

Pathology of Birds – An Overview

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Birds: Of all the higher forms of life the birds are the most beautiful, most musical, most admired, most watched and most defended.

Roger Tory Peterson (1974)

1. Introduction

Similar to other animals, birds are susceptible to a variety of diseases. Knowledge about the type of birds, their anatomy and how they are managed helps to understand the type and kind of diseases different birds are susceptible to. Because some types of birds are raised for egg production or meat, such as commercial poultry, infectious diseases can spread rapidly among birds raised in a confined space. Poultry can also be raised in small numbers as backyard flocks. Often poultry raised in such conditions are more often exposed to natural elements and are often not vaccinated; poor nutrition and lax biosecurity can lead to frequent viral, bacterial, parasitic and nutritional diseases. Pet and exotic birds such as psittacines and passerines are raised in small or large aviaries, sold in pet shops and kept as pets. These birds have their own unique diseases that can be influenced by management. There are also free flying birds that face ever shrinking habitats and ecosystems as well as undergoing changes. Therefore, diseases in such birds are greatly influenced by environmental factors. Numerous birds raised or kept in captivity as in zoos have a different and unique environment. Regardless of whatever management practices are used, genetics and nutrition play a significant role in the initiation and outcome of a disease.

This handout on the pathology of birds is an outline and is by no means complete. There are a large number of miscellaneous diseases or pathological conditions that have not been included in this outline. Those who are interested in learning more are advised to review the references provided at the end of this outline.

2. Taxonomy

There are over 22,000 subspecies and 9300 species of birds classified in 166 families, 27 orders in the class **Aves**. Order Passeriformes contains the largest number with 5243 species of birds, and the Order Struthioniformes contains only one species (ostrich).

The number of species in each order, along with representative species, is listed in the following table. The list starts with orders believed to be the most primitive and continuing to the most advanced.

<u>Order</u>	<u>Species</u>	<u># Species</u>
Struthioniformes	ostrich	1
Rheiformes	rheas	2
Casuariiformes	emus, cassowary	4
Apterygiformes	kiwis	3
Tinamiformes	tinamous	40
Sphenisciformes	penguins	17
Gaviiformes	loons	4
Podicipediformes	grebes	18
Procellariiformes	albatrosses, fulmars	86
Peliconiformes	pelicans, cormorants, frigate, boobies	55
Ciconiiformes	herons, egrets, storks, ibises, spoonbills, flamingos, bitterns.	116
Anseriformes	Ducks, geese, swans	145
Falconiformes	vultures, eagles, hawks, harriers, kites, osprey, falcons, buzzards	272
Galliformes	chickens, turkeys, quail, pheasant, partridge, Guinea fowl, peafowl, grouse, chachalaca, guan, currasow, capercaille, ptarmigan, megapods	252
Gruiformes	cranes, coots, rails, trumpeters, seriemas, bustards, bustard quails	199

Charadriiformes	gulls, murres, terns, avocets, puffins, woodcock, oystercatchers, sandpipers, plovers, surfbirds, snipes, skimmers	334
Columbiformes	pigeons, doves and sand grouse	289
Psittaciformes	parakeets, Budgerigar, cockatiels, cockatoos, macaws, parrots, lorries, lorikeets, love birds	317
Cuculiformes	turacos, cuckoos, roadrunners	147
Strigiformes	owls	134
Apodiformes	hummingbirds	398
Trogoniformes	quetzal, trogons	34
Coliiformes	mousebirds	6
Caprimulgiformes	Oilbird, frogmouths, potoos, goatsuckers, nightjars	
Coraciiformes	toucans, barbets, woodpeckers, jacamars	379
Piciformes	kingfishers, hornbills, hoopoes, rollers	199
Passeriformes	Perching birds; finches, canaries, crows, ravens, magpies, jays, American robins, mockingbirds, bulbuls, sparrows, starlings, mynahs, blackbirds, cardinals, chickadees, thrushes, tits, grosbeaks, buntings, tanagers, orioles, birds of paradise, larks, wrens, waxwings, waxbills, weavers, swallows, manakins, martins, antbirds, shrikes, <i>etc.</i> , <i>etc.</i>	5243

3. Anatomy and Physiology

Birds have a close evolutionary relationship with reptiles especially crocodiles. Their unique anatomy has helped the birds to adapt well to the environment. Even though there are numerous different species of birds, their anatomy shows a greater uniformity of structure than many single orders of fishes, amphibians, reptiles and mammals (King and McLelland, 1984). A few salient features on the anatomy and physiology of birds are given below.

Birds skin lack glands except for the uropygeal gland or preen gland present at the base of the tail and glands in the external ear. The uropygial gland is not found in all birds. Various appendages such as comb, wattles, ear lobes, snood, caruncles, beard, spurs, claws, scales are present in a variety of birds.

Birds have pneumatic bones and air sacs extend in to the proximal humerus, vertebrae and pelvic girdle. Vertebrae are articulating and thoracic to sacral vertebrae are fused except for T-4 (previously T-6). Laying hens form medullary bone in response to estrogen, which serves as a source of calcium during laying.

Trachea has complete rings and can overlap and syrinx is present. Syrinx is large in male waterfowl. Lungs are attached to the body wall. From trachea the primary bronchi passes through the lungs giving rise to many secondary bronchi before entering the abdominal air sacs. The secondary bronchi give rise to tertiary or parabronchioles and from there to atria and air capillaries where air exchange takes place. Lungs are of 'paleopulmo' (unidirectional movement of air) and 'neopulmo' (bi-directional) types. Cervical (paired), clavicular (single), anterior and posterior thoracic (paired) and abdominal (paired) air sacs are present. Birds have no diaphragm and they have 8 coelomic cavities.

Birds have four-chambered heart and the right atrioventricular valve is a muscular flap.

Birds have beak, lack teeth, have mucus glands in the oral cavity and most birds have a food storage organ called crop. Proventriculus is the primary glandular stomach and the muscular stomach; gizzard is well developed in seed eating birds. It is lined by mucoproteinaceous material or koilin. Duodenum in the form of a loop encloses pancreas, a long jejunum and a small ileum comprises the small intestine. Ceca are paired and their presence varies among different species of birds. It is well developed in gallinaceous birds and ratites but appear as small knobs in columbiformes, passeriformes and absent in psittacines. Colon is longer than the entire small

intestine in ostrich. Cloaca is compartmentalized and is the common opening for digestive, urinary and genital systems. Liver is composed of right and left lobes, which join cranially, and gall bladder is present. Some birds such as most pigeons, ostriches, and many parrots lack gall bladder and in some birds such as toucans, woodpeckers and barbets it is exceptionally long.

Birds have no lymph nodes; thymus and bursa are the primary lymphoid organs. Thymus, seven pairs in chickens are located along the jugular vein. Bursa of Fabricius is pale and round in most birds elongated in ducks and is located dorsal to the cloaca. Bursa in chickens is present at hatch reaches maximum size between 6-12 weeks and undergoes involution between 18-22 weeks of age. Spleen is a secondary lymphoid organ and is round to oval in gallinaceous birds, ducks and psittacines but elongated in charadiiformes and passeriformes. Gland of Harder (Harderian gland) is another secondary lymphoid organ and is situated medially and dorsally on the posterior surface of the eye and it contains numerous plasma cells. Ceca have well developed lymphoid tissue, 'cecal tonsils' at the junction of ceca and colon. Cecal tonsils as well as Payer's patches and gut associated lymphoid tissue occur as annular bands in waterfowl. Duodenum has well developed Payer's patches. Paired lymph node-like structures present in duck and goose, one at the thoracic inlet near the thyroids and the second pair at the lumbar region. Lymphatics are present but not well developed.

Kidneys are lobulated have no capsule and lack renal pelvis and have both mammalian and reptilian nephrons. Renal portal circulation present, venous blood from the legs, pelvic region and hindgut is carried to the kidneys. Avian excretory system is uricotelic; uric acid is the end product. Urinary bladder is absent.

Most avian species have only left ovary and oviduct. Oviduct has five parts, infundibulum, magnum (albumen secreting), isthmus (shell membranes), uterus (shell formation) and vagina. Testes are paired and located at the cranial poles of the kidneys. Testes can enlarge greatly during breeding season. Seminal vesicle, prostate, bulbourethral glands are absent. Ratites, ducks, geese, swan have intromittent (protruding) phallus.

Thyroids are oval fleshy organs located in association with the common carotid artery at the thoracic inlet. Parathyroids and ultimobronchial bodies (have C cells) are separate and are located posterior to the thyroids. Adrenals are located at the anterior poles of the kidneys. Adrenals lack a distinct cortex (pale staining cells with vacuoles in cytoplasm) and medulla (basophilic cells) but

are 'scrambled'. Pituitary is present in sella turcica posterior to the optic chiasm. There is no intermediate lobe in the pituitary. Most of the islets are located in the splenic lobe of the pancreas at least in chickens and turkeys.

Brain lacks sulci and gyri but cerebellum has folia. Optic lobes are well developed, prominent and lie beside the corpora. Spinal cord has 'glycogen body' in the rhomboid sinus of lumbar segment. Eyes have pecten, scleral ossicles, single and multiple foveas. Extra orbital nasal or salt glands are present in the nasal septum, well developed in marine birds.

Ears lack external pinna and have a well-developed sound conducting structure in the middle ear called columella. External ears have glands.

