta gets attached to the uterus in a disk-shaped area only Eg: Guinea pigs, Rabbits, and rats.
* **Zonary**: The chorion of the fetal placenta is attached in a grill-like band with the uterus of the dam. Eg: Bitch and Queen.
* **Cotyledonary**: Here the attachment of the portion of the chorion of the fetus (Cotyledons) with the uterine epithelium of the dam in a mushroom-like area is called the caruncles. Eg: Ewe, Doe, Cow, and Buffalo.

**PH of the female reproductive tract;**

* Vaginal PH - is acidic 4.0
* Cervical mucus – is basic 8.4
* Uterus - intermediate 7.8
* Oviductal fluid – 7.1 to 7.3 in the follicular phase

 - 7.5 to 7.8 in the luteal phase

**Transport time of ova in the oviduct;**

* Cattle - 90 hrs
* Sheep – 72 hrs
* Horse - 98 hrs
* Pig - 50 hrs
* Cat - 148 hrs
* Dog - 168 hrs
* Women - 48 to 72 hrs

**Regression of corpus luteum starts (days from ovulation);**

* Cow – 14 – 15
* Ewe – 12 – 14
* Sow – 13
* Mare - 17

**Table: Estrus period and ovulation time in different animals;**

|  |  |  |  |
| --- | --- | --- | --- |
| **Species** | **Duration of the estrous cycle (in days)** | **Duration of estrus** | **Time of Ovulation** |
| Ewe | 16-17 | 24 hrs | After the onset of estrus |
| Doe | 20-21 | 24 – 36 hrs | After the onset of estrus |
| Pig | 19-21 | 38 – 42 hrs | After the onset of estrus |
| Mare | 19-25 (21) | 4-8days | Before the end of the estrus |
| Cat | In estrus at 7-8 m intervals | 24 – 36 hrs | Post copulation |
| Cow | 21-22 | 12 – 14 hrs | After the end of estrus |
| Bitch | In estrus at 7-8 m intervals | 7-9 days | Post copulation |

**Table: Signs of estrus in different species;**

|  |  |
| --- | --- |
| **Species** | **SIGNS OF ESTRUS** |
| Cow | Bellowing, mounting, Cervical mucus discharge, Frequent urination, Swollenvulva, Reduced milk yield, and Reduced feed intake. |
| Mare | Frequent urination, Exposure of clitoris (winking of clitoris). |
| Doe | Edema and hyperemia of the vulva, Frequent and rapid tail wagging. |
| Sow | Watery vulval discharge, standing quietly while pressing loin (lordosis) |
| Bitch | During proestrus, bleeding from the vulva and vulva swelling; during estrus-diminishing of vulval swelling, Less turgid vagina. |
| Queen | Characteristic call and Rollover on its back. |

**Table: Maternal Recognition of Pregnancy;**

|  |  |  |
| --- | --- | --- |
| **Species** | **MRP days** | **MRP Signal** |
| Cow | 16 -19 days of pregnancy | Bovine trophoblast protein bTP-1 |
| Sheep | 16-19 days of pregnancy | OTP -1 or Type I conceptus interferon |
| Pigs | 11-12 days of pregnancy | Estrogen |

**Table: Gestation length and days of implantation in different animals;**

|  |  |  |
| --- | --- | --- |
| **Species** | **Days of implantation** | **Gestation length** |
| Cow | 30 – 35 days | 280 days |
| Doe | 20 - 25 days | 150 days |
| Ewe | 15 – 18 days | 150 days |
| Sow | 14 - 20 days | 114 days |
| Bitch | 15 days | 60 – 63 days |
| Queen | 13 days | 56 - 65 days |

