Comparative Placentation
Domestic Dog
Canis familiaris

by K. Benirschke

In: Comparative Placentation, Benirschke K. (Ed.). International Veterinary Information Service, Ithaca NY (www.ivis.org), Last updated: 1-Aug-2007; A4101.0607

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Order: Carnivora
Family: Canidae

1) General zoological data of species

Domestic dogs have a worldwide distribution and breeding occurs in numerous colonies and by private owners. A photograph of a typical animal, a "Sheltie", from which I obtained placentas, is shown here. The life span of most dogs varies, and is up to 16 years; fertility is expected to occur around 2 years of age.

The domestication of the presumed wolf ancestors occurred presumably about 100,000 years ago. Recent studies have employed mtDNA control region data to further delineate the timing (Vila et al., 1997). Dog/wolf showed 12 substitutions of 261 base pairs. Multiple origins and perhaps recurrent interbreeding with wolves was a possible result of these studies conducted on a large variety of dogs and 162 wolves. Dogs are first observed in Northern America's Tertiary deposits.

Shetland sheep dog whose placentas are shown in these photographs.

The neonatally dead pup of above animal. T

Stillborn sixth fetus of second dog delivery.

2) General gestational data

The length of gestation is usually 63 days (60-63) after mating; the litter size varies greatly. The dog shown here first, a Shetland Sheep Dog ("Sheltie"), usually has had between 5-6 young. This pregnancy was at term, with three of the four young surviving. The newborns weighed 180 to 270 g. The maternal weight of this bitch was 10 kg nonpregnant, 10.8 kg pregnant and at term. Two placentas were available, as the bitch ate two, an usual event in this species. One placenta weighed 22.5 g; the other was 32.7 g with membranes attached. These fetuses were at term, and the placental weights include the membranes and the diminutive umbilical cord. There is an enormous variation in size and weights of the ca. 400 races of domestic dogs. Thus, the placental and neonatal weights need also to be adjusted.

A second group of placentas from a German shepherd had somewhat different parameters. There were six pups; the last was a stillborn female that weighed 460 g with crown-rump length of 23 cm.

Three placentas were available from that litter. Their "gross" weights were 115, 99, and 98 g respectively. The first one, with gross weight of 115 g, had a disk weight (membranes and cord removed) of 65 g. The disk measured 21 x 4 x 0.5 cm. Although the owner suspected that meconium was present, it was actually the normal green color of dog placentas that was mistaken for meconium.

Since this report was issued I have had the opportunity to examine three further dog placentas (from Great Pyrenees dogs at term) through the great courtesy of Dr. Barbara Durrant. Their zonary disks weighed 31, 35 and 42 g respectively and had the characteristic green discoloration on their maternal surface. The fetal surfaces, on the other hand, ere entirely unstained. One of the placentas had its allantoic sac markedly distended with light red urine. When the green pigment was extracted with water and hydrogen peroxide added, the pigment bleached immediately and completely, but it was returned by adding ascorbic acid. These placentas are shown next. An additional placenta weighed 35 g and had the same appearance.

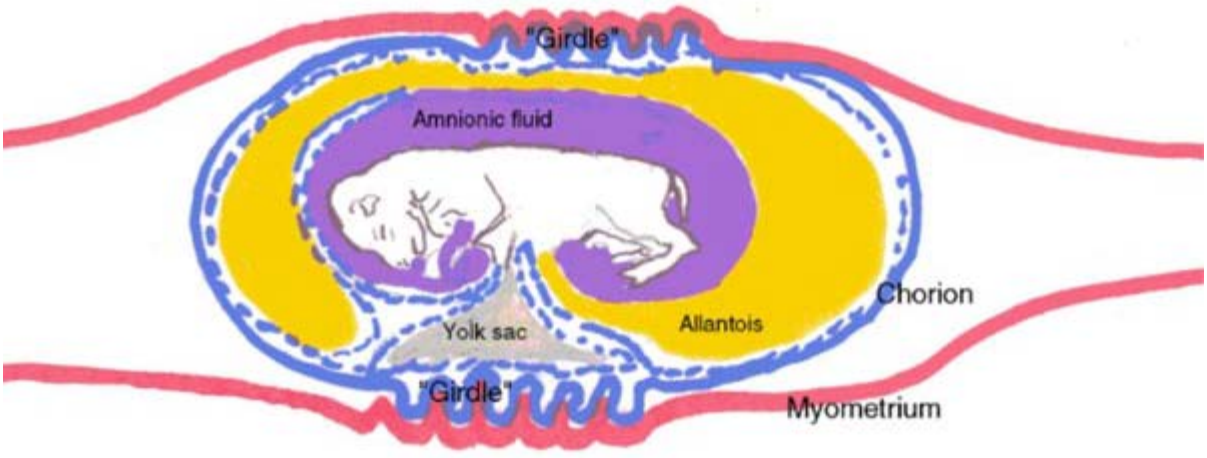
Three Pyrenees dog placentas.