4. Inflammation

- Reaction is rapid in birds, 36 hours
- Leakage of fibrin and fibrinogen common in early exudate
- Intense granulomatous reaction (12 hours)
 - Coagulum of eosinophilic debris, degranulating heterophils, macrophages and giant cells
- Macrophages, heterophils and thrombocytes are active phagocytes
- Pus is caseous but liquefaction can occur
- Birds respond with granulomatous inflammation to many insults
- Acute inflammatory reaction in birds involve edema, congestion and vascular changes mediated by basophils and mast cells
 - 1-3 hours: basophils, heterophils and monocytes
 - 2-6 hours: basophils degranulate and die
 - 6-12 hours: lymphocytes, monocytes, macrophages
 - 12-36 hours: lymphocytes, macrophages, giant cells
 - ✓ Acute reaction peak by 12 hours (when giant cells appear)
 - 36-72 hours: regeneration and repair
 - ✓ Fibroblasts, secondary lymphoid follicles, plasma cells
 - ✓ Chronic reaction with caseation, macrophages, giant cells, granuloma formation
- Cells involved in inflammation
 - **Heterophils:** have lance-shaped granules, lack myeloperoxidase and alkaline phosphatase, have β -glucuronidase and acid phosphatase
 - ✓ Very phagocytic
 - ✓ Granules tend to round up in tissues, difficult to identify
 - **Eosinophils:** have spherical granules
 - ✓ Function is not known, delayed type IV hypersensitivity?
 - ✓ Associated with eosinophilic enteritis in turkeys due to ascarids

Basophils: contain histamine, involved in acute inflammation

Thrombocytes: small round to oval cells with clear cytoplasm and small round nucleus (looks like small lymphocyte), phagocytic

Monocytes: precursors to cells of Mononuclear Phagocytic System (MPS), phagocytic, can fuse to form multinucleated giant cells.

Make monokines; IL-1, IL-2, (IL-4?), IL-6, IL-8, (IL-10?), (IL-12?), IL-15, IL-16, IL-17, IL-18, TNF, G-CSF, gamma interferon

Lymphocytes: various morphologies involved in subacute inflammation including plasma cells

5. Coagulation

- Extrinsic system active and efficient but intrinsic system relatively weak
- Tissue thromboplastin (III) and platelets play important role
- Has a vitamin K dependent factor similar to mammalian factor IX
 - Plasma thromboplastin and Hageman factor may be lacking
 - Low levels or absence of factors V and VII
- Fibrinogen (I), prothrombin (II), antihemophilic factor (VIII) and Stuart factor (X) are present
- Clot retraction is very slow in birds
 - Has thrombolytic mechanism and t-PA activation for fibrinolysis

6. Complement

- Not well understood
- Classical complement (CCP) and alternate complement pathways (ACP) are present
- A few components have been identified such as C1, C3, B
 - may lack C2 and C4.
- Factor B in chickens may play a dual role in ACP and substituting for C2 in CCP
- Differences in C components may exist among avian species

7. Bacterial Diseases

Disease caused by *E. coli*, Salmonella, Chlamydia, Clostridia, Mycobacteria, Mycoplasma, *Pasteurella multocida*, *Ornithobacterium rhinotracheale*, Erysipelas, Bordetella, Avibacterium (previously Haemophilus and Pasteurella), *Yersinia pseudotuberculosis*, *Riemerella anatipestifer*, Staphylococcus, Streptococcus, Coxiella, Pseudomonas and other miscellaneous bacteria

a. Colibacillosis

- Disease of great economic significance in poultry
- Any one of the syndromes in poultry caused by *E. coli*

- Colisepticemia, air sac disease (CRD), peritonitis, coligranuloma, salpingitis, omphalitis/yolk sac infection, cellulitis, osteomyelitis/synovitis, swollen head syndrome and panophthalmitis
 - Enteritis with AEEC, *eae* gene present
 - Ceca most commonly involved
 - Common in turkeys, others; chickens, pigeons, quail, partridges, pheasants, ducks, ostriches, psittacines, passerines, *etc.*
 - Septicemia and enteritis in other birds?
- b. Salmonellosis**
- Large group of acute, subacute or chronic diseases caused by one or more members of bacterial genus *Salmonella*
 - Pullorum Disease in poultry, *S. Pullorum*
 - Fowl Typhoid in poultry, *S. Gallinarum*
 - Paratyphoid in poultry, ducks, pigeons, wild birds, psittacines, passerines, *etc.*
 - 10-20 species: *S. Typhimurium*, *S. Enteritidis*, *S. Heidelberg*, *S. Anatum*, *S. Derby*, *S. Bredeney*, *etc.*
 - Arizonosis in turkey poults, *S. arizonae*
 - Also in chicks, ducklings, psittacines, passerines, *etc.*
 - Lesions
 - **Pullorum/Typhoid**
 - ✓ In chicks: Septicemic lesions of omphalitis, hepatitis, peritonitis, necrotic typhlitis, pericarditis, splenitis, pneumonia, synovitis, nephritis, ophthalmitis, *etc.*
 - Pale yellow nodules in myocardium (histiocytes), intestine and gizzard in chronic cases
 - ✓ In adults: oophoritis, salpingitis, peritonitis, orchitis
 - **Paratyphoid**
 - ✓ *S. Typhimurium* most important
 - ✓ In different species of birds: similar to acute septicemic lesions of pullorum and typhoid,
 - ✓ In pigeons: brain, bone, and gonads often involved
 - ✓ *S. Enteritidis* can cause septicemic lesions in chicks
 - Important in egg-associated food poisoning
 - **Arizonosis**, in turkey poults
 - ✓ Septicemic lesions, omphalitis, typhlitis, meningitis, Ophthalmitis, hepatitis, *etc.*
- c. Chlamydiosis**
- Naturally occurring contagious systemic disease of various species of birds
 - *Chlamydophila psittaci*, many serotypes (A, B, C, D, E, F, G, E/B, others). *C. abortus* has also been associated with disease in psittacines
 - Diagnosed in more than 400 avian species, 15 orders and 30 families
 - Psittacines, 25% of the reported host species, others; pigeons, passerines, wild and feral birds, rheas, turkeys, pheasants, *etc.*

- Chickens relatively resistant
- Clinical signs: vary greatly, species and age of bird, and strain of Chlamydia
 - Respiratory signs, oculonasal discharge, diarrhea often greenish colored, swelling above eye (turkeys), conjunctivitis (pigeons), *etc.*
- Lesions: airsacculitis, pericarditis, pneumonia, hepatitis, splenitis, enteritis, conjunctivitis, nasal adenitis (turkeys), synovitis, encephalitis, nephritis, *etc.*
 - Can also infect endothelial cells
- *Chlamydia pneumoniae* has been associated with atherosclerosis in humans
- Chlamydia-taxonomy
- Order: Chlamydiales
 - Family: Chlamydiaceae
 - Genus: Chlamydophila
 - Species: *C. psittaci*
 - C. pneumoniae*
 - C. pecorum*
 - C. felis*
 - C. caviae*
 - C. abortus*
 - Genus: Chlamydia
 - Species: *C. trachomatis*
 - C. suis*
 - C. muridarum*
- ***Chlamydophila psittaci***
 - Obligate nonmotile, coccoid intracellular bacteria
 - Depends on host cells for ATP metabolites
 - Multiply within membrane-bound inclusions, in the cytoplasm of host cells
 - Have a non-synchronous multimorphic developmental cycle:
 - ✓ Spore-like, non-vegetative elementary body (EB), uniformly spherical particle of 300 nm diameter
 - ✓ Ingestion by host cell, fusion of bacterial endosome with host lysosomes?
 - ✓ EB undergoes conversion to metabolically active reticulate body (RB), 800-1200 nm
 - ✓ RB replicate by binary fission, within a membrane bound vacuole, the chlamydial inclusion
 - ✓ Intermediate bodies (IB) can also be seen
 - ✓ Mature to infectious EB's which infect other cells by lysis of host cells or by extrusion of chlamydial inclusion
- d. ***Clostridial diseases***
 - *C. perfringens* (type A most common) - **necrotic enteritis** in poultry, ratites, psittacines, *etc.*
 - *C. colinum* - **ulcerative enteritis** in poultry, especially in quail ('quail disease'), toucans, ratites, chickens, psittacines, *etc.* *C. colinum* has also been associated with focal duodenal necrosis in chickens.