**Table: reproductive hormone and their functions;**

|  |  |  |
| --- | --- | --- |
| **Sl. No.** | **Hormones** | **functions** |
| 1 | Melatonin | * Control the reproduction in seasonal breeding species
* Influencing the release of FSH, LH, Prolactin
* Onset of puberty
 |
| 2 | Serotonin | * Inhibits the basal secretion of LH and regulates other neurosecretory systems
 |
| 3 | Noradrenaline (Norepinephrine) | * Stimulate the release of FSH & LH
* Inhibition of the conversion of dopamine to noradrenaline,
* Blocks the oestradiol–induced release of LH, which is responsible for ovulation.
 |
| 4 | Dopamine | * Control of prolactin release
 |
| 56 | LH | * Stimulate Leydig cells
* Stimulate testosterone production
* Responsible for ovulation and formation of CL
 |
| 7 | FSH | * Stimulates Sertoli cells
* Stimulates secretion of estrogen and inhibin
 |
| 8 | Testosterone | * Maintains spermatogenesis - Supports meiosis
* Develops and maintains secondary male sexual characteristics
* Anabolic hormone
 |
| 9 | C-16 unsaturated androgens - 5α-androstenone | * Primarily in the boar acts as a pheromone in saliva and urine
* Responsible for boar taint
 |
| 10 | Inhibin & oestradiol | * Act in concert in suppressing FSH secretion
 |
| 11 | Oocyte maturation inhibitor | * Maintains oocyte at dictyate stage of meiosis.
 |
| 12 | Estradiol | * Estradiol is responsible for the secondary sex characteristic of the female
* It causes the growth of the duct system of the mammary gland
* It stops the growth of long bones by initiating the closure of the epiphyseal growth plate
 |
| 13 | Relaxin | * Dilation of pelvic structure, cervix, and vagina before parturition
 |
| 14 | Activin | * Present in the follicular fluid and rete testis fluid and have a stimulatory effect on FSH release
 |
| 15 | Progesterone | * Prepares the endometrium for implantation and maintenance of pregnancy by increasing the activity of the secretory glands in the endometrium and by inhibiting the motility of the myometrium.
* Acts synergistically with estrogen to induce behavioral signs of estrus.
* Responsible for lobular and alveolar growth in the mammary gland.
 |

**QUESTIONS**

1. Accessory sex gland discharges their content into;
2. Ductus deference only
3. Pelvic portion of urethra only
4. **Ductus deference or Pelvic portion of the urethra**
5. none
6. Scrotal hernia is particularly common in;
7. **Boar**
8. Stallion
9. Bull
10. Buck
11. Which of the following is true for cryptorchid males;
12. **They are sterile but show normal sexual desire**
13. They are fertile but don’t normally show sexual desire
14. They are fertile and show normal sexual desire
15. They are sterile and also don’t normally show sexual desire
16. Glyceryl phosphorylcholine is a distinctive component of;
17. Vesicular gland
18. **Epididymal secretion**
19. Prostate secretion
20. None of the above
21. Which of the following statements is true;
22. Ejaculation consists of movement of the spermatic fluid along the deferens to the pelvic urethra where it is mixed with the secretion of accessory sex glands
23. Emission is passage of semen along the penile urethra
24. **Emission brought about by smooth muscle under autonomic control**
25. Ejaculation brought about by para-sympathetic nerve action on smooth muscle
26. The CL of pregnancy is known as the;
27. **Corpus luteum verum**
28. Corpus luteum spurium
29. Corpus albicans
30. All of the above
31. Maternal recognition of pregnancy in cattle occurs between days;
32. 20-25 days of gestation
33. 10-15 days of gestation
34. **15-17 days of gestation**
35. 25-30 days of gestation
36. In which of the following species there is a presence of a definite ovulation fossa, and indentation in the attached border of the ovary;

a) Cattle

b) Buffaloes

c) Dog

d) **Horse**

1. There is an obligatory requirement for continued secretory activity of the CL throughout pregnancy because the placenta does not secrete progesterone in these species;

