Disease of Bone

SKELETAL DYSPLASIAS

Generalized skeletal dysplasias

- The underlying defect may lie in the formation of cartilage, thus affecting all bones that form by endochondral ossification. Such disorders are referred to as chondrodysplasias.
- Achondroplasia is often used in place of chondrodysplasia to describe diseases characterized by disproportionate dwarfism.

Generalized skeletal dysplasias

- **Dexter/Bulldog type chondrodysplasia:**
- occurs in the Dexter and Holstein breeds, and possibly in Charolais and Jersey.
- They possess severe, relatively consistent, skeletal abnormalities.
- They have extremely short limbs, which are usually rotated, a domed head with retruded muzzle and protruding mandible, and a large ventral abdominal hernia.
- The tongue is of normal size so protrudes markedly, and the hard palate is absent.
- The shortened limb bones consist of mushroomshaped, cartilaginous epiphyses separated by a short, central segment of diaphyseal bone.

Generalized skeletal dysplasias

- **Telemark type chondrodysplasia:**
- is inherited as an *autosomal recessive trait* and, as such, the heterozygous parents are phenotypically normal.
- Affected calves are born alive but cannot stand, and die of suffocation shortly after birth.
- The lesions in Jerseys may include a short, broad head, deformed mandible, cleft palate, and short, spiraled limbs, but many calves have mild lesions.

Generalized skeletal dysplasias

- **Brachycephalic ("snorter") type:**
- dwarfism was common in the Hereford breed in North America and New Zealand, but also occurred in other beef breeds, especially the Angus.
- It is inherited as an *autosomal recessive trait*.
- Affected calves have a short, broad head with bulging forehead, retruded upper jaw and a slightly protruding mandible. The eyes are prominent and laterally displaced.
- The vertebral column is shortened and the ventral borders of individual vertebrae are flattened, a useful diagnostic feature visible radiographically in young calves.
- These anomalies in some cattle breeds are also observed **in pigs, dogs and cats.**

Localized Skeletal Dysplasias

- The legs mostly were affected.
- **Amelia:**
- Absence of legs
- **Hemimelia:**
- It is a defect in the middle part of a leg.
- It may be transversal or paraxial.
- There is no anterior-posterior leg bones or the radius-ulna tibia-fibula is aplasic.

Localized Skeletal Dysplasias

- **Syndactyly:** Fusion of digits
- **Polydactyly:** Presence of supernumerary digits
- **Ectrodactyly:** Partial or complete absence of a digit
- **Adactyly:** Absence of a digit
- **Dactylomegaly:** Abnormally large digits

Localized Skeletal Dysplasias

- **Head**
- Brachycephalic - Shortening of the head
- Brachygnathia - Abnormally short jaw (inferior or superior)
- Campylognathia **-** HareLip
- Palatoschisis - Cleft palate
- Prognathia - Abnormal projection of the jaw
- **Spine**
- Kyphosis - Abnormal dorsal curvature of the spinal column
- Lordosis - Abnormal ventral curvature of the spinal column
- Scoliosis - Lateral deviation in the spinal column

Metabolic Diseases of Bones

- Metabolic bone diseases, also referred to as **osteodystrophies,** are the result of disturbed bone growth, modeling, or remodeling due to either nutritional or hormonal imbalances.
- Metabolic bone diseases are traditionally classified as **rickets, osteomalacia, fibrous osteodystrophy,** or **osteoporosis.**

Adrenal Cortex

- Hyperadrenocorticism is the cause of osteoporosis.

OSTEOPOROSİS

- *Osteoporosis is easily the most common of the metabolic bone diseases,* both in man and animals. Rather than being a specific disease, *osteoporosis is a lesion characterized by a reduction in the quantity of bone, the quality of which is normal.*
- In effect, osteoporosis represents an imbalance between bone formation and resorption in favor of the latter, resulting in bone that is structurally normal but with reduced breaking strength.

OSTEOPOROSİS

- It show marked fragility.
- It is especially common in farm animals.
- Most cases are of nutritional origin.
- Calcium failure in development is an important contributing factor.
- A few cases are due to an uncomplicated nutrient deficiency.