- *C. perfringens* can also cause ulcerative enteritis in quail and turkeys
- *C. difficile* - entero/typhlocolitis in ratites (ostrich)
- *C. sordelli* - enterocolitis in ratites (ostrich), omphalitis in baby chickens, ulcerative enteritis and hepatitis in quail (similar to Quail Disease)
- *C. chauvoei* - enteritis in ostriches
- Liver may have foci of necrosis and inflammation with the above clostridial diseases
- *C. septicum* - **gangrenous dermatitis** in poultry, especially in turkeys, also in chickens (*C. perfringens* can also cause similar lesions).
- *C. botulinum* - **limberneck** in poultry. One of the most important causes (others; lead and *Pasteurella multocida*) of mortality in wild waterfowl.
- *Clostridium piliformis* (Tyzzer's disease) - hepatic necrosis in psittacines
- *C. tertium* – associated with enteritis in Lorikeets

e. *Mycobacteriosis*

- Chronic progressive disease of a variety of species of birds with unthriftiness, loss of weight, diarrhea, *etc.*
 - *M. avium* - wide host spectrum, poultry, pigeons, raptors, ratites, wild birds, psittacines, passerines, *etc.* *M. avium* subspecies *hominissuis* associated with hepatic cirrhosis in a Blue Front Amazon.
 - *M. genavense* – most common mycobacteria of psittacines and probably passerines such as canaries and finches.
 - *M. tuberculosis* - psittacines, others?
 - *M. bovis* – pigeons, psittacine, others?
 - *M. peregrinum* – granulomatous hepatitis in Gouldian finches and parrots
 - *M. intermedium* – granulomatous pneumonia in Oropendola
 - *M. celatum* - granulomatous pneumonia, hepatitis, splenitis, nephritis, osteomyelitis in white-tailed Trogon
 - *M. avium* subspecies *paratuberculosis* associated with granulomatous hepatitis in a Diamant sparrow
 - *M. simiae* complex associated with histiocytic hepatitis in Micronesian kingfishers
- Lesions
 - Poultry, pigeons, raptors, ratites; grossly pale yellow or grey nodules in liver, spleen, intestine, bone marrow, lung, heart, *etc.*
 - ✓ micro: caseous necrosis surrounded by multinucleated giant cells and fibrosis
 - Psittacines, passerines, turacos; grossly pale mottling or diffuse enlargement of liver, spleen, intestine, lung, heart, eyelid, skin, *etc.*
 - ✓ micro: diffuse or focal infiltration of foamy macrophages with myriads of acid fast bacilli in the cytoplasm. Lymphocytes and necrosis is not common.

f. *Mycoplasmosis*

- Important economic diseases of poultry caused by

- *M. gallisepticum*
 - *M. synoviae*
 - *M. meleagridis*
 - *M. iowae*
 - 14-20 or more Mycoplasma sp. are known
 - Isolated from chickens, turkeys, pigeons, raptors, ratites, wild birds, psittacines, passerines, *etc.*
 - Pathogenic significance?
 - *M. imitans* can cause conjunctivitis and sinusitis in red-legged partridges
 - *M. sturni* has been associated with conjunctivitis in a European starling, Blue Jays and Mockingbirds
 - ***M. gallisepticum* (MG)** – Disease called chronic respiratory disease (CRD) in chickens and infectious sinusitis in turkeys. Other birds susceptible include, quail, pheasants, partridges, peafowl, finches, *etc.*
 - Egg transmitted
 - Respiratory disease with swollen infraorbital sinus, tracheitis, airsacculitis, conjunctivitis, *etc.*
 - Primarily lymphocytic inflammation
 - MG can cause decreased egg production in layers
 - Some strains of MG can cause neurological signs in turkeys due to vasculitis in the brain
 - MG has caused conjunctivitis in wild finches in the East, Midwest and Western regions of the US. MG can cause amyloid arthropathy in Brown Leghorn chickens
 - ***M. synoviae* (MS)** - in chickens, turkeys, geese, quail, partridge, ducks, *etc.*
 - Egg transmitted
 - Subclinical infection of respiratory disease, sinusitis, tracheitis, air sacculitis, conjunctivitis
 - It can cause severe synovitis, ulceration
 - Lymphocytic inflammation, proliferation of synovial cells
 - Some strains of MS can cause neurological signs in turkeys, and chickens due to vasculitis in the brain
 - Disseminated vasculitis in synovium, eye, kidney, skeletal muscle, heart, lung, *etc.*, can be seen in turkeys
 - Has also been associated with amyloid arthropathy in Brown Leghorn chickens
 - ***M. meleagridis*** - affects turkeys
 - Egg transmitted
 - Airsacculitis in day-old poults
 - Decreased hatchability, swelling of hock joint (chondrodystrophy), bowing of tarsometatarsus (TS-65 syndrome), deformation of cervical vertebrae (wry neck)
 - ***M. iowae*** - affects turkeys
 - Egg transmitted
 - Causes decreased hatchability and embryo mortality
 - Chondrodystrophy has been described
- g. Turkey *Coryza* (*Bordetellosis*)**

- Caused by *Bordetella avium*
 - Upper respiratory tract infection primarily of young turkey poults; swollen sinus, collapsed trachea, watery eyes
 - ✓ Tracheitis: deciliation, squamous metaplasia, and lymphoplasmacytic inflammation
 - Decrease of GAGS (?) in the cartilage, effect of toxin?
- *B. avium* can be a significant pathogen in young broiler chickens, ratites, passerines and psittacines

h. *Infectious Coryza*

- Disease primarily of young chickens caused by *Avibacterium* (previously *Haemophilus*) *paragallinarum*
 - Pheasants and guinea fowl are also susceptible
- Upper respiratory tract infection; swollen sinus (sinusitis/rhinitis), facial edema, conjunctivitis
- Occasionally tracheitis, bronchitis and airsacculitis

i. *Fowl Cholera*

- Also called avian cholera, pasteurellosis
- Septicemic disease of birds with high mortality and morbidity
- Etiology: *P. multocida*
- Most common in turkeys, chickens, wild waterfowl
- Other birds such as geese, quail, pheasants, raptors, psittacines, passerines, zoo birds, *etc.*, are susceptible
- Lesions
 - **Acute:** petechiae on viscera, consolidated lungs (common in turkeys), enlarged liver with foci of necrosis, pericarditis, airsacculitis, cellulitis, endocarditis, *etc.*
 - ✓ Mucoid enteritis in waterfowl
 - ✓ Peritonitis and oophoritis in breeders
 - **Chronic:** swollen wattles, synovitis, otitis, osteomyelitis of cranial bones, sinusitis, conjunctivitis, *etc.*
 - ✓ Esophageal abscesses in raptors

j. *Ornithobacterium rhinotracheale*

- Gram negative bacillus associated with respiratory disease in poultry, primarily turkeys and broiler chickens
- It has been isolated from layer-type chickens, pheasants, partridges, pigeons, psittacines, *etc.*
- Consolidated lungs (can be similar to fowl cholera in turkeys), tracheitis, airsacculitis, sinusitis, peritonitis, hepatic necrosis, *etc.*

k. *Erysipelas*

- Acute septicemic disease of primarily turkeys
- Etiology: *Erysipelothrix rhusiopathiae*

- Chickens, emus, pheasants, ducks, grebes, geese, chukars, raptors, psittacines, zoo birds, *etc.*
- Lesions
 - **Acute cases:** hemorrhages over epicardium, abdominal fat, skin, muscle, congested and enlarged spleen, foci of hepatic necrosis
 - **Chronic cases:** vegetative endocarditis and arthritis
- l. *Pseudotuberculosis***
 - Chronic contagious disease of psittacines, canaries, finches, doves, poultry, raptors, wild birds, *etc.*
 - *Yersinia pseudotuberculosis*
 - Birds often found dead, loss of weight, digestive and respiratory signs can be seen
 - Lesions
 - Pale yellow nodules of caseous granulomas in liver, spleen, intestine, lung, air sacs, bone, muscle, *etc.*
 - Gross lesions can be confused with mycobacteriosis or coligranuloma
 - Necrosis and inflammation associated with large numbers of Gram negative bacteria
- m. *Riemerella anatipestifer***
 - Previously classified as *Pasteurella anatipestifer*
 - Disease called **new duck disease, goose influenza**
 - Disease of young domestic ducks, geese and turkeys
 - Respiratory signs, ocular discharge, diarrhea, neurological signs, as much as 10% mortality
 - Fibrinosuppurative airsacculitis, pericarditis, perihepatitis, meningitis, uveitis, *etc.*
 - Skin and joints may be involved
- n. *Staphylococcosis***
 - Systemic infection of birds caused by *S. aureus*
 - Less commonly by *S. epidermidis* and *S. hyicus*
 - *S. aureus* most common in turkeys and broiler chickens, but has been isolated from a variety of other bird species
 - Lesions: omphalitis, pneumonia, synovitis, arthritis, osteomyelitis, green liver, gangrenous dermatitis, cellulitis, endocarditis, abscesses (bumblefoot), *etc.*
 - Lesions in lungs can be similar to aspergillosis in turkeys
- o. *Streptococcosis***
 - Systemic infection of a variety of birds caused by species of genus *Streptococcus*
 - *S. zooepidemicus*, septicemia in chickens, turkeys, pigeons, wild birds, *etc.*
 - ✓ Valvular endocarditis with secondary infarcts in heart, liver, spleen, *etc.*
 - ✓ Others: osteomyelitis, arthritis, tenosynovitis, salpingitis
 - *Streptococcus gallolyticus subsp. gallolyticus* (previously *S. bovis*), septicemia in chickens, turkeys, pigeons, goslings, *etc.*
 - *S. faecium*, septicemia in ducklings, goslings, chickens, *etc.*

- *Enterococcus hirae*, encephalomalacia with vascular thrombosis and meningitis in broiler chicks
- *Enterococcus faecalis*, associated with amyloid arthropathy in chickens (Brown Leghorns)
- *Enterococcus cecorum*, associated with spondylitis, osteomyelitis and septicemia in chickens

p. *Coxiella*

- Described in various species of Psittacines and a Toucan
- Severe hepatitis, splenitis, pneumonia, nephritis, encephalitis, *etc.*
- Small basophilic coccoid organisms in the cytoplasm of macrophages
- 96 – 97 % relationship to *Coxiella burnetii*

q. *Miscellaneous bacteria*

r. *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* - can cause localized or systemic infection in poultry and other birds. *Burkholderia (Pseudomonas) pseudomallei* has been associated with septicemia in psittacines.