 a) Cattle

b) Buffaloes

c) Dog

d) **Horse**

1. In swine, the uterus is of the;
2. **Bicornuate type (uterus bicornis)**
3. Bipartite type
4. Both Bicornuate and Bipartite
5. None
6. Which of the following is not a function of the uterus;
7. Sperm transport from the site of ejaculation to the site of fertilization in the oviduct
8. Regulation of the function of the CL
9. Initiation of implantation, pregnancy and parturition
10. **It may play a role in the selection of viable sperm, thus preventing the transport of nonviable and defective sperm.**
11. Which hormone is responsible for the Stimulates contraction of pregnancy and also causes milk ejection;
12. Prolactin (PRL)
13. **Oxytocin**
14. Luteinizing hormone (LH)
15. Both a and b
16. Which of the following is not a function of Progesterone;
17. Acts synergistically with estrogen to induce behavioural oestrus
18. Develops the secretory tissue (alveoli) of the mammary glands
19. **Physical development of female secondary sexual characteristics**
20. Inhibits oestrus and the ovulatory surge of LH at high levels
21. In normal breeding conditions puberty occurs at the age of about …………….in sheep, goats, and swine; &…………… in cattle;
22. **6 to 7 months &12 months**
23. 10-12 months & 24 months
24. 6 to 7 months & 24 months
25. 12 months &12 months
26. Which species has the shortest length of estrous cycle in days;
27. **Ewe**
28. Goat
29. Cow
30. Horse
31. Which species has the longest duration of estrous in days;
32. Ewe
33. Goat
34. Cow
35. **Horse**
36. Dairy cattle reach puberty when the body weight is about;
37. 25% to 30% of the adult weight
38. **30% to 40% of the adult weight**
39. 45% to 55% of the adult weight
40. > than 55% of the adult weight
41. The maturation phase, whereby spermatids undergo nuclear and cytoplasmic changes is known as;
42. Spermatidosis
43. Spermiation
44. Spermatogenesis
45. **Spermiogenesis**
46. Fertilizing ability of spermatozoa can be achieved by;
47. Changes in the nature of surface plasma membrane
48. Changes in the nuclear chromatin
49. Unidirectional progressive motility
50. **All of the above**
51. The exclusive supply is the artery of the penis;
52. **Terminal branch of the internal pudendal arteries**
53. Terminal branch of the external pudendal arteries
54. Abdominal artery
55. None of the above
56. The no. of sperms intended for artificial insemination in cattle and sheep;
57. 125 and 10 million respectively
58. **10 and 125 million respectively**
59. 100 and 125 million respectively
60. 80 and 200 million respectively
61. Prostaglandins aid in fertilization by;
62. It reacts with cervical mucus and make it more receptive to sperm
63. Prostaglandins cause smooth muscle contraction
64. **Both a and b**
65. None of the above
66. Cryptorchid testes are;
67. Testis is in inguinal canal but not in the scrotum
68. **More prevalent in horse and pig**
69. Both a and b
70. None of the above
71. Beef cattle reach puberty when the body weight is about;
72. 25% to 30% of the adult weight
73. 30% to 40% of the adult weight
74. **45% to 55% of the adult weight**
75. > than 55% of the adult weight
76. Which of the following statement false for breeding season in animals;
77. wild animals have well defined breeding season when both sexes have sexual activity
78. Cattle and swine exhibit no seasonality of breeding
79. sheep, goats, and horses have a breeding season
80. **In horse estrous occurs regularly throughout the year, and seasonality is discrete**
81. Domestic animals with long day and shortday breeding are;
82. Mare & Sow respectively
83. **Mare & Ewe respectively**
84. Ewe & Mare respectively
85. Sow &Mare respectively
86. Freezing point depression of bull semen is;

a) 1ºC

b) -0.75 ºC

c) -0.65 ºC

d) **-0.55 ºC**

1. High content of ergotheonine and inositol in vesicular gland is characteristic of which species;
2. Bull
3. **Boar**
4. Buck
5. stallion
6. Urethral gland is found in;
7. Horse
8. Cattle
9. **Humans**
10. Sheep
11. The primordial follicle reserve is formed during;
12. **Fetal life or soon after birth**
13. Adult life or soon after puberty
14. Fetal life or soon after fertilisation
15. Adult life or before the puberty
16. Production of androgens in response to increasing basal LH is a function of;
17. Granulosa cells
18. Primordial follicle
19. Follicular wall
20. **Thecal cells**
21. The principal hormones associated with ovarian cycling, pregnancy, and parturition are;
22. Estrogens
23. Progesterone
24. Gonadotropins
25. **All of the above**
26. FSH and LH levels are controlled by;
27. Negative feedback from the gonads
28. Positive feedback from the gonads
29. Tonic levels are increased by estrogen
30. Tonic levels are decreased by progesterone
31. Tonic levels are independent of estrogen and progesterone
32. i, ii. iii, iv statements are correct
33. **i, iii, iv statements are correct**
34. ii, iii, iv statements are correct
35. All statements are correct
36. Progesterone, is a steroid sex hormone produced by;
37. Corpus luteum of Ovary
38. Placenta
39. Adrenal cortex
40. **All of the above**
41. Which of the following statement is false for follicular fluid;
42. Follicular fluid originates mainly from the peripheral plasma.
43. Contains steroids and glycoproteins synthesized by the cells of the follicle wall.
44. Large antral follicles contain remarkably high levels of estradiol.
45. **Small follicles contain remarkably high levels of androstenedione**
46. The regulatory factor presents in follicular fluid which inhibits completion of oocyte meiosis is;
47. Luteinization inhibitor
48. **Oocyte maturation inhibitor (OMI)**
49. FSH receptor binding inhibitor
50. Inhibin
51. Which of the following statement is false for number of follicles that develop during follicular growth;
52. In cattle one follicle usually develops more rapidly than others.
53. In horse at each estrous only one egg is released.
54. In swine, 10-25 follicles ripen at each estrous.
55. **In buffaloes, one to three follicles may reach maturity.**
56. Which of the following is a site of ovulation in ovary;
57. **Any point on ovary surface except hilus.**
58. Any point on ovary surface except ovulation fossa.
59. Any point on ovary surface.
60. None of the above.
61. First A.I in domestic animals was conducted by;
62. G. Amantea
63. Leeuwenhoek
64. **L.Spallanzani**
65. Rapiquet
66. In most of mammals, the pH of semen is generally;
67. **Alkaline**
68. Acidic
69. Neutral
70. None of the above
71. Urethral process is found in penis of;