Etiologic Factors

- **Starvation induced osteoporosis:**
- Most cases of osteoporosis in animals, especially farm animals, are nutritional in origin and may be due to deficiency of a specific nutrient, such as calcium, phosphorus, or copper, or to starvation, where there is restricted intake of an otherwise balanced ration.
- The *effects of starvation* on the skeleton are greater in young growing animals than in adults.
- Growth of the skeleton is retarded and may cease during periods of starvation due to reduced production of bone matrix.

- **Disuse osteoporosis**
  - is a loss of bone mass due to muscular inactivity and reduced weight bearing.
  - It may be localized, following paralysis or fracture of a limb, or more generalized in association with prolonged recumbency or inactivity.
  - Bones that normally carry the greatest loads suffer the greatest proportional loss in mass from disuse.

- ***Senile osteoporosis***

- is common in humans and occurs in other animals, but *seldom appears as a clinical problem in veterinary medicine.*
- Insufficiency of active vitamin D metabolites
- The decrease in secretion of parathyroid hormone and sex steroids causes the decrease in physical activity.

- ***Gastrointestinal Parasitism Induced Osteoporosis***
- Osteoporosis is often present in animals with severe gastrointestinal parasitism, most likely *secondary to malabsorption.*
- *It is important for ruminants. The cause is parasitic (Trichostrongylus colubriformis) infestation.*

- **Corticosteroid-induced osteoporosis** is common in humans and its occurrence in animals may be underestimated.
- **Inflammatory bowel disease-induced osteoporosis**

- ***Calcium Deficiency Induced Osteoporosis***
- It can be experimentally. It is asymptomatic in adult animals.
- Generalized osteoporosis, and a tendency to fracture vertebrae, femurs, and phalanges, characterizes the condition.
- The osteoporosis induced by calcium deficiency is due to excess bone resorption as a result of increased activity of parathyroid hormone following a reduction in plasma-ionized calcium concentration.
- Both adult and growing animals, there is severe loss of cancellous bone, especially in bones with a high trabecular component such as vertebrae.

- **Phosphorus Deficiency Induced *Osteoporosis***
- Phosphorus deficiency produces osteomalacia in adults and rickets in growing animals, both under natural and experimental conditions.
- **Copper Deficiency Induced Osteoporosis**
- a component of the enzyme lysyl oxidase, *copper is required for the cross-linkage of collagen and elastin.*
- Impaired cross linkage of collagen in bone matrix most likely accounts for the increased bone fragility in copper-deficient animals.

Rickets and Osteomalacia

- It is convenient to consider these two diseases together as they have *a similar etiology and pathogenesis, differing only in the age at which they occur.*
- Rickets is a disease of the developing skeleton in young animals and is accompanied *by abnormal endochondral ossification at growth plates, in addition to defective bone formation.*
- Osteomalacia occurs only in adults and although there are no lesions associated with growth cartilages, *the bone changes are the same as those that occur in rickets.*
- Both diseases occur in all domestic animal species and wildlife.

Rickets and Osteomalacia

- The pathogenesis of both rickets and osteomalacia involves defective mineralization.
- Anything that interferes with the mineralization of cartilage or bone matrix may cause rickets or osteomalacia, but most cases in animals result from dietary deficiencies of either vitamin D or phosphorus.

- **Phosphorus Deficiency Induced *Osteomalacia***

- Phosphorus deficiency is well established as a cause of rickets and osteomalacia, although the exact mechanism is uncertain.
- Rickets and osteomalacia due to phosphorus deficiency are uncommon, but do occur in animals grazing pastures low in phosphorus.
- Signs of phosphorus deficiency develop slowly.
- Clinical disease is most likely to occur in cows where the deficiency is exacerbated by the extra demands of pregnancy or lactation.

- **Phosphorus Deficiency Induced *Osteomalacia***

- Such animals lose condition, develop transient, shifting lameness, and show an increased susceptibility to fractures.
- They may crave phosphorus-rich materials, and osteophagia and pica are characteristic signs of the deficiency.
- Fertility can be severely reduced and estrum may be irregular, inapparent, or absent.
- Hypophosphatemia develops early but also returns to normal rapidly if the animals are supplemented.