s. *Bordetella hinzii* has been associated with tracheitis in chickens and turkeys.

t. Long segmented filamentous bacteria (LSFO) – associated (?) with enteritis in turkeys, chickens, quail, psittacines, *etc.*

u. *Bacillus anthracis* - been reported in ostriches as a cause of septicemia

v. *Listeria monocytogenes* - can cause septicemia, myocarditis and encephalitis in chickens, septicemia in psittacines and canaries but brain and heart not involved

w. *Campylobacter jejuni* - been associated with enteritis and hepatic necrosis in ostriches

x. *Lawsonia intracellulare* - associated with enteritis in ratites

y. *Eubacterium tortuosum* - granulomas in liver and spleen, broiler chickens and turkeys

z. Nocardiforms – been associated with pectenitis in Lorikeets

aa. Spirochetosis:

- *Borrelia anserina*, septicemia in poultry and canaries
- *Borrelia* related to *B. hirsii* associated with hepatitis, splenitis and encephalitis in Northern Spotted Owl
- *Serpulina hyodysenteriae* associated with typhlitis in rheas, in poultry?
- *Serpulina piloscholi* in ceca of pheasants, disease?
- *Brachispira pilosicoli* in ceca of chickens, game birds, turkeys, *etc.*

8. Fungal diseases

a. *Aspergillosis*

- One of the most common fungal diseases of poultry, water fowl, psittacines, passerines, ratites, raptors, zoo birds (penguins), *etc.*

- *Aspergillus fumigatus* and *A. flavus* most common
 - Others: *A. niger*, *A. terreus*, *A. glaucus*, etc.
 - ✓ *A. niger* is a black mold that can produce oxalic acid which can be seen in the tissues especially in the walls of the blood vessels like in lungs.
- Respiratory signs (brooder pneumonia in poultry), unthrifty, diarrhea, neurological signs, ocular involvement, sudden death, etc.
- Lesions
 - Pale yellow nodules in lungs, air sac, syrinx, sinus, liver, brain, cloudy cornea, heart, etc.
 - White plaques with fuzzy green or grey or blue material (conidiophores- ‘fruity’ bodies) on air sacs, pleura, etc.
 - Fibrinosuppurative or granulomatous pneumonia, airsacculitis, syringitis, sinusitis, encephalitis, ophthalmitis, vasculitis, aortitis (aortic rupture), hepatitis, osteomyelitis, pericarditis, myocarditis, blepharoconjunctivitis, nephritis, etc.

b. *Candidiasis*

- Common mycosis of the upper digestive tract
 - Also called thrush, crop mycosis, moniliasis
 - Young birds most susceptible
- *Candida albicans* most common etiology
- Poultry especially in turkeys, psittacines, passerines, ratites, raptors, pigeons, water fowl, etc.
- Oral cavity, esophagus and crop involved with white proliferative plaques
 - Proventriculus, gizzard, intestine less often involved
 - Systemic and ocular candidiasis have been described
- *Candida glabrata* (Torulopsis)
 - Associated with hyperkeratosis of the skin in various species of birds

c. *Zygomycosis*

- In ostriches, psittacines, water fowl, canaries involving proventriculus and gizzard and air sacs in a pigeon
 - *Mucor* sp, *Absidia* sp. and *Rhizopus* sp. isolated
 - necrotizing lesions with granulomatous reaction

d. *Favus* (avian ringworm)

- Due to *Microsporium gallinae*, dermatophyte of chickens with white powdery material on head, face and eyelids
- Acanthosis, hyperkeratosis, dermatitis, folliculitis, etc.

e. *Ochroconis* (Previously *Dactylariosis*)

- Due to *O. gallopava* in turkeys and quail
- Fibrinosuppurative encephalitis and ophthalmitis

f. *Cryptococcosis*

- Due to *C. neoformans* in psittacines, pigeons, pheasant, kiwis and experimental infection in chickens
 - Other species, *Cryptococcus bacillosporus*, *C. neoformans* var. *gattii* and *C. neoformans* var. *grubii*
 - Sinusitis, laryngitis, tracheitis, encephalitis, hepatitis, pneumonia, dermatitis, stomatitis, retrobulbar space, *etc.*
- g. *Macrorhabdus ornithogaster*** (previously known as **Megabacteria**) an ascomycetous yeast.
Been associated with proventriculitis in psittacines, passerines, ostriches, poultry, *etc.*
- h. Others fungal diseases**
- **Pythiosis**
 - *Pythium insidiosum*, associated with cutaneous ulcerative lesions in a White-faced Ibis
 - Multifocal necrotizing eosinophilic granulomatous inflammation
 - **Malassezia**
 - *Malassezia* sp. has been associated with dermatitis in pet and exotic birds
 - **Rhodotorula**
 - *R. mucilaginosa* and *R. glutens* have been associated with ulcerative dermatitis in chickens
 - **Histoplasmosis** - due to *H. encapsulatum*
 - Granulomatous iridocyclitis in experimental infection of chickens
 - **Penicillium**
 - *Penicillium griseofulvum*, systemic infection in a toucanet
 - *P. cyclopium*, beak infection in a macaw
 - *Penicillium* sp. isolated from lungs of turkeys with granuloma's resembling aspergillosis
 - **Trichosporon**
 - *Trichosporon beigeli*, granulomatous pneumonia, myocarditis, hepatitis in a macaw
 - **Curvularia**
 - *Curvularia geniculata*, mycetoma in a parrot
 - **Scedosporium**
 - *Scedosporium prolificans* isolated from feet of an ostrich with severe hyperkeratosis
 - **Geotrichum and Paecilomyces**
 - *Geotrichum candidum* and *Paecilomyces variota* have been isolated with disease

9. Viral diseases

Diseases caused by herpesvirus, retrovirus, coronavirus, paramyxovirus, orthomyxovirus, picornavirus, poxvirus, birnavirus, parvovirus, adenovirus, reovirus, enterovirus, astrovirus, circovirus, papovavirus, arbovirus, Bunyavirus, Bornavirus and other miscellaneous viruses

a. *Marek's Disease*

- One of the most common and well studied diseases of young chickens
 - Quail and turkeys are also susceptible
 - Etiology: cell-associated alpha herpesvirus
- Pathogenesis: virus replicates in feather follicle epithelium, infection through respiratory route, viremia → infection of B cells → cytolysis → infection of activated T cells → cytolysis → immunosuppression → infection of other organs like nerves (paralysis) & blindness → latency → transformation of T cells (CD4) → lymphoma
- Lesions
 - **Gross**: bursal and thymic atrophy, swollen peripheral nerves, enlarged organs with pale white tumors in liver, spleen, kidney, lung, proventriculus, intestine, heart, gonads, thymus, irregular/gray iris, prominent feather follicles, *etc.*
 - **Microscopic**: lymphoid necrosis and depletion in bursa, and thymus, neuritis, encephalomyelitis, pleomorphic lymphocytic lymphoma in various organs
 - ✓ Intranuclear inclusion bodies in feather epithelium
 - ✓ Atherosclerosis can be produced with MD virus

b. *Leukosis/Sarcoma Group*

- Genus, *ALV-related* viruses of family Retrovirus
 - Six subgroups; A, B, C and D (exogenous viruses), E (endogenous) & J (recombinant)
 - ✓ A, B and J are common in the field, C and D are rare
 - Various oncogenes have been identified (see table 1)
- They can produce a variety of neoplasms in chickens
- Influenced by strain of virus, dose, route of inoculation, age of host, genotype and sex of host
- Neoplasms: sarcoma's (fibro, osteochondro, myxo, histio, lympho, hemangio), meningioma, mesothelioma, erythroblastosis, myeloblastosis, nephroblastoma, granulosa cell tumor, hepatocellular carcinoma, glioma, (osteopetrosis), *etc.*
- Multicentric histiocytosis or histiosarcoma in broiler chickens has been associated with J virus infected at hatch but not in immunotolerized chickens (different mechanism- see transmission below in LL)
- **Lymphoid Leukosis (LL)**
 - Disease of semi mature and mature chickens
 - Etiology: retrovirus of leukosis/sarcoma group
 - ✓ Exogenous viruses, subgroups A, B, C and D
 - Transmission
 - ✓ Horizontal, transient viremia, immunity, LL rare
 - ✓ Egg transmission, chronic viremia, immune tolerance, LL common
 - B cell lymphoma in various organs, bursa of Fabricius, liver, spleen, kidney, gonads, *etc.*
 - **Osteopetrosis**
 - thickening of long bones
 - ✓ Effect of virus on osteoblasts

