A COMPARATIVE MORPHOLOGICAL STUDY ON THE PANCREAS OF THE DROMEDARY (Camelus dromedarius) AND THE DONKEY (Equus asinus)

By

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Dedication

To my father Ali, mother Ryea,
to my brothers, sisters and to the soul of
my best friend Waleed Sorketi.
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CHAPTER ONE
LITRETURE REVIEW

1.1 Gross anatomy:

1.1.A: Colour, shape and lobation:

The colour of the pancreas varied in various domestic animals. It was described as being pinkish yellow or yellowish brown in bovines (Dyce and Wensing, 1971; Nickel, Schummer and Seiferle, 1973; Habel 1975; Dyce, Sack and Wensing, 1987), pinkish yellow, grey, light or dark yellow red or reddish cream in equines (Bradley, 1946; Nickel et al 1973; Sisson, 1975) grey pinkish in the camel (Sultan, 1999). It was observed that the colour of the equine pancreas when unpreserved became dark (Bradley, 1946; Sisson, 1975). Similarly variations in the shape of the pancreas were reported in different domestic animals. In the horse, Indian donkey and sheep the shape was irregular but triangular in outline (Bradley, 1946; May, 1970; Sisson, 1975; Dyce et al., 1987; Dhoolappa Ashok, Ramakarishna, and Gadre, 2004); in ruminant it was irregular (Dyce and Wensing, 1971; Sultan, 1999).

As to the lobation of the pancreas, it was clear that there was a general agreement that the pancreas consists of a left lobe, a right lobe
and a body. However; differences were seen within these lobes. A long right lobe and a short left lobe were reported in ruminants (Dyce and Wensing, 1971; Nickel et al., 1973; Habel 1975; Dyce et al., 1987) and in the Indian donkey (Dhoolappa et al., 2004). On the contrary, the equine pancreas showed a long left lobe and a short right lobe (Nickel et al., 1973; Sisson 1975). Although the camel is a ruminant yet the lobation of the pancreas more or less, resembled that of the horse (Mustafa, Ali, Amar and Ali, 1983; Smuts and Bezuidenhout, 1987; Taha and Abd El-magied, 1998; Sultan, 1999).

1.1. B. Topography of the pancreas:

The ruminant pancreas was located almost in the mesoduodenum and the root of the greater omentum entirely to the right of the median plane (Habel, 1975, 1989). In the horse the pancreas lay ventral to the aorta and the caudal vena cava, at the level of the 16th, 17th and 18th thoracic vertebrae; the bulk of the gland being to the right of the median plane (Bradley, 1946; Nickel et al., 1973; Sisson, 1975; dyce et al., 1987). However Dhoolappa et al. (2004) reported that the pancreas of the Indian donkey extended between the 14th, 15th and 16th ribs at the right side of the median plane.
The pancreas of the camel lay at the level of the first five lumbar vertebrae (Mustafa et al., 1983; Sultan, 1999). The ruminant pancreas is related dorsally to the liver, diaphragm and the celiac and the cranial mesenteric arteries; ventrally, it is related to the intestine and the rumen (Dyce, 1971; Habel, 1975, 1989). The equine pancreas is related dorsally to the right kidney, the caudal vena cava, portal vein, the stomach and the right and caudate lobes of the liver. Ventrally it is related to the base of the cecum, the right dorsal colon and the transverse colon (Bradley, 1946; Nickel et al., 1973; Sisson, 1975). In the camel, the body of the pancreas is related dorsally to the portal vein, caudate lobe of the liver and left crus of the diaphragm and ventrally it is related to the transverse colon (Mustafa et al., 1983 and Sultan, 1999). The right lobe is related dorsally to the visceral surface of the liver, right crus of the diaphragm and the sublumbar muscles. Ventrally it is related to the transverse colon, the hepatic lymph node, mesenteric node and the second duodenal flexure; cranially it is related to the bulb of the duodenum and descending duodenum, caudally to the transverse and descending colon (Mustafa et al., 1983; Smuts and Bezuidenhout, 1987; Taha and Abdel-Magied, 1998; Sultan, 1999). The left lobe is related cranially to the
dorsal sac of the rumen, transverse and descending colons; caudally and laterally to the spleen, left kidney and the left adrenal gland (Mustafa et al., 1983; Smuts and Bezuidenhout, 1987; Taha and Abdel-Magied, 1998; Sultan, 1999).

There were variations regarding the way the portal vein passed through the pancreas. In ruminants it passed through the pancreatic notch (Nickel et al., 1973; Habel, 1975); in equine through a portal ring (Bradley, 1946; Nickel et al., 1973; Sisson, 1975 and Dyce et al., 1987). In the camel, glandular tissue extended between the right lobe and left lobe forming a ring for the passage of the portal vein (Sultan, 1999). Taha and Abdel-Magied (1998) have described two bridges of pancreatic tissue dorsal to the portal vein. One bridge is always present, extending from the right lobe to the left lobe thus forming a ring through which the portal vein passes; the presence of the other bridge was not consistent.

**1. 1. C. Weight and dimensions:**

The weight of the pancreas increased dramatically from small ruminants (sheep and goats) to large ruminants (ox and camel). The average weight in sheep and goats was about 60 g, whereas in the ox it was about 425 g (Habel, 1975) and in the camel was about 500 g (Smuts
and Beziudenhout, 1987; Sultan, 1999). However, Mustafa et al. (1983) have reported that the camel pancreas weighed no more than 300 g. In the horse the pancreas weighed about 350 g (Bradley, 1946; Sisson, 1975), while in the Indian donkey its weight was about 95 g (Dhoolappa et al., 2004).

There appeared to be an agreement by previous workers on the dimensions of the pancreas of the camel regarding the length, width and thickness of the right lobe, left lobe or the body. The length of the right lobe was about 13 cm (Mustafa et al., 1983; Sultan, 1999) and 15 cm (Taha and Abdel-magied, 1998); the length of the left lobe was about 28 cm (Mustafa et al., 1983; Sultan, 1999) and 29 cm (Taha and Abdel-magied, 1998). The width of the right lobe was about 5 cm (Mustafa et al., 1983) and 8 cm (Sultan, 1999); the width of the left lobe was about 5 cm (Mustafa et al., 1983; Sultan, 1999). The thickness of the right and left lobes was more or less similar about 1.5 cm (Mustafa et al., 1983; Sultan, 1999). Although there was no variation between the right and left lobes concerning width and thickness, yet the difference in the length between the right and left lobes was clearly obvious; it was twice as much in the left lobe compared to the right lobe.
1.1. D. The duct system:

The pancreas was closely associated with the duodenum; it has developed by evaginating from the primitive gut as dorsal and ventral bud-like primordia that remained connected to it by secretory ducts (Shively, 1987). One of these two primordia may regress during development, which will result in a pancreas with only one duct. If regression does not occur then both ducts will exist reflecting the double origin of the pancreas. There was a variation between different species in relations to the presence of the pancreatic ducts. In bovines only one duct was present; the dorsal (accessory) pancreatic duct (Wass, 1965; Dyce and Wensing, 1971; Nickel et al., 1973; Habel, 1975; Dyce et al., 1987; Shively, 1987; Habel, 1989), but Wass (1965) and Habel (1975) mentioned that the left lobe of the bovine pancreas was drained by a small duct as a ventral pancreatic duct that joins the common bile duct in the substance of the gland. In sheep and goats only the ventral (pancreatic) duct was present and it joins the common bile duct before it reaches the duodenum (Nickel et al., 1973; Habel, 1975; Dyce et al., 1987). An accessory pancreatic duct in sheep was reported by Abdalla and Sack (1983), but was not seen grossly. In the equine, pancreas the
two ducts were present (Bradley, 1946; Nickel et al., 1973; Sisson, 1975 and Dyce et al., 1987; Shively, 1987). In the camel and the Indian donkey, only the ventral (pancreatic) duct was present (Mustafa et al., 1983; Smuts and Bezuidenhout, 1987; Taha and Abdel- Magied, 1998; Sultan, 1999; Dhoolappa et al., 2004). In the bovine, the dorsal pancreatic duct opens into the duodenum at the major duodenal papilla 30-40 cm away from the pylorus (Nickel et al., 1973); in the horse and Indian donkey, the ventral pancreatic duct opens in the major duodenal papilla along side the opening of the bile duct (Didio and Boyden, 1962; Nickel et al., 1973; Sisson, 1975; Dhoolappa et al., 2004)). The accessory duct of the pancreas of the horse opens in the minor duodenal papilla opposite to the major one (Didio and Boyden, 1962; Nickel et al., 1973; Sisson, 1975). In the camel, the pancreatic duct after emerging from the body, immediately joins the hepatic duct and thus forming the hepatopancreatic duct which opens into the major duodenal papilla (Mustafa et al., 1983; Smuts and Bezuidenhout, 1987; Taha and Abdel Magied, 1998; Sultan, 1999). Sultan (1999) has claimed that this junction occurred in the substance of the gland. There was a general agreement by the various workers (Radmanesh, 1974; Mustafa et al., 1983; Sultan,
that the heptatopancreatic duct of the camel opened in the descending duodenum about 20-25cm from the pylorus. In the Llama (South American camel) the pancreatic duct joins the bile duct at about 3 cm before opening in the duodenum forming the hepatopancreatic duct. The hepatopancreatic duct had a terminal bevel-shaped foramen; located at about 40 cm from the pylorus. The accessory pancreatic duct was not observed (Ghezzi, Alzola, Lupido, Massone, Castro and Rodriguez, 2002).

1.1. E. The blood supply:

The blood supply of the pancreas was mainly from the celiac artery and partially from the cranial mesenteric artery. The ruminant pancreas received direct branches from the celiac artery and also from each of its three branches; the left gastric, the hepatic and the splenic arteries. The cranial pancreateoduodenal artery arose from the gastroduodenal artery; whereas the cranial mesenteric artery furnished the caudal pancreateoduodenal artery (Habel, 1975). The blood supply of the equine pancreas was from the celiac and the cranial mesenteric arteries (Sisson, 1975). The pancreas of the camel received its blood supply from the hepatic and the splenic arteries, branches of the celiac artery. The
intestinal and pancreatoduodenal arteries, which are branches of the cranial mesenteric artery, also contributed to the blood supply of the pancreas (Mustafa et al., 1983; Sultan, 1999).

1. 2. The histological studies:

The pancreas which is a compound tubulo-acinar gland is encapsulated, lobulated and consisted of both exocrine and endocrine secretary portions in animals (Stinson and Calhoun, 1981). The human pancreas was covered by a thin layer of connective tissue that does not form a definite capsule (Bloom and Fawcett, 1986).