- **Vitamin D deficiency induced *Osteomalacia***
- Pre Vit. D3 (cholecalciferol) one of the important components of Vitamin D is formed in the skin.
- When the winter sun is at an angle of less than 30 degrees to the horizontal, the short-wavelength ultraviolet rays required for the activation of 7-dehydrocholesterol in the skin are reflected by the atmosphere and dermal synthesis of previtamin D 3 is impaired.

Vitamin D deficiency induced *Osteomalacia*

- Vitamin D deficiency may occur in grazing animals where the combination of relatively high latitudes and temperate climates allows them to be pastured for much of the year. Such conditions occur in parts of the United Kingdom, South America, New Zealand, and southern Australia.
- *It is likely that many grazing animals are vitamin D deficient for a period during the winter.*
- Sheep appear to be more susceptible to vitamin D deficiency than cattle, possibly because a dense fleece covers much of their skin.

HYPERPARATIROIDISM and BONE DISORDERS

- ***Fibrous osteodystrophy (****osteodystrophia fibrosa, osteitis fibrosa cystica)*
- Fibrous osteodystrophy is a relatively common metabolic bone disease characterized by extensive bone resorption accompanied by proliferation of fibrous tissue and poorly mineralized, immature bone.
- The pathogenesis involves persistent elevation of plasma PTH and the lesion can be considered to represent the skeletal manifestation of primary or secondary hyperparathyroidism.

Fibrous osteodystrophy

- Different animal species vary in their susceptibility to fibrous osteodystrophy and, to some degree, in the distribution of lesions.
- Horses, pigs, dogs, cats, ferrets, and goats are often affected, as are reptiles and New World nonhuman primates, but the disease is rare in sheep and cattle.
- In the **horse,** the disease occurs at any time after weaning but the prevalence, and possibly the susceptibility, declines after about the seventh year.

Fibrous osteodystrophy

- Horses require a calcium:phosphorus ratio of approximately 1:1.
- Diets in which the calcium:phosphorus ratio is 1:3 or wider, can result in osteodystrophia fibrosa depending to some extent on individual and familial susceptibility, and on alternative sources of calcium, such as drinking water.
- The condition usually occurs after maintenance for some months on diets consisting largely of grain, corn, and grain by-products such as bran, hence the term **"bran disease."**

Fibrous osteodystrophy

- **Primary hyperparathyroidism** *is usually the result of a functional parathyroid gland adenoma.*
- In primary hyperparathyroidism, autonomous secretion of PTH results in persistent hypercalcemia and hypophosphatemia, the latter reflecting increased urinary clearance of phosphate.
- The persistent hypercalcernia in primary hyperparathyroidism is generally accompanied by *polydipsia/polyuria, muscular weakness, and widespread mineralization of soft tissues*.
- Affected animals may succumb to the effects of *nephrocalcinosis* before the skeletal changes are severe enough to become clinically apparent.

Fibrous osteodystrophy

- **Secondary hyperparathyroidism** is a much more common cause of fibrous osteodystrophy in animals than primary hyperparathyroidism and *may be due to either chronic renal disease or a dietary imbalance of calcium and phosphorus.*
- PTH secretion is stimulated by a reduction in plasma-ionized calcium, whatever the cause, and if the stimulus persists then generalized bone resorption results.
- **Renal secondary hyperparathyroidism** occurs most often in dogs, and occasionally in cats, as a complication of chronic renal failure.
- Impaired glomerular filtration in animals with renal failure leads to progressive hyperphosphatemia due to reduced renal clearance of phosphate.

Fibrous osteodystrophy

- **Clinically;** Affected animals become depressed and may develop sudden lameness due to infractions of long bones or vertebrae, the latter resulting in paralysis.
- Signs of the disease are progressive and include reluctance to move, hindlimb lameness and incoordination.
- Early signs consist of minor changes in gait, stiffness, transient and shifting lameness, and lassitude.
- Loss of appetite with progressive cachexia and anemia develop later. The anemia may be due to depression of erythropoiesis by parathyroid hormone or its metabolites.