- **Myelocytomatosis**
 - Neoplastic disease primarily of broiler breeders and broilers
 - Etiology: retrovirus, subgroup J (leukosis/sarcoma group)
 - Lesions: liver, spleen, kidney, sternum, *etc.*, with nodules made up immature granulocytes
 - Hemangiosarcoma, histiocytoma, myxoma, carcinoma in liver, fibrosarcoma, lymphoma, ganglioneuroma, renal tumors, *etc.*, have also been associated with subgroup J virus
- **Reticuloendotheliosis**
 - Includes runting syndrome, chronic lymphoma and acute reticulum cell sarcoma
 - Primarily in chickens and turkeys but neoplasia associated with REV has been observed in quail, ducks, pheasants, geese and peafowl
 - Etiology: retrovirus of REV group, distinctly different from leukosis/sarcoma group, more closely related to murine leukemia virus
 - Other viruses in REV group include chick syncytial virus, duck infectious anemia virus, spleen necrosis virus and others
 - Lesions
 - ✓ In **runting syndrome**: thymic and bursal atrophy, neuritis, lymphoma (similar to Marek’s disease)
 - ✓ In **chronic lymphoma**: bursal and visceral lymphoma (similar to Lymphoid Leukosis)
 - ✓ In **acute reticulum cell sarcoma**: enlarged liver, spleen, kidney, heart, gonads, *etc.*

c. Infectious laryngotracheitis (ILT)

- Acute viral respiratory disease of primarily chickens
 - Pheasants and peafowl are also susceptible
- Etiology: Gallid herpesvirus 1.
- Lesions: oculonasal discharge, trachea with hemorrhage and/or fibrinous exudate
 - Conjunctivitis, tracheitis, bronchitis and sinusitis with intranuclear inclusions. Syncytia formation with intranuclear inclusion bodies is characteristic.

d. Infectious Bronchitis

- Highly contagious viral respiratory disease of young chickens
 - Drop in egg production and poor egg quality (poor shell and thin albumen) in layers
- Etiology: coronavirus, many serotypes, and great antigenic variation among strains of virus
- Lesions: catarrhal tracheitis, conjunctivitis, bronchitis, and airsacculitis
 - Fibrinosuppurative inflammation in cases complicated with *E. coli*
 - Interstitial nephritis with nephrotropic strains

e. Avian Paramyxoviruses

Based on antigenic relatedness (HI test) avian paramyxoviruses are classified into nine groups

Groups	Primary Host	Other Hosts
APMV-1/Newcastle Disease Virus	numerous	many
APMV-2/Yukaipa	Passerines, turkeys	Chickens, psittacines, rail

APMV-3/Turkeys	Turkeys	None (chickens?)
APMV-3/Psittacines	Psittacine	Passerines
APMV-4/Duck	Ducks	Geese, rails
APMV-5/Budgerigar	Budgerigar	none
APMV-6/Duck	Ducks, geese	Turkeys
APMV-7/Dove	Pigeons, dove	none
APMV-8/Goose	Ducks, geese	none
APMV-9/Duck	Ducks	none

- **Newcastle Disease**
 - Acute viral disease of chickens, turkeys, pigeons, doves, pheasants, ratites, psittacines, cormorants, *etc.*
 - ✓ 236 species of birds comprising 27 orders
 - **Etiology:** avian paramyxovirus - 1, isolates vary greatly in pathogenicity to chickens
 - ✓ **Lentogenic:** mild or inapparent infection in chickens
 - ✓ **Mesogenic:** cause disease and mortality in young chickens
 - ✓ **Velogenic** (viscerotropic and neurotropic): lethal infection of chickens of all ages
 - ✓ **Present OIE classification based on chick intra-cerebral pathogenicity index (ICPI)**
 - **ICPI of > 0.7 is Newcastle disease virus (formerly Velogenic and mesogenic)**
 - **ICPI of < 0.7 is Avian Paramyxovirus –1 (formerly Lentogenic)**
 - **Clinical signs**
 - ✓ Vary with strain, respiratory, digestive, ocular, neurological, sudden death
 - ✓ In mature chickens, egg production and quality problems (mesogenic strain)
 - **Lesions**
 - ✓ In pigeons: enteritis, pancreatitis, nephritis, encephalitis, otitis interna, respiratory system rarely involved
 - ✓ In chickens; tracheitis, pneumonia, enteritis, conjunctivitis, encephalitis, myocarditis, lymphoid necrosis
 - ✓ Velogenic; hemorrhages in conjunctiva, trachea, oral cavity, esophagus, proventriculus, ceca, rectum
 - ✓ Disseminated vasculitis, lymphoid necrosis and depletion, mucosal necrosis and ulceration
 - ✓ Inclusions are rare but both intranuclear and intracytoplasmic inclusions have been described
 - ✓ In one case, discrete eosinophilic intranuclear and intracytoplasmic inclusions in conjunctiva, esophagus, lung, brain, adrenal ganglia of a pheasant and in the brain of a chicken with NDV
 - ✓ Eosinophilic intranuclear inclusions in hepatocytes in doves associated with lentogenic type of NDV

- **Other Avian Paramyxoviruses**
 - **APMV - 2 (Yucaipa):**

- ✓ Respiratory disease in young turkeys and drop in egg production in layers, chickens are susceptible
- **APMV - 3**, two strains, turkey and psittacine
 - ✓ Turkey: egg production drop in turkeys
 - ✓ Psittacine; neurological and digestive problems in psittacines and passerines
 - Encephalitis with intranuclear and intracytoplasmic inclusion bodies in neurons and glial cells
 - Myocarditis, pancreatitis with intranuclear inclusions
- **APMV -5** (Kunitachi):
 - ✓ Enteritis and mortality in budgerigars and lorikeets

f. Avian metapneumovirus

- Cause of **Turkey Rhino Tracheitis** (TRT) of turkeys, **Swollen Head Syndrome** (SHS) of chickens, highly contagious respiratory diseases
- Etiology: pneumovirus (*Paramyxoviridae*)
- Lesions: swollen sinuses, sinusitis, tracheitis, rhinitis, conjunctivitis

g. Avian Influenza

Acute viral disease of poultry; turkeys and chickens and psittacines, passerines, ratites, *etc.*

- It has been isolated from many species of birds
- Waterfowl and shore birds serve as reservoirs

Etiology: type A influenza virus of family Orthomyxoviridae

- Numerous subtypes based on surface antigens, hemagglutinin (16) and neuraminidase (9)
 - ✓ Viruses of H5 (H5N2) and H7 (H7N1) subtypes are considered highly pathogenic. Low pathogenic H5 and H7 subtypes do exist but have the potential to change to highly pathogenic subtypes
 - ✓ H1N1 (swine flu) and novel H1N1 in turkeys – drop in egg production
 - ✓ H4N8, H4N6, H3N8 in exotic birds
 - ✓ **H5N1 (bird flu)**; gallinaceous birds including chickens, turkeys, quail, pheasants, partridges, Guinea fowl are highly susceptible
 - Humans are susceptible
 - Numerous other bird species are also susceptible; Bar headed geese and other geese, ducks, swan, flamingos, gulls, egrets, herons, pigeons, crows, sparrows, starlings, magpies, finches, emus, budgerigars, ostriches, *etc.*
 - H5N1 first identified in Hong Kong in 1997 but was present in China in 1996
 - Since 2002 outbreaks in Asia, Europe and Africa

Clinical signs: varies greatly with pathogenicity; none to respiratory, digestive, ocular, neurological, sudden death, *etc.*

- Drop in egg production in layers

Lesions: vary greatly in pathogenicity

- **Mildly pathogenic**: catarrhal tracheitis, sinusitis, airsacculitis, conjunctivitis, pneumonia, peritonitis, oophoritis, salpingitis, *etc.*

- **Highly pathogenic:** hemorrhagic lesions in skin of face, comb & shanks and GI tract, interstitial pneumonia & nephritis, encephalitis, conjunctivitis, myocarditis, adrenalitis, pancreatitis, myositis, lymphoid necrosis, vasculitis and thrombosis, *etc.*

h. Avian Encephalomyelitis

Viral disease of young (1-3 weeks) chickens, turkeys, pheasants and coturnix quail

- Neurological signs (epidemic tremor)
- Drop in egg production in layers
- Egg transmitted
- Etiology: Picornavirus (genus: *Tremovirus*)

Lesions: neuronal swelling, central chromatolysis, lymphocytic perivascular cuffing, gliosis in brain and lymphocytic foci in muscular layer of proventriculus and gizzard, pancreatitis, myocarditis, myositis, peripheral neuritis, *etc.*

- A few survivors can develop cataracts later

i. Avian Pox

Slow spreading viral disease of chickens, turkeys, quail, pigeons, canaries, raptors, psittacines, ostrich, peacock, waterfowl, *etc.*

- 60 species of wild birds

Etiology: poxvirus of genus *Avipoxvirus*, many strains

- Fowl pox, turkey pox, pigeon pox, canary pox, quail, mynah, psittacine, junco, sparrow, starling, *etc.*

Signs: cutaneous, respiratory, digestive, ocular

- Septicemic form in canaries, 70 - 90% mortality

Lesions

- Gross:
 - ✓ **Dry pox or cutaneous form:** proliferative skin lesions on face, eyelids, beak, feet, legs, vent, *etc.*
 - ✓ **Wet pox or diphtheritic form:** yellow raised plaques in sinus, trachea, oral cavity esophagus/crop, conjunctiva, *etc.*
- Micro:
 - ✓ Proliferation of epithelial cells, ballooning degeneration with eosinophilic intracytoplasmic inclusion bodies (pathognomonic)
 - ✓ Pneumonia in canaries. Others: spleen, bone marrow, thymus, bursa, air sacs, dermis, *etc.*
 - ✓ Some avipoxviruses are oncogenic, wart-like growth

j. Infectious Bursal disease (IBD)

- Acute viral disease of young chickens (1-6 weeks) and secondary immunosuppression
- Turkeys and ducks, subclinical infection
- Etiology: birnavirus

