Pathology of Bones
Structural and Congenital Defects

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These are two hemisections of normal bovine bone.

**gp** corresponds to the growth plate also known as epiphyseal plate. The growth plate is responsible for the growth in length of the bone. The normal growth plate should be thin and regular cartilaginous line that eventually closes and disappear in the mature animal.

**t** shows the trabecular bone also known as cancellous bone. The red appearance of the trabecular bone is due to active bone marrow.

**c** shows the cortical bone also known as compact bone that has a much higher bone density than the trabecular bone (**t**)

**d** shows the diaphysis which is a space filled with bone marrow

See figure 16-14 page 1049 in Pathological Basis of Veterinary Diseases
This is a low magnification (x10) histological section of a normal femoral heath stained with H&E.

(c) corresponds to the articular cartilage. The chondrocytes forming the cartilage appear as dark cells surrounded by pale substance that corresponds to the cartilage matrix.

(tb) shows the trabecular bone (bone spicules) which arise beneath the articular cartilage and extend into the epiphysis. The trabecular bone formed by osteocytes (dark cells) surrounded by a pink bone matrix.

(bm) shows the bone marrow filling the spaces between the trabecular bone.

See figure 16-19 in Pathological Basis of Veterinary Diseases (page 1052).
Trabecular bone:
Spicules surrounded by bone marrow. Dark cells inside the bone lacunae are the **osteocytes** (arrows). The bone marrow (square).

Cortical bone:
Concentric layers of bone forming the Haversian system. The small spaces (arrows) are the bone lacunae and the large spaces (circle) are the central canal.

Microscopic Features of trabecular and cortical bone:
- Dark cells inside the bone lacunae are the **osteocytes** (arrows).
- The bone marrow (square).
- The small spaces (arrows) are the bone lacunae.
- The large spaces (circle) are the central canal.
This is a diagram that illustrate the normal trabecular bone.

Note the numerous osteoblasts along the bone spicules (pink color). The "plump" appearance of osteoblasts indicates that these cells are actively producing a protein matrix known as osteoid.

Eventually, osteoblasts become trapped in osteoid giving origin to osteocytes. The osteocytes lie within the bone lacunae and their main function is to reabsorb bone during remodeling or in response to hypocalcemic states (osteocytic osteolysis).

Note also a large multinucleated cell known as osteoclasts. These phagocytic cells create small concave spaces known as Howship's lacunae. Osteoclastic osteolysis is also part of bone remodeling or bone reabsorption in hypocalcemic states.

See figure 16-11 in Pathological Basis of Veterinary Diseases (page 1046)
Bone cells/diagram

Bone cells/Histology

Osteoclasts

Osteoblasts

Osteocytes

Osteoclasts

Osteocytes
Bone Growth: Endochondral Ossification

Epiphyseal vessel
Endplate
Resting chondrocytes
Proliferative chondrocytes
Mature chondrocytes
Hypertrophic chondrocytes
Calcified cartilage
Woven bone on calcified cartilage spicule
Capillary loop

Cartilage matrix
Calcified cartilage
Woven bone

Chondrodysplasia. *Bovine.*

Chondrodysplasia in an Angus calf. Note the short/thick legs and "domed" shortened cranial base with prominent eyes.

**Chondrodysplasia**, also known as *disproportionate dwarfism*, is a genetic abnormality in which the endochondral growth (length) is absent while appositional growth is normal. As a result of this abnormal ossification, bones grow in width but not in length causing disproportionate dwarfsms.
Chondrodysplasia. *Bovine Hereford.*

Chondrodysplastic bovines are also referred to as “bull dog” calves.

Note the small sized calf with the large head and pendulous abdomen reflecting *disproportionate dwarfism.* On postmortem examination, the long bones would appear much shorter than those of an animal of similar age. The appositional growth in affected animals is normal.
**Chondrodysplasia. Alaskan Malamute**

An Alaskan Malamute showing disproportionate genetic dwarfism. Note the abnormally shortened legs and normal body length. Alaskan Malamutes with Chondrodysplasia also suffer with anemia. The reason for the anemia is not clear.

Other forms of Chondrodysplasia have also been reported in miniature poodles, Norwegian Elkhounds and Scottish Deerhounds.
Osteopetrosis. Newborn Angus Calf

normal (left) vs. Osteopetrosis (right)

Note the increased density of trabecular bone with the reduction of medullary cavity in the bone with Osteopetrosis. This is a genetic defect of osteoclasts which fail to reabsorb the primary spongiosa.