a) Bull

b) Tom cat

c) **Ram**

d) Boar

1. Percentage of spermatozoa in semen is;

a) **20%**

b) 15%

c) 10%

d) 5%

1. Choose the correct statement about semen ejaculate deposited in the female reproductive tract during copulation;
2. In boar the small volume of semen is ejaculated.
3. In horse semen is ejaculated in the cranial end of the vagina and onto the cervix.
4. In cattle voluminous semen is ejaculated.
5. **In pig ejaculated semen is deposited through the relaxed cervical canal into the uterus.**
6. Choose the incorrect statement;
7. Egg acquires plasma membranes from sperm.
8. As oocyte matures, the amount of its cytoplasm increases.
9. Ova Survival in female reproductive tract is 12-24 hours after ovulation.
10. **Sperm removed from the vas deferens and epididymis cannot be used in artificial insemination.**
11. Sperm fertilizability is maintained in female reproductive tract up to;
12. 6-12 hours after ejaculation.
13. 12-24 hours after ejaculation.
14. **24 hours after ejaculation.**
15. 48 hours after ejaculation.
16. Retention of penis during copulation is observed in;

a) Dog only

b) Pig only

c) Dog and Horse

d) **Dog and Pig**

1. Which of the following is not a function described the cervix and its secretion;
2. It acts as a sperm reservoir.
3. It provides sperm with energy requirements.
4. It filters defective and immobile sperm.
5. **It is receptive to sperm penetration at all phases of the cycle.**
6. Transuterine migration of egg is a common phenomenon in;
7. Ruminants
8. Canines
9. Felines
10. **Ungulates**
11. Percentage of spermatozoa in semen is;
12. 5%
13. 10%
14. 15%
15. **20%**
16. The ions necessary for optimum sperm motility is;
17. Mg+
18. Na+
19. **K+**
20. Cu+
21. Most important spermicidal heavy metal is;
22. Mg+
23. Na+
24. K+
25. **Cu+**
26. Number of caruncles in cattle;