- Lesions: enlarged and edematous bursa of Fabricius some times with hemorrhages and atrophy in later stages, hemorrhages in skeletal muscle, thymic atrophy with virulent IBD, hemorrhages most of the times in the bursa with very virulent (vv) IBDV
 - Lymphoid necrosis and depletion
 - May or may not be hemorrhages with vv IBDV
 - Secondary infections with inclusion body hepatitis, gangrenous dermatitis, bursal cryptosporidiosis, *etc.*

k. *Chicken Infectious Anemia (CIAV)*

- Viral disease of young chickens characterized by aplastic anemia and immunosuppression
Chicks 1-3 weeks of age most susceptible
- Vertically transmitted
- Etiology: a circovirus, genus Gyrovirus, family *Circoviridae*
- Hematology: anemia, hematocrit less than 27% (N 35%), leukopenia, thrombocytopenia
 - Due to cytotoxic effect of virus on bone marrow precursor cells
- Lesions: pale bone marrow, severe thymic atrophy, atrophy of bursa, hemorrhages in skeletal muscles
- Lymphoid necrosis and depletion, bone marrow hypoplasia
 - Gangrenous dermatitis, colibacillosis, aspergillosis, viral infection, *etc.*
- Eosinophilic (red) intranuclear inclusions in mononuclear inflammatory cells (macrophages?) of thymus, spleen, bone marrow, bursa, lung, *etc.* in some cases
 - True nature of these inclusions is not known

l. *Duck Viral Enteritis (DVE)*

- Acute viral disease of primarily adult ducks, geese and swans characterized by high mortality
- Etiology: herpesvirus
- Lesions: hemorrhages on heart, liver, gizzard, fibrinonecrotic lesions in esophagus, rectum, cloaca, bursa, annular band of hemorrhage and necrosis in intestine, ceca, and thymic atrophy
 - Necrosis, inflammation and intranuclear inclusions in liver, intestine, thymus, gland of Harder, conjunctiva, *etc.*
 - Esophagitis and bursal necrosis with intranuclear and intracytoplasmic inclusions in mucosal cells

m. *Duck virus hepatitis (DVH)*

- Peracute viral infection of ducklings (< 5 weeks) characterized by high mortality
- Etiology:
 - DVH - 1, picornavirus (DVHA)
 - DVH - 2, astrovirus

– DVH - 3, astrovirus

- Lesions: petechiae or ecchymotic hemorrhages and necrosis in liver, minimal inflammation

n. *Parvovirus Infections*

- **Goose parvovirus** (Derzsy's disease): highly contagious disease of young geese and Muscovy ducks
 - Serofibrinous pericarditis and perihepatitis
 - Myocarditis with intranuclear inclusions
- **Muscovy duck parvovirus**
 - Serologically related to goose parvovirus
 - Causes locomotor problems with high mortality in 1-3 weeks-old ducks, loss of weight, pale leg muscles, serofibrinous pericarditis and perihepatitis
 - ✓ Myositis, myocarditis, encephalomyelitis, neuritis, *etc.*
 - Ascites, round hearts in ducks recovered from infection

o. *Avian Reoviruses*

- Causes disease in chickens, turkeys, ducks, geese, psittacines, *etc.*
- Chickens and turkeys: arthritis and proliferative tenosynovitis, enteritis, myocarditis, thymic and bursal atrophy. Encephalitis in chickens.
- Ducks and geese: tenosynovitis, pericarditis, myocarditis, bursal and thymic atrophy
- Psittacines: hepatitis and splenitis.

p. *Avian Adenoviruses*

- Three groups:
 - **Group I** - quail bronchitis, inclusion body hepatitis and hydropericardium syndrome in chickens, also disease in turkeys, pigeons, psittacines, raptors, *etc.*
 - **Group II** - hemorrhagic enteritis virus of turkeys (HEV), marble spleen disease of pheasants (MSD) and splenomegaly of chickens
 - **Group III** - egg drop syndrome of chickens with no apparent lesions but caused tracheitis and bronchitis in goslings
- **Quail bronchitis**
 - High mortality in young bobwhite quail associated with bronchopneumonia, tracheitis, hepatitis, pancreatitis, bursal necrosis, intranuclear inclusions
- **Inclusion body hepatitis** of chickens, also in turkeys, guinea fowl, pigeons, psittacines, *etc.*
 - In chickens usually secondary to immunosuppression caused by IBDV, CIAV
 - Liver enlarged and mottled red/pale, foci of necrosis, inflammation and intranuclear inclusion bodies, also pancreatitis
 - Similar lesions seen in turkey poults, guinea fowl, pigeons
 - Hepatitis, enteritis, bronchitis, pancreatitis, nephritis, encephalitis, *etc.*, associated with intranuclear inclusions in psittacines
- **Hemorrhagic enteritis virus (HEV)** of turkeys and **Marble spleen disease (MSD)** of pheasants

- Caused by group II adenovirus
- Guinea fowl, psittacines, (partridge) susceptible
- Young turkeys (4-12 weeks) and pheasants (3-8 months)
- With HEV, intestinal hemorrhage and enlarged mottled white spleen and immunosuppression
 - ✓ Intranuclear inclusions in mononuclear cells of spleen and intestine, renal epithelial cells in HEV
- In pheasants mottled white enlarged spleen, MPS cell hyperplasia, intranuclear inclusions
- Splenomegaly in chickens

q. Enteritis

▪ **Poult enteritis**

- Disease of young turkeys, multiple etiologies such as viruses, bacteria, protozoa
- Viruses include coronavirus (blue comb disease), enterovirus, rotavirus, astrovirus, reovirus, *etc.* AEEC can play significant role
- Diarrhea, loss of weight, small intestine and ceca distended with watery or frothy contents
- Mortality 1 - 55%, caseous exudate in bursa with coronavirus infection and AEEC infection
- Increased cellularity of lamina propria, necrosis of cells in lamina propria and enterocytes, villus atrophy, lymphoid necrosis in thymus and bursa (virus?)
- **Runting Stunting Syndrome in (RSS) chickens**
 - Failure to gain weight or thrive normally in chicks
 - Clinical signs, pathology, etiologies (rotavirus, astrovirus, reovirus) very similar to poult enteritis
 - Cystic enteritis; crypt necrosis and dilation, increased cellularity of the lamina propria, atrophy of villi have been observed in 1 to 3 week-old chicks
- Enteritis associated with rotavirus and enterovirus has also been described in young pheasants, quail, chukars, *etc.*

r. Herpesviruses (Marek's disease, see page 16)

▪ **Psittacine Herpesvirus**

- Diverse group of viruses which infect a variety of psittacines
- Four genotypes (Psittacid Herpesvirus 1, 2, 3 and 4) and three serotypes are known
- More than four genotypes may exist such as Bourke's Parakeet Herpesvirus
- According to one classification three diseases are known but this may change
 - ✓ PACHECO'S DISEASE
 - Acute viral disease of a variety of psittacines (common in 1980's in US)
 - Lesions:
 - ◆ Enlarged liver occasionally with petechiae, enlarged spleen, fluid filled intestine, diphtheritic membrane in oral cavity, esophagus, *etc.*

- ◆ liver necrosis with or without inflammation, enteritis, stomatitis, esophagitis, pancreatitis, conjunctivitis, splenic and bursal necrosis, nephritis with intranuclear inclusion bodies
 - ◆ syncytia formation with inclusions in liver
 - ✓ AMAZON TRACHEITIS, disease characterized by tracheitis, bronchitis, rhinitis, laryngitis with syncytia formation and intranuclear inclusions
 - Virus has some cross reactivity with ILT virus of chickens
 - Similar lesions such as in Amazon tracheitis has been observed in Rosy Bourke parakeets associated with a novel herpesvirus
 - ✓ BUDGERIGAR HERPESVIRUS, rare disease associated with decreased hatchability and “feather duster” plumage
 - ✓ Herpesvirus in cutaneous tissue (with intranuclear inclusions) has been identified in psittacines
 - ✓ Herpesvirus sequences have been demonstrated in cloacal Papilloma’s of psittacines
- **Miscellaneous Herpesviruses**
 - GOOSE HERPESVIRUS
 - ✓ Lesions like in Duck viral enteritis with intranuclear inclusion bodies and high mortality in goslings
 - PIGEON HERPESVIRUS (COLUMBID HERPESVIRUS – 1)
 - ✓ Common in young squabs characterized by hepatitis, pancreatitis, esophagitis associated with intranuclear inclusions
 - ✓ Conjunctivitis, enteritis, myocarditis, encephalitis, laryngitis, splenitis, *etc.* can also be seen
 - ✓ Raptors and budgies are susceptible
 - FINCH HERPESVIRUS
 - ✓ Disease of primarily Gouldian finches characterized by high mortality, conjunctivitis, tracheitis, bronchitis, associated with cytomegalic cells and intranuclear inclusions
 - OTHERS HERPES VIRUSES OF OWLS, FALCONS, EAGLES, CRANES, *etc.*
 - ✓ Hepatitis associated with intranuclear inclusion bodies
 - ✓ Viruses not well characterized
 - Herpesvirus sequences have been identified in cloacal papillomas of psittacines
 - Herpesvirus has been identified in an Indian Gyps Vulture
- s. ***Psittacine Beak and Feather Disease***
 - Viral disease of many species of psittacines characterized by chronic feather and beak dystrophy
 - Acute immunosuppression and sudden death in young birds due to secondary bacterial septicemia and fungal infections
 - Etiology: Psittacine circovirus, genus circovirus, family *Circoviridae*
 - Psittacine circovirus 2 in Lorikeets
 - ✓ Other genotypes exist