Bone tissue accumulates filling the medullary cavity normally occupied by the bone marrow which in turn results in anemia.

Although bone density in Osteopetrosis is increased, there is an abnormal fragility of bones often leading to pathological fractures. In other words, bones with Osteopetrosis have poor resistance to physical stress.

See figure 16-44 Pathologic Basis of Veterinary Diseases (page 1065).
Schematic representation of normal bone and osteopetrosis. Note in osteopetrosis an increased bone density due to defective osteoclasts which fail to reabsorb bone.
**Osteopetrosis. Bovine.**
**Aberdeen Angus / Humerus.**

Note the increased density of the trabecular bone with concurrent reduction in the medullary cavity.

Osteopetrosis-like lesions are sporadically seen in the bones of stillborn calves infected with BVD virus.

Osteopetrosis is rarely seen in dogs or cats.

Interestingly, some poultry diseases that affect phagocytic cells, like avian leucosis, also induce osteopetrosis. It could be speculated that the virus infects osteoclasts causing a positive imbalance between deposition and resorption of bone.
Porcine Hyperostosis. Two live piglets.

Note the swelling of the forelegs. **Porcine hyperostosis** is a genetic disease of pigs characterized by the abnormal deposition of bone along the periosteal surface of long bones. The lesions may affect one or more limbs.

Most piglets suffering of Hyperostosis are born dead or die shortly thereafter. The cause of death is not well understood but it has been suggested that affected piglets suffered from cardiac problems.
**Micromelia. Canine.** Note the abnormally short and poorly developed forelegs.

There are many types of limb malformation most of which have a genetic etiology. In micromelia the entire limb is poorly developed.
**Phocomelia. Canine**

Note the short and poorly developed forelegs. The humerus and radius are missing so the carpal and digits appear like flippers. This malformation is reminiscent of seals (family Phocidae) hence the name phocomelia.

Between 1950 and 1960 there was a major outbreak of limb malformation in human beings due to the ingestion of a teratogenic substance known as **Thalidomide**. This drug was prescribed to pregnant women to prevent symptoms associated with morning sickness. Thousands of children around the world were born with limb malformation. These children became known as "**Thalidomide babies**".

[http://www.chm.bris.ac.uk/motm/thalidomide/first.html](http://www.chm.bris.ac.uk/motm/thalidomide/first.html)
Peromelia. Bovine.

Another form of congenital malformation is Peromelia in which the distal portion of the limb is missing.

Note the absence of the distal metatarsus and digits in this calf with peromelia.
Various types of abnormal limb development are found in other species, particularly amphibians. These malformations have been reported in many places including Canada. It has been suggested that toxins and contamination may be involved but infectious causes cannot be ruled-out.

Dr. Teather (UPEI), has been investigating the prevalence and origin of amphibian malformations in PEI.
Syndactylia. Porcine

Note the fusion of digits.

Syndactylia (syn. Syndatyly) or fusion of the toes is a common genetic malformation in pigs. One or more feet may be involved and the fore feet are more commonly affected in pigs.

Syndactylia also occurs sporadically in cattle and sheep.
Polydactyly. Porcine

Polydactylyia is an increase in the number of digits which occurs practically in all domestic species as an inherited condition. It can also be the result of congenital exposure to some teratogenic compounds.

Note the supernumerary digits. This specimen was collected in a PEI slaughter house. The skin has already been shaved.
Scoliosis.

The embryological development of vertebrae is complex and subject to various malformations. Scoliosis (lateral deviation), lordosis (ventral deviation) and kyphosis (dorsal deviation) of the spine are sporadically observed in domestic animals. Vertebral malformation is sometimes associated with spinal cord anomalies (dysraphism).

Note the lateral deviation (abnormal curvature) of the vertebrae.
**Kyphoscoliosis (fish).**

This specimen was obtained from a prestigious and expensive restaurant during a romantic dinner. In the menu it was listed as *Fish Almondine* ($22.00 not including the white wine) An abnormal spinal curvature was noted after the muscle was brilliantly removed and eaten.

Kyphoscoliosis is commonly found in fish and it could be reproduced experimentally by physically "traumatizing" developing ova or by exposure to environmental contaminants. Although the etiology of this fish malformation was never elucidated, the dinner was regarded as highly successful.
Once you have reviewed this module you may wish to do a Quiz to reinforce the learning process. Quiz-1 is available in the following website:

http://people.upei.ca/lopez/bones/bone_1.htm

If you have any questions, please do not hesitate to call me at my office (902) 566-0943 or by e-mail at mailto:lopez@upei.ca