- *The most characteristic feature is bilateral swelling of the bones of the skull* including both the maxillae and mandibles, hence the term *"bighead'.*
- The *lesions of renal osteodystrophy in dogs are usually most severe in the bones of the skull.*
- As the disease progresses, there is accelerated resorption of cancellous bones of the maxilla and mandibles, occasionally resulting in soft, pliable mandibles (so-called "rubber jaw").

Nutritional Secondary Hyperparathyroidism

- *It may be due to a simple dietary deficiency of calcium, excess dietary phosphorus, or to a deficiency of vitamin D.*
- Vitamin D deficiency alone is also a cause of rickets or osteomalacia.
- Horses seem to be remarkably sensitive to the effects of high-phosphorus diets and relatively resistant to the effects of rations low in phosphorus.

Nutritional Secondary Hyperparathyroidism

- In practice, *nutritional secondary hyperparathyroidism is most often caused by diets containing low calcium and a relatively high concentration of phosphorus* and, with the exception of horses, affects young, rapidly growing animals.
- In pathogenesis increased plasma phosphate concentration, resulting from increased intestinal absorption of phosphorus, depresses plasma-ionized calcium and indirectly stimulates the release of PTH.

SCURVY

- **Scurvy** is a disease resulting from a lack of vitamin C (ascorbic acid).
- **Vitamin** C (ascorbic acid) is a co-factor for the enzymes prolyl and lysyl hydroxylase, which are required for the hydroxylation of proline and lysine during collagen synthesis, and is also an important antioxidant.
- In vitamin C **deficiency,** *there is reduction or failure in the secretion and deposition of collagen*.

SCURVY

- Most mammals synthesize ascorbic acid from glucose via glucuronic acid and gulonic acid.
- Some species, including humans, certain nonhuman primates, and guinea pigs, lack the hepatic microsomal enzyme L-gulonolactone oxidase and, in the absence of a dietar source of ascorbic acid, **develop scurvy.**

SCURVY

- **Gross lesions** are dominated by *sub-periosteal accumulations of clotted blood* around the shafts of the long bones, the scapulas, the bones of the head, especially the mandible, and on the ribs.
- The metaphyses are fragile, discolored by hemorrhage and separate easily from the adjacent physes.
- The bones are <u>osteopenic and fragile.</u>

SCURVY

- **The most characteristic microscopic lesion of scurvy** is in the metaphysis.
- *Naked spicules of calcified cartilage, derived from the zone of provisional calcification in the growth plate, persist as a "scorbutic lattice«.*
- The layer of bone that is normally deposited on this cartilage framework by active osteoblasts is absent or deficient.
- Osteoblasts are sparse and appear to have lost their polarity.

Toxic Osteodystrophies/ Vitamin D Toxicity

- Vitamin D is essential for normal bone development, in particular mineralization of cartilage during endochondral ossification and of newly formed osteoid, but in excess, it is highly toxic.
- **Vitamin** D toxicity may result from accidental over-supplementation of young animals, ingestion of plants that contain the active form of the vitamin, or accidental ingestion of rodenticide containing cholecalciferol (vitamin D3).
- The potency of the latter toxin is illustrated by the fact that cats and dogs may be poisoned by ingesting the carcasses of poisoned rats.
- Cats appear to be more sensitive to vitamin D toxicity than dogs.

Toxic Osteodystrophies/ Vitamin D Toxicity

- Vitamin D appears to prevent postparturient hypocalcemia ("milk fever") in cows but mineralization of soft tissues may result, particularly in pregnant Jersey cows, and in this breed its use is contraindicated.
- The *mechanism of vitamin D toxicity* is related primarily to its effect on increasing calcium absorption from the intestine, mobilizing it from bone and reducing its excretion by the kidney.
- The end result is *hypercalcemia* together with *hyperphosphatemia,* which, if persistent, will lead to widespread mineralization of soft tissues, in particular the kidneys, gastric mucosa, lungs, endocardium, and arterial walls.

Hypervitaminosis D Lesions

- *The skeletal changes in hypervitaminosis D may be characterized by either sclerosis or rarefaction,* depending on the level of dietary calcium and the pattern of exposure.
- An early response in bone is widespread, intense osteoclastic activity.
- With continued administration, the matrix produced by osteoblasts accumulates, sometimes in large amounts and in a distinctive pattern.
- It often has a tangled fibrillary arrangement and appears somewhat mucoid, floccular, and intensely basophilic.