- Clinical signs: dystrophic feathers first noticed of the powder down, progress to contour feathers, followed by primary, secondary tail and crest feathers, almost symmetrical
 - Dystrophy of the beak
- Lesions
 - **Gross**: abnormal and loss of feathers, sloughing of claws, beak necrosis, necrosis of oral mucosa, liver, bursa, thymus, *etc.*
 - **Microscopic**: pteryilitis and pulpitis associated with botryoid inclusions in macrophages, also in bursa, bone marrow, thymus, beak, claws, liver, pancreas, thyroid, testes, *etc.*
 - ✓ Intranuclear inclusions in feather epithelium, intestine, esophagus, hepatocytes
 - Liver necrosis and inclusions in bursa of Fabricius in African Grays
- **Pigeons and doves**
 - Etiology: Pigeon circovirus, genus circovirus
 - Feather dystrophy, exudate in bursa (due to bacterial infection), pteryilitis, bursal lymphoid depletion and intracytoplasmic circovirus inclusions in macrophages of bursa of Fabricius, spleen, thymus, cecal tonsil, *etc.*
 - secondary bacterial, parasitic, fungal and other concurrent viral infections common
- **Canaries and Finches**
 - Etiologies: Canary and Finch circoviruses, genus circovirus, family *Circoviridae*
 - Feather dystrophy and characteristic circovirus inclusions in bursa of Fabricius in finches
 - In canaries intracytoplasmic inclusions in smooth cells of the muscular layer of the intestine, arteries of spleen and pancreas
- **Gulls, Geese, Ducks, Ravens, Starlings, Pheasants** are also susceptible to circovirus
 - Circovirus inclusions in the bursa of Fabricius in gulls, geese
 - Feather abnormalities in ducks and ravens
- t. **Papovavirus**
 - Two genera are known to cause disease in psittacines and passerines
 - Papillomavirus
 - Polyomavirus
 - **Papillomavirus**
 - It has been associated with cutaneous papillomas in wild finches (*Fringilla*) and in African Grey Parrots
 - Herpesvirus sequences have been associated with cloaca papillomas in psittacines
 - **Polyomavirus**
 - **Three groups, A, B and C**
 - Causes BUDGERIGAR FLEDGLING DISEASE (BFD)
 - ✓ One of the most common diseases of psittacines (disease of 90's?) and passerines
 - Antibodies to BFDV been detected in chickens, but chickens are resistant to infection
 - ✓ Etiology: polyomavirus, different strains such as psittacine, passerine, *etc.*, may exist
 - Variety of psittacines and passerines (finches, canaries, seed crackers and blue bills).
 - Buzzards, Aracaris and Falcons are also susceptible

- Young psittacines are highly susceptible with very high mortality (30 - 100%) but adults are also susceptible
- Feather dystrophy in budgerigars, acute death, digestive, neurological, respiratory signs, *etc.*
- ✓ Lesions
 - **Gross:** variation among psittacines and also passerines
 - ◆ In most of psittacines feather dystrophy, hemorrhages in skin, subcutis, skeletal muscle, heart, and intestine, liver enlarged and mottled red or with white foci, splenomegaly, pale kidneys, ascites, lung congestion, pale carcass, *etc.*
 - ◆ In passerines, liver enlarged and mottled white, serosal or subserosal hemorrhage of intestine, pale myocardium, *etc.*
 - **Microscopic:** hemorrhages in various organs, necrosis in spleen, bursa, thymus and bone marrow, mid zonal or random necrosis in liver, myocarditis, enteritis, nephritis, membranous glomerulopathy, pancreatitis, conjunctivitis, encephalomyelitis, ganglionitis (spinal), *etc.*
 - ◆ Bluish karyomegalic inclusions in various tissues; epidermis, feather follicle epithelium, esophagus, kidney, macro/lympho of spleen, bursa, thymus, bone marrow, liver, *etc.*, hepatocytes, myocytes, endothelial cells, glial cells, Purkinje cells, *etc.*
- Goose hemorrhagic polyomavirus:
 - ✓ causes high mortality in 4-10 week old geese, 100 % mortality in one week-old geese
 - ✓ subcutaneous edema, ascites, hemorrhagic enteritis, nephritis and lymphoid necrosis in bursa of Fabricius

u. *Proventricular Dilatation Disease (PDD)*

- A common primarily a chronic disease of psittacines (>80 species) known since 1970's. Been called by many names. Budgerigars may be resistant and chickens are not susceptible.
 - Dilation of proventriculus, anorexia, regurgitation, passing of undigested seeds in feces, diarrhea, neurological signs, loss of weight, *etc.*
- PDD has also been reported in a Peregrine Falcon, Red Tail Hawk, Canada geese*, Trumpeter Swans*, Toucan, Finches, Canary*, Bearded Barbet, Spoon Bill, Honey Creeper, Long-wattled umbrella bird, *etc.* * Species in which ABV has been demonstrated.
- Etiology: Avian Bornavirus (ABV), many genotypes; ABV1 to ABV6. Canary - ABV7?
 - ABV is distinct from Borna Disease virus (BDV) of ungulates, 65 % homology
 - ABV can also be found in non-neural tissues and also in non-symptomatic birds
- Lesions
 - **Gross:** dilated thin proventriculus in 70% of cases, distended duodenum, emaciation, *etc.*
 - **Microscopic:** lymphoplasmacytic ganglioneuritis of splanchnic nerves of crop/esophagus, proventriculus, gizzard, intestine, adrenalitis, myocarditis, neuritis, encephalomyelitis, choroiditis, retinitis, *etc.* (see table 2)
 - Unusual lesions of lymphoid foci or nodules in visceral organs has also been reported

v. *Miscellaneous Viral Diseases*

- **Turkey viral hepatitis**
 - Disease of young turkeys
 - Etiology: 25 - 30 nm virus (Novel Picornavirus)
 - Liver and pancreas with foci of necrosis and inflammation, syncytia in liver
- **Avian nephritis**
 - Highly contagious disease of chickens
 - Etiology: Astrovirus
 - Nephritis and secondary visceral urate deposition
- **Hepadna virus (hepatitis B virus)**
 - Common in ducks, but no significant clinical disease or lesions
 - Also in swans and geese, no associated clinical disease
- **Avian Hepatitis E virus**
 - Hepevirus - *Hepeviridae*
 - Has been associated with hepatitis-splenomegaly syndrome in mature chickens
 - Disease is called big liver and spleen disease (BLSD) in Australia
 - Drop in egg production and increased mortality
 - Periportal hepatitis, vasculitis, necrosis and hemorrhage in liver. Spleen with increased number of MPS cells with amyloidosis frequently
- **Chicken Proventricular Necrosis Virus (CPNV)**
 - Novel birnavirus (different from IBD virus)
 - Has been associated with transmissible proventriculitis primarily in young broiler chickens
 - Necrosis of glandular epithelium, lymphocytic inflammation, ductular hyperplasia and lymphoid nodule formations in proventriculus
- **Louping ill virus**
 - Red grouse are susceptible
- **Arboviruses**
 - **WEST NILE VIRUS**
 - ✓ Etiology: Flavivirus
 - ✓ First appeared in people in the US in NY city in 1999, flu-like symptoms, 7/61 died
 - Spread to West coast in 2003 and is endemic now in US
 - ✓ Over 14 orders and over 325 species of birds are susceptible but most severe in crows, blue jays, geese, herons, raptors (owls, hawks), *etc.*
 - ✓ Others; pigeons, kestrels, gulls, storks, geese, magpie, bald eagles, ducks, flamingos, rosella, lorikeets, Australian parakeets, cockatoo, conures, cockatiel, *etc.*
 - ✓ Among psittacines Rosella's and other Australian Parakeets and Lorikeets are most susceptible
 - ✓ Chickens and turkeys are resistant to infection except for a report in a wild turkey

- ✓ Clinical signs vary from sudden death to depression, weight loss, ataxia, tremors, opisthotonus, impaired vision, *etc.*
- ✓ **Gross:** variable depending on the species affected. Hemorrhages in brain in some corvids, pale areas in the myocardium especially in raptors, enlarged liver and spleen, nephritis, hemorrhage and necrosis in the intestine
- ✓ **Histo:** variable, primarily nonsuppurative encephalitis and myocarditis in corvids and raptors. Others include hepatitis, splenitis, pancreatitis, enteritis, nephritis, adrenalitis, feather folliculitis (pterylitis) and pulmonary hemorrhage. Some birds may not have any lesions especially in acute stages.
- ✓ Virus widespread in many tissues but kidney and brain are good for virus isolation
- USUTU VIRUS (Flavivirus)
 - ✓ Encephalitis, myocarditis, hepatic necrosis in Eurasian Black birds (Austria). Great grey owls and Barn swallows are also susceptible.
- EASTERN EQUINE ENCEPHALOMYELITIS VIRUS (TOGAVIRUS)
 - ✓ Causes neurological signs and encephalitis in pheasants, partridges, finches, raptors and turkeys
 - ✓ In young turkeys and chickens, myocarditis, lymphoid necrosis in bursa and thymus
 - ✓ Hemorrhagic enteritis and splenic necrosis in emus
 - ✓ Been associated with serositis, epicarditis and myocarditis, interstitial pneumonia, hepatic necrosis, lymphocytic proventriculitis, *etc.*, in psittacines
- WESTERN EQUINE ENCEPHALOMYELITIS VIRUS (TOGAVIRUS)
 - ✓ Encephalitis, myocarditis, hemorrhagic leiomyositis of intestine associated with vasculitis in emus
 - ✓ Encephalitis in pigeon and neurological signs in turkeys
- HIGHLAND J VIRUS (TOGAVIRUS)
 - ✓ Encephalitis and myocarditis in partridges and young turkeys
 - ✓ Associated with precipitous drop in egg production in turkeys
- BUGGY CREEK VIRUS (TOGAVIRUS)
 - ✓ Encephalitis, myocarditis, myositis in nestling sparrows
- ISRAEL TURKEY MENINGOENCEPHALITIS VIRUS (TOGAVIRUS)
 - ✓ Encephalitis and myocardial necrosis in 10-12 week-old turkeys
- BUNYA VIRUS (Turlock-like):
 - ✓ Associated with encephalomyelitis and myocarditis in an ostrich chick