a) 40-80

b) **70-120**

c) 12-160

d) >200

1. The female that conceived for first time is called as;

a) **Primipara**

b) Nullipara

c) Pluripara

d) Unipara

1. Epitheliochorial diffuse type of placenta is found in;
2. Pig
3. **Horse**
4. Goat
5. Cattle
6. Corpus luteum is absent in;
7. Mare
8. Ewe
9. **Hen**
10. Bitch
11. Arrangement of microtubules is in the form;
12. 2+9
13. **9+2**
14. 4+8
15. 8+4
16. Spermiogenesis does not include;
17. Condensation of the nuclear chromatin,
18. Formation of the sperm tail or flagellar apparatus
19. Development of the acrosomal cap
20. **Cellular divisions and developmental changes**
21. Duration of Spermatogenic cycle in bull is;
22. 9 days
23. 10 days
24. 12days
25. **14 days**
26. Kidney shaped ovary present in;
27. Cow
28. Sow
29. **Mare**
30. Ewe
31. The fertilizing ability of spermatozoa is achieved;
32. After completion of Spermatogenesis
33. During transit through seminiferous tubule
34. **During transit through epididymis**
35. During transit through vas deferens
36. When a male mouse is introduced into a group of female mice, it causes synchronization of estrus in females of that group and this effect is called as;
37. **Whitten Effect**
38. Bruce Effect
39. Ram Effect
40. Lee boot Effect
41. The follicular periods (proestrus and estrus) are characterized by;
42. **Estrogen dominance**
43. Progesterone dominance
44. Gonadotropin dominance
45. All of the above
46. In pregnant mare endometrial cups begin to secrete PMSG at about;
47. **35 days of pregnancy**
48. 25 days of pregnancy
49. 28 days of pregnancy
50. 45 days of pregnancy
51. Counter current mechanism of the ovarian artery with the uterine vein serves to:
52. **Transport PGF2α from the uterus to the ovary**
53. Cool the ovary
54. Enhance the chance of fertilization
55. Transport spermatozoa from the uterus to the ovary
56. Estrogen secretion from fetoplacental unit during prepartum period is responsible for;
57. Increase in PGF2α secretion
58. Increase in relaxin hormone secretion
59. Increase in Myometrial protein synthesis
60. **All of the above**
61. PGF2α increases the sensitivity of the uterus to which hormone;
62. **Oxytocin**
63. Progesterone
64. Estrogen
65. Relaxin
66. Strong uterine and abdominal contraction takes place in which stage of labour;
67. Stage I
68. **Stage II**
69. Stage III
70. None of the above
71. In which species the stage II and III of labour are not separate;
72. Sow
73. Ewe
74. Doe
75. **All of the above**
76. FSH stimulates production of which of the following hormones by sertoli cells;
77. Androgen
78. E2 & androgen
79. ABP& Androgen
80. **ABP& Inhibin**
81. The development of fertilizing ability of spermatozoa does not involve;
82. Development of the potential for sustained progressive motility.
83. Changes in nuclear chromatin.
84. Changes in nature of the surface of the plasma membrane.
85. **Droplet movement and loss.**
86. Examples of reflex ovulators;
87. Cat
88. Mink
89. Ferret
90. **All of the above**
91. Incidence of Polyspermy in most of the domestic animal’s accounts for;
92. **1-2%**
93. 2-5%
94. 5-10%
95. >10%
96. Average gestation period of sheep and swine is;
97. 114 and 148 respectively.
98. **148 and 114 respectively.**
99. 279 and 114 respectively.
100. 178 and 158 respectively.
101. Epididymis is the principal storage organ;
102. Corpus
103. **Cauda**
104. Caput
105. All of the above
106. Gestation period for twin calves is;
107. 3-6 days more
108. **3-6 days less**
109. Same
110. 6-9 days more
111. Which of the following is true for Freemartin animals;
112. Freemartin heifer is an intersexual individual.
113. Freemartins are more common in cattle.
114. It is a genetic female that was born as a co-twin with a male.
115. Only A
116. ONLY B&C
117. ONLY A&B
118. **A, B &C**
119. Consider two statements and choose the correct word to explain them;
120. genetic female was born as a co-twin with a male, leading to the modification of female genitalia in the male direction

B- presence of both male and female gonads in one individual

1. A - Hermaphrodite and B - Freemartin
2. **A - Freemartin and B - Hermaphrodite**
3. A - Freemartin and B - Freemartin
4. A - Hermaphrodite and B - Hermaphrodite
5. Which of the following is not a function of the cervix;
6. Transport of sperm
7. Sperm reservoir
8. Sperm selection center
9. Capacitation of sperm
10. Absorption of seminal plasma
11. A&B
12. B&E
13. C&E
14. **D&E**
15. Choose the correct examples of animals explained in the below statements;
16. Animals in which copulation initiates neuroendocrine reflex that results in ovulation
17. Animals in which ovulation occurs spontaneously after normal follicle growth during the estrus cycle.
18. A - goat and B - Cattle
19. **A - cat and B - dog**
20. A - cat and B - rabbit
21. A - cattle and B - Cat
22. Choose correct examples of animals explained in the below statements;
23. Animals have only one estrous cycle per year
24. The estrous cycle occurs when days get longer
25. A - goat and B - Cattle
26. **A - dog and B - horse**
27. A - horse and B - dog
28. A - dog and B - Cat
29. What happens if;
30. male mouse is introduced into a group of female mice cage
31. A pregnant female mouse is placed in a cage with a strange male mouse
32. A - female mice will get pregnant, B - female mice pregnancy fails
33. A – female mice pregnancy fails, B - females parturiates
34. **A - female mice estrus will synchronization, B - female mice pregnancy fails**
35. None of the above
36. Choose the correct answer from the following statements;
37. Bitch is in proestrus
38. There is vaginal secretion of Methyl-p-hydroxybenzoate
39. Bitch secrete 5α androstenone
40. **Statement B is true and A is the reason for B**
41. Statements A&B are true and A is the reason for B
42. Statement B is true and A is not the reason for B
43. Statements A&B are true and A is not the reason for B
44. Choose the correct answer from the following statements;