Hypervitaminosis D Lesions

- Initially, the maturation of the matrix is local and irregular in distribution, and is unrelated to normal patterns of osteogenesis.
- If toxicity is prolonged, the abnormal matrices continue to accumulate and virtually obliterate the marrow spaces.
- This produces a mosaic of basophilic and acidophilic matrix, and newly formed woven bone.

Hypervitaminosis D Lesions

- The *presence of abundant basophilic matrix is virtually pathognomonic for vitamin D toxicity* and is valuable diagnostically when plasma levels of the vitamin are not known.
- Necrosis of osteocytes occurs with high doses of vitamin D and groups of empty lacunae are often present in cortical bone and in the center of trabeculae.

Deficiencies and Excesses of Vitamin A

- Toxic injury of bones in excess and hard tissue disorders in deficiency occurs.
- Depending on the age and species of animal, and the duration and level of exposure to excess vitamin A, ***the manifestations of toxicity*** *may include physeal damage, osteoporosis, or the development of exostoses (osteophytes).*
- The physeal lesions of vitamin A toxicity are characterized by reduced chondrocyte proliferation and reduced size of hypertrophic chondrocytes, resulting in narrowing of growth plates.

Vitamin A Toxicity

- The **osteoporosis** of vitamin A toxicity is associated with decreased numbers of osteoblasts and fewer, thinner osteoid seams than normal.
- It is most severe in cortical bone and some of the membranous bones of the skull.

Fluoride Toxicity

- Fluoride is an essential trace element but, when present in chronic excess, is capable of inducing *characteristic dental and~or bony changes.*
- Fluorosis *is the term used to denote chronic fluoride toxicity.*
- *All* species are susceptible but *fluorosis is most common in herbivorous animals.*
- **Acute intoxication leads to gastroenteritis.**
- *Fluoride is removed rapidly from the blood, by renal excretion and deposition in bones and teeth.* A small amount is deposited in soft tissues.

Fluorosis

- Toxic levels may be obtained from subsurface waters, especially where *rock phosphate* is plentiful. Rock phosphates vary considerably in their fluoride content, and chronic poisoning has been observed in cattle and sheep given rock phosphates as "licks."
- Contamination of pastures adjacent to *mineral ore refineries* may also cause toxicity, either directly or by uptake of fluorine by plants.
- **The characteristic changes of severe fluorosis occur in teeth and bones and are accompanied by shifting lameness, loss of production, and a variety of nonspecific signs of debility.**

LESIONS

- **Dental lesions** develop only if intoxication occurs while teeth are in the developmental stages and enamel is forming.
- The mildest macroscopic evidence of dental fluorosis is the *presence of small foci with a dry, chalky appearance compared to the normal glistening surface of enamel.*
- In more severe cases, *all the enamel in affected teeth may be chalky, opaque and show various degrees of yellow, dark brown, or black discoloration, which is virtually pathognomonic for fluorosis.*
- Affected teeth show accelerated wear and may develop chip fractures. In chronic cases, they may be worn to the gum line.

LESIONS

- Lesions of similar severity should be present in teeth that develop simultaneously.
- These associations include the first incisor with the second molar, second incisor with the third molar, and the third incisor with the second premolar.
- Lesions in the second incisor must be severe before lesions are prominent in the third molar, and in general, incisor abrasion develops prior to molar abrasion.
- Lesions may develop in the fourth incisor in the absence of changes in other teeth.

LESIONS

- The bone lesions of fluorine toxicity, **osteofluorosis,** are generalized but not uniform and, in severe cases, are characterized grossly by the formation of periosteal *hyperostoses*, which give the macerated bones a chalky roughened appearance.
- Lesions occur first on the medial surface of the proximal third of the metatarsal and later on the mandible, metacarpals, and ribs.
- The pelvis, vertebrae, and other bones of the distal limbs are also affected.