Placenta from Pyrenees dog with the fetal surface unstained.

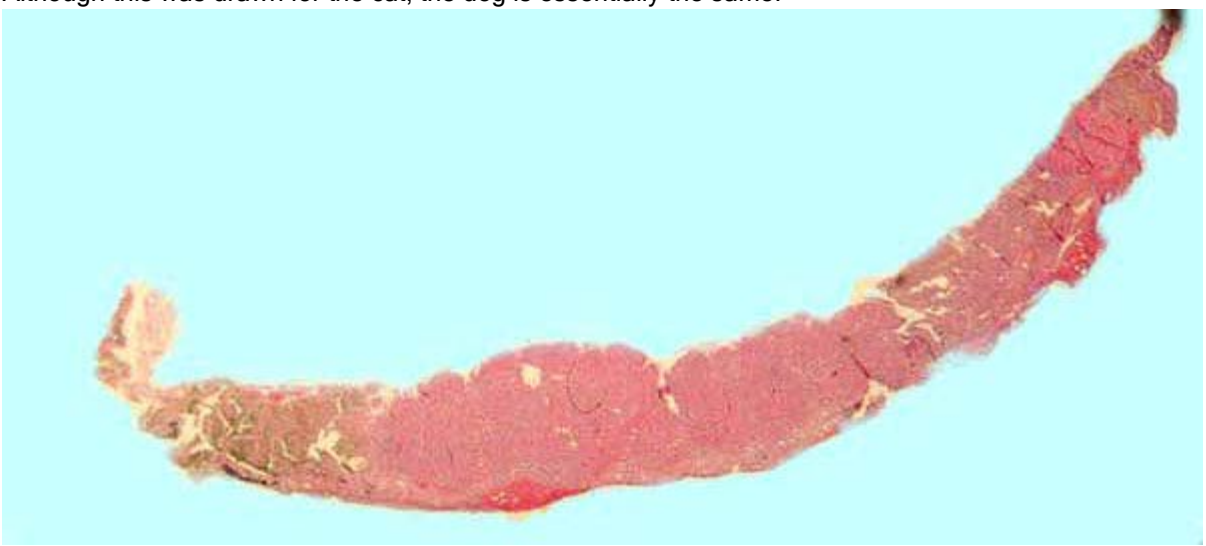
3) Implantation

Kehrer (1973) described the development of dog and cat placentas in detail and provided excellent illustrations. He also attached an extensive bibliography of the large literature on the topic. The blastocyst arrives in the uterus between days 6-8. It implants approximately 17-18 days after coitus and implants, circumferentially in the entire diameter of the uterine horns. This follows migration of embryos from one uterine horn to the other. Thereafter, the development of the lamellar, endotheliochorial placenta is similar to that of the cat, although Kehrer described differences as well.