The pancreas of the camel consisted of both exocrine and endocrine portions and it is enclosed by a thick connective tissue capsule which is rich in adipose tissue, reticular fibers, collagen fibers, elastic fibers, blood vessels and nerve fibers (Sultan, 1999).

The connective tissue septa extended into the gland to divide it into lobules. These septa contained adipose tissue, blood vessels, nerve fibers, ducts and groups of lymphatic cells (Stinson and Calhoun, 1981; Bloom and Fawcett, 1986; Sultan, 1999).

1. 2. A. The exocrine portion:

This portion is made of secretory units and duct system.
1.2. A. 1: The secretory units:

The secretory units of the pancreas were tubulo-acinar with the tubular portion more prominent in ruminants (Stinson and Calhoun, 1981). In the horse, the pancreas was tubulo-alveolar and the alveoli were long, like those of the duodenal glands (Sisson and Grossman, 1964). In the pig pancreas, the secretory units showed different shapes: round, oval or irregular (Singh and Singh, 1980).

In the camel, they were tubulo-acinar with the acinar portion more prominent (Sultan, 1999).

The secretory epithelial cells were generally pyramidal in shape with spherical nuclei near the base of the cell (Stinson and Calhoun, 1981); they rested upon a basal lamina supported by delicate reticular fibres (Bloom and Fawcett, 1986). The acinar cells of sheep were mononucleated but a few were binucleated and the nuclei were mostly spherical or oval in shape (Mukherjee, Singh, Roy, Barnwal and Sharan, 1986). In the camel and the Indian donkey, the acinar cells were pyramidal in shape with spherical basal nuclei and their lumina were narrow; the acinus cells rested upon a basal lamina and supported by a network of reticular fibres (Sultan, 1999; Dhoolappa et al., 2004). Three
types of acinar cells were recognized in the pancreas of sheep, buffaloes, ox, goats, horses, dogs, cats, pigs and fowl. These types were active acinar-cell, exhausted acinar-cell and resting acinar-cell (Singh, 1980; Singh and Singh, 1980; Mukherjee et al., 1986).

1. 2. A. 2. The duct system:

The duct system began as flattened centroacinar cells in the lumen of the acini (Bloom and Fawcett, 1986; Lone, Prasad and Sinha, 1988; Sultan, 1999; Dhoolappa et al., 2004). All of these authors agreed on the presence of intercalated, intralobular, interlobular and the main pancreatic ducts.

1. 2. A. 2. 1. The intercalated duct:

In sheep it was lined by spindle-shaped cells and the nuclei were oval and directed along the duct wall (Lone et al., 1988); but Gemmel and Heath (1973) in sheep and Dhoolappa et al. (2004) in the Indian donkey, reported that this duct was lined by cuboidal cells. In the camel it was lined by simple cuboidal cells which were supported by a basal lamina (Sultan, 1999).

1. 2. A. 2. 2. The intralobular duct:

The intralobular duct was lined by low cuboidal epithelial cells in
the goat (Stinson and Calhoun, 1981). Gemmel and heath (1973) reported that this duct was lined by columnar cells while Lone et al. (1988) reported that it was lined by low to tall cuboidal cells in sheep. In the camel, it was lined by simple cuboidal cells (Sultan, 1999).

1. 2. A. 2. 3. The interlobular duct:

The interlobular duct of the pancreas of sheep was surrounded by a thick coat of connective tissue. It was lined with tall cuboidal to columnar cells with goblet cells interspersed among them in sheep (Lone et al., 1988) and the Indian donkey (Dhoolappa et al., 2004). In addition to the lining columnar cells and goblet cells, small mucous glands were also observed (Bloom and Fawcett, 1986). In the camel, the interlobular duct started as small duct which was lined by simple cuboidal epithelium which then changed into stratified cuboidal epithelium which was supported by a basal lamina and thick dense connective tissue layer (Sultan, 1999).

1. 2. A. 2. 4. The main pancreatic duct:

In sheep, the main pancreatic duct was lined by columnar cells with goblet cells and mucous glands (Gemmel and heath, 1973; Lone et al., 1988). Lone et al (1988) reported also that this duct was surrounded
by connective tissue in sheep. In the camel this duct was lined by columnar cells supported by a basal lamina and connective tissue (Sultan, 1999).

1. 2. A. 2. 5. The hepatopancreatic duct:

   This duct was lined by columnar cells with goblet cells in the guinea pig, but in dogs and cats it has mucosal folds with saccular glands but no goblet cells, whereas in the monkey, goblet cells were present (Mcminn and Kugler, 1961). The hepatopancreatic duct of the camel was lined by a single layer of folded simple columnar epithelium with dense lamina propria of connective tissue mainly of elastic fibers (Sultan, 1999). Siddig (2002) reported that, in the camel, there were mucous glands surrounded by collagen fibers.

1. 2. B. The endocrine portion (islets of Langerhans):

   The endocrine portion was incorporated among the exocrine portion of the pancreas. It was in the form of small masses of endocrine cells which were highly vascular and were known as islets of Langerhans.

   The endocrine portion of sheep pancreas was organized in irregular clumps of cells which were dispersed intralobularly. These clumps
showed no distinct capsule but they were separated from the pancreatic acini by a thin layer of reticular tissue. These clumps of cells were actually the islets of Langerhans. The islets were of variable size and shape (Mukherjee, Singh, Barnwal and Sharan, 1988).

In the camel, the islets displayed different shapes which varied from round, oval, elongated to irregular (Alani, 1987; Sultan, 1999). Sultan (1999) has claimed that interlobular islets of Langerhans were present but they were much smaller than the intralobular islets. Some of the intralobular islets were located near the ducts while others were connected by slender epithelial cords to the duct in the camel (Sultan, 1999). In the camel, the islets had a rich blood supply and they were divided by connective tissue septa; some of the blood capillaries were enlarged forming a large central cyst–like structure (Alani, 1987; Sultan, 1999).

In a number of animals, the pancreas showed three types of endocrine cells, alpha cells (A cells), beta cells (B cells) and delta cells (D cells) (Bloom and Fawcett, 1986). These types of cells were also described in the horse (Furuoka, Ito, Hamada, Suma, Satoh and Itakora, 1989), man and rat (Erladnsen, Hegre, Parsons, Mcevoy and Elde, 1976),
canine (Muranishi, Takehana, Hiratsuka, Kobayashi, Eerdunchaolu, Iwasa and Abe 1999), bovine (Bonner-Wier and Like 1980) and camel (Alani, 1987; Khatim, Gumaa, Petersson, Lundqvist, Grimelius and Hellerstrom, 1985; Sultan, 1999).

1. 2. B. 1. The beta cells:

   The central location of the beta cells in the islets seemed to be the general rule for the vast majority of domestic animals (Erlandsen et al., 1976; Bonner-Wier and Like, 1980; Khatim et al., 1985; Alani, 1987; Mukherjee et al., 1988; Sultan, 1999). However, the horse seemed to be the exception since the beta cells were located peripherally in the islets (Helmstaedter, Feurle and Frossmann, 1976; Dellmann, 1981; Furuoka et al., 1989). In the camel pancreas the beta cells have oval nuclei and arranged in cords (Sultan, 1999).

1. 2. B. 2. The alpha cells:

   The alpha cells were few in number compared to the beta cells and they were located at the periphery of the islets, but their central location was not uncommon. Their nuclei were generally ovoid in shape, although spherical nuclei were sometimes present (Mukherjee et al., 1988). The peripheral location of the alpha cells in the islets seemed to be the general
rule for the vast majority of domestic animals (Erlandsen et al., 1976; Bonner-Wier and Like, 1980; Dellmann, 1981; Khatim et al, 1985; Alani, 1987; Sultan, 1999). Again the horse seemed to be the exception since the alpha cells were located centrally in the islets (Helmstaedter et al., 1976; Furuoka et al., 1989).

1. 2. B. 3. The delta cells:

Most of these cells were located in the periphery of the islets in bovines (Bonner-Wier and Like, 1980), the horse (Helmstaedter et al., 1976 and Furuoka et al., 1989), and the camel (Alani, 1987), but in camels their location could be peripheral or central (Khatim et al., 1985; Sultan, 1999).

1. 3. The ultrastructural studies:

1. 3. A. The exocrine cells:

The cytoplasm of the acinar cells around the nuclear region contained well developed endoplasmic reticulum and numerous mitochondria, the apical region contained membrane-bound zymogen granules, and there was a well developed Golgi complex between the nucleus and the zymogen granules (Stinson and Calhoun, 1981). The basal half of the exocrine pancreatic cells was occupied by parallel cisternae of granular endoplasmic reticulum, long mitochondria with well
developed cristae, numerous matrix granules, and lipid droplets (Bloom and Fowcet, 1986).

1.3. B. The endocrine cells (islets of Langerhans):

1.3. B. 1. The beta cell:

In some species the granules of beta cell were only lightly different in size and electron density from those of alpha cell but in the dog and some other species they showed crystalloid structure of variable shapes embedded in a pale matrix. The endoplasmic reticulum was less abundant than in the alpha cell, the Golgi complex was more extensive and the mitochondria were larger (Dellmann, 1981; Bloom and Fawcett, 1986). In the bovine beta cell, the granules were larger in size than that of the alpha cell but they were less electron dense and they showed a large halo around the dense material. Other organelles included long slender mitochondria and few cisternae of rough endoplasmic reticulum which were interspersed among the numerous beta granules (Bonner-Wier and Like, 1980). In the horse, the B-cell granules were round and less electron dense than the A-cell granules. The halo was wider in the more electron dense than in the pale granules of the same cell. The pale granules were generally predominating in the B-cells. The Golgi
apparatus was specially well-developed. The mitochondria did not show any peculiarities (Frossmann, 1976).

1. 3. B. 2. The alpha cell:

The cytoplasm of the alpha cell showed membrane-bound granules, few granular endoplasmic reticulum, small Golgi complex and a few long slender mitochondria. These organelles mainly occupied the apical part of the cell (Dellmann, 1981; Bloom and Fawcett, 1986). In bovines, the mitochondria were large with three common profiles: round, doughnut and sausage shape (Bonner-Wier and Like, 1980). In the horse, the granules of the A-cells were round in shape and contained an electron-dense material with smooth membrane. A distinct halo was present. The granules were usually closely packed with each other and a few granular endoplasmic reticulum was found between them. The A-cells had round, oval, kidney or rod shaped mitochondria. Near the nucleus, a distinct Golgi apparatus was sometimes seen (Frossmann, 1976). In guinea pigs, rats, rabbits, and dogs alpha cells showed pale cytoplasm with dense round granules (Lacy, 1957).

