The descriptive attributes of gross lesions observed at post mortem examination may provide information about the type of pathologic process, cause, parts of the organ or tissue affected or involved and pathogenesis. As pathologists we can learn to read these lesions like “hieroglyphics” interpret their meaning and by putting strings of lesion attributes together with the patient signalment and history, arrive at a presumptive but often accurate diagnosis. A carefully prepared postmortem examination with accurate description of the lesions can be a valuable adjunct to the histopathologic examination if for no other reason than histopathology examines such a tiny fraction of the patient. By establishing some guidelines for the significance of the observed gross lesion attributes and interpreting them in the aggregate, we can often reach logical conclusions about the nature of the pathologic process observed. The long term goal of gross pathology is never to have to do histopathology. Of course this is a receding goal as we always confirm by histopathology what we deduce from the post mortem. But histopathology is relatively expensive (compared to visual observation at postmortem) and takes time.

I. OBJECTIVE

Understand how microscopic lesions produce the macroscopic lesion attributes we see in a variety of organs and tissues and shape the appearance of the lesions we see during the
port mortem examination. The approach will be to evaluate different types of lesion attributes in pairs, observing the gross specimen and the sub-gross or microscopic lesion.

INTERPRETATIVE PATHOLOGY OF SPECIFIC ORGANS AND TISSUES

II. LIVER - Dense solid organ normally dark, with symmetrical lobular microscopic architecture defined by peripheral portal triads and a system of bile ducts. Provides good contrast for pathologic processes causing a light or pale color

1. Multifocal to miliary, well demarcated, random small foci = implies a recent embolic shower. A common pattern in septicemia in many species which can look striking in livers due to the high contrast between the necrotic foci that are often white or light and the dark color of the background. The pattern is called military because it has the appearance of millet seed (“Miliarius”; Latin for millet seed)

   a. Beaver with yersiniosis. The tiny foci are discrete because they consist of a bacterial colony surrounded by a zone of degenerate or necrotic hepatocytes

   b. Horse with septicemic salmonellosis. A similar appearance to the beaver liver

   c. Snake with salmonellosis. In this case there is a peripheral layer of fibrosis that contributes to the abrupt edge of the small granulomas.

2. Nonrandom well demarcated symmetrical nodules in linear array may indicate a pathologic process which is highlighting the bile ducts. On a gross or subgross level, the only structure in the liver that is symmetrically organized is the system of bile ducts. As the ducts dilate, they assume a tortuous course and can cause a linear pattern of nodules where the ducts bend and raise the hepatic surface. The nodules are well demarcated with high contrast because there is a distinct histologic difference between the hepatic parenchyma and the tissue of the bile ducts and the interface is abrupt.
a. **Rabbit** with *hepatic coccidiosis* ( *Eimeria stiedae*) - cystic biliary hyperplasia. If you look carefully in this rabbit liver, you can discern a vague pattern of short linear arrays of white nodules. Histologically they can be seen to be dilated hyperplastic bile ducts with many coccidian organisms.

3 Multifocal **poorly demarcated nodules** = a process that tends to blend into the surrounding normal tissue or the nodules are composed of altered normal tissue. Poorly demarcated nodules may indicate the cellular or histological composition of the nodules is similar to hepatic parenchyma and thus nodular proliferation of hepatocytes. Cirrhosis may be pale or dark depending on the lipid content of the affected cells.

a. **Dog** with *cirrhosis* ~ Porto systemic shunt. In this case the regenerative nodules are very small giving an almost granular appearance to the liver surface.
b. **Cat** with chronic hepatitis and nodular regeneration (*cirrhosis*). The irregular poor demarcation of nodules is created by the proliferating hepatocytes forming nodules that are separated by zones of atrophy, mild inflammation and fibrosis. There is also a nodular pattern in the spleen but as we will see later, it is another and separate process.

c. **Horse** with *chronic hepatitis and cirrhosis*. In this case the regenerative nodules are larger and a mixture of yellow (lipid) and green (bile). The histopathology indicates substantial bile retention which imparts the green-yellow discoloration. The trichrome stain reveals how much fibrosis there is in this liver that is not appreciated on gross examination.

4. **Multifocal, random and red - can mask a process causing white foci.**

   a. **Puppy** liver with hemorrhage masking necrosis ~ *herpes viral septicemia*. The red hemorrhage can be seen easily on gross. Within these areas there is a barely visible pale area what corresponds to hepatic necrosis but it is masked by the sinusoidal congestion and hemorrhage.

5. **Multifocal, well demarcated but random red depressed foci** - depressed suggests necrosis; we see the red color over the liver color because of hepatic necrosis or dilation of sinusoids with pooling of blood similar to pigs with Vit E/Se deficiency.

   a. **Dog** with *metastatic hemangiosarcoma* in liver. In this liver we can see a miliary organized symmetrical pattern that reflects congestion in lobules, a common pattern. The
real pattern is the blotchy discrete red depressed areas that correspond to tumor infiltration that causes necrosis of hepatocytes, collapse of the architecture and pooling of blood in the empty space. The pattern is the same for telangiectasis in cats and cattle.