Thus, the branching "leaves" or "lamellae" of the dog placenta are less "straight" and have more, but shorter, secondary branches. The diameter of these leaves varies greatly (15-35 micrometers), but they are of similar width in cats. Another striking difference is the large size (20-45 micrometers) of the maternal blood vessels between the chorionic leaves (lamellae). The lamellae are composed of trophoblast, fetal connective tissue, and thin-walled capillaries with discontinuous basement membranes. The maternal capillaries' endothelial cells are surrounded by thick amorphous extracellular deposits (Wynn & Corbett, 1969 - EM study). The trophoblast is mostly syncytial, with cytotrophoblast having largely vanished at term. At the placental margin, the trophoblast is columnar and contains degenerating blood and green pigment. Despite the large amount of green pigment at the edges of the placenta, there is no hemosiderin. While there is much phagocytosis of this black/green material, especially by the trophoblast, hemosiderin stains (Prussian blue) are negative. Another puzzling aspect is that this green pigment is so readily water-soluble. Thus, when the placenta is fixed in formalin solution, this becomes deeply green quickly. So soluble is this pigment that one is surprised that a dog, pregnant with sextuplets, is not green all over.



Although this was drawn for the cat, the dog is essentially the same.



Low power section of placental disk with prominent marginal green staining.

4) General characteristics of the placenta

The macroscopic shape of the dog placenta is similar to that of all other canidae, if not carnivora; it is ring-shaped, circumferentially implanted in the uterine horns, with the membranes protruding on both sides.

The fetus lies within (but protruding on both sides through) the ring that is formed by the villous tissue. It is thus a "zonary" placenta. There is only a hint at lobulation in this thin placenta. The maternal surface usually has some yellowish discoloration.

Perhaps best known is the circumferential, marginal hematoma of old, stagnant blood, with its green discoloration from the formation of biliverdin, at least according to Mossman (1987). When the placenta was fixed in formalin solution, the green pigment became

more prominent and readily eluted, coloring the fluid deep green. The dog placental hematoma is much more pronounced than that present in the cat or tiger placenta. The hematoma at the margin of the dog placenta envelops some maternal glands but virtually no villous tissue.

The dog placental implantation is superficial and the barrier is endotheliochorial, but the maternal endothelial cells are difficult to identify in paraffin sections. They are clearly shown electronmicrographically, however (e.g. Wynn & Corbett, 1969). The microscopic placental structure is labryrinthine. There is a large allantoic sac that surrounds the amnionic cavity. Hippomanes are not reported. In early developmental stages, there is a large yolk sac that soon atrophies (Ramsey 1975).

The fine structure of the amnion has also been described by Wynn and Corbett (1969). It is similar to that of other placentas, has a single layer of epithelial cells that are connected by desmosomes. These authors described the epithelial cells as being of two types, electron-dense, and not. The epithelial surface has numerous microvilli. The epithelial cells rest on ordinary connective tissue that contains some macrophages.

The final site of the placenta is circumferential and organized much like the placenta of the cat and tiger.