1. 3. B. 3. The delta cell:

The delta cell contained large membrane-bound granules with
moderate electron density (Dellmann, 1981). In bovine, the delta cell had a homogenous moderately electron dense material that filled the limiting membrane and the electron density of the granules was variable within the individual cell (Bonner-Wier and Like, 1980). In the horse islets, the delta cells granules were always lighter than those of the A-cells and had a very closely attached membrane with no or incomplete halo. Mitochondria and endoplasmic reticulum were similar to those of alpha cells (Frossmann, 1976).
Objectives

According to the available literature on the morphology of the pancreas of the camel and equines, it appears that there are several gaps which need to be filled, especially the lobation, duct system and blood supply. Moreover, little if any was done on the ultrastructure of the pancreas on dromedary camel and donkey.

The present study aims to investigate:

1. Position and lobation of the pancreas.
2. The duct system.
3. The blood supply.
4. Histology of the acinar and endocrine parts (islets of Langerhans).
5. Total lipids determination.
6. The ultrastructure with special emphasis on acinar cells and islets of Langerhans.
CHAPTER TWO

MATERIAL AND METHODS

Specimens of the pancreas from 63 adult camels and 20 adult donkeys were used in this study. Sex was not considered. Their age varied from 6-15 years old in the camels and in the donkeys. All camels and donkeys were healthy and no signs of illness were observed.

2. A. Gross anatomy:

Some of these specimens (specimens from 5 camels and 4 donkeys) were used to study the topography of the pancreas, others (specimens from 10 camels and 6 donkeys) were used for the injection techniques in order to study the duct system and the blood supply. For recording the dimensions and the weight of the pancreas, specimens from 10 camels and 5 donkeys were used.

Dimensions of the pancreas were measured by a vernier caliber. The pancreas was weighed by a sensitive digital balance (manufactured by A& D CO/ LTD. Japan).

For the duct system, specimens from 5 camels and 3 donkeys were used, each gland was flushed with normal saline and was then injected with vinyl acetate. It was then transferred to a fridge and left there
overnight. After that, the injected gland was removed from the fridge and placed in a well ventilated room. It was then covered with concentrated solution of hydrochloric acid, left there for 24-48 hrs until the tissues were well rotted.

To study the blood supply specimens from 5 camels and 3 donkeys were used, each of the specimens of the pancreas was removed together with a portion of the abdominal aorta where the celiac and the cranial mesenteric arteries originated. Moreover, a portion of the duodenum which is related to the pancreas was also removed. Each specimen was flushed with normal saline solution, and then specimens of 3 camels and 2 donkeys were injected first with 10% formalin and then immersed in a jar filled with 5% formalin overnight and then carefully dissected. The other specimens were injected with vinyl acetate. They were transferred to a fridge and left there overnight. They were finally removed from the fridge and carefully dissected.

2. B. Histology:

Pancreatic specimens from 30 camels and 5 donkeys were used to study the microscopic structure. Small pieces of tissue were taken from three regions of every pancreas; the body, the right lobe and the left lobe.
Fixation was carried out in 10% Formalin, 10% buffered neutral formalin, 10% formal saline, and Bouins fluid for different periods of time. This was followed by dehydration in ascending grades of alcohol (70%, 90% and 100%). Then they were cleared in chloroform and embedded in paraffin wax. Sections, 5-7µ thick, were cut using 820 microtome (manufactured by American optical company. U S A). Sections were spread in water path at 40c° and mounted on clean slides and were then put in an oven at 37c° to dry. The slides were then cleared in xylene and rehydrated in descending grades of alcohol (100%, 90%, and 70%). After that the slides were washed with distilled water and finally stained with haematoxyline and eosin (H&E) for routine histology (Culling, 1974).

The following special stains were used to study certain structures:

1. Masson trichrome for collagen fibers and alpha and beta cells of islets of Langerhans (Culling, 1974).

2. Gordon and Sweet reticulum stain for the reticular fibers (Drury and Wallington, 1980).

3. Aldhyde fuchsine and Orcen for elastic fibers (Drury and Wallington, 1980).
4. Periodic acid Schiff (PAS) reagent for basement membrane and goblet cells. (Drury and Wallington, 1980).

5. Modified Aldhyde fuchsine for alpha, beta and delta cells of the islets of the Langerhans (Culling, 1974).

Histometrical measurements were carried out in order to determine the diameter of the nuclei of the exocrine cells. The objective lens X40 was used to measure the diameter of the nucleus after calibrating the ocular scale of the microscope (Tienpot, Rochette and Vamparijs, 1986).

2. C. Ultrastructure:

Specimens of the pancreas were taken from three adult camels. Small pieces from the body, right lobe and the left lobe were excised and immersed in 5% gluteraldehyde for 2-24 hours. Then they were washed with phosphate buffer (PH 7.2) 3-4 times for 20 minutes in each change. Then they were post-fixed in 1% Osmium tetroxide for 2 hours, and they were then washed four times for 20 minutes in each change in phosphate buffer. Dehydration was carried out in ascending grades of alcohol (30%, 50%, 70%, 90% and 100%) and they were finally embedded in Epon 812 in gelatin capsules. Polymerization was carried out in an incubator at 35 c°, 45 c° and 60 c°. Semi thin sections of 0.5-1µ were cut
using LKB 8800 microtome. These sections were stained with toluidine blue and examined by the light microscope. The desired areas were chosen and then ultra thin sections were cut by Reichert ultra cuts microtome 500-800 Å in thickness. They were mounted on copper grids. They were then stained in uranyl acetate for 25 minutes and followed by lead citrate for 5 minutes and finally examined with electron microscope JEM 100 CX.

2. D. Total lipids extraction:

Fresh specimens from 5 camels were used to determinate the total lipids of the pancreatic tissue.

Lipids were extracted in chloroform: methanol (2/1 V/V) according to the method of Folch, lees and Sloan (1957) as modified by Overtarf and Dryer (1969).

One gram of tissue was homogenized in nine volume chloroform / methanol (2: 1 V/V) in a homogenizer for 2 min. The homogenate was allowed to stand at 5 °C for 30 min, and then decanted through a fat- free filter paper into a measuring cylinder. The residue was rehomogenized in 10 volume chloroform / methanol (2: 1 V/V) and the homogenate was then filtered. The combined filtrate was washed with 0.2 volume of
freshly prepared 0.29% sodium chloride solution. The washed extract was allowed to stand overnight at 5 c°. The extract was separated in 2 phases. The upper phase was removed with a Pastier pipette and discarded; the lower chloroform phase contains the lipids.

2. E. Total lipids determination:

Total lipids in camel pancreatic tissue were determined as described by Fringes and Dunn (1970). An aliquot of lipid extract in chloroform was pipetted into test tubes and evaporated to dryness. The dried lipids were digested with 2 ml concentrated sulphuric acid. The tubes were incubated for 10 min. in a boiling water bath. The digest (0.1 ml) was added to 5 ml of phosphovanillin reagent and the mixture incubated at 37 c° for 15 min. Using spectrophotometer the absorbance was read at 540 nm against the blank.
CHAPTER THREE
RESULTS

3.1. Gross anatomy

3.1.1. Camel:

3.1.1.1. General topography:

The pancreas of the camel is grayish pink in color in the fresh state. It is covered by great amount of fat (Fig 1&2), this amount of fat is about 14g/171g (14g/gland). The camel pancreas has no definite shape, lies at the level of the first five lumbar vertebrae. It weighs about 171gm.

The camel pancreas consists of a quadrilateral body, long tongue-shaped left lobe and a wide quadrate right lobe (Fig1). A bridge of glandular tissue was observed dorsal to the portal vein, extending from the right lobe to the left lobe thus forming a ring through which the portal vein passes (Fig 1, 2).

The body lies entirely to the right of the median plane at the region of the porta hepatis. It measured about 10cm in length, 4cm in width and 1.5cm in thickness. It is related cranially to the ampulla of the duodenum, mediodorsally to the portal vein and the hepatic lymph node; laterally to the first flexure of the descending duodenum. Dorsally, the body is
related to the visceral surface of the liver at the region of the porta hepatis and to the hepatic duct, ventrally it is related to the transverse colon.

The right lobe is situated in between the two layers of the mesoduodenum. It measured about 16 cm in length, 5 cm in width and 1.5 cm in thickness. It is related dorsally to the visceral surface of the liver and the right kidney, medially to the portal vein, the hepatic lymph node and the caudal vena cava. Laterally it is related to the descending duodenum and ventrally to the transverse colon.

The left lobe is lying in between the two layers of the greater omentum. It measured about 29 cm in length, 5 cm in width and 1 cm in thickness. It is related cranially and ventrally to the caudodorsal sac of the rumen, caudolaterally to the spleen and the splenic vessels, dorsally to the left crus of the diaphragm and the left kidney.

3.1. A. 2. Duct system:

Only one pancreatic duct was observed in the camel; this duct is the ventral one which emerged from the body of the pancreas and immediately joined the common hepatic duct and thus forming the hepatopancreatic duct (Fig 3). This union usually occurs at the dorsal part
of the body (Fig 3). The cast of the duct system of the pancreas showed that it is made up of two main radicals; a long one corresponding to the left lobe and a short one which conforms to the right lobe. The two main radicals become united at the body thus forming the main pancreatic duct (Fig 4). The hepatopancreatic duct enters the duodenum and courses obliquely in its submucosa about 3 cm before it opens by a bevel-shaped foramen (Fig 5&6). The hepatopancreatic duct enters the duodenum about 42 cm away from the pylorus.

3. 1. A. 3. Blood supply:

The blood supply of the pancreas of the camel is furnished via the celiac and cranial mesenteric arteries. The celiac branches are the hepatic and splenic arteries; whereas the cranial mesenteric artery gives one branch, the caudal pancreaticoduodenal artery (Fig 7).

The body of the pancreas receives its blood supply from many resources. These include: 1/ Pancreatic branch from the hepatic artery. 2/ Three branches from the gastroduodenal artery; the caudal branch supplies the body and the cranial part of the left lobe, the middle one supplies the left half of the body and terminates at the cranial part of the right lobe, and the cranial branch supplies the middle part of the body. 3/
Branches from the cranial pancreaticoduodenal artery (Fig 7).

The right lobe received its blood from: 1/ Right pancreatic branch of the hepatic artery, which divides into 2-3 branches that supply the cranial, middle and caudal aspects of the lobe. 2/ Pancreatic branch from the caudal pancreaticoduodenal artery (Fig 7).