6. **Diffuse pale liver** usually means **lipidosis**. Systemic metabolic disorders usually cause diffuse lipidosis. Actually, hepatocytes can be pale because of other substances that produce vacuolated hepatocytes; intracellular fluid, glycogen.

a. **Cat** with **hepatic lipidosis**. This liver also exhibits a symmetrical military centrilobular pattern with a red center surrounded by pale areas that correspond to vacuolated, swollen, lipid filled hepatocytes. The swollen hepatocytes squeeze the sinusoids which likely impedes blood flow and may cause some hypoperfusion and paleness of the liver.

b. Cat with **hepatic lipidosis**, necrosis with hemorrhage. The depressed red foci = something taken away are the areas of necrosis with pooling of blood. These areas are depressed. The pale areas appear raised and swollen and are filled with lipid

7. **Symmetry or organization** to the lesion suggests **process accentuating the normal lobular architecture**. Multifocal widespread symmetrical pale and red show high contrast but what is the abnormal part? The architecture of the liver is laid out in a diffuse pattern of symmetrical hexagonal lobules but because in most species (except swine) there is a minimal or no border, we cannot see this pattern unless a pathologic process highlights it. That process could be highlighting the central portion of the lobule or the portal triads or the periphery of the lobules. When this happens it creates a fine almost military organized but evenly spaced pattern we recognize as “symmetrical”. However, in many cases it is difficult at the gross level to determine which part is abnormal. If the pattern looks more “irregular”, and not organized as tiny round foci, it may be a cellular infiltrate, inflammatory or neoplastic, in the portal triads.
a. **Cat** with centrilobular hepatic lipidosis (pale) and periportal hepatic necrosis with hemorrhage (red). Grossly it is often impossible to determine if the pale is centrilobular or periportal.

b. **Llama** with periportal LSA - In this case the white areas are the portal triads which are filled with lymphoma and often spill out into adjacent hepatic lobules giving the ramifying or branched appearance. This is a characteristic appearance seen in diffuse hepatic lymphoma in many species.

c. **Dog** with *histoplasmosis* - cells fill portal tracts + random sinusoids

8. **Pan lobular pattern** - “massive” in the liver implies an entire lobule is affected. This pattern is most easily appreciated when not every lobule is affected so you see affected and normal lobules in an almost multifocal miliary but not regular distribution.

a. Characteristic pattern in **pigs** with *Vit E/Se deficiency, cocklebur, coal tar pitch* or *gossypol* toxicity. We see the lighter colored hemorrhage over the darker color of hepatocytes only because of the necrosis. “Fine Arts 101"
“Nutmeg” pattern = chronic passive congestion.
Differential retention of blood in sinusoids. Not every sinus or lobule is equally affected, so the pattern is “irregular.” The contrast is enhanced if there is concurrent hepatic lipidosis.

a. **Cow** with *lipidosis and CPC* secondary to hardware disease

III. **SPLEEN** - a dark colored sinusoidal organ containing variable amount of blood and multifocal white pulp. Size variation in the spleen can be physiological as well as pathologic. Immunologically stimulated spleens have hyperplastic white pulp visible grossly.

1. **Diffuse infiltrations** of the spleen increase size and may cause the color to be **light** (= “raspberry jam”) or **dark** (= “blackberry jam”). Enlarged light spleens (raspberry jam spleens) are light because they are filled with cells that contain no pigment or hemoglobin. Almost always this means diffuse lymphoreticular neoplasia (LSA or leukemia). Enlarged dark red spleens contain abundant hemoglobin. This may be within RBC’s (congestion or hemorrhage) or free in the parenchyma (hemolytic disease). Blackberry jam spleens may indicate shock, septicemia or hemolysis. Because the agents that we use to perform euthanasia result in vascular dilation and pooling of blood in the spleen, animals that have been euthanized with these agents have blackberry jam spleens at post mortem examination. The spleens in this panel are from a dog with LSA on the Lt and a dog that was euthanized on the Rt.

a. **K9** spleen *w/ Lymphoma* (“Raspberry jam” appearance)

b. K9 with a “Blackberry jam” spleen due to hemolytic disease
2. **Well demarcated nodules** with **organized texture on cut surface** ("Can’t spread it with a butter knife"). = viable tissue and cells.

   **Dogs** with nodular lymphoid hyperplasia (**fibrohistiocytic nodule**). Although the cells in these nodules are no different than the lymphoreticular cells in the adjacent red pulp the combination of cells and fibrous stroma make a dense mass that has an abrupt edge from the red pulp sinusoids. The cells are viable and connected which makes the cut surface cohesive and not friable.

   ![Image of well demarcated nodules](image1.png)

   ![Image of fibrohistiocytic nodule](image2.png)

b. **Dog** with metastatic **histiocytic sarcoma**

3. Multifocal **well demarcated nodules without organized texture on cut surface** ("Spreadable with a butter knife"). = necrosis and suppurative exudate

   **Cow** with **Arcanobacterium pyogenes** abscesses. As is common with abscesses there is an abrupt margin between the red pulp and the lesion usually caused by a band of necrosis or a fibrous capsule. The center is friable because it is composed of pus, dead or dying cells that are not cohesive or connected.

   ![Image of abscess](image3.png)

   ![Image of histiocytic sarcoma](image4.png)

   **Dog** with splenic HSA - “sampling is everything”. **Hemangiosarcomas** in the spleen may be red or white and may have a discrete or blurred margin. The white color is most often caused by fibrin but may be due to dense tumor cells with minimal congestion of the vascular spaces. Often the tumor tissue is a minor part of the volume of the mass with most being fibrin. This makes sampling for biopsy a critical step in diagnosis because if the tumor tissue is not included, the diagnosis will be missed. You should sample at least 4-6 pieces of splenic masses that are suspected to be hemangiosarcomas.

