1. Although the skin of the scrotum lies directly over the testes, testicular and scrotal cancers have very different initial routes of metastasis. Cancer of the testes metastasizes to the lumbar lymph nodes, while cancer of the scrotum metastasizes to the superficial inguinal lymph nodes.

A. Explain why these cancers have such different routes of metastasis. (4 points)

The reason that testicular and scrotal cancers have different routes of metastasis is because they have different lymphatic drainage. This difference arises because the testes develop within the abdomen where lymphatic connections are made with lumbar lymph nodes and these connections are maintained as the testes descend thru the inguinal canal. The scrotum, on the other hand develops as an outpouching of skin that doesn't travel and therefore drains to the nearby superficial inguinal lymph nodes.

B. On the figure to the right, draw an X at the location of the lumbar lymph nodes, and draw an O at the location of the superficial inguinal lymph nodes. (2 points)

2. During pregnancy, women may experience sharp pain from the skin overlying the labia majora. What structure associated with the skin of the labia majora may be pulled during pregnancy such that it causes this pain? (2 points)

Round ligament of the uterus

3. The bladder and the uterus are so close to one another that they are physically in contact. However, the internal linings, smooth muscle and connective tissues that make up these organs are derived from different embryonic tissues. Describe these differences in light of the embryology of these two structures. (4 points)

The uterus develops from the vaginal plate, an enlargement of the paravesical ducts where they fuse posterior to the bladder. The bladder forms from the urogenital sinus, which is part of the cloaca. This was originally continuous with the GI tract and therefore has internal structure lining derived from endoderm and smooth muscle and connective tissue. The reproductive system does get some contribution from ectoderm and endoderm such that reproductive tract.
4. The figure to the left is a schematic view of the developing urogenital system of an embryo that is still in the sexually ambiguous stage of development. The questions below are in reference to this figure.

A. Identify region D and tube B. (2 points)

D = metanephric cap  
B = mesonephric duct

B. Describe the interaction that occurs between D and B that leads to the development of the adult kidney. (4 points)

The mesonephric duct gives off a bud called the uroteric bud that grows out and contacts the mesonephros part of the intermediate mesoderm. This contact induces the formation of the mesonephric cap that will give rise to the adult kidney and the uroteric tube will form the ureter, thus connecting the bladder and kidney.

C. Identify tube A. (1 point)

paramesonephric duct

D. Describe the interaction that occurs between A and C in the developing female. (4 points)

The developing urinary bladder does not incorporate the paramesonephric ducts in the female as it does the mesonephric ducts in the male but rather induces fusion and enlargement of the paramesonephric ducts to form the vaginal plate. The vaginal plate grows and becomes hollow to form the uterus, cervix, and upper vagina.

E. Assuming normal development, degeneration of A is accompanied by the development of B into what structure(s)? (2 points)

vas deferens  
semen vesical  
ejaculatory duct  
epididymis

C induces a bud off of the bladder that becomes distal vagina.

Points missed: 4
5. The right vagus nerve innervates the posterior wall of the stomach, while the left vagus nerve innervates the anterior stomach wall. **Explain** this in light of the embryology of the foregut. (4 points)

The stomach undergoes two 90° rotations during development. Rotation explains why the vagus nerve innervates the parts that it does. Innervation of the stomach by the right and left vagus early in development before rotation occurs for the first time is on the right and left sides of the stomach. However, after the 90° rotation, the right vagus is now innervating the posterior stomach and the left vagus the anterior stomach.

6. **List two abdominal structures** that fall into each of the following peritoneal designations: (6 points)

   A. Intraperitoneal: **ileum** — **transverse colon**

   B. Retroperitoneal: **kidneys** — **bladder**

   C. Secondarily retroperitoneal: **ascending colon** — **descending colon**

7. **Compare and contrast** the development of the pancreas with the development of the spleen. (6 points)

The pancreas develops as two diverticula formed at the gastro-duodenal junction; a dorsal and a ventral diverticulum. These two diverticula fuse to form the pancreas. Therefore, the pancreas is lined with endoderm, as is the GI tract from which it formed. In contrast, the spleen is formed from mesoderm and does not develop as a diverticulum from the GI tract. The similarity between the pancreas and spleen is that both are supplied by blood from the celiac trunk. The splenic artery to the spleen is one branch of the celiac trunk and it gives off branches to the pancreas (greater pancreatic artery, inferior pancreatic artery, dorsal pancreatic artery).