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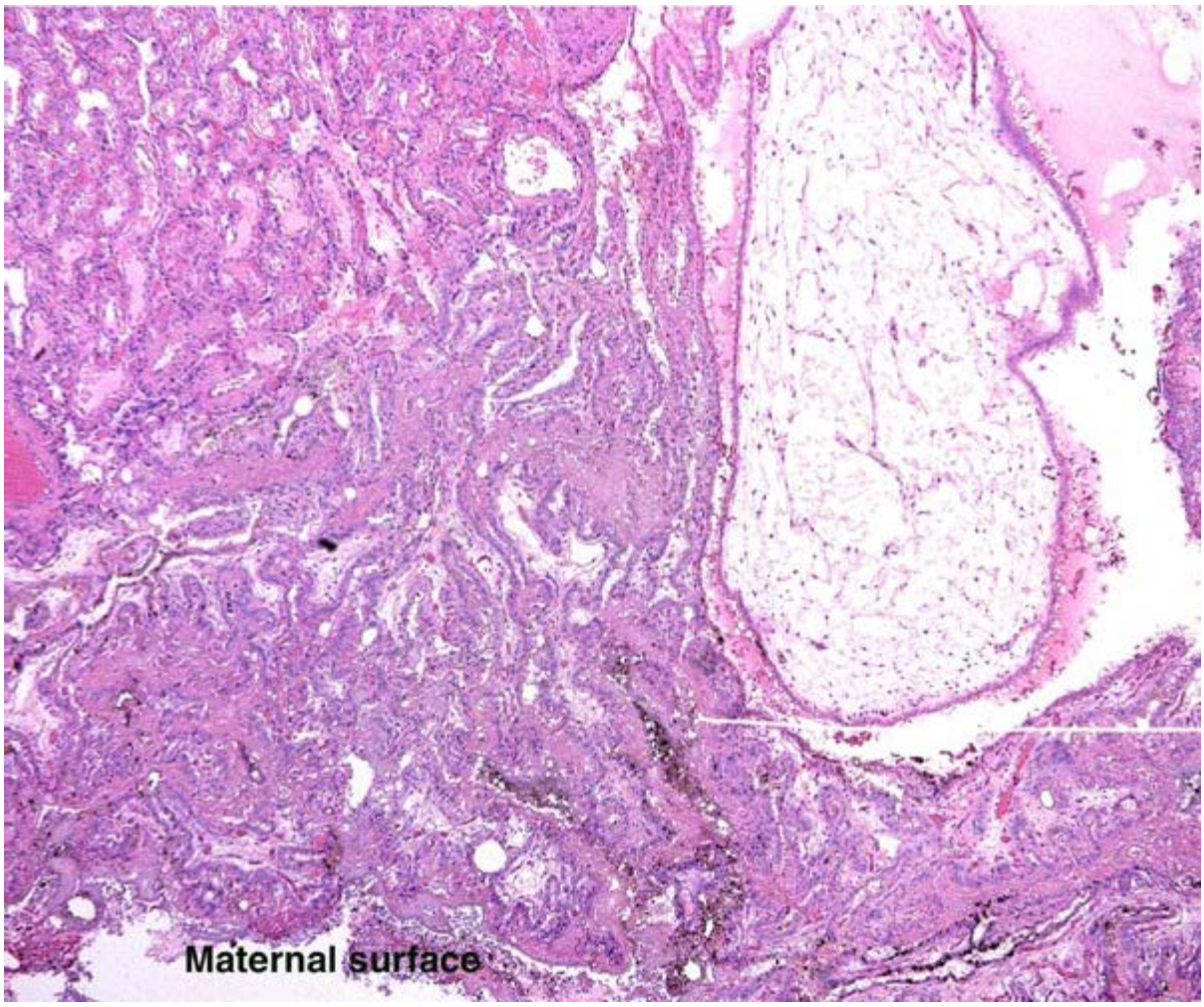
After one-day fixation in formalin, the green color is pervasive. View from maternal side. There is minimal lobulation in cross sections.

The amnion is folded back on this fetal surface and the allantoic sac is shown to occupy the largest surface area.

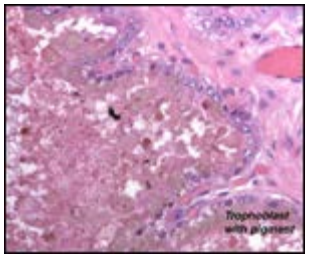
5) Details of barrier structure

The description by Wynn & Corbett (1969) essentially confirms the earliest description of Duval (1893) that the interhemal membrane consists of maternal endothelium, some extracellular debris, trophoblast, very thin fetal connective tissue and fetal capillary endothelium. The debris has been likened to a basement membrane and its function has been speculated to serve an immune function (prevention of fetal antigen recognition). The transport through this seemingly simple barrier is controversial. It is especially unclear what the origin of the basement membrane material is and what the nature of the debris is that is here found. These aspects have been studied and shown electronmicrographically by Björkman (1973), without having found a final resolution.



Focal edematous region (villus) in dog placenta.