   ![Image of hemangiosarcoma](image5.png)

b.
4. **Poorly demarcated masses**; blend into surrounding tissue. No abrupt transition from lesion to normal.

   a. **Equine** spleen with *EIA* and lymphoid hyperplasia in white pulp. Hyperplastic white pulp often is not as dense as neoplastic white pulp and can be blurred at the margin. If the white pulp is diffusely affected as in a very reactive spleen, it can give the spleen a “raspberry jam” appearance with a subtle multifocal widespread pattern.

   b. **Cat** with *spleenic mast cell tumor* (mast cells are PAS +). Here you can see anastomosing islands of neoplastic mast cells that are sufficiently dense to be seen grossly

5. **Diffuse pale spleen with prominent stroma.** May = loss of blood and lymphoid tissue

   a. **Dog** with *histoplasmosis* - spleen filled with low contrast mixed granulomatous, lymphoplasmacytic inflammation, fibrosis, amyloid and hemosiderin. This case is somewhat unique in that there is inflammation added to the spleen but the overall cross sectional area of the organ is not increased. Because the spleen is not enlarged, the septal connective tissue and muscle are visible grossly

   b. **Arab foal** with *CID* and splenic lymphoid aplasia - the spleen is “empty” of lymphocytes, somewhat collapsed so stroma is prominent. This is similar to the dog with histoplasmosis. Because there is much less cellular content, the fibrous connective tissue stands out.

IV. **LYMPH NODES** - pale organs with a distinct cortex and medulla. Most significant changes cause enlargement. “Immunologically dynamic” tissue.

   *Stromberg’s Law of Lymph Nodes*

   “If you can’t find them, they were not important”

Diffuse enlarged pale with **effacement of architecture; organized cut surface** (“Not spreadable with a butter knife” = viable tissue). Always consider a “domestic” (primary) neoplasm before an “imported” (metastatic) neoplasm.

   **Cow** with *LSA*. This node has lost the distinction between cortex and medulla indicating diffuse proliferation or infiltration of lymphoid cells that blurs the normal architecture.
b. **Bovine** bronchial *lymph node* with lymphadenitis, hyperplasia and edema secondary to pneumonia. In this slide there is a clear boundary between the cortex and medulla. The cut surface of the node is bulging (indicating something has been added) but the intact architecture supports an interpretation of lymphoid hyperplasia and inflammatory exudate rather than neoplasia. On gross appearance the medulla is translucent, gelatinous typical of extracellular fluid (edema). On histopath, it appears as clear space or separated fibers.

**The Texture Caveat**

“*Sometimes granulomatous inflammation looks like neoplasia*”

**Dog** with *histoplasmosis* - noncaseating granulomatous inflammation may infiltrate but not cause necrosis; the texture may present with an organized appearance because the cells are alive and adhering to each other. Chronic inflammation may stimulate cytokine mediated fibrosis, amyloidosis etc that adds organization and a “viable” appearance. This node is firm to the touch and smooth. Histologically you can see a solid sheet of epithelioid macrophages containing small organisms as well as fibrosis.

2. Diffuse enlarged pale lymph node with effacement of architecture; amorphous cut surface (“spreadable with a butter knife”) = inflammation; suppurative or caseating.

a. **Sheep LN** with caseous lymphadenitis abscess. The surface is amorphous because of the pus and the distinction between cortex and medulla is lost because al of the tissue is destroyed. This is readily apparent on histopathology where the field is filled with degenerate, dying and dead neutrophils.
3. Diffuse enlargement with **retention of corticomedullary architecture = lymphoid hyperplasia.**

   **Goat** intestinal LN with coccidiosis. This node is enlarged but the architecture is intact with a hint of edema in the medulla. The histopathology clearly reveals abundant follicular and paracortical lymphoid hyperplasia.

V. **KIDNEY** - a complex organ with many subunits (glomeruli, tubules, lobules defined by vasculature, interstitium) divided into cortex, medulla and pelvis. Complex lesion patterns may highlight any of these.

1. **Lesions confined to or centered on the cortex likely = a vascular portal.** Multifocal well or poorly demarcated lesions.

   **RAISED =** something added (cells).

   **DEPRESSED =** something taken away (necrosis, fibrosis)

   a. **Cat** with septicemic *Cryptococcus neoformans*. Looks like FIP. Multifocality implies embolic shower. The corroborative testimony is that the lesions are centered on or predominately in the cortex which is the expected pattern for septic lesions in the kidney. The lesions are well demarcated with an abrupt interface to normal cortex and have a symmetrical shape suggesting they highlight a vascular unit or lobule of the cortex. There is no hemorrhage and very little inflammation. The white color is caused by the organisms themselves

   b.
**Cat** with *FIP* - multifocal immune complex vasculitis/interstitial nephritis. Similar to the *Cryptococcus* case. Here the white color is caused by inflammation.

c. **Puppy** with *septicemic herpesvirus* - small hemorrhages mask the necrosis. The military cortical lesions support a recent embolic shower and like the liver in this case, the necrosis is masked by the hemorrhage.

d. **Horse** with *suppurative embolic nephritis* (*Actinobacillus* sp). Abrupt transition between pus and normal cortex. Vertical orientation ~ path of least resistance. Discrete “almond shaped” cortical lesions. These foci are large enough that we can see the pus on the cut surface.

e. **Cow** with *LSA* - poorly demarcated = infiltrate without lytic necrosis. Unlike the previous case of equine suppurative embolic nephritis, the white foci here are poorly demarcated because the neoplastic lymphocytes “irregularly infiltrate” into the adjacent renal tissue creating a blurred margin. There is little or no necrosis to demarcate these foci.

2. **Keystone pyramidal or wedge-shaped, flat**, pale or red color in cortex = **acute cortical infarct**
a. **Mountain lion** with *septic embolization*, thrombosis and infarct (*Aspergillus*). Because vascular beds are often laid out in distinct geometric patterns, lesions that exhibit such shapes may be outlining a pathologic process in such a vascular segment or bed. In the kidney, the end arteries often describe triangles, keystones or pyramidal shapes that follow lobular units.