A- Pseudopregnancy in bitch

B- Corpora lutea of nonpregnant bitch remain functional for an extended period

C- Exaggerated diestral response in bitch

1. **A is the reason for B&C**
2. A is the reason for only B but not for C
3. A is the reason for only C but not for B
4. A is the reason for neither B nor C
5. Match the following and choose the correct answer;
6. Estus observed in mare 8 to 12 days postpartum
7. Infertile estrus
8. Estus in Pig 1 to 2 days postpartum
9. Non-ovulatory estrus
10. A - B and C - B
11. A - D and C - B
12. **A - B and C - D**
13. A - D and C - D
14. Which of the following statements are false;
15. Puberty in males occurs earlier in the tropics than in the temperate zones.
16. Puberty in Jersey heifers earlier than Holsteins.
17. In general, smaller breeds experience puberty at an earlier age.
18. All of the above statements
19. Only B
20. Only A
21. **None of the above**
22. Assertion: PMSG is used to induce superovulation in domestic animals.

Reasoning: PMSG is ineffective in the mare and will not induce superovulation.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. **If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion**
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: Inhibin is also termed as folliculostatin.

Reasoning: Inhibin can inhibit the release of FSH without altering LH release.

1. **If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion**
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: Secretary protein (OTP -1 or Type I conceptus interferon) is essential for successful pregnancy in sheep.

Reasoning: Secretary proteins inhibit Progesterone production.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. **If Assertion is true but Reasoning is false**
4. If Assertion is false but Reasoning is true
5. Assertion: Primates have an Invasive type of implantation.

Reasoning: Blastocyst of Primates penetrate the uterine epithelium during implantation.

1. **If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion**
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: The gestation lengths of Mule and Hinny are the same.

Reasoning: The parents of Mule and Hinny are the same i.e. horse and donkey.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. **If Assertion is false but Reasoning is true**
5. Assertion: The cow has an Epitheliochorial type of placenta.

Reasoning: The placentation of a cow consists of all six layers.

1. **If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion**
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: Primates have a chorionic type of placentation.

Reasoning: In primates the chorion (trophoblast), is bathed by the blood of the dam.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. **If Assertion is false but Reasoning is true**
5. Assertion: In Nondeciduate type of placentation, there is no loss of maternal tissue at the time of parturition.

Reasoning: In Nondeciduate type placenta, fetal membranes are expelled at the time of parturition.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. **If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion**
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: Introducing a pregnant mare to induce sexual maturity in immature rats.

Reasoning: A pregnant mare produces ECG hormone.

1. **If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion**
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. If Assertion is true but Reasoning is false
4. If Assertion is false but Reasoning is true
5. Assertion: Progesterone is called as pregnancy hormone.

Reasoning: Increased progesterone level always indicates that animal is pregnant.