Margin of dog placenta with pigmented ring at top right. To view click on figure

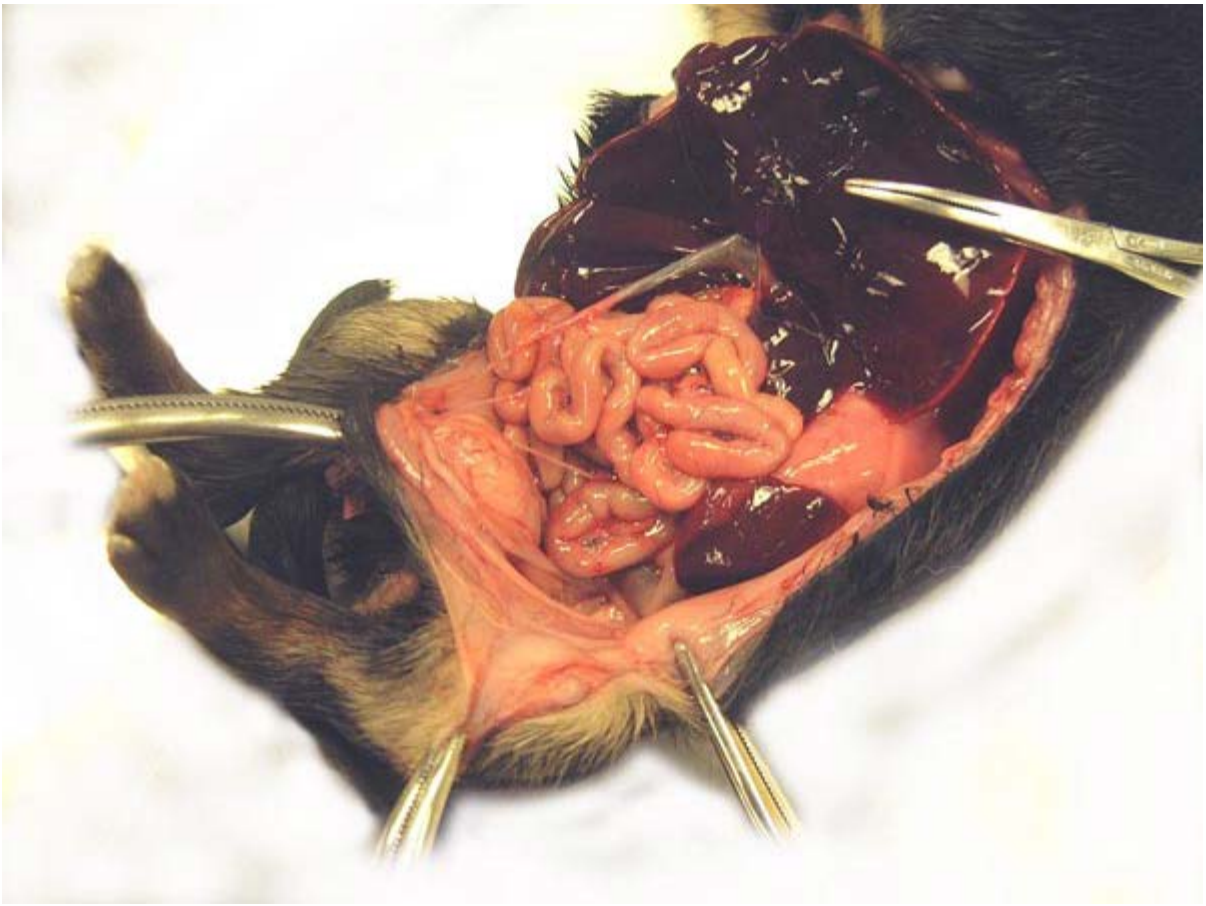


High power view of trophoblast with pigment content and debris. To view click on figure

6) Umbilical cord

The cord has a latero-mesometrial attachment, is short and has few twists. They were 7 and 8 cm in length in these newborns, had an allantoic duct and contained three vessels, two arteries and one vein. There are some additional tiny vessels, which may be of

vitelline origin. Immediately behind the abdominal wall, the umbilical vein pursues its normal course to the liver. The arteries pursue a course next to the bladder to the iliac arteries, as is usual. The tiny "umbilical veins" separate and both take their origin from the mesentery. One of them reaches the lower pancreas, the other goes to the mesentery. There are no caruncles on the cord's surface.



Division of umbilical and vitelline veins in abdomen.