The dorsal surface of the left lobe of the camel pancreas is supplied by the left pancreatic branch of the hepatic artery which originated caudally to the right branch. The ruminal (ventral) surface of the left lobe is supplied by a major branch from the splenic artery which also extended to the caudal end of it (Fig 7)

3. 1. B. donkey:

3. 1. B. 1. General topography:

The color of the pancreas of the donkey is reddish cream. The pancreas is triangular in shape. It consists of a body, right lobe, and left lobe (Fig 8). Glandular tissue from the caudal end of the right lobe extended over the portal vein to the left lobe thus forming a ring (Fig8,9).

The body measured about 7 cm in length, 6 cm in width and 1 cm in thickness. The right lobe measured about 10 cm in length, 7 cm in
width and 1 cm in thickness. The left lobe measured about 16 cm in length, 6 cm in width and 1 cm in thickness.

The pancreas of the donkey lies transversely under the 16, 17 and 18 thoracic vertebrae but the greater bulk of it lies to the right of the median plane.

The pancreas is related dorsally to the right and the caudate lobes of the liver, the cranial part of the duodenum, the portal vein, the caudal vena cava, the right kidney and the right adrenal gland. Ventrally, it is related to the base of the cecum, the right dorsal colon, the left kidney and the left adrenal gland (Fig. 10 & 11).

3. 1. B. 2. Duct system:

Only one pancreatic duct, the ventral one, appeared to drain the pancreas of the donkey. It emerged from the body and ran for a short distance before it perforated the duodenal wall (Fig 12) to open alongside the common hepatic duct at the major duodenal papilla (Fig 13). The cast of the duct system of the pancreas showed that it consisted of two main radicals, a long radical corresponding to the left lobe and a short one corresponding to the right lobe. The left and right radicals united at the body to form the main ventral pancreatic duct (Fig 14).
3. 1. B. 3. Blood supply:

The pancreas received its blood supply from the celiac and cranial mesenteric arteries.

The celiac artery divided into three branches, splenic, hepatic, and left gastric arteries immediately after its origin from the aorta; this division occurred at the dorsal aspect of the caudal third of the left lobe (Fig 15).

The body of the pancreas received its blood supply from: 1/ Two pancreatic branches of the gastroduodenal artery, the first branch was the larger one and originated from the gastroduodenal artery just after its origin from the hepatic artery, the second smaller branch has originated just before the gastroduodenal artery divided into right gastroepiploic and cranial pancreaticoduodenal arteries. 2/ Two to three pancreatic branches from the cranial pancreaticoduodenal artery (Fig 15).

The left lobe received its blood supply via three branches; a branch from the splenic artery and two branches from the hepatic artery(Fig 15).

The right lobe received its blood supply mainly from a branch of the cranial mesenteric artery (Fig 15).
3.2. Histology of the pancreas:

3.2. A. Camel:

The camel pancreas is made up of exocrine as well as endocrine portions.

The pancreas is covered by a connective tissue capsule which was rich in adipose tissue, collagen fibers, few elastic fibers and blood vessels (Fig 16, 17, 18). Nerve fibers (Fig 19) were also present in the capsule.

Many connective tissue septa extended from the capsule into the parenchyma of the pancreas dividing it into lobules (Fig 20). These septa contained adipose tissue, blood vessels, nerve fibers (Fig 21) and ducts (Fig 22). The adipose tissue was not confined only to the septa but it was also observed infiltrating the parenchyma (Figs 17, 20, 23).

3.2. A. 1. Exocrine portion:

The exocrine portion of the pancreas was made up of secretory units and duct system. The secretory units were tubulo-acinar with the acinar portion more pronounced (Fig 24). The secretory units consisted of a single row of pyramidal epithelial cells converging toward a central narrow lumen (Fig 24). These cells were resting upon a basal lamina supported by delicate reticular fibers (Fig 25). The nuclei of these cells
were spherical in shape, and they were usually located near the base of the cell although some of them were centrally located (Fig 24). Nuclei which were oval in shape were observed occasionally (Fig 24). The apical region of the cell contained zymogen granules (Fig 24, 26, 27). Three types of acinar cells can be identified on the basis of shape, size and location of the nucleus and its chromatin content (Table. 1). The amount of zymogen granules present in the cytoplasm was an additional criterion (Table. 1). These types were active, exhausted, and resting acinar cells.

The nucleus of the active acinar cell was euchromatic with spherical shape and a basal position. It had a diameter of about 5.2 µm. The amount of zymogen granules was less than that in the resting cell but it was greater than in the exhausted cell (Fig 27).

The nucleus of the exhausted cell was euchromatic, spherical in shape, centrally located and had a diameter of about 7.8 µm. The amount of zymogen granules was less than in the active and resting cells (Fig 24).
**Table 1:** Table summarizing the characteristic features of the three types of acinar cells of the camel pancreas regarding nuclear shape, size, position and type of chromatin of the nucleus in addition to the amount of zymogen granules.

<table>
<thead>
<tr>
<th>Types of acinar cell</th>
<th>Nucleus</th>
<th>Zymogen granules</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shape</td>
<td>Size (µm)</td>
</tr>
<tr>
<td>Active</td>
<td>Spherical</td>
<td>5.2</td>
</tr>
<tr>
<td>Exhausted</td>
<td>Spherical</td>
<td>7.8</td>
</tr>
<tr>
<td>Resting</td>
<td>Oval</td>
<td>3.2</td>
</tr>
</tbody>
</table>
The resting cell nucleus was heterochromatic, oval in shape, basally positioned and lied toward the basal lamina of the cell. It measured about 3.02 µm. The amount of zymogen granules was more than both of the active and exhausted cells (Fig 27).

The cells located in the lumen of the acini were identified as centroacinar cells (Fig 28, 29). The centroacinar cells formed the beginning of the intercalated duct which constituted the first part of the duct system.

The duct system was divided into five segments which include intercalated duct, intralobular duct, interlobular duct, main duct and the hepatopancreatic duct. The intercalated duct started as centroacinar cells; it was lined by low cuboidal cells with flattened nuclei (Fig 29). The intralobular duct was lined by cuboidal cells supported by a basal lamina and collagen fibers (Fig 30). The interlobular duct was found between the lobules in the connective tissue septa (Fig 31). It was lined by cuboidal cells and was supported by a thick layer of collagen fibers. The main duct was lined by columnar cells supported by dense layer of collagen fibers (Fig 32, 33). The hepatopancreatic duct showed a folded mucosa (Fig 34) which was lined by tall columnar cells (Fig 35), no goblet cells were
seen. This mucosa was surrounded by a dense layer of connective tissue mainly collagen fibers (Fig 36). Few elastic fibers were also present (Fig 37). Mucous glands were present in the form of irregular groups in the connective tissue layer (Fig 35, 36, 38, 39). These glands were made of pyramidal cuboidal cells with basally situated round nuclei (Fig 38). The glands were small in size and had narrow lumina (Fig 38). These mucous glands and their ducts contained mucopolysacharides (Fig 39).

3. 2. A. 2. Endocrine portion (Islets of Langerhans):

The islets of Langerhans which represented the endocrine portion of the camel pancreas appeared as pale areas among the acini. The islets varied in shape; they were round, oval or irregular (Fig 40). Some islets were small others were large. The islets were separated from the acini by a thin layer of reticular fibers which were seen extending into the interior of the islets; but no distinct capsule encircling the islets was observed. Beside the intralobular islets there were interlobular islets of Langerhans in the connective tissue septa (Fig 41). Occasionally the intralobular ducts were observed in the vicinity of the islets of Langerhans (Fig 42). The islets had a rich vascular supply, some blood capillaries were
enlarged forming a large cyst-like structure (Fig 43). These cysts were filled by red blood cells (Fig 43) and acidophilic material (Fig 44).

The cells of the islets of Langerhans were arranged as irregular coils surrounding the blood capillaries. Many of these cells were beta cells; they comprised about 64% of islet cells. They were centrally located and their nuclei were spherical in shape (Fig 44). The alpha cells appeared to be fewer in number than the beta cells; they comprised about 24% of the islet cells. They were located at the periphery of the islets; their nuclei were oval in shape (Fig 44). The delta cells with round nuclei were seen at the periphery of the islets among the alpha cells, they constituted about 6% of the islet cells.

3. 2. B. donkey:

The pancreas of the donkey was also covered by connective tissue capsule which consisted of collagen fibers mainly and a few elastic fibers (Fig 45, 46). Many connective tissue septa extended from the capsule into the parenchyma of the pancreas dividing it into complete and incomplete lobules (Fig 45). These septa contained collagen fibers, blood vessels and ducts (Fig 47, 48). Nerve fibers were also present in the septa.
3. 2. B. 1. Exocrine portion:

The exocrine portion was made up of excretory units and duct system.

The excretory units were tubulo-alveolar (Fig 49, 50). They were consisted of pyramidal cells which were resting upon a basal lamina and were surrounded by delicate reticular fibers (Fig 51). The nuclei of these cells were spherical in shape and they were usually located near the base of the cell although some of them were centrally located (Fig 52, 53). Oval nuclei were observed occasionally (Fig 52). The apical region of the cell contains zymogen granules (Fig 52, 53). Three acinar cell types were identified on the basis of the nuclear shape, position, size and the chromatin type (Table. 2) and also the amount of the zymogen granules (Table. 2). These types were active, exhausted and resting acinar cells.

The active acinar cell nucleus was euchromatic with spherical shape and basal position. It measured about 5.2 µm. The amount of zymogen granules was less than that of the resting cell but it was more than the exhausted cell (Fig 52).
**Table 2:** Table summarizes the characteristic feature of the three types of acinar cells of the donkey pancreas regarding shape, size, position and type of chromatin of the nucleus in addition to the amount of zymogen granules.

<table>
<thead>
<tr>
<th>Types of acinar cell</th>
<th>Nucleus</th>
<th>Zymogen granules</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shape</td>
<td>Size [μm]</td>
</tr>
<tr>
<td>Active</td>
<td>Spherical</td>
<td>5.2</td>
</tr>
<tr>
<td>Exhausted</td>
<td>Spherical</td>
<td>6.5</td>
</tr>
<tr>
<td>Resting</td>
<td>Oval</td>
<td>3.5</td>
</tr>
</tbody>
</table>
The exhausted cell nucleus was euchromatic, spherical shape, and central position and measured about 6.5 µm. The amount of zymogen granules was less than both of active and resting cells (Fig 53).

The resting cell nucleus was heterochromatic, oval shape, basal position and lied toward the basal membrane of the cell. It measured about 3.5 µm and the amount of zymogen granules was more than both of active and exhausted cells (Fig 52).

The cells which were located in the lumen of the acini are identified as centroacinar cells (Fig49, 50).