3. **Multifocal petecchia** in the cortex = **endothelial damage, septicemia, DIC**

   a. “*Turkey egg kidney*” from a *pig* with *erysipelas* septicemia. This is the classic expression of septicemic damage to small capillaries that is seen in a variety of infectious diseases that have a septicemic component. Notice that the red foci of petecchia are irregular in size and larger than glomeruli which distinguishes them from glomeruli.
4. **Glomerulonephritis is often difficult to see grossly** - pattern is multifocal, somewhat symmetrical and should be confined to cortex. Glomeruli are less than 1mm in diameter so details of pathologic processes that affect them are difficult to interpret with the naked eye. Congestion and hemorrhage can be seen but if they do not accompany inflammation, glomerulitis is hard to definitively appreciate with confidence. But any lesion interpreted to be glomerulonephritis grossly should be confined to the renal cortex because there are no glomeruli below the CM junction.

   a. **Dog** kidney with *glomerular disease* and markedly dilated Bowman’s spaces. This dog’s glomerular disease is easier to see because the Bowman’s spaces are markedly dilated

   b. **Dog** kidney w/ *acute glomerulonephritis*. This dog has acute glomerulonephritis which can only be seen because of the hemorrhage. This cannot be distinguished grossly from glomerular congestion.

5. **Diffuse dark colored = hemoglobinuria/myoglobinuria.** “Port wine” colored urine is classic. Think about hemolytic diseases and check in the bladder. Hemolytic disease always causes a diffuse dark color to both kidneys because of the hemoglobin deposited widely in tubules
Cow kidney w/ hemoglobinuria ~ leptospirosis

Cow urinary bladder w/ Port Wine colored urine ~ hemolytic anemia

c. Sheep with Cu toxicity – The color of the kidney ranges from orange to dark red with the classic color of “Gun Metal Grey”

*The “corroborative testimony” is in the urinary bladder. The urine should be dark colored and translucent
**Dark colored urine which is turbid, is hematuria Histologically the dark color is produced by hemoglobin in the tubules.
6. Diffuse **cortical** dark **greyish-brown color in goats** = **Cloisonné kidney**. Pigmented thickened b.m. of **only proximal convoluted tubules**. Suggests gold wire inlay around porcelain seen in Cloisonné style jewelry. Don’t Dx hemoglobinuria!

a. **Cloisonné kidney** from a **goat**. Only the cortex is discolored
7. **Diffuse “soft” kidney = “Pulpy Kidney” = autolysis unless evidence of reaction**
   
a. **Sheep** with enterotoxemia - flaccid, wet kidney with hemorrhage. If there is no reaction, be careful of diagnosing “pulpy kidney disease”, it just may be autolysis alone. You have to “feel” these kidneys!

   ![Autolysis](image1.png) ![Enterotoxemia](image2.png)

8. **Lesions confined to or centered in the medulla or pelvis likely = a urogenous portal**
   Exception = symmetrical lesions defining a vascular unit in the medulla may be ischemic. Usually pyelonephritis is almost always due to ascending bacterial infection so it makes sense the lesion is centered or most severe in the lower parts of the kidney
   
a. **Cow** kidney w/ suppurative pyelonephritis ~ *Corynebacterium renale*

b. **Dog** with medullary necrosis, ascending pyelonephritis breaking out under capsule. The discrete demarcation in the renal crest is caused by a acute necrosis and mineralization with the pale color due to ischemia.
c. **Dog** with *granulomatous nephritis ~ Prototheca*: vascular or pelvic portal? Sometimes the distribution of the renal lesion is impossible to interpret as in this case. This dog has protochecosis which was likely acquired secondary to immunosuppression and because the dog had similar lesions in multiple organs, it likely arrived in the kidney by the vascular route and descended into the medulla.

9. **Lesion defining tubules** - well demarcated, linear in the cortex or medulla; could be **tubulointerstitial nephritis or deposits in tubules**. Tubulointerstitial nephritis can be hematogenous or urogenous.

   a. **Cow** with suppurative *tubulointerstitial nephritis*. Ascending pyelonephritis or descending embolic nephritis? This lesion is often attributed to ascending pyelonephritis but this cow had no lesions in the medulla and no exudate in the medulla.

   b. **Pig** with nephrosis and *urates* in medullary tubules. Grossly the opaque white linear streaks in the medulla are caused by the deposition of urates that outline them giving symmetry to the lesion. But histologically the tubules appear only as dilated tubules because the mineral dissolves out in processing of the tissue.
MEUTEN’S LAWS FOR PALE KIDNEYS

The 1st Law  Swollen pale, wet kidneys = nephrosis. Necrosis and edema [P within capsule. When that P exceeds the renal arterial P, renal plasma flow stops, causing pre-renal azotemia. BUN, Cr [. The kidney is hypoperfused and becomes pale.

a. Cat kidney with food associated acute renal failure due to melamine and cyanuric acid (Pet food nephrosis)

b. Sheep with lead toxicity

c. Cow with oak bud nephrosis
d. **Cat** with *ethylene glycol toxicity*

All of these cases appear similar grossly because of swelling, deceased perfusion and some edema. The actual tubular necrosis is invisible grossly. If you look carefully, in some cases of ethylene glycol toxicity, you can see minute faint opaque specks that = the oxalate crystals. This is often overlooked on the autopsy room floor but can be seen in well lighted photographs.

**The 2nd Law  Swollen pale, waxy kidneys = amyloidosis.** Amyloid can make the kidney very pale or less so but the amyloid is usually present only in the glomeruli. Some or much of the paleness and waxy feeling to these kidneys is caused by the massive proteinuria.

**Cow** kidneys with *amyloidosis*. Notice the massive protein deposition in the tubules and visible grossly. Histologically it appears as eosinophilic material distending the tubules.