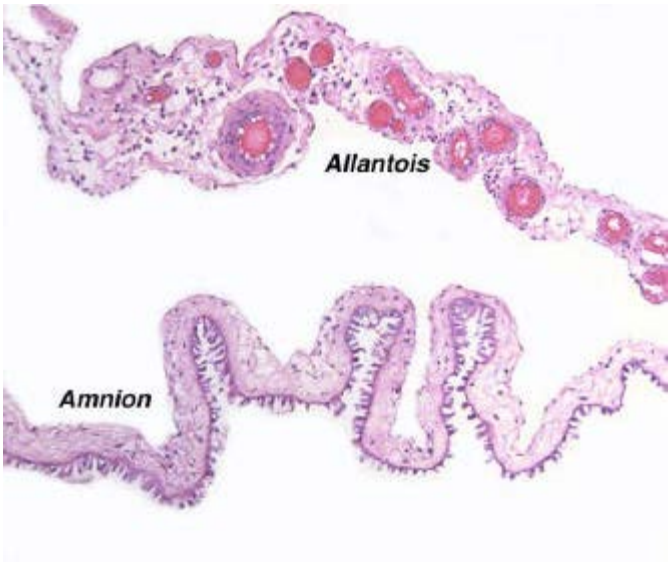
7) Uteroplacental circulation

No specific studies can be found that relate to the general uterine vasculature.

8) Extraplacental membranes

There is no true decidua in carnivora. The "giant cells" may or may not be decidual; a final decision is forthcoming when their physiology is better understood. They are very sparse in dogs.

The allantoic sac is very large and surrounds the amnion. There are many small blood vessels in the allantoic membrane's connective tissue.



Cross-section of the abutting allantoic (above) and amnionic (below) membranes. Note the numerous allantoic blood vessels.

9) Trophoblast external to barrier

Mossman (1987) said the following of specific giant cells at the floor of the placenta in carnivora: "Most carefully examined carnivore placentas have been shown to have scattered, usually moderately enlarged cells of presumed maternal stromal origin alongside the maternal vessels of the zona intima. These have been called "giant decidual cells" in the hyena (Wynn & Amoroso, 1964) and cat (Malassiné, 1974), or simply "giant cells" (Wynn & Björkman, 1968) in the cat and "decidual cells" (Anderson, 1969) in the dog. Their ultrastructure in the dog was described in detail by Anderson (1969) and in the cat by Malassiné (1974). Obviously these cells of carnivores are not in the classical position of decidua, but their presumed origin from endometrial stroma may justify associating them tentatively with decidua. They are often not markedly large (Anderson could not recognize them in paraffin sections of the dog placenta) and have not been reported in raccoon, mustelids, or bears, possibly, as Wimsatt (1974) has suggested, because specimen from these have not been examined by electron microscopy. Both "giant" and "decidual" cells must be considered tentatively designations until some definite anatomical or physiological characteristics are discovered that set these cells distinctly apart and justify a specific name."

Extravillous packets of trophoblast do not exist and the invasion of endometrium is very superficial, i.e., only through the superficial "compacta" of the endometrium.

It is of historical interest to note that von Baer (1828) first convincingly demonstrated that there was no confluence between the maternal and fetal circulations. He injected a variety of uterine and fetal vessels of animals with dyes and showed independence of the two vascular systems. This monograph also provides a beautiful illustration of the dog placenta with partial separation from the uterus and its broad green marginal regions. For historical interest it might be nice to learn that this elegant contribution by v. Baer was dedicated to S.T. v. Soemmerring at his 50th medical anniversary.

10) Endometrium

Dogs are said to have a "deciduate" placentation but typical decidual cells are hard to identify, and endometrial glands are present throughout pregnancy. Thus, no true decidua as in primates is found and there is further disagreement whether all of the giant cells disappear after delivery of the placenta.

11) Various features

The marginal "hematoma" (green zone) has also been referred to as "paraplacenta" or a hematophagous organ.