The duct system was divided into five segments which included intercalated duct, intralobular duct, interlobular duct, main duct and the ventral pancreatic duct.

The intercalated duct (Fig 54) started as the cenroacinar cells; it was lined by low cuboidal cells supported by thin layer of collagen fibers. The intralobular duct (Fig 55) was lined by cuboidal cells and was surrounded by collagen fibers. The interlobular duct which was located in the connective tissue septa started as small interlobular duct (Fig 56) which was lined by cuboidal cells, while the large interlobular duct with folded mucosa was lined by simple columnar cells (Fig 57). The small
and large interlobular ducts were surrounded by thick layer of collagen fibers. The main duct showed a folded mucosa too and was lined by columnar cells and supported by a layer of dense collagen fibers (Fig 58). The ventral pancreatic duct showed also a folded mucosa which was lined by columnar cells (Fig 59). A layer of dense connective tissue, mainly collagen fibers, surrounded the duct (Fig 59). A few elastic fibers were also present (Fig 60). Mucous glands were present in the form of goblet cells interspersed among the epithelial cells (Fig 61) and irregular groups in the connective tissue layer (Fig 59). The glands in the connective tissue were lined by pyramidal cells with basal oval nuclei.

3. 2. B. 2. Endocrine portion (islets of Langerhans):

The islets of Langerhans which represented the endocrine portion of the donkey pancreas appeared as pale areas among the acini. The islets were varied in shape and size (Fig 62). They were separated from the acini by a thin layer of reticular fibers which were seen extending into the interior of the islets; but no distinct capsule encircling the islets was observed. Occasionally the intralobular duct was observed in the vicinity of the islets of Langerhans. The islets had a rich vascular supply; some blood capillaries were enlarged forming cyst-like structure.
The cells of the islets were arranged as irregular cords surrounding the blood capillaries. Many of these cells were beta cells; they comprised about 60% of islet cells. They were located at the periphery of the islet and their nuclei were spherical in shape (Fig 63). The alpha cells were located in the center of the islet and amounted to about 25% of the islet cells; their nuclei were oval in shape (Fig 63). The delta cells were located in the periphery of the islets and they constituted about 8% of the islet cells, their nuclei were spherical in shape.

3.3. The ultrastructure:

The ultrastructure of the exocrine and endocrine cells (islets of Langerhans) of the camel pancreas had been studied.

In the exocrine cell the area at the basal part of the cell and around the nucleus was occupied by tubular elements and parallel cisternae of granular endoplasmic reticulum (Fig 64, 65). The mitochondria were short or round in shape (Fig 64, 65). The apical region of the cell was filled by the zymogen granules which varied in size and shape (Fig 66, 67). The granules showed highly electron dense material and were surrounded with ambiguous limiting membranes (Fig 66, 67). The Golgi complex was found supranuclearly between the nucleus and the zymogen
granules (Fig 65, 68). The lumen of the acinus was usually filled with moderate amount of dense homogenous material (Fig 64, 66). The acinar cells were joined together by junctional complexes (Fig 64, 66) mainly of desmosomes. The centroacinar cells (Fig 69) were usually present in the lumen of the acini and showed a cytoplasm with poor organelles, that gave the cells a light appearance. The intercalated duct, which is the continuation of the centroacinar cells showed a row of low cuboidal cells with elongated nuclei, and surrounded by collagen fibers in which fibroblast appeared with oval nuclei (Fig 70). The low cuboidal cells which lined this duct showed a cytoplasm with poor organelles.

Three types of endocrine cells were observed in the islets of Langerhans of the camel pancreas. These cells were alpha, beta and delta cells (Fig 71). All these cells showed dense-cored granular vesicles in their cytoplasm (Fig 71). Other organelles present in the cytoplasm included: a few rough endoplasmic reticulum, round mitochondria and some lipid droplets (Fig 71, 72, 73, 74, 75). The endocrine cells of the islets can be differentiated on the basis of:

1. Their location.
2. Their granular vesicles.
The beta cells were found in the center of the islets (Fig 71). They had round granules which were moderately electron dense. The granular vesicles showed a distinct halo (Fig 72).

The alpha cells were located at the periphery of the islets (Fig 71). The dense-cored granular vesicles were rounded in shape and were highly electron dense. They showed a narrow halo (Fig 73, 74).

The delta cells were located in the periphery of the islets (Fig 71). Their granules were small in size compared to the alpha and beta cells. The halo is not clear (Fig 75).
CHAPTER FOUR
DISCUSSION

4.1. Anatomical studies:

In the present study, the colour of the pancreas of the camel was different from that in the donkey; it was greyish pink in the camel whereas in the donkey it was reddish cream. This observation was in conformity to that mentioned by Sultan (1999) in the camel and by Sisson (1975) in the horse. But Dhoolappa et al. (2004) reported that the colour of the pancreas of the Indian donkey was greyish pink to pale brown.

It appeared that there is a general agreement that the pancreas of the camel has no definite shape (Taha and Abdel-Magied, 1998; Sultan, 1999). This is also true for the present study. But the shape of the pancreas of the donkey is triangular. A triangular shape of the pancreas has previously been mentioned in the horse, Indian donkey and sheep (May, 1970; Sisson, 1975 and Dhoolappa et al., 2004). A totally different shape of the pancreas, a V- shape, was observed in the dog (Miller, Christensen, and Evans., 1964).
Like other domestic animals, the pancreas of the camel and donkey consisted of a left lobe, a right lobe and a body. But it differed in that the left lobe was longer than the right lobe. This observation is similar to what had already been described by Mustafa et al. (1983), Smuts and Bezuidenhout (1987), Taha and abdel-Magied (1998) and Sultan (1999) in the camel, and in the horse (Nickel et al., 1973 and Sisson, 1975).

However, Dhoolappa et al. (2004) have a different notion that in the pancreas of the Indian donkey the right lobe is longer than the left lobe. The presence of an accessory lobe, which was ascribed to the pancreas of the camel by Hegazi (1945), Mustafa et al. (1983) and Sultan (1999), was not seen during the present study. It was also not reported by Taha and Abdel-Magied (1998).

In the present study the pancreas of the camel is situated at the level of the first five lumbar vertebrae; this is similar to the finding of Mustafa et al. (1983) and Sultan (1999). In the donkey, the pancreas is situated at the level of the 16th, 17th and 18th thoracic vertebrae; this resembles the position of the pancreas in the horse (Bradley, 1964; Nickel et al., 1973; Sisson, 1975; Dyce et al, 1987). However, Dhoolappa et al. (2004) have claimed that the pancreas was situated
more cranially at the level of the 14th, 15th and 16th ribs in the Indian donkey. In the present investigation, the body of the pancreas did not show a notch for the passage of the portal vein and cranial mesenteric artery as the case in ruminants. Instead, a ring formed by a glandular tissue extending from the right lobe to the left lobe was observed. This confirms previous findings in both the camel and horse (Bradley, 1946; Nickel et al., 1973; Sisson, 1975; Mustafa et al., 1983; Dyce et al., 1987; Taha and Abdel-Magied, 1998; Sultan, 1999). The relationships of the pancreas of both the camel and donkey with the stomach, duodenum, liver, hepatic lymph node, kidneys and the large intestine were generally in agreement with the observation of Bradley (1946) and Sisson (1975) in the horse, Nickel et al. (1973) in ruminants, Mustafa et al. (1983), Smuts and Bezuidenhout (1987), Taha and Abdel-Magied (1998) and Sultan (1999) in the camel. In the dog, Bradley (1948) stated that the left lobe of the pancreas extends dorsally to the stomach. Bradley’s observation was not found in the present study or in any other simple-stomach animal.

Different values of the weight of the pancreas of the camel were mentioned in the literature. While Mustafa et al. (1983) have given a value of 300 gm, Smuts and Bezuidenhout (1987) and Sultan (1999) have
reported a value of 500 gm. In the present study yet another different value was given which is 171 gm. Again the weight of the pancreas of the donkey was about 110 gm as revealed in the present study and about 95 gm in the results of Dhoolappa et al. (2004) in the Indian donkey which is less than half the weight of the pancreas of the horse (Bradley, 1946 and Sisson, 1975). This large difference in the weight of the pancreas of the camel and donkey in the present investigation and other previous work may be due to the removal of the portal vein in the present study before weighing the gland.

In the present study, only one pancreatic duct (the ventral one) was observed in the pancreas of the camel and donkey. As regard to the camel, this finding confirms previous findings reported by Mustafa et al. (1983), Smuts and Bezuidenhout (1987), Taha and Abdel-Magied (1998) and Sultan (1999). In the donkey, the present finding confirmed the recent finding of Dhoolappa et al. (2004) but disagreed with previous reports in equines which showed that two pancreatic ducts existed (Bradley, 1946; Nickel et al., 1973; Sisson, 1975; Dyce et al., 1987; Shively, 1987). The dog is the only species, in which more than two pancreatic ducts existed (Bradley, 1948; Nielsin; Bishop, 1954) but
according to Evans and de Lahunta (1971) most dogs have two ducts: the pancreatic (ventral) is smaller and inconsistent and opens in the major duodenal papilla, the accessory pancreatic duct (dorsal) is larger and opens in the minor duodenal papilla. In the present study the pancreatic duct of the camel after emerging from the body of the pancreas, joined immediately the common hepatic duct, thus forming the common hepatopancreatic duct. This is in accord with the previous findings of Mustafa et al. (1983), Smuts and Bezuidenhout (1987), Taha and Abdel-Magied (1998) and Sultan (1999) in the camel. Sultan (1999) has claimed that this junction occurred in the substance of the gland, rather than outside the gland as reported by previous workers. In the small ruminants, the pancreatic duct after emerging from the body joins the common bile duct and thus forming the common bile pancreatic duct (Nickel et al., 1973; Habel, 1975; Dyce et al., 1987). The course of the ventral pancreatic duct in the donkey as observed in the present investigation and as reported by previous workers (Didio and Boyden, 1962; Nickel et al., 1973; Sisson, 1975) pursued a different course from that described for the camel. Following its emergence from the body of
the pancreas it ran for a short distance before it opened in the duodenum in the major duodenal papilla along side the bile duct.

While several previous workers (Mustafa et al., 1983; Smuts and Bezuidenhout, 1987; Taha and Abdel-Magied, 1998; Sultan, 1999) have mentioned that the common hepatopancreatic duct opened in the major duodenal papilla yet such a major duodenal papilla was not seen in any of the many specimens dissected in the present work. Therefore the finding of this investigation agreed with the work of Ghezzi et al. (2000) that no major duodenal papilla exists in the llama.