8. **Fill in the blanks** in the following paragraph:
Parasympathetic innervation of the fore- and mid-gut comes from the **vagus nerve**, whereas the hind gut and pelvic structures are served by neurons with cell bodies at spinal levels **S2 - S4**. Postganglionic parasympathetic cell bodies are located in the **target organ**. Sympathetic outflow from the CNS is restricted to spinal levels **T1 - L2**. Most preganglionic sympathetic axons synapse with postganglionic cell bodies in the sympathetic chain ganglia, but those en route to the abdomen and pelvis synapse in the **prevertebral ganglia**, such as the celiac and superior mesenteric ganglia. Postganglionic sympathetic fibers typically follow splanchic nerves to their target organs. (6 points)

Page 3

Points missed: 2
9. Arrange the following developmental events in the correct temporal sequence from earliest to latest. The 6\textsuperscript{th} and 11\textsuperscript{th} steps have been done for you, as a guide. (6 pts.)

A. Paramesonephric tube degenerates 15\textsuperscript{th}
B. Fertilization 13\textsuperscript{rd}
C. Division of the cloaca 12\textsuperscript{th}
D. Zona pelucida degeneration 5\textsuperscript{th}
E. Descent of testes 14\textsuperscript{th}
F. Cleavage 3\textsuperscript{rd}
G. Blastocoeal formation 4\textsuperscript{th}
H. Chorionic cavity formation 3\textsuperscript{rd}
I. Neurulation 10\textsuperscript{th}
J. Gastrulation 9\textsuperscript{th}
K. Ovulation 1\textsuperscript{st}
L. Urogenital sinus formation 11\textsuperscript{th}
M. Implantation 6\textsuperscript{th}
N. Amniotic cavity formation 7\textsuperscript{th}

1. \underline{K}
2. \underline{B}
3. \underline{F}
4. \underline{G}
5. \underline{D}
6. \underline{M}
7. \underline{N}
8. \underline{H}
9. \underline{J}
10. \underline{I}
11. \underline{L}
12. \underline{C}
13. \underline{A}
14. \underline{E}

10. Amniocentesis ("puncture of the amnion") is a procedure in which a syringe is used to sample amniotic fluid early in the second trimester of pregnancy. Fetal cells in the collected fluid are then screened for genetic disorders such as Down's syndrome. Trans-abdominal insertion of the needle is guided by ultrasound imaging. List in sequence from superficial to deep the layers the needle penetrates on route to the amniotic cavity. Begin with the epidermis overlying the mother's ventral midline. (4 points)

Epidermis \rightarrow \text{deminis} \rightarrow \text{superficial fascia} \left(\text{camper's, scarpa's}\right) \rightarrow \text{rectus sheath} \rightarrow \text{rectus abdominis} \rightarrow \text{transverse abdominis} \rightarrow \text{fascia} \rightarrow \text{parietal peritoneum} \rightarrow \text{amnion} \rightarrow \text{amniotic cavity}

11. For each area of the gut, describe an alternate route of blood from the aorta if the artery listed is blocked: (3 points each)

A. Transverse colon if middle colic artery blocked-
   - abdominal aorta \rightarrow \text{right colic artery} \rightarrow \text{marginal artery} \rightarrow \text{superior mesenteric artery}