![Kidney images](image-url)

The Color of the kidney varies from extremely pale to merely lighter than normal but Almost always they have a distinct waxy feeling
Massive proteinuria. The amyloid is in the glomeruli
Not the tubules

The 3rd Law  Small pale, irregular firm kidneys = fibrosis, atrophy, old infarcts

Dog with end stage kidney. This kidney is smaller and irregular in outline because of the
necrosis and loss of cortical tissue (mostly tubules). The white color and firmness is due
to the fibrosis which is easily seen on the Masson’s trichrome stain.
I. **BRAIN AND SPINAL CORD (CNS)** -

Diffusely light colored tissues due to the high fat content. Some definition between grey and white matter. Hemorrhage stands out, cellular infiltrates and edema can be indistinct. Symmetry is very important in evaluation. The CNS lives in a closed space surrounded by bone. There is no room for anything else.

**Lesions with hemoglobin (hemorrhage, congestion) are most visible because of contrast.** The Distribution of the hemoglobin is the key to interpretation.

1. **Multifocal** lesions suggest **embolic** shower with/without blood. Septicemia, DIC, platelet malfunction, endothelial damage.
   
   a. **Calf** with **septicemic meningitis** ~ Colibacillosis. We do not see the inflammatory exudate partly because the foci are very small and partly there is poor contrast of the exudate with the white background of the neuropil.

   ![Image](image1.jpg)

   ![Image](image2.jpg)

   b. **Cow** with **TEME** lesions ~ *Hemophilus somnus*. Similar to the colibacillosis case. Although there is considerable inflammation and infarction, all we see is the hemorrhage.

   c. **Cat** with **soap bubble lesions** of *Cryptococcus*. The “soap bubbles” are caused by the gelatinous capsular material of the yeast which provides minimal contrast with the neuropil; only a faint translucent appearance. Often there is no inflammation in these cases so no hemorrhage.
2. **Diffuse red** may = congestion or hemorrhage; distribution ~ where it is

   a. **Cow** with *babesiosis* – in this case the brain appears diffuse pink because the vessels that are affected are capillaries, not larger vessels which might stand out. The affect is produced by RBC’s adhering to the vascular endothelium because the Babesia organisms change the glycocalyx on the RBC making them sticky. On histopathology you can see all of the small vessels are congested.

   ![Image 1](image1.png)

   ![Image 2](image2.png)

   b. **Dog** with *submeningeal hemorrhage* ~ spinal tap. There is regional severe hemorrhage over the medulla. The subgross examination of the sections reveals it is confined to the surface which is what we expect if a superficial vessels were lacerated and bleeds into the subdural or arachnoid space

3. **Dilated ventricles = hydrocephalus**

   a. **Cat** with high protein CSF in dilated ventricles = *FIP*; pyogranulomatous periventricular encephalitis. In his case, the dilated ventricles contain opaque fluid that is gelatinous (because otherwise it would flow out of the coronal section). Much of the fluid has been removed during processing of the slide but the adjacent periventricular inflammation, not apparent grossly, is typical of FIP.

   ![Image 3](image3.png)

   **Any asymmetry in the brain is suggestive of an abnormality. Often subtle and easily overlooked.** Look at paired structures for size, shape, color. The horse brain with the abscess clearly exhibits asymmetry. Notice that the midline is shifted to the Rt and that the Lt hemisphere is swollen. Also the boundary between grey matter, distinct in the Rt, is blurred on the Lt side because edema fluid.

4. Asymmetrical cerebral hemispheres with collapse, **missing grey matter = polioencephalomalacia**.
a. **Dog** with *polio lesions*. This brain is asymmetrical with loss of grey matter on the Rt side that is clearly evident in the histopathology image.

5. Asymmetrical cerebral hemispheres with collapse, **discoloration in white matter - leukomalacia or inflammation**

   a. **Goat** w/ *leukoencephalitis ~ CAEV*. Here the lost tissue is on the Lt side. It is grossly apparent there is a discoloration in the white matter that corresponds to the inflammation and loss of white matter.

   b. **Horse** with *moldy corn poisoning*. Only the white matter is affected. It is slightly yellow in color and flecked with hemorrhage which is associated with the malacia or pan necrosis. *As a general rule, malacia appears yellow*, although there is nothing microscopically that explains this.

6. Asymmetrical cerebrum with swelling, and a mass or masses - *something added*. Abscess (amorphous cut surface) neoplasia (organized cut surface); primary (solitary) or metastatic (multiple).

   a. **Horse** w/ *Rhodococcus equi abscess in Rt cerebral hemisphere*. Typical of cerebral abscesses; the pus is well demarcated from the adjacent neuropil. The texture of the surface is consistent with pus.

   b. **Dog** with *oligodendroglioma*. Here the mass is gelatinous because of the myelin component to oligos and it is clearly well demarcated in the microscopic image because these tumor tend to grow by expansion and not invade or infiltrate as astrocytomas do.

   c. **Dog** with *metastatic hemangiosarcoma*. Hemangiosarcomas stand out because of the blood they contain. The multifocal nature tends to support an interpretation of a metastatic process.
**Dog** with *metastatic pulmonary carcinoma*. This metastatic pulmonary carcinoma is difficult to interpret in isolation because of the texture of the surface and the hemorrhage. But in the context of a radiographic lung mass, it raises the suspicion of a metastatic tumor.

7. **Translucence in the CNS = malacia and edema.** Can be masked by other pigments. This horse brain with leukoencephalomalacia exhibits the typical blurred boundary between grey and white matter that edema causes. The lesion is confined to the white matter which helps to interpret the disease. The congestion and hemorrhage obscures the pale color of the lesion

   a. **Horse** spinal cord with *EPM* lesion - hemorrhage masks the edema and malacia, the severity of which can be seen in the histopathologic section.