Radmanesh (1974), Mustafa et al. (1983), Sultan (1999) and Siddig (2002) have claimed that the hepatopancreatic duct opens in the duodenum about 22 cm away from the pylorus in the camel. The present investigation as well as the study carried out by Ghezzi et al. (2000) in the llama found that the distance from the pylorus to the opening of the common hepatopancreatic duct was about 42 cm. This large difference in measurements could have been due to whether the starting point was actually the pylorus or the bulb of the duodenum.

In the present study, the blood supply of the pancreas of both the camel and donkey comes from the splenic, hepatic, gastroduodenal and
the cranial pancreaticoduodenal arteries which are branches of the celiac artery. The other source of the blood supply is the caudal pancreaticoduodenal artery which comes from the cranial mesenteric artery. This is similar to the findings of Mustafa et al. (1983) and Sultan (1999) in the camel, Bradley (1946) in the horse, Miller et al. (1964) in dogs and Gomercic and Babic (1975) in the cat.

4. 2. Histological studies:

4. 2. A. The exocrine portion:

In the present investigation in both the camel and the donkey, the pancreas is covered by a connective tissue capsule, which is composed mainly of collagen fibers with a few elastic fibers, blood vessels, and nerve fibers. A striking feature of the camel pancreas is that the capsule is loaded with adipose tissue, which infiltrated inside the parenchyma; some of this adipose tissue shall be converted to water when the animal is dehydrated. Furthermore, it could also serve as a source of energy. The connective tissue septa extend from the capsule into the parenchyma dividing it into incomplete lobules. This last observation is similar to that in other animals and man (Arey, 1968; Stinson and Calhoun, 1981; Bloom and Fawcett, 1986; Sultan, 1999; Dhoolappa et al., 2004).
The secretory units of the pancreas of the camel as seen in this study and as reported by Sultan (1999) are tubuloacinar with the acinar portion more prominent. This is slightly different from the exocrine portion of the ruminant pancreas (Stinson and Calhoun, 1981) since the later showed dominance of the tubular portion. However, according to the present study the secretory units of the pancreas of the donkey and that of the horse (Sisson and Grossman, 1964) are tubulo-alveolar.

In the present study, the acinar cells of the pancreas are pyramidal in shape, and have spherical or oval nuclei near the base of the cell, this is similar to the observation of Stinson and Calhoun (1981) in goats, Mukherjee et al. (1986) in sheep, Sultan (1999) in the camel and Dhoolappa et al. (2004) in the Indian donkey. The present investigation agrees with the previous worker (Singh, 1980; Singh and Singh, 1980, and Mukherjee et al., 1986) that in both the camel and donkey pancreas there are three acinar cell types: Active, exhausted and resting acinar cells.

The present study showed that the duct system of the pancreas of both camel and donkey started as centroacinar cells, similar to the findings of Bloom and Fawcett. (1986) in humans, Lone et al. (1988) in
sheep, Sultan (1999) in the camel and Dhoolappa et al. (2004) in the Indian donkey. Gemmel and Heath (1973), Sultan (1999), Dhoolappa et al. (2004) and the present study reported that the intercalated duct lined by low cuboidal cells. This disagrees with the findings of Lone et al. (1988) in sheep.

In the present investigation, the intralobular duct is lined by cuboidal cells, similar to the previous observation made by Stinson and Calhoun (1981); Lone et al. (1988) and Sultan (1999). Nevertheless, Gemmel and Heath (1973) have found that the intralobular duct is lined by columnar cells and not cuboidal cells.

Lone et al. (1988) and Dhoolappa et al. (2004) stated that in the interlobular duct there are goblet cells interspersed amongst the columnar lining cells in sheep and Indian donkey respectively. On the other hand, Bloom and Fawcett (1986) have reported that in addition to the goblet cells, small mucous glands are present in the connective which supported the inter lobular duct. In the present investigation, neither the goblet cells nor the small mucous glands were observed in relation to the lining epithelium or the surrounding connective tissue of the interlobular duct of the pancreas of the camel and donkey.
In the present study, the main pancreatic duct of the camel and donkey is lined by columnar cells, and this is similar to that in sheep (Gemmel and Heath, 1973; Lone et al., 1988) and in the camel (Sultan, 1999). The goblet cells and the mucous glands in the wall of the main pancreatic duct which were reported by Gemmel and Heath (1973) were not observed in the present study.

The present study has shown that the common hepatopancreatic duct of the camel and the ventral pancreatic duct of the donkey are lined by columnar cells and their mucosa is folded. This is in accord with the previous work of Mcminn and Kugler (1961) in dog, cat, monkey and guinea pig, Sultan (1999) and Siddig (2002) in the camel and Dhoolappa et al. (2004) in the Indian donkey. Absence of goblet cells from the pancreas of the camel is not a unique feature of this species alone but is also observed in cats and dogs (Mcminn and Kugler, 1961). In the present study the presence of goblet cells in the ventral pancreatic duct of the donkey, confirms the finding of Mcminn and Kugler (1961) in the monkey and guinea pig. In the present study groups of mucous glands are present in the connective tissue layer of the common hepatopancreatic duct of the camel and the ventral pancreatic duct of the donkey. This is

As far as the mucous glands are concerned, they were first reported by Mcminn and kugler (1961) and then followed by Gemmel and Heath (1973), Lone et al. (1988) and Dhoolapa et al. (2004). In the present investigation in both the camel and donkey, and in the study which was carried out by Siddig (2002) in the camel, such mucous glands have not been observed in any part of the duct system inside the parenchyma but they were seen in the pancreatic duct after it emerged from the pancreas.

4. 2. B. The endocrine portion (islets of Langerhans):

In the present study the islets of Langerhans of the camel and donkey displayed different size and shape and were made up of irregular clumps of cells. This confirms the findings of Alani (1987) and Sultan (1999) in the camel and Mukherjee et al. (1988) in sheep. Sultan (1999) claimed that there are interlobular islets of Langerhans in the camel pancreas. Nevertheless, interlobular islets of Langerhans were observed in only one specimen out of thirty specimens investigated. On the other hand the pancreas of the donkey showed no such interlobular islets of Langerhans. I believe that this unusual phenomenon does occur only
occasionally and not on a regular basis. Another extraordinary feature of the pancreas of the camel was the presence of some ducts close to the islets of Langerhans (Alani, 1987; Sultan, 1999). This is also true in the present study. Sultan (1999) believed that there is relationship between these ducts and the islets in the form of epithelial cords.

Three types of endocrine cells were observed in the islets of Langerhans in the pancreas of the camel and donkey. These cells are beta, alpha and delta.

The present study showed a difference in the location of the beta and alpha cells in the islets of Langerhans in the pancreas of the camel and that of the donkey.

Regarding their presence in the islets of Langerhans, it appeared that the beta cells were the most numerous followed by the alpha cells, and the delta cells were the fewest. As far as the location of these cells is concerned in the islets in both the camel and donkey, the beta and alpha cells displayed an exchange of location. The beta cells were located centrally in the islets in the camel, but were confined to the periphery in the donkey. This is similar to the finding of Erlandsen et al. (1976) in human and rat, Bonner-Weir and Like (1980) and Dellmann (1981) in the
cattle, Helmastaerdter et al. (1976) and Furuoko et al. (1989) in the horse and Khatim et al. (1985), Alani (1987) and Sultan (1999) in the camel. On the other hand, the alpha cells were located peripherally in the islets of the camel, but centrally in the islets of the donkey. This is similar to the finding of Erlandsen et al. (1976) in human and rat, Bonner-Weir and Like (1980) and Dellmann (1981) in the cattle, Helmastaerdter et al. (1976) and Furuoko et al (1989) in the horse and Khatim et al. (1985), Alani (1987) and Sultan (1999) in the camel.

In the present study and the study of Mukherjee et al. (1988) in sheep, the beta and alpha cells could be identified in the islets of Langerhans by the shape of their nuclei. The nucleus of the beta cell is round in shape, while the nucleus of alpha cell is oval in shape; this disagrees with the observation of Sultan (1999) in the camel, who reported that the nucleus of the beta cell is oval in shape, while the nucleus of the alpha cell is round.

Regarding the delta cells there is a general agreement that these cells are located peripherally in the islets of Langerhans.
4.3. Ultrastructural studies:

As far as I know the present ultrastructural study of the acinar and endocrine cells of the camel pancreas is the first one.

4.3. A. Acinar cell:

In the present study, the acinar cell cytoplasm showed a well developed rough endoplasmic reticulum at the basal half of the cell and around the nucleus and many round mitochondria. The apical region was crowded by membrane-bound zymogen granules, and there was a well developed Golgi complex between the zymogen granules and the nucleus. This is similar to the findings of Bloom and Fawcett (1986) in the bat and dog.

4.3. B: The endocrine cells (Islets of Langerhans):

In the present study, the differentiation of the beta, alpha and delta cells in the islets of Langerhans could be carried out on the basis of the presence of membrane-bound granules which are electron dense in the cytoplasm of these cells. The beta cell cytoplasm showed membrane-bound granules with high electron dense material which did not fill the limiting membrane, thus leaving a distinct halo. The dense-cored vesicles in the cytoplasm of the alpha cells are more or less similar to those of the
beta cells except that the dense material almost filled their limiting membrane leaving a narrow halo. This observation confirms the findings of Lacy (1957) in the dog; Frossmann (1976) in the horse, Bonner-Weir and Like (1980) and Dellmann (1981) in bovines.

The granules of the delta cells are smaller than those of the beta and alpha cells and they have a moderate electron density and filled their limiting membranes. This is in agreement with Frossmann (1976) in the horse and Bonner-Weir and Like (1980) in bovines.
Summary

- The colour of the pancreas is grayish pink in the camel and reddish cream in the donkey.

- The camel pancreas is covered by great amount of fat (14g/171g).

- The weight of the pancreas is 171 gm in the camel and 110 gm in the donkey.

- The pancreas of the camel and donkey has a complete pancreatic ring through which the portal vein passes.

- The left lobe is longer than the right lobe in both the camel and donkey.

- The camel and donkey pancreas has only one pancreatic duct (the ventral pancreatic one).

- The blood supply of the pancreas of the camel and donkey comes from the hepatic, splenic and cranial mesenteric arteries.

- The pancreas of the camel and donkey is covered by connective tissue capsule mainly of collagen fibers and a few elastic fibers. The capsule is also rich in adipose tissue.

- The capsule sent connective tissue septa mainly of collagen to the parenchyma dividing it into lobules.
- The secretory units of the exocrine portion are tubulo-acinar in the camel, and tubulo-alveolar in the donkey.