1. If both Assertion and Reasoning are true and the reasoning is a correct explanation of the Assertion
2. If both Assertion and Reasoning are true and the reasoning is not a correct explanation of the Assertion
3. **If Assertion is true but Reasoning is false**
4. If Assertion is false but Reasoning is true
5. The species in which the ovum is in first meiotic division at the time of ovulation;
6. **Horse, Dog, and Fox**
7. Cattle and Sheep
8. Dog and Cat
9. In all domestic animals
10. Primordial germ cells migrate to the gonadal ridge at about …………… days in bull fetus. (26)
11. Transport of spermatozoa through the epididymis takes about…………. days. (9-13 days)
12. Developmental fate of genital tubercle in male and female mammalian fetus is ……………………and …………………………. Respectively. (penis and clitoris)
13. The female ………………………………fuse caudally to form a uterus, a cervix, and the anterior part of a vagina. (Mullerian ducts)
14. In cattle and sheep, the ovary is…………... shaped, whereas in the horse it is ……….........Shaped (almond, bean)
15. The interstitial cells that are located among the seminiferous tubules are also called as …………… cells. (Leydig cells)
16. The Leydig cells secrete …………….in the male whereas the theca interna cells of the Graafian follicle are the primary source of circulating……………….. (testosterone, estrogen)
17. Maximal fertility in the cow occurs ………………after calving. (60 to 90 days)
18. Gartner’s duct is remnant of ……………………. (wolffian duct)
19. ……………………… (right/left) ovary is more physiologically active in domestic animals. (Right)
20. One primary spermatocyte produces …………… spermatids. (4)
21. One spermatogonia produces ……………spermatids. (64)
22. Dual functions of ovary are…………………and …………………. (Gametogenesis and Steroidogenesis)
23. The growth of the follicle up to the stage of ………………. is not strictly gonadotropin dependent. (antrum formation)
24. Production of ……………. hormone determines which follicle will gain the LH receptors necessary for ovulation and luteinization. (Estradiol)
25. ………………. is predominant immunoglobulin in follicular fluid. (IgG)
26. Active corpora lutea are present in the ovaries during a large part of the estrous cycle called the ……………… phase. (Luteal)
27. The period from antral follicle formation to ovulation is called as ……….. phase of the estrous cycle. (follicular phase)
28. From oogenesis onward, the diplotene nucleus of the oocyte remains in the resting stage called the ……………… nucleus. (Dictyate)
29. Polyspermy is a common phenomenon in …………….and …………... (Birds and Reptiles)
30. The Corpus luteum persists throughout pregnancy in all domestic animals except……………. (Mare)
31. ………………………….. is the major metabolic fuel for foetus. (Glucose)
32. ……………………. is most commonly used cryoprotectant for freezing of semen. (Glycerol)
33. …………… is a unique species in which epididymis can produce testosterone. (Horse)
34. The vagina is acidic, around pH……… and cervical mucus is basic, around pH………. (4.0, 8.4)
35. Cervix is poorly defined in ………… species. (Dog)
36. In…………species ovulation occurs in metestrous. (Cattle)
37. First A.I in India was done by …….. in Mysore palace dairy farm. (Sampat Kumaram)
38. Osmotic pressure of semen ranges from…………. (280-300 mOsmol)
39. Uterine involution completed by …………days in cattle. (26-52 days)
40. Postpartum uterine discharge is called as ………. (Lochia)
41. ……………….is called as true water bag of foetus. (Amnion)
42. The release of formed germ cells into the lumen of the seminiferous tubules is known as………….. (Spermiation)
43. The entire process of Spermatocytogenesis takes approximately ………. days in bull. (45 days)
44. The release of formed germ cells into the lumen of the seminiferous tubule is known as……………… (Spermiation)
45. Series of changes in a given area of seminiferous epithelium between two appearances of the cellular association or developmental stages is called as ………………… (Spermatogenic cycle)
46. Sequential change in stage of cycle along the length of the seminiferous tubule is known as………………… (Spermatogenic Wave)
47. The tail of the epididymis contains ………. % of the total number of spermatozoa in the excurrent ducts, whereas the vas deference contains only …….. %. (70%, 2%)
48. Development of egg without fertilization is called as ………… (Parthenogenesis)
49. Twining in monotocous domestic animals is most frequently of ……….. type. (Dizygotic)
50. At least 2 conceptus per uterine horn must be present for pregnancy to be established in ………………species. (Swine)
51. Fusion and vesiculation of acrosome release …………… and …………. enzymes. (Hyaluronidase and Acrosin)
52. Acrosome reaction involve massive influx of …………….. ions. (Ca2+)
53. Endotheliochorial type of placenta present in ……….. species. (Dog)
54. Match the following;

|  |  |
| --- | --- |
| **A** | **B** |
| 1. LH
 | 1. Responsible for the growth of the duct system of the mammary gland
 |
| 1. Testosterone
 | 1. Responsible for lobular and alveolar growth in the mammary gland
 |
| 1. Progesterone
 | 1. Stimulate testosterone production
 |
| 1. FSH
 | 1. Anabolic hormone
 |
| 1. Estradiol
 | 1. Stimulates secretion of estrogen and inhibin
 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. **a-iii, b-iv, c-ii, d-v, e-i**
3. a-ii, b-iii, c-iv, d-v, e-i
4. a-iii, b-iv, c-v, d-ii, e-i
5. Match the following;

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Inhibin
 | 1. Influencing the release of FSH, LH, Prolactin
 |
| 1. Melatonin
 | 1. Control prolactin release
 |
| 1. Dopamine
 | 1. Dilation of pelvic structure, cervix, and vagina before parturition
 |
| 1. 5-α-Androstenone
 | 1. Inhibits FSH secretion
 |
| 1. Relaxin
 | 1. Responsible for boar taint
 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. a-iii, b-iv, c-v, d-I, e-ii
3. **a-iv, b-i, c-ii, d-v, e-iii**
4. a-ii, b-iii, c-iv, d-v, e-i
5. Match the following; (pH of secretions of female reproductive organ):