12) Endocrinology

The estrous cycle of dogs averages two per year. Ovulation is spontaneous.
Breeders suggest that the temperature of the pregnant bitch decreases by about 1□ the day before the delivery is expected. They

infer from this that the temperature drop relates to falling progesterone levels. Actual steroid measurements, however, are unknown to us. Estrogen is not expected to be produced by the placenta. Relaxin has apparently been demonstrated. Parturition is believed to be induced by fetal cortisol and an increased prostaglandin production by the gravid uterus. The canine corpus luteum is said to be remarkably resistant to prostaglandin-induced regression. Prostaglandins are also believed to cause the notorious vomiting in late pregnancy.

The endocrine patterns of red wolves (Canis rufus) were delineated in captive animals by fecal and serum analysis (Walker et al., 2002). I realize that this is a different species, but it seems likely that the results would be similar to what might be found in domestic dogs. These investigators studied LH secretion and estrogens, as well as progesterone. No native testosterone but a more polar androgen metabolite was detected in males.

Oophorectomy or hypophysectomy during pregnancy leads to pregnancy termination (Tienhoven, 1983). There are apparently no publications on the placental production of gonadotropins or estrogens, although Courrier (1945) has stated that no gonadotropins have been detected in the urine of the pregnant dog. Histologically, the placenta does not give the impression of being an endocrine organ.

The fetal/neonatal ovary has a large "interstitial gland".