VII. **GASTROINTESTINAL SYSTEM** - hollow tubular organ system separated into distinct segments with mucous membrane and muscular tunics. Dense white color due to musculature may mask color changes in the mucosa. *“No evaluation of the GI is complete without direct visualization of the mucosa”*

Fibrinonecrotic inflammation (pseudomembranous or diphtheritic) with ulceration is a common response to necrosis on mucous membranes. It often signals lytic viral, bacterial, fungal, parasitic or ischemic disease.

1. Focal, multifocal, segmental and diffuse ulceration with fibrinonecrotic inflammation may have different implications as to pathogenesis. Ulcers are usually depressed (something missing).

   a. **Cow** with a focal ruminal ulcer ~ *mycotic ruminitis*. There is a discrete circular lesion that appears off colored but not ulcerated yet consistent with acute necrosis. The red rim of reaction is caused by peripheral congestion and hemorrhage. With time this lesion will ulcerate

   b. **Cow** with focal abomasal ulcer. The lesion is sharply demarcated and depressed. Ingesta adheres to the surface because of the fibrin exudation.
The depth of the ulcer and pseudomembrane can clearly be seen in the histological section. The deep ulcer with extensive loss of tissue and pseudomembrane is typical of an older lesion.

c. **Cow** with multifocal *esophageal ulcers* ~ *BVD*. Similar to the previous abomasal ulcer. These multifocal lesions are hyperemic and have a pseudomembrane. But the distinction is in there multifocal distribution, their location in the esophagus. Microscopically you can see the vascular congestion which imparts the hyperemic appearance and the adherent pseudomembrane.

d. **Snake** with diffuse fibrinonecrotic colitis ~ *salmonellosis*. Abundant fibrinonecrotic exudate in the lumen and adhering to the colonic surface

e. **Chukar** with diffuse fibrinonecrotic typhlitis ~ *histomoniasis*. Similar to the snake colon with a thick fibrinonecrotic membrane but only histologically do we appreciate that there is an amebia penetrating deeply into the cecal wall accompanied by intense inflammation (which is not generally visible grossly) and eventually spreading to the liver through the portal vasculature.

2. Lesions that cause **thickening without mucosal ulceration and necrosis** ("*Morocco Leather*") may be caused by **epithelial proliferation** or **granulomatous inflammation**. Granulomatous inflammation infiltrates beneath the surface but may not cause necrosis; = "*space occupying inflammation*". Looks like "sulci and gyri".
a. **Sheep** abomasum with “Morocco leather” appearance from glandular hyperplasia ~ *chronic ostertagiosis*. The glandular proliferation produces confluent swellings of glandular groups incompletely divided from each other which causes the sulci and gyri appearance grossly. There is often less inflammation and fibrosis than you would think.

b. **Dog** with *hypertrophic pyloric gastropathy*. A cluster of polypoid masses in the pylorus caused by glandular proliferation with dilated lumens causes the same sulci and gyri appearance on the surface. This can be a challenging lesion to fully appreciate when looking at endoscopic fragments of the surface unless you know what the gross appearance looks like. Although there is often inflammation present in this lesion, the gross effect is nearly all caused by the increase in number and size of the glands.

c. **Cow** with *Johne’s Disease* - “sulci and gyri” and submucosal edema. Notice there is no ulceration or fibrinonecrotic inflammation because there is no necrosis of the epithelium. The non-necrotizing inflammation is beneath the surface filling the lamina propria. Submucosal edema contributes to the thickening and the Morocco leather appearance. It is clear from the histopathology that the effect is caused by the inflammation and edema with little additive effect from epithelial hyperplasia. “Morocco leather”

d. **Cat** with granulomatous enteritis ~ *histoplasmosis*. Grossly similar to other cases of the Morocco leather appearance. In this case there is diffuse granulomatous inflammation in the lamina propria accompanied by many macrophages filled with *Histoplasma* organisms which thickens the mucosa and no epithelial proliferation.

e. **Horse** with *idiopathic granulomatous enteritis*. The inflammation almost completely effaces the entire wall of the GI. The submucosa is markedly thickened and it penetrates through the muscular tunics and accumulates on the serosal surface. All of the thickening is caused by inflammation that
throws the mucosal surface into “sulci and gyri”. DDx = LSA

e. **Pig** with *proliferative enteritis* - *Lawsonia* sp. The surface looks the same but in this case the thickening is caused by epithelial hyperplasia as well as inflammation in the lamina propria.

3. **Lesions on the serosal surface = peritonitis or serositis, not enteritis.** For me, if the lesion is peripheral to the submucosa and affects the outer muscular tunics and serosa, it peritonitis as in this case of sheep intestine with *Oesophagostomum* sp.

   a. **Cat** with *FIP*. Although sometimes there is inflammation affecting the mucosa in FIP in this case the histological section clearly demonstrates the inflammation is primarily in the outer layers of the bowel wall

   b. **Horse** with *hemomelasma ilei*. Likewise this lesion typically affects only the serosa. The hemorrhage and hemosiderin cause the dark color and the firm adherent feel is caused by the granulation tissue component.

VIII. **LUNG** - a very complex organ with lobules, interstitium, many variably sized airways all of which can reflect lesions. Symmetry and organization of lesions is important in localizing disease. Physiologically dynamic size. A light pink color, light weight, dry tissue.

*King’s Law of Pneumonia*

“If it’s not firm, it’s probably not pneumonia”

1. Lesion distribution is important indicator of pathogenesis. **Anterior ventral** patterns suggest an *aerogenous portal* and often = *bronchopneumonia*. If the lesions look organized (symmetrical), they may be defining an architectural subunit (lobule, airway etc).

   a. **Rat** with *mycoplasmosis* and a “symmetrical” (linearly arranged) AV pattern of white “nodules” which are dilated airways filled with suppurative exudate (= bronchiectasis/bronchiolitis).
Cow with suppurative bronchiolitis and necrosis - *pasteurellosis*. The pus shows up well grossly as does the dilated septal lymphatics that are filled with fibrin. Histologically the lung field is very dense and filled with inflammatory cells, hemorrhage and fibrin obscuring the open alveoli typical of normal lung.