B. Lesser curvature of stomach if left gastric is blocked-
   - abdominal aorta \rightarrow \text{coronary arteries} \rightarrow \text{proper hepatic artery} \rightarrow \text{right gastric artery}
12. It is well documented that the 237th 2am feeding, the 42nd volcanic diaper blowout, or the third Barney episode triggers in young fathers a survival reflex that may ultimately lead to a trip to the local urologist. In the no scalpel vasectomy, the goal is to ligate and excise a portion of the *vas deferens* to block the movement of sperm from the testes to the urethra. After the anterior wall of the scrotum is pierced with a sharp forceps, the two muscles that must be dissected, in order, are the *dartos muscle* and the *cremaster muscle*. The former is responsible for contracting to close the incision at the end of the procedure. The external spermatic fascia, the outermost layer of the spermatic cord and a derivative of the *external oblique* muscle of the abdominal wall, must also be transected. Surgeons aim to avoid damage to the posterior scrotal nerves, which are terminal branches of the *perineal* nerve. (5 points) 

13. Write the letter in front of each structure in the male next to the homologous structures in the female and in the sexually indifferent stage of development. (8 points)

<table>
<thead>
<tr>
<th>Male</th>
<th>Female</th>
<th>Indifferent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. scrotum</td>
<td>c. glans clitoris</td>
<td>c. genital tubercle</td>
</tr>
<tr>
<td>b. raphe of penis</td>
<td>e. crura of clitoris</td>
<td></td>
</tr>
<tr>
<td>c. glans penis</td>
<td>d. bulb of the vestibule</td>
<td>b. urethral fold</td>
</tr>
<tr>
<td>d. corpus spongiousum</td>
<td>a. labia majora</td>
<td></td>
</tr>
<tr>
<td>e. corpus cavernosum</td>
<td>b. labia minora</td>
<td>a. labioscrotal swellings</td>
</tr>
</tbody>
</table>
14. George W. Bush had an appendectomy in 1956, and according to www.thefirsttwins.com, Jenna Bush got one in 2000. George’s surgery probably involved an incision at the location shown in (A), while Jenna’s more recent surgery was probably laposcopic, with instrument entry points shown in (B).

A. For George’s surgery, **name, in order**, the muscles or muscular aponeuroses that were traversed as the surgeon worked from superficial to deep at the indicated location. (3 points)

   external oblique → internal oblique → **transversus abdominus**

B. For Jenna’s surgery, the laproscope entries at the midline passed through an aponeurotic structure called the _________. (1 point)

   **rectus sheath or linea alba**

C. **Name** 1 muscle of the abdominal body wall that was not pierced in either of these surgeries. (1 point)

   **quadratus lumborum**

D. **Name** 1 abdominal wall structure (not skin) that was pierced in both of these surgeries. (1 point)

   **transversalis fascia**

E. On A, **put an X** at the location of the deep inguinal ring. (1 point)

F. On B, **draw in** the rectus abdominus. (1 point)
15. On the left is a list of bony attachment points and passageways. Write the letters corresponding to the structures on the right that attach to the bony structure or pass through the opening. Note that some letters will be used more than once and some not at all. (8 points)

- anterior superior iliac spine
- obturator canal
- inguinal canal
- pubis
- greater sciatic foramen
- ischial tuberosity
- lesser sciatic foramen
- coccyx
- sacrum
- ischial spine
- ductus deferens
- piriformis muscle
- ovarian artery
- sacrospinous ligament
- pudendal nerve
- rectus abdominus
- iliococcygeus muscle
- sciatic nerve
- obturator internus muscle
- round ligament of the uterus
- sacrotuberous ligament
- obturator nerve
- inguinal ligament

16. Trace the normal flow of blood from the descending colon to the right kidney, naming all blood vessels and capillary beds the blood flows through (in correct order). Ignore the details of the heart and lungs, just indicate when you pass through each. (6 points)

capillary bed in descending colon → left colic vein → inferior mesenteric vein → portal vein → capillary bed in liver → hepatic vein → inferior vena cava → heart → pulmonary arteries → capillary bed in lungs → pulmonary vein → heart → aorta (arch, thoracic, abdominal) → right renal artery → right kidney

-10 90/100

Page 7 Points missed: 21/2