- Three acinar cells types are reported in the secretory units of the pancreas; active, exhausted, and resting.

- The duct system of the exocrine portion is divided into intercalated, intralobular, interlobular and main pancreatic.

- The goblet cells are present only in the ventral pancreatic duct in the donkey pancreas, but none is observed in the camel pancreas.

- The islets of Langerhans appear as a pale area within the secretory units in both camel and donkey pancreas.

- The beta cells with spherical nuclei are located in the centre of the islets of the camel pancreas, whereas in the donkey are located in the periphery of the islets.

- The alpha cells with ovoid nuclei are located in the periphery of the islets of the camel pancreas, but they are located in the centre of the islets in the donkey pancreas.

- The ultrastructure of the acinar and endocrine cells has been studied in the camel pancreas only.
- The acinar cell cytoplasm contains a well developed rough endoplasmic reticulum, Golgi complex, round mitochondria, lysosomes and zymogen granules of different shapes and size.
- The cytoplasm of the endocrine cells: alpha, beta and delta cells contain round mitochondria, a few rough endoplasmic reticulum, round granules with different electron density and lipid droplets.
- The granules of beta cells are less electron dense but larger in size than alpha cells; they have a distinct halo between the dense material and their limiting membrane.
- The granules of alpha cells are highly electron dense and fill their limiting membranes.
- The delta cells are smaller in size and less electron dense than both alpha and beta cells. They fill their limiting membranes.
لا يمكنني قراءة النص العربي بشكل طبيعي. إذا كنت بحاجة إلى مساعدة في شيء آخر، فأنا هنا للمساعدة.
ثالثة تحديد المنكه وخلايا نشطة وخلايا ويعتبر الإفراء خارجياء الخلايا من أنواع السكانية وخلايا ويعتبر الجزء في النمو بين النظام وإلى مقسم الإفراء داخل والناء إلى الرئسية الفصيصات ونائفة الفصيصات.

الكأسية والخلايا في النمو في البنكيراسية النائفة في فقط موجودة الإبل البنكرياس في القط توجد كما، الحمر البنكرياس.

نجرانا للكمتدقيحة شابة الإفراء وحدات بين البنكرياس والفحصيات من حيث، الإبل البنكرياس.

تتوضع الشكل الدائرية النوعية ذات البيتية والخلايا بينما الإبل البنكرياس في الجزء مراكز الأطراف على توضع فيه الحمر البنكرياس في الجزء.

بنكرياس في الأجزاء الأطراف على توضع الشكل البيضوية النوعية ذات الألفية الخلايا مرتاحا جيدا كمكلا واليدية والходитьة والحبيبات والأشكال.

شركت عليه من المحتويات والنوايا ونائفة الإفراء وداخليات الإفراء خارجية الخلايا على برنامجها ونائفة بنكيراسية.
Ark (العبر: "النهاية") ذلك بالحرف "الحاء" -

تغطي 수행 (الإب) في الجبل لقاح كأرضية. نحن لاتبحث أن نعرف لذيذ.

نحن كسرت، لست عبء ينوي خلية

من أجل، حيث نحن بهاء معينة.

فليس وبك، حيث نحن بهاء معينة.

تغطي 수행 (الإب) في الجبل لقاح كأرضية

فليس وبك، حيث نحن بهاء معينة.

فليس وبك، حيث نحن بهاء معينة.
Conclusion

1. The left lobe of the pancreas is longer than the right one in both camel and donkey; this is different from that of ruminants.

2. The pancreas of both camel and donkey has a complete pancreatic ring, rather than a notch in the body as the case of ruminants.

3. The camel pancreas loaded with adipose tissue (14mg/ 171gm).

4. The camel and donkey has only one pancreatic duct (the ventral one).

5. The pancreas received its blood supply from the hepatic, splenic and cranial mesenteric arteries in both camel and donkey.

6. The secretory units in the camel pancreas are tubulo-acinar; in donkey they are tubulo-alveolar.

7. The position of the beta cells is central and that of alpha cells is peripheral in the islets of Langerhans of the camel. However, the opposite occurs in the islets of the pancreas of the donkey.

8. The acinar cells of the pancreas of the camel are characterized by elaborated system of rough endoplasmic reticulum and the presence of zymogen granules.
9. The endocrine cells in the islets of Langerhans in the pancreas of the camel are characterized by the presence of few rough endoplasmic reticulum and prominent dense-cored granular vesicles
Recommendations

Further studies are needed:

1. To determine the nature of the innervation of the pancreas ultrastructurally and histochemically.

2. To reveal the peptide hormones which are present in the pancreas Immunohistochemical.

3. To determine the volume densities occupied by the various components of the pancreas.
REFERENCES


Fig 1. Camel pancreas. Dorsal view. Showing the tongue-shape left lobe (L), the quadrate right lobe (R), and the body (B). Note that the glandular tissue extending between the left and right lobes and over the portal vein (P) forming a bridge (b). Also note the great amount of fat covering the pancreas.
Fig 2. Camel pancreas. The portal vein has been removed, note the bridge (b) between the left lobe (L) and the right lobe (R) forming the pancreatic ring (Pr) through which the portal vein passes. Note the great amount of fat covering the pancreas.
Fig 3. Camel pancreas. The hepatic duct (H) passed dorsally to the cranial part of the body of the pancreas (B), joined by the pancreatic duct (arrow head) and thus forming the hepatopancreatic duct (HP) which opens in the duodenum (D).
Fig 4. Vinyl acetate cast of the duct system of the camel pancreas. Note the two main radicals (left (L) and right (R)) corresponding to the left and right lobes of the pancreas. Each of these two main radicals had many fine branches giving the appearance of a tree. The left and right radicals unite at the body to form the main ventral pancreatic duct (MD) which too, presented numerous fine branches.
Fig. 5& 6. Camel pancreas. Showing the course of the hepatopancreatic duct (HP) as it enters the duodenum. The duodenum in Fig. 5 is opened, but the hepatopancreatic duct is totally embedded in the duodenal wall (dotted lines), In Fig. 6 the duodenum is opened, and the hepatopancreatic duct is opened too (arrows). (D) Duodenum, (bs) bevel-shaped opening, (hp) the hepatopancreatic duct and (B) body of the pancreas.
Fig. 7. A drawing showing the arterial blood supply of the camel pancreas:

1. Abdominal aorta.
2. Celiac artery.
3. Left gastric artery.
5. Left pancreatic branch of hepatic artery.
6. Right pancreatic branch of the hepatic artery.
7. Pancreatic branch of the hepatic artery to the body.
9, 10, 11. Pancreatic branches from the gastroduodenal artery.
12. Right gastroepiploic artery.
13. Cranial pancreaticoduodenal artery.
14, 15, 16, 17. Pancreatic Branches of the cranial pancreaticoduodenal artery.


19. Pancreatic branch of the splenic artery.

20. Cranial mesenteric artery.


22. Pancreatic branch of the caudal pancreaticoduodenal artery.

Fig 8. Donkey pancreas. Dorsal view. Showing the triangular shape of the pancreas which consists of left lobe (L), right lobe (R), and body (B). Note the glandular tissue extending between the left and right lobes and over the portal vein (P) forming a bridge (b).
Fig 9. Donkey pancreas. The portal vein has been removed. Showing the glandular tissue bridge (b) extending between the left lobe (L) and the right lobe (R) forming the pancreatic ring (Pr). B: body.
Fig 10. Donkey. Right view of the pancreas in situ showing its topographical relations

A. Right adrenal gland.
B. Base of the cecum.
D. Duodenum.
L. Liver.
K. Right kidney.
P. Pancreas.
Pv. Portal vein.
R. Right dorsal colon.
S. Stomach.
V. Caudal vena cava.
Fig 11. Donkey. Left view of the pancreas in situ showing its topographical relations

A: Left adrenal gland.

K: Left kidney

P: Pancreas.

S: Stomach.

SP: Spleen.
Fig 12. Donkey pancreas. Showing the ventral pancreatic duct (arrow) which leaves the body (B) to enter the duodenum (D) along side the common hepatic duct (held by the forceps). B: Body, L: Left lobe, R: Right lobe, P: Portal vein, b: Glandular tissue bridge. Broken arrow: indicates the course of the portal vein.
Fig 13. Donkey. The duodenum (D) was opened to show the major duodenal papilla (arrow).
Fig 14. Vinyl acetate cast of the duct system of the donkey pancreas. Note the two main radicals (left (L) and right (R)) which corresponded to the left and right lobes of the pancreas. Each of these two main radicals had many fine branches (arrows) giving the appearance of a tree. The left and right radicals unite at the body to form the main ventral pancreatic duct (VD) which too, presented numerous fine branches.
Fig 15. A drawing to show the arterial blood supply of the donkey pancreas.

1 Abdominal aorta, 2 Celiac artery, 3 Splenic artery, 4 Left gastric artery, 5 Hepatic artery, 6 Pancreatic branch of the splenic artery, 7, 8 Pancreatic branch of the hepatic artery, 9 Gastroduodenal artery, 10, 11 Pancreatic branches of the gastro-duodenal artery, 12 Right gastroepiploic artery, 13 Cranial pancreaticoduodenal artery, 14, 15, 16 Pancreatic branches of the cranial pancreaticoduodenal artery, 17 Cranial mesenteric artery, 18 First intestinal artery, Pancreatic branch of the First intestinal artery. B: Body, L: Left lobe, R: Right lobe, D: duodenum.
Fig 16. Camel pancreas. Showing the capsule (Ca) of pancreas which is rich in adipose tissue (At), connective tissue septa (S). The connective tissue septa extended into the parenchyma dividing it into incomplete lobules (L). Bv: Blood vessel. H & E stain. X 40.
Fig. 17. Camel pancreas. Showing the blood vessels (Bv) and the collagen fibers (arrows) in the capsule. Note the adipose tissue (At) in the septa and infiltrates (Ati) the parenchyma. Masson trichrome stain. X 40.
Fig 18. Camel pancreas. Showing bands of elastic fibers (arrows) and blood vessels (Bv) in the capsule. Aldhyde fuchsin stain. X 40.
Fig 19. Camel pancreas. Showing nerve fibers (N) and blood vessels (Bv) in the capsule. H& E stain. X 40.
Fig 20. Camel pancreas. Micrograph showing the septa which are highly rich in adipose tissue (At). Note the infiltrated adipose tissue (Ati) inside the parenchyma. H&E stain. X40.
Fig 21. Camel pancreas. Showing nerve fibers (N), blood vessels (V) and adipose tissue (At) in the septa (S). Toluidine blue stain. X400.
Fig 22. Camel pancreas. Showing interlobular duct (D) in the connective tissue septa (S). H&E stain. X 250.
Fig 23. Camel pancreas. Toluidine-blue thick section showing the adipose tissue (At) in the septa and infiltrates (arrow) the parenchyma. X250.
Fig 25. Camel pancreas. Micrograph showing the reticular fibers in the parenchyma of the pancreas. Gordon and Sweat stain. X100.
Fig 26. Camel pancreas. Showing the active acinar cell (A) and the exhausted acinar cell (E). Note that the zymogen appears red.
Masson trichrome stain. X 500.
Fig 27. Camel pancreas. Showing the resting acinar cell (R). Note that the zymogen appears red. Masson trichrome stain. X 500.
Fig 28. Camel. The parenchyma of the pancreas, showing part of islets of langerhans (IL), acini (A) and centroacinar cell (arrowhead).