2. Multifocal **poorly demarcated pale foci** may be highlighting airways without necrosis or pus; peribronchiolar and mucoid inflammation

   a. Horse with *heaves* lesion - “mucoid or catarrhal bronchiolitis”. There is no necrosis or pus but a distinct inflammatory reaction associated with airways more in the wall and outside. The small airways are plugged with mucus. The lack of necrosis blurs the distinction giving the poorly demarcated appearance.

3. **Hilar to diffuse patterns** suggest a vascular portal and may indicate edema or interstitial pneumonia. Interstitial pneumonia may be exudative or nonexudative. The distinction between interstitial pneumonia and pulmonary edema is extremely difficult to distinguish in a photograph. Interpretation depends on how heavy the lung feels and is there clear fluid on the surface which cannot be appreciated from just the gross appearance. Also low protein edema fluid may be invisible in histopathology slides so your gross observations are very important in making the final diagnosis.

   a. This lung from an okapi that died suddenly from an *anaphylactic reaction* to an injection had extremely heavy and wet lungs which may be appreciated grossly from the lights glistening on the surface and the widened interlobular septae also had an enormous amount of clear fluid run off the cut surface. Microscopically you do not see the edema fluid. The alveolar septae are thickened with fibrin and perhaps fluid but there is minimal cellular reaction.
b. **Sheep** with *lentiviral pneumonia* - lungs are enlarged and were heavy and the lung did not collapse which the rib impressions reinforce. The cut surface was dry. That can be difficult to see in a photograph but easily appreciated on the necropsy room. Microscopically the alveoli are free of cellular exudate. Only lymphocytes around airways and in the alveolar septae are present. In this case and the last, there is no apparent fluid present in the histopath section so you must rely on your gross observations to confidently diagnose edema.

d. **Cow** with acute bovine pulmonary edema and emphysema ("Fog Fever"). Marked exudative interstitial pneumonia with edema. The emphysema is caused by dyspnea due to edema and inflammation. The translucent appearance is due to all of the emphysema but the lung was heavy and dripped edema fluid when cut. Microscopically you can see the emphysema as dilated interlobular lymphatics. The remainder of the lung is dense with edema and acute inflammation with fibrin accumulating in the alveoli.
4. **Darker than normal lung can mean atelectasis.** Diffuse or lobular

a. **Neonatal calf** with incomplete inflation and interstitial edema due to surfactant failure. Microscopically there are some lobules that are relatively normally inflated but several that are dense with no apparent open alveoli. Collapsed alveoli creates relatively more blood filled capillaries together giving the dark color to atelectasis.

![Image of neonatal calf lung](image1)

b. **Cow** with irregular lobular atelectasis and edema of the interlobular septae. In this case the microscopic sections exhibits suppurative exudate in a small airway giving the reason for the atelectasis.

![Image of cow lung and microscopic section](image2)

5. **Diffuse dark red wet lung** with **miliary poorly demarcated white foci** (*“Multifocality implies an embolic shower”*)

a. **Cat** with **FIP**. The white foci are foci of immune complex vasculitis/interstitial pneumonia on a background of congestion and edema ~ vascular leakage. Microscopically the white foci are seen to be collections of fibrin and lymphocytes consistent with a Type III immune complex vasculitis center on the alveolar septae.

![Image of cat lung and microscopic section](image3)
6. **Multifocal red lesions** = *petecchia*; think vascular damage/septicemia, platelet defect or DIC

b. **Pig** with *erysipelas*. What looks like a petecchia grossly is actually a small localized focus of hemorrhage in the lung, likely centered on an alveolar capillary likely caused by the bacteria.

7. **Multifocal white lesions** (= *embolic shower*). Metastatic neoplasms or abscesses. The multifocal lesions are easily seen grossly and well demarcated because of the high contrast with the adjacent normal lung parenchyma.

a. **Antelope** with *septicemic Aspergillosis* and pyogranulomas. Microscopically you can see discrete areas of pyogranuloma formation with good contrast against the lung and on high power clearly visible are the fungal hyphae typical of *Aspergillus*.

b. **Rat with Corynebacterium kutcheri** pyogranulomas
c. **Dog** with *Blastomyces dermatiditis*. Here the foci appear to grow or blend together as the process expands. High power histopathology bears out the presence of the yeast organisms

d. **Dog** w/ *metastatic thyroid carcinoma*

**IX. BONE** - a dense white homogeneous hard tissue. Marrow cavities with active marrow, vessels and hematopoietic elements provide good contrast but mostly there is poor contrast among bone, cartilage, marrow fat and cellular infiltrate.

1. **Opaque white** lesions could be necrosis (*infarction*), **cellular infiltrate** (neoplastic or inflammatory) or **bony proliferation**, or all 3!

   a. **Cow** rib with *LSA* - infiltrate of neoplastic cells, coagulation necrosis of bone and hyperostosis. Architecture is preserved but there is opaque white infiltration of tumor in the marrow as well as in the periosteum

2. **Subphyseal lesions may indicate an embolic event** ~ blood supply to the growth plate. Capillaries fenestrated and turn back 180 degrees. Good site for septic emboli/metastases

   a. **Dog** with *metastatic carcinoma* in proximal humerus. There is opaque white-grey tissue with hemorrhage in the epiphysis which on histopathological section resolves into mammary carcinoma with foci of hemorrhage and necrosis that provide enough contrast to be seen grossly

   b. **Foal** with *septicemic salmonellosis* - multifocal phalangial subphyseal infarction with osteomyelitis. Just beneath the growth plate there is a distinct sequestrum with central necrosis that is rimmed by a fibrous capsule. Although there is some residual inflammation, most has resolved. The distinct white color is produced by ischemia in the sequestrum
d. **Goat** with *CLA lesion* in epiphysis and diaphysis - well demarcated exudate bounded by a fibrous capsule. Similar to the sequestrum in the foal, the opaque white area is caused by pus which on histopathology can be seen to be laminated and surrounded by a capsule that was appreciated on the gross.