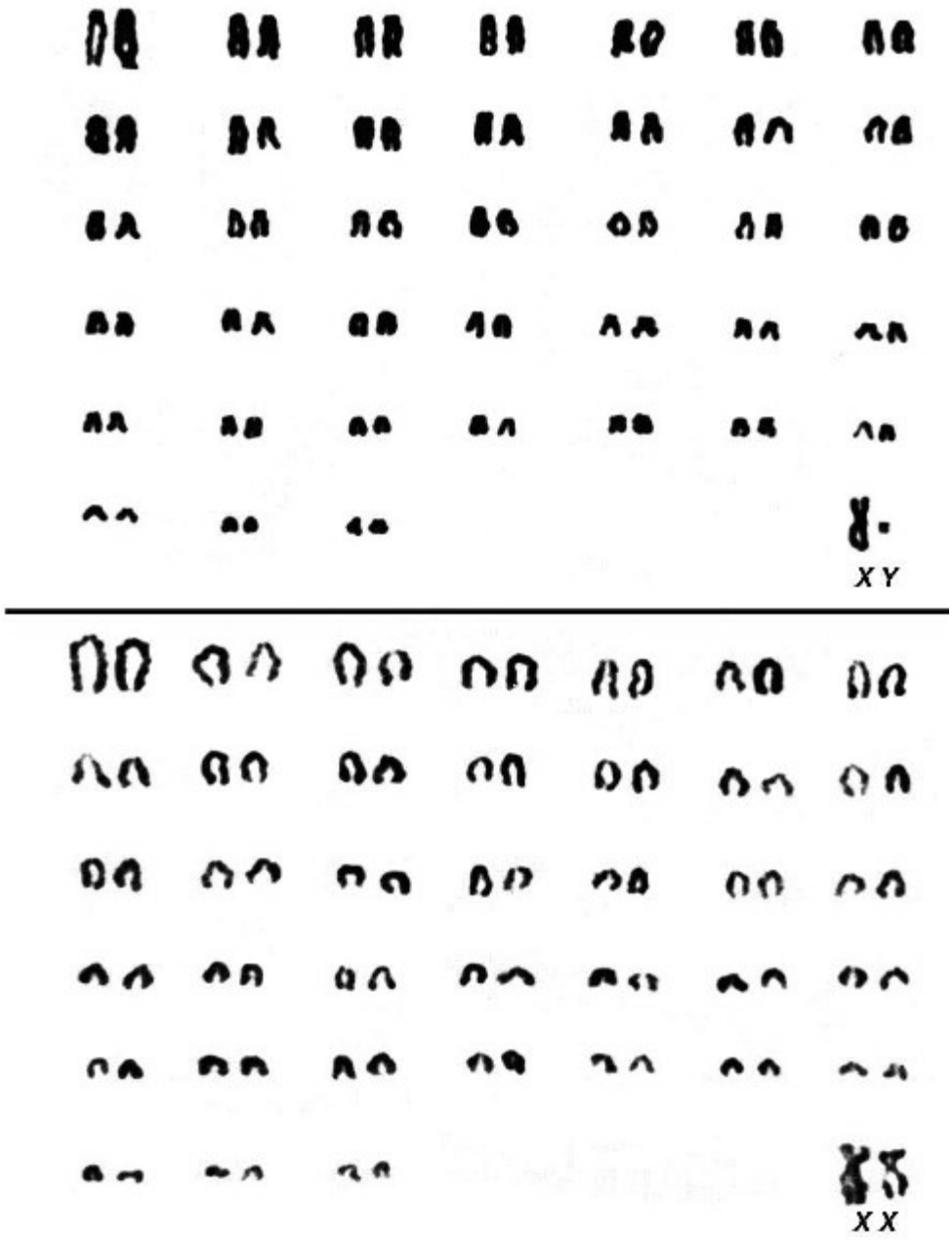
13) Genetics

The domestic dog has 78 chromosomes. The autosomes are all acrocentrics; the X chromosome is submetacentric and the Y is a diminutive metacentric chromosome. Switonski et al. (1996) further defined the fine structure of chromosomes with excellent G-banding. Hybridization has been reported to occur with dingo, coyote, wolf, and possibly some foxes. Cats have not hybridized with dogs, despite rumors in the popular press. A wide variety of genetic diseases have been recorded in domestic dogs, best known of which is perhaps the hip dysplasia in shepherds.

More recent information on genes and linkage maps are contained in a report of a symposium on "Advances in Canine and Feline Genomics: Comparative Genome Anatomy and Genetic Disease" in J. Hered. 94, Issue 1 (January), 2003. It contains a paper on 78XX/77C mosaics.

Several chromosomal errors have been identified in dog. Thus, Switonski et al. (2000) found trisomy X in an infertile bitch. Her ovaries appeared to be normal, but the dental arcades showed abnormalities. Sex-reversal (male to female) was interpreted to be the result of a reciprocal X/A translocation (Schelling et al., 2001). The bitch had ovotestes, uterus and epididymis. Two infertile bitches were mosaic 78XX/77/X (Switonski et al., 2003).

A comprehensive study of dog races, diseases, genetics, neoplasms and other topics has come from Ostrander et al. (2006).



Karyotype of male and female domestic dogs.

14) Immunology

Despite the occasionally voiced notion that dogs have no blood group antigens, the studies by Swisher et al. (1962) are a convincing demonstration of their existence and of the development of iso-antibodies under appropriate conditions.

The developmental landmarks of the immune system have recently been summarized by Holsapple et al. (2003). Splenic primordial appear on day 28, their “demarcation” occurs on day 45; thymic primordial are recognized on day 28 also, and hematopoiesis in the bone marrow begins on day 45. Proliferation in response to mitogens begins on day 50.

15) Pathological features

Subinvolution of the placental site has occasionally been described (Beck & McEntee, 1966). Their illustration suggests to me the retention of placental tissue in the case that they described. Schlotthauer (1939) described a choriocarcinoma in a 2-year-old bitch. The involution of the canine placental site and of the adjacent endometrium has been reviewed in some detail by McEntee (1990).

There is, of course, a vast literature on pathologic findings in dogs. They can be accessed through texts on veterinary pathology and from the Armed Forces Institute of Pathology (AFIP) in Washington.

16) Physiological data

No data are known to me.

17) Other resources

Numerous dog-breeding clubs exist and can be identified locally. The Armed Forces Institute of Pathology (AFIP) in Washington, DC has an extensive repository of pathologic lesions from the guard dogs in the military services. Cell lines of dog and related carnivores are available through CRES, the research facility of the Zoological Society of San Diego.

18) Future needs for investigation

Considering that so many placental abnormalities exist in human placentas, one should expect that similar pathology might occur in other species. With rare exception these have not been described. Future attention to such pathologic lesions, especially in stillborn pups, might be rewarding. The green pigment should be better defined chemically.

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