LESIONS

- In chronically affected cattle, fracture of the digital bones in the medial claw is common, leading to lameness and a preference for affected animals to stand cross-legged.
- At *highly toxic levels,* the gross lesions of osteofluorosis occur rapidly.
- *In young, growing dogs and pigs, and presumably in other species, fluorine intoxication produces lesions, which, in many respects, resemble rickets.*

RESPONSE to MECHANICAL FORCES and INJURY

- The cells of bone tissue are capable of the same basic cellular responses as most other tissues, including *atrophy, hypertrophy, hyperplasia, metaplasia, neoplasia, degeneration, and necrosis*.
- Depending on the stimulus, the response may be localized or generalized but, in general, the magnitude of skeletal response is greater in young growing animals than in adults.

Fracture repair

- *Bone fractures are very common in animals* and occur either when a bone is subjected to a mechanical force beyond that to which it is designed to withstand, or when there is an *underlying disease process that has reduced its normal breaking strength.*
- The latter is referred to as a **pathological fracture** and unless the predisposing disorder is corrected then the repair process is unlikely to be successful.
- The possibility of a localized bone disease (e.g., neoplasia or osteomyelitis) or a generalized disorder (e.g., fibrous osteodystrophy or osteoporosis) should always be considered if bone fracture has occurred without evidence of trauma.

Fracture types

- Fractures are classified as **simple,** if there is a clean break separating the bone into two parts, or **comminuted,** if several fragments of bone exist at the fracture site.
- When one segment of bone is driven into another the fracture is referred to as an **impacted fracture,** and when there is a break in the overlying skin, usually due to penetration by a sharp fragment of bone, the fracture is referred to **as compound.**
- If there has been minimal separation between the fractured bone ends, and the periosteum remains intact, the lesion is classified as **a greenstick fracture.**
- An **avulsion fracture** occurs when there is excessive trauma at sites of ligamentous or tendinous insertions and a fragment of bone is torn away.

Process of fracture repair

There are three major phases of fracture healing, two of which can be further sub-divided to make a total of five phases:

1-Reaction

i. Inflammation

ii. Granulation tissue formation

2-Repair

iii. Cartilage callus formation

iv. Lamellar bone deposition

3-Remodeling

v. Remodeling to original bone contour

Process of fracture repair

- ***I.* Stage:**
- After bone fracture, blood cells accumulate adjacent to the injury site.
- Soon after fracture, blood vessels constrict, stopping further bleeding.
- Within a few hours, the extravascular blood cells form a clot called a hematoma that acts as a template for callus formation.
- These cells, including macrophages, release inflammatory mediators such as cytokines (tumor necrosis factor alpha (TNFα), interleukin-1 family (IL-1), interleukin 6 (IL-6), 11 (IL-11), and 18 (IL-18)) and increase blood capillary permeability.

Process of fracture repair

- ***I.* Stage:**
- Inflammation peaks by 24 hours and completes by seven days. Through tumor necrosis factor receptor 1 (TNFR1) and tumor necrosis factor receptor 2, TNFα mediates the differentiation of mesenchymal stem cell (originated from the bone marrow) into osteoblast and chondrocytes.
- Stromal cell-derived factor 1 (SDF-1) and CXCR4 mediate recruitment of mesenchymal stem cells.
- IL-1 and IL-6 are the most important cytokines for bone healing.
- IL-1 promotes formation of callus and of blood vessels.
- IL-6 promotes differentiation of osteoblasts and osteoclasts.

Process of fracture repair

- **II. Stage:**
- All cells within the blood clot degenerate and die. Within this area, the fibroblasts replicate.
- Within 7-14 days, they form a loose aggregate of cells, interspersed with small blood vessels, known as granulation tissue.
- Osteoclasts move in to reabsorb dead bone ends, and other necrotic tissue is removed.

Process of fracture repair

- **III. Stage:**
- Bony callous formation:
- The fibrocartilaginous callus is converted into a bony callus of spongy bone.
- It takes about two months for the broken bone ends to be firmly joined together after the fracture.
- This is similar to the endochondral formation of bone when cartilage becomes ossified; osteoblasts, osteoclasts, and bone matrix are present.

Process of fracture repair

- **IV. Stage:**
- Lamellar bone deposition. Remodeling.
- The process substitutes the trabecular bone with compact bone and forms lamellar bone tissue.
- **V. Stage:**
- Remodeling to original bone contour
- The bone regains its original form and function and the healing is complete.