H&E stain. X 500.
Fig 29. Camel. Exocrine portion of the pancreas, showing intercalated duct (D) and centroacinar cell (arrow). P. A. S. stain. X500.
Fig 30. Camel pancreas. Showing the intralobular duct (arrow) which is lined by cupoidal cell. Note the collagen fibers with green colour around the duct. Masson trichrome stain. X 100.
Fig 31. Camel pancreas. interlobular duct (D) in the septa (S), the duct is lined by cuboidal cells. H&E stain. X100.
Fig 32. Camel. Showing the main pancreatic duct (M) surrounded by collagen fibers (Co). Masson trichrome stain. X 40.
Fig 33. Camel. A higher magnification of the main pancreatic duct (MD) in Fig (32), showing that it is lined by columnar cells (arrow) and surrounded with collagen fibers (Co). Masson trichrome stain. X 100.
Fig 34. Camel. Showing the highly folded mucosa of the hepatopancreatic duct (arrow heads). H&E stain. X40.
Fig 35. Camel. Micrograph of the hepatopancreatic duct, showing the tall columnar cells (c) which lined the duct. Mucous glands (g) and their duct (d) are also present. P. A. S. stain. X250.
Fig 36. Camel. Showing the hepatopancreatic duct surrounded by dense collagen fibers (Co) and irregular groups of mucous glands (g). Masson trichrome stain. X 40.
Fig 37. Camel. Showing the elastic fibers (arrows) in the wall of the hepatopancreatic duct. Aldhyde fuchsin stain. X 500.
Fig 38. Camel. Groups of mucous glands (g) surrounded by collagen fibers (Co) in the wall of the hepatopancreatic duct. Masson trichrome stain. X 250.
Fig 39. Camel. A hepatopancreatic duct showing groups of mucous glands (g) and their ducts (d). Note the reaction of the aldhyde fuchsin positive materials in the mucous glands and their ducts indicating the presence of mucopolysacharides. Aldhyde fuchsin stain. X 100.
Fig 40. Camel pancreas. Showing the different shapes and sizes of the islets of Langerhans, (E) elongated, (I) irregular, (O) oval and (R) round. At: Adipose tissue, S: Connective tissue septa. H&E stain. X100.
Fig 41. Camel pancreas. Islets of Langerhans (IL) in the interlobular connective tissue septa. Note also the interlobular duct (D). Modified aldhyde fuchsin. X 250.
Fig 42. Camel pancreas. Micrograph showing two islets of Langerhans (IL) and an intralobular duct (arrowhead) which is closely related to the islets. Masson trichrome stain. X250.
Fig 43. Camel pancreas. Islets of Langerhans (IL) showing the cyst-like capillaries (arrows) and red blood cells inside them. Toluidine blue stain. X 400.
Fig 44. Camel pancreas. Islets of Langerhans (IL) showing the beta cells (b) with round nuclei (arrow head) in the centre of the islet and the alpha cells (a) with oval nuclei (arrow) in the periphery of the islets. Note that the blood capillaries are filled by homogenous red material. Masson trichrome stain. X250.
Fig 45. Donkey. The capsule (Ca) of the pancreas showing collagen fibers (Co). Note that the connective tissue septa (S) extended from the capsule into the parenchyma to divide it into incomplete lobules (L). Masson trichrome stain. X40.
Fig 46. Donkey pancreas. Showing the elastic fibers (arrows) in the capsule.

Aldhyde fuchsin. X100.
Fig 47. Donkey pancreas. The connective tissue septa (S) extended into the parenchyma for variable distance dividing it into incomplete lobules (Lo). Note the blood vessels (Bv) in the septa. H&E stain. X 100.
Fig 48. Donkey pancreas. Connective tissue septa showing collagen fibers (Co) and ducts (D). Masson trichrome stain. X250.
Fig 49. Donkey pancreas. Showing tubulo-alveolar secretory units, T. Tubular portion, and Al. Alveolar portion. Note the centroacinar cell (arrow) in the lumen of the alveolus. H&E stain. X400.
Fig 50. Donkey pancreas. Showing the secretory units, T. Tubular portion, Al. Alveolar portion and centroacinar cell (arrow). Masson trichrome stain. X400.
Fig 51. Donkey. Micrograph showing the reticular fibers in the parenchyma of the pancreas. Gordon and Sweet stain. X100
Fig 52. Donkey pancreas. Showing the active acinar cell (A) and the resting acinar cell (R). Note that the zymogen appears red. Masson trichrome stain. X500.
Fig 53. Donkey. Showing the exhausted acinar cell (E). Note that the zymogen appears red. Masson trichrome stain. X500.
Fig 54. Donkey pancreas. Micrograph showing the intercalated duct (D) which is lined by low cuboidal cells. Masson trichrome stain. X400.
Fig 55. Donkey pancreas. The intralobular duct (D) is lined by cuboidal cells and surrounded by collagen fibers (Co). Masson trichrome stain. X250.
Fig 56. Donkey. Showing small interlobular duct (D) lined by cuboidal cells and surrounded by collagen fibers (Co). Masson trichrome stain. X250.
Fig 57. Donkey pancreas. Large interlobular duct (D) with folded mucosa and lined by columnar cells (arrow). d. Small interlobular duct, S. Connective tissue septa. H&E stain. X100.
Fig 58. Donkey pancreas. Showing the main pancreatic duct (MD) with folded mucosa and lined by simple columnar cells (arrow) and surrounded by dense layer of collagen fibers (Co). S. Connective tissue septa, Lo. Lobules. Masson trichrome stain. X100.
Fig 59. Donkey. The ventral pancreatic duct showing folded mucosa (arrowheads). The duct is surrounded by dense layer of collagen fibers (Co). Mucous glands (g) and their ducts (d) also present in the wall of the ventral pancreatic duct. H&E stain. X400.
Fig 60. Donkey. Showing the elastic fibers (arrows) with pink colour in the wall of the ventral pancreatic duct. Aldhyde fuchsin. X 500.
Fig 61. Donkey. Ventral pancreatic duct showing Goblet cells (G) among the lining epithelium. Aldhyde fuchsin stain. X500.
Fig 62. Donkey. Showing the large islet of Langerhans (IL1) and small one (IL2) in the parenchyma of the pancreas. S. Connective tissue septa. Masson trichrome stain. X100.
Fig 63. Donkey pancreas. An islet of Langerhan (IL) showing the beta cells (b) with round nuclei (arrow head) are located peripherally and alpha cells (a) with oval nuclei (arrow) are located centrally. Masson trichrome stain. X500.
Fig 64. EM graph. showing Acinar cells (Ac) displaying various organell in their cytoplasm. Some cells showed many large zymogen granules (Zg), others showed only few granules. Other organelles include, nucleus (N) rough endoplasmic reticulum (RER), mitochondria (M), lysosomes (L). Lu. Lumin of the acinus. Note the various junctional complexes (arrows) between these cells. X 2700.
Fig 65. EM graph. Acinar cell showing nucleus (N), Golgi complex (GO), well developed rough endoplasmic reticulum (RER), mitochondria (M), and zymogen granules. Note that the elaborate system of the rough endoplasmic reticulum filled most of the cytoplasm and the cisternae are extensively interconnected and dilated. X 5000.
Fig 66. EM graph showing apical regions of 6 acinar cells (Ac) forming the acinus (A). All apical regions displayed zymogen granules (Zg) of various shape and size. Lu. Lumen of the acinus. Note the various junctional complexes (arrows) between these cells. X6700.
Fig 67. EM graph. Showing acinar cells (Ac). (N) Nucleus, (RER) well developed rough endoplasmic reticulum, (L) lysosomes and (V) empty vesicles. Note the different shapes and sizes of zymogen granules. X2700.
Fig 68. EM graph Acinar cell showing a semilunar shaped nucleus (N) and most of the cytoplasm is filled with well developed rough endoplasmic reticulum (RER). Mitochondria (M), Golgi complex (GO), empty vesicles (V) and zymogen granules (Z) are also present in the cytoplasm. X5000.
Fig 69. EM graph. Acinus lumen (Lu) showing a centroacinar cell (Ca) with an elongated nucleus (N) and the cytoplasm contains mitochondria (M) and lipid droplets (Li). Note that the poor organelles in the cytoplasm give the cell a light appearance. Ac: acinar cell. X 2700.
Fig 70. EM graph. Showing intercalated duct which lined by low cuboidal cells with elongated nuclei (N). The duct is surrounded by collagen fibers (Co). Note that fibroblast with oval nucleus (n) appears within the collagen fibers. X 2700.
Fig 71. EM graph. An islet of Langerhans showing beta cell (B), alpha cell (A) and delta cell (D). The cytoplasm of these cells showing, N. Nucleus with euchromatin, dense cored granular vesicle, M. Mitochondria, RER. Rough endoplasmic reticulum. The blood capillary (BC) is closely related to endocrine cells. X 2700.
Fig 72. EM graph. Beta cell showing nucleus (N) with euchromatin. The cytoplasm displayed dense-cored granular vesicles (arrows) with distinct halo, mitochondria (M) and lipid droplets (L). X 8000.
Fig 73. EM graph. Two adjacent alpha cells showing nucleus (N) with euchromatin. The cytoplasm contains dense-cored granular vesicles (arrows) and round mitochondria (M). X 8000.
Fig 74. EM graph. Two adjacent alpha cells showing nucleus (N) with euchromatin. The cytoplasm displayed dense-cored granular vesicles (arrows), round mitochondria (M), lipid droplets (L). X 8000.
Fig 75. EM graph. Showing delta cell adjacent to a blood capillary (B). The delta cell displayed nucleus (N) with euchromatin, dense-cored granular vesicles (arrows) round mitochondria (M), lipid droplet (L) and moderate electron dense granules filled their limiting membrane (arrow). X8000.