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d. **Foal** metatarsus with linear ischemic necrosis below physis ~ *septicemia*
There is coagulation necrosis, microfracture and fibrosis. The narrow band of subphyseal necrosis occurs in the classic location for a septic event. The zone is pale and corresponds to the area on histopathology of necrotic bone and inflammatory exudate. Below this there is a zone of microfractures and fibrosis that is not as distinct on the gross but blends into the necrotic area. The periosteal new bone on the lateral cortex can be seen grossly but is clearly distinctive in histopath.
e. **Foal** metatarsus with wedge-shaped infarction and sequestrum—vascular thrombosis, infarction, necrotic trabeculae, fracture, fibrosis all from *septicemic salmonellosis*. This infarct is also in the classic location for a septic event hinting at the pathogenesis. However, this lesion is more chronic as there has been time for the necrotic bone to separate from the viable bone. The texture of the affected bone is similar to the surrounding viable bone and is surrounded by a rim of reaction visible as a vague pale area below the sequestrum that corresponds to the necrosis and fibrosis in the histopath slide. The separation of the bone from the physis is nearly complete and affects the entire growth plate.

3. **Fractured trabeculae may mask or distract you from the underlying problem**
   Always look for a process that may suggest a cause. In this photo of the bovine vertebral body, the marrow cavity of the bone is discolored due to a combination of necrosis and suppurative exudate characteristic of bacterial infection.

a. **Horse** with vertebral compression *fracture and nutritional osteoporosis*. Its easy to see the shortened vertebral body and the disorganized trabeculae—compression fracture. It may be harder to appreciate that the trabecular of bone are thinner than normal. This is partially due to “The Paradox” that the bone is diffuse affected and there is no normal for comparison. Histologically the problem of appreciating thin trabeculae is similar but in this case there is no necrosis or exudate.
b. **Dog** with *hypertrophic osteodystrophy* (HOD) - which is really fracture secondary to suppurative subphyseal osteomyelitis and hemorrhage. The infraction and hemorrhage is visible both grossly as well as histologically but the exudate is not easily seen on the gross specimen.

4. **Bony proliferation looks pretty much the same everywhere** but the location and characteristics can be instructive.

   a. **Cow** humerus with *growth retardation lattice* ("The pause that refreshes") - subphyseal lateral trabecularization. (Longitudinal growth stops trabeculae add bone laterally)

   b. **Pig** diaphyseal femur with cortical osteoporosis and *nutritional fibrous osteodystrophy* (FOD). Improper Ca/P balance in feed ration. The details of the linear band of cortex is difficult to see partly because the photo is
overexposed. Histopathology clearly reveals that the cortex is porotic but accompanied by attempted hyperostosis that is poorly mineralized and excessively fibrous (FOD)

c. **Pig** distal femur with *nutritional FOD*. Fibrous stroma, few trabeculae w/o mineralization. A distinct subphyseal white band is visible in the femur but the details in the gross view are not clear. Histologically the causae is clearly a zone of FOD where there is little or no marrow that causes the white color.

*Horse* maxilla with *nutritional FOD* (“Big Head”); abundant unmineralized matrix is the “*something added*” that enlarges the maxillae. Similar to the pig with FOD. The marrow cavity is pale because the marrow elements are replaced by FOD. The maxilla is swollen because something is added to the bone.

d. **Cow** humerus with diffuse symmetrical medullary hyperostosis (*osteopretosis*); mineralized trabeculae replace and fill the marrow cavity. The entire marrow is affected because normal remodeling does not occur.

e. **Cow** rib with a *fracture and callus*. The outline of the fracture rib can be seen grossly surrounded by pale dense white tissue. This is extensive periosteal new bone induced by the fracture. In the context of the obvious fracture, the pathogenesis of this bony proliferation is obvious
5. **Chondroid proliferation is a lot like bone** but the location and how it grows is instructive; its somewhat translucent though. The translucent retained cartilage core in the metaphysis of a chicken is pathognomonic for tibial dyschondroplasia

a. **Dog** femur with *osteochondroma* - cartilage-capped polarized well differentiated trabecular bone forming a mass. Dense white band under cartilage is trabeculae and marrow elements. These zones can be easily seen in both the gross and histoloic preparation with the translucent cartilaginous nature of the tissue clear on gross examination. The boundary between normal cortical bone and the tumor is poorly demarcated or blurred because both types of bone look similar.

c. **Pig** with *osteoochondrosis* in the growth plate. This is similar to the lesion in the chicken and indeed it is the same pathologic process. The distinct wedge of growth plate cartilage is easily seen on both gross and histopathology.
**Young horse** with *osteochondritis dessicans* lesion on the articular facet and cervical instability - the cartilage flap is separated from the subchondral bone by necrotic cartilage, plasma, granulation tissue, new chondroid matrix all of which contribute to the discoloration. The lesion stands out and is well demarcated from the adjacent healthy pure white articular cartilage.

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d. **Alpaca** with *rickets* (= physeal osteodystrophy).

1. Elongated zone of hypertrophied cartilage
2. Retained cartilage core on the trabeculae
3. Trabecular microfractures
4. Wide osteoid seams

Notice how flared the rib is typical of rickets. This is a chronic lesion as you can see there is much trabecular bone forming in the metaphysis.
Dense disorganized trabeculae

Irregular thickening of the growth plate

Necrosis in the growth plate
Necrosis in the physis