Complications of fracture repair

- **Technic:**
- Delay or failure of treatment
- **Biological:**
- Delay and deficiency in tissue response
- Deformations and excessive callus formation
- The repair of compound fractures may be delayed by the development of bacterial osteomyelitis following contamination of the fracture site through the open skin wound.

Complications of fracture repair

- When it becomes chronic, large callus formation is seen.
- In chronic cases, fistulizations and pseudarthrosis (pseudo joint) are formed.
- **Pseudodarthrosis formation factors:**
- lack of adequate fixation
- osteomyelitis
- blood circulation disorder
- Pseudoarthrosis may also develop if soft tissues separate the fractured bone ends or if persistent infection inhibits callus formation.

OSTEOSIS

- Like any living tissue, *bone will die when deprived of its blood supply.* This is referred to as **osteonecrosis,** or the synonymous term **osteosis.**
- In animals, bone ischemia is most often associated with trauma, particularly fractures.
- It is mostly not recognized macroscopically.
- *Microscopically, zones of empty lacunae due to loss of osteocytes characterize necrotic bone.*

OSTEOSIS

- The prognosis is more favorable if the necrotic bone is at a site that is both sterile and has good collateral circulation, and the volume of necrotic bone is small.
- In such cases, a zone of granulation tissue develops at the interface between the necrotic and viable tissue.

Aseptic Necrosis of The Hood Femoris
Legg-Calve-Perthes disease

- This disease, characterized by avascular necrosis of the femoral head occurs with some frequency in dogs, especially smaller breeds (Miniature Poodles, West Highland white and Yorkshire Terriers etc).
- The disease is inherited as an autosomal recessive trait.

Aseptic Necrosis of The Hood Femoris
Legg-Calve-Perthes disease

- Clinically, the disease has an insidious onset, usually between 4 and 8 months of age, and is bilateral in approximately 15% of cases.
- There is no obvious sex or leg preference in dogs.
- In the clinic only lameness is seen.

Aseptic Necrosis of The Hood Femoris
Legg-Calve-Perthes disease

- *The osteonecrosis in Legg-Calve-Perthes disease is initiated by one or more episodes of ischemia.*
- Hyperemia at the beginning of the case, then necrosis develop.
- When the subchondral infarct is more extensive, *continued weightbearing leads to fracture and collapse of the necrotic trabecular bone and flattening of the femoral head*, predisposing to degenerative arthropathy.

INFLAMMATORY DISEASES OF BONES

- **Osteitis** is inflammation of bones.
- Inflammation of bones inevitably originates in vascular areas of either the medullary cavity or the periosteum and is referred to as either **osteomyelitis** **or** **periostitis** **respectively.**

Bacterial infections of bones

- Bacterial infections of bones are very common in animals, especially young horses and ruminants.
- Since the route of infection is *usually hematogenous*, most are centered on the medullary cavity and are referred to as osteomyelitis.

Bacterial infections of bones

❖ Vertebral osteomyelitis

- Arcanobacterium pyogenes is the most common causative organism in vertebral osteomyelitis in most species.
- These include: Escherichia coli, Salmonella typhimurium, staphylococci, streptococci, and R. equi in foals;
- Tuberculosis in older horses;
- Fusobacterium necrophorum in calves;
- Mannheimia (Pasteurella) haemolytica, E necrophorum, and staphylococci in sheep;
- and Erysipelothrix rhusiopathiae, Brucella suis, staphylococci, and streptococci in pigs

Bacterial infections of bones

- **Localized bacterial periostitis** → the feet of cattle with *F. necrophorum* ("footrot")
- **Atrophic rhinitis of pigs** → *Pasteurella multocida*
- **Mandibular osteomyelitis** → *Actinomyces bovis*

Actinomycosis

- **Mandibular osteomyelitis** is primarily a disease of cattle caused by *Actinomyces bovis,* but occasionally occurs in horses, pigs, deer, sheep, and dogs.
- In cattle, the disease is known as **actinomycosis** or **"lumpy jaw,"** and *the classic lesion is confined to the mandible.*
- *The* maxilia is rarely involved and the organism rarely spreads even to regional lymph nodes, which, although large and indurated, are not infected.