|  |  |
| --- | --- |
| **A** | **B** |
| a. Vaginal fluid | i. 7.8 |
| b. Cervical mucus | ii. 4.0 |
| c. Oviductal fluid in the follicular phase | iii. 8.4 |
| d. Uterus | iv. 7.5 to 7.8 |
| 1. Oviductal fluid in the luteal phase
 | v.7.1 to 7.3 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. a-iii, b-iv, c-v, d-I, e-ii
3. a-iv, b-i, c-ii, d-v, e-iii
4. **a-ii, b-iii, c-v, d-i, e-iv**
5. Match the following; (Daily Sperm Production per gram of testis):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Bull
 | i. 24 – 27 million |
| 1. Ram
 | ii. 23.7– 32.3 million |
| 1. Boar
 | iii. 24 – 31 million |
| 1. Stallion
 | iv. 13 – 19 million |

1. a-i, b-ii, c-iii, d-iv
2. a-iii, b-iv, c-ii, d-i
3. **a-iv, b-i, c-ii, d-iii**
4. a-ii, b-iii, c-iv, d-i
5. Match the following; (Transport time of ova in oviduct in different species):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Cattle
 | 1. 50 hrs
 |
| 1. Sheep
 | 1. 148 hrs
 |
| 1. Horse
 | 1. 90 hrs
 |
| 1. Pig
 | 1. 72 hrs
 |
| 1. Cat

  | 1. 98 hrs
 |
| 1. Dog
 | 1. 168 hrs
 |

1. a-i, b-ii, c-iii, d-iv, e-v, f-vi
2. **a-iii, b-iv, c-v, d-i, e-ii, f-vi**
3. a-iv, b-i, c-ii, d-vi, e-iii. f-v
4. a-vi, b-iii, c-iv, d-v, e-i, f-ii
5. Match of the following; (Sperm reservoir site in different species):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Cattle
 | 1. Utero-tubal junction
 |
| 1. Mare
 | 1. Utero-tubal junction
 |
| 1. Sow
 | 1. Endometrial glands.
 |
| 1. Bitch
 | 1. Cervical crypts
 |

1. a-i, b-ii, c-iii, d-iv
2. a-iii, b-iv, c-ii, d-i
3. **a-iv, b-i, c-ii, d-iii**
4. a-ii, b-iii, c-iv, d-i
5. Match the following; (Spermatogenic cycle):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Pig
 | 1. 8 days
 |
| 1. Sheep
 | 1. 10 days
 |
| 1. Cattle
 | 1. 14 days
 |
| 1. Human
 | 1. 16 days
 |

1. **a-i, b-ii, c-iii, d-iv**
2. a-iii, b-iv, c-ii, d-i
3. a-iv, b-i, c-ii, d-iii
4. a-ii, b-iii, c-iv, d-i
5. Match the following; (Homologies organ of male reproductive system in different animal):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Mesonephric duct
 | 1. Glans penis, Corpus penis
 |
| 1. Mullerian duct
 | 1. Raphe of scrotum and

penis |
| 1. Urogenital sinus
 | 1. Epididymis
 |
| 1. Genital tubercle
 | 1. Appendage of testis
 |
| 1. Urethral folds
 | 1. Bulbourethral glands, Prostate gland
 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. **a-iii, b-iv, c-v, d-i, e-ii**
3. a-iv, b-i, c-ii, d-v, e-iii
4. a-ii, b-iii, c-iv, d-v, e-i
5. Match the following; (Age of puberty in different female animal):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Cattle
 | 1. 6-8 months
 |
| 1. Sheep
 | 1. 6-10 months
 |
| 1. Goat
 | 1. 4-15 months
 |
| 1. Horse
 | 1. 4-15 months
 |
| 1. Pig
 | 1. 12-18months
 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. a-iii, b-iv, c-v, d-i, e-ii
3. a-iv, b-i, c-ii, d-v, e-iii
4. **a-ii, b-iii, c-iv, d-v, e-i**
5. Match the following; (Placentation type):

|  |  |
| --- | --- |
| **A** | **B** |
| 1. Zonary
 | 1. Mare
 |
| 1. Diffuse
 | 1. Cattle
 |
| 1. Cotyledonary
 | 1. Guinea pig
 |
| 1. Haemochorial
 | 1. Queen
 |
| 1. Discoidal
 | 1. Monkey
 |

1. a-i, b-ii, c-iii, d-iv, e-v
2. a-iii, b-iv, c-v, d-I, e-ii
3. **a-iv, b-i, c-ii, d-v, e-iii**
4. a-ii, b-iii, c-iv, d-v, e-i