Actinomycosis

- A. bovis is probably an obligate parasite of the oropharyngeal mucosa in a number of animal species, and most infections involve the buccal tissues.
- The organism is not particularly virulent, and in most, perhaps all cases, the surface tissues must be injured by some other agent or by a foreign body for invasion to occur.
- The osteomyelitis follows direct extension of the infection from the gums and periodontium.
- Once in the bone, A. bovis causes **a chronic, pyogranulomatous inflammatory reaction**.

Actinomycosis

- Suppurative tracts permeate the medullary spaces leading to multiple foci of bone resorption and proliferation.
- Large sequestra do not develop, even when the cortex is invaded, probably because of the slow, progressive nature of the disease.
- Fistulae often extend into the overlying soft tissue and may discharge through the skin or mucous membranes.
- Periosteal proliferation is excessive and the bone may become enormously enlarged, the normal architecture of the mandible being destroyed.
- The teeth in the affected portion of the jaw become loosened, lost, or buried in granulation tissue.

Actinomycosis

- On cut surface, the affected mandible has a "**honeycomb«** appearance with reactive bone surrounding pockets of inflammatory tissue.
- Fragments of necrotic trabecular bone accumulate in purulent exudate as **"bone sand.«**
- The pus is also likely to contain many 1-2-mm diameter, soft, light yellow granules referred to as **"sulfur granules."**
- These consist of an internal mass of tangled, gram-positive filaments mixed with some bacillary and coccoid forms, and a periphery consisting of closely packed, club-shaped, gram-negative bodies.

Viral Infections of Bones

- **Classical swine fever**
- **Canine distemper virus**
- **Canine adenovirus type I** infection in pups may be accompanied by grossly visible metaphyseal hemorrhages at costochondral junctions due to virus-induced injury to endothelial cells, some of which contain characteristic intranuclear inclusion bodies.

Viral Infections of Bones

- **Feline herpes virus** causes necrosis in the turbinate bones of germfree cats following intranasal inoculation, and produces necrosis in the metaphyses and periosteum of growing bone when administered intravenously.
- **Feline leukemia virusu,** Medullary sclerosis may occur in cats infected with *Feline leukemia virus.*
- **Bovine viral diarrhea**

TUMORS AND TUMOR-LIKE LESIONS OF BONES

- *Primary tumors of bones are common in dogs and to a lesser extent in cats,* but occur infrequently or rarely in other domestic animals.
- In dogs, most tumors of bones are malignant.
- They may arise from any of the mesenchymal tissues present in bones, including precursors of bone, cartilage, fibrous tissue, adipose tissue, and vascular tissue, but *tumors of bone and cartilage-forming cell lines are the most common.*
- The clinical history and radiographic appearance are often crucial to an accurate diagnosis of a bone lesion and the pathologist should not rely on microscopic features alone.

TUMORS OF BONES

- **Bone-forming tumors:** *Osteoma, ossifying fibroma, and fibrous dysplasia,*
- *Osteosarcoma* ➔
- Poorly differentiated osteosarcoma
- Osteoblastic osteosarcomas
- Chondroblastic osteosarcomas
- Fibroblastic osteosarcomas
- Telangiectatic osteosarcoma
- Giant cell osteosarcomas

TUMORS OF BONES

- **Cartilage-forming tumors:**
- *Chondroma, Osteochondroma, Multilobular tumor of bone* and *Chondrosarcoma.*
- **Fibrous tumors of bones:** fibromas, fibrosarcoma
  ➔In dogs,
- Central fibrosarcomas
- Periosteal fibrosarcomas
- Maxillary fibrosarcoma
- ***Vascular tumors of bones:*** hemangioma, hemangiosarcoma

TUMORS OF BONES

- **Other primary tumors of bones:**
- Giant cell tumor of bone,
- Liposarcoma
- Plasma cell myeloma,
- Malignant lymphoma.
- **Secondary tumors of bones:**
- *Carcinomas metastasize to the skeleton of dogs much more commonly than sarcomas and the most common tissues of origin are the mammary gland, thyroid, prostate, ovary, and lung.*
- *The ribs, vertebrae, and proximal long bones are the favored locations for skeletal metastases in dogs.*