10. Parasitic diseases

- **Protozoa:** coccidia, histomonas, cryptosporidia, sarcocystis, toxoplasma, atoxoplasma, amoeba, microsporidia, trichomonas, leucocytozoon, malaria, haemoproteus, paraemoproteus, giardia, cochlosoma, spironucleus (Hexamita), balantidium, trypanosomes, hemosporozoa, besnoitia, chilomastix, caryospora, *etc.*
 - ◆ *Blastocystis* is classified as protista (commonly found in the ceca of gallinaceous birds, significance unknown).

- **Nematodes:** Ascarids, Capillaria, Syngamus, Tetrameres, Heterakis, Baylisascaris, *etc.*
- **Cestodes:** Raillietina, Davainea, Hymenolepis, *etc.*
- **Trematodes:** Prosthogonimus, Schistosomes, *etc.*
- **Arthropods:** mites, fleas, lice, *etc.*

Protozoa

a. COCCIDIOSIS

- Common disease of many species of birds caused by species of genera primarily *Eimeria* and *Isospora* and are quite host specific
- Chickens: disease of universal importance
 - *Eimeria tenella* (ceca), *E. acervulina* (upper small intestine), *E. maxima* and *E. necatrix* (mid small intestine)
 - Hemorrhagic, mucoid, necrotic, proliferative enteritis
 - Numerous coccidia in different stages of development
- Turkeys: common, lesions less severe than in chickens
 - *E. adenoides* (ceca), *E. meleagrimitis* (mid small intestine)
 - Mucoid enteritis, sometimes hemorrhagic and necrotic enteritis
- Geese: *E. truncata* occurs in kidney
 - Nephritis and urate deposits
 - *E. anseris* causes enteritis
- Ducks: renal coccidia due to *E. boschadis*, *E. truncata*, *etc.*
 - Intestinal Coccidiosis is not common in commercial ducks
- Quail, partridges, and pheasants: various species of *Eimeria* causes enteritis
 - In quail coccidiosis is commonly associated with ulcerative enteritis caused by *Clostridium colinum*
- Pigeons: *E. labbeana* causes enteritis
- Psittacines:
 - Species of *Eimeria*, *E. dunsingi* and *Isospora* can cause enteritis in budgerigars, lorries, parakeets, parrots, *etc.*
- Passerines:
 - Finches: *Isospora lacazei* has been associated with enteritis
- Cranes:
 - *E. gruis* and *E. reichenowi* causes granulomatous enteritis, hepatitis, splenitis, pneumonia, myocarditis, *etc.* in whooping and sandhill cranes

b. HISTOMONIASIS

- Also called black head, a common protozoal disease of turkeys and partridges
 - Also in chickens, peafowl, quail, pheasants, rhea, *etc.*
- Etiology: *Histomonas meleagridis*

- Cecal worm, *Heterakis gallinarum* and earth worms can act as accessory hosts
- Lesions: saucer shaped depressions (subacute to chronic lesions) or pale white foci (acute lesions) in liver and fibrinonecrotic mucosa and thickened wall of ceca
 - Pale white nodules in the liver can resemble lymphoma sometimes
 - Granulomatous hepatitis and typhlitis associated with spherical protozoa, 8 - 21 um in diameter
 - Splenitis, nephritis, bursitis (bursa of Fabricius), pneumonia and proventriculitis. Peritonitis secondary to perforating typhlitis can be seen in turkeys

c. CRYPTOSPORIDIOSIS

- Common protozoa of various species of birds
 - Chickens, turkeys, quail, ratites, ducks, pheasants, peafowl, psittacines, passerines, falcons, *etc.*
- *C. baileyi*, *C. meleagridis*, *Cryptosporidium galli* and probably others
- Infect various body systems
 - Cloaca, bursa of Fabricius and trachea most common
 - Nasal cavity, sinus, bronchus, air sac, conjunctiva
 - Intestine, ducts of pancreas, salivary and esophageal glands and bile duct
 - Ureters, collecting tubules of kidney, middle ear
 - Proventriculus – *C. galli* in passerines
- Inflammation and hyperplasia of epithelium

d. SARCOCYSTOSIS

- Systemic protozoal disease of psittacines caused by *S. falcatula* and others
 - Opossum is the definitive host, cowbirds and grackles are intermediate hosts
 - Old World psittacines highly susceptible
 - Young new world psittacines, canaries, finches, pigeons are also susceptible
 - Gallinaceous birds and anseriformes are resistant
- Sarcocystis with encephalitis has been described in a golden eagle, capercaillies and chickens
- *S. riley* causes sarcocystosis in skeletal muscle (rice breast) of ducks, an innocuous incidental finding
- Lesions
 - Pulmonary edema, congestion, liver may be enlarged and mottled white, splenomegaly
 - Lymphoplasmacytic interstitial pneumonia, edema and schizonts in capillaries
 - Myocarditis, hepatitis, splenitis, nephritis, encephalomyelitis, neuritis, myositis, uveitis, *etc.*, associated with schizonts
 - Mature cysts in the heart and skeletal muscle
 - ✓ Generally no reaction to cysts in muscles

e. TOXOPLASMOSIS

- Sporadic disease of various species of birds

- It has been described in passerines (canaries), chickens, psittacines, pigeons, ducks, penguin, Japanese quail, chukar partridges, *etc.*
- Turkeys, chickens, pheasants, Bob White quail, owls, house sparrows resistant

- Etiology: *T. gondii*

- Lesions: encephalomyelitis, ophthalmitis, pneumonia, myocarditis, hepatitis, splenitis, neuritis, myositis, enteritis, adrenalitis, *etc.* associated with zoites and cysts
 - Optic nerve; may be enlarged and yellow with necrotizing and granulomatous neuritis in chickens

f. ATOXOPLASMOSIS

- Common coccidian infection of canaries and finches, (previously called Lankesterella)
 - Also in mynah's, sparrows, grosbeaks, thrush, cowbirds, raptors and many birds of order Passeriformes
- Etiology: *A. serini* (*Isospora serini*), *A. adiei* and probably others
- Lesions
 - Liver enlarged with white foci, splenomegaly
 - Enteritis, hepatitis, myocarditis with arteritis, splenitis, myositis, dermatitis, pneumonia, *etc.*
 - Schizonts in cytoplasm of macrophages
- Lankesterella-like coccidia associated with pneumonia in a Northern Cardinal

g. MICROSPORIDIOSIS

- It can be a significant disease of psittacines
- It has been reported in a variety of lovebirds, budgerigars, parrots, cockatiels, *etc.*
 - Also reported in ostrich and Hummingbirds
 - *Encephalitozoon hellum*, others?
- Lesions: granulomatous nephritis, necrosis and inflammation in liver, enteritis, pneumonia, conjunctivitis, *etc.* associated with Gram-positive organisms

h. TRICHOMONIASIS

- A common infection of pigeons and raptors
 - Also in canaries, finches, doves, psittacines, ducks, poultry, wild birds, *etc.*
- Etiology: *Trichomonas gallinae*
 - Tetratrichomonas anatis* has been associated with sinusitis/rhinitis, tracheitis and enteritis and *Tetratrichomonas gallinarum* has been associated with typhlohepatitis in ducks
 - Tetratrichomonas gallinarum* in a mocking bird
 - Tri/tetratrichomonas gallinarum* are common in the ceca of chickens and turkeys - diarrhea
- Lesions of *Trichomonas gallinae*
 - Granulomatous stomatitis, pharyngitis, esophagitis, ingluvitis, and enteritis
 - Hepatitis, pericarditis, airsacculitis, tracheitis, pneumonia, meningoencephalitis

- Sinusitis, rhinitis, episcleritis
- Salpingitis in ducks

i. LEUCOCYTOZOONOSIS

- Disease of anseriformes, turkeys, raptors, wild birds and columbiformes
 - Black flies (*Simuliidae*) are vectors
- Etiology: *L. simondi* in anseriformes, *L. smithi* in turkeys, *L. marchouxi* in columbiformes, *L. toddi* in falconiformes, *L. ziemanni* in owls
 - Infect both white and red blood cells
- Lesions
 - Disseminated characteristic megaloschizonts in endothelial cells of liver, spleen, heart, brain, eye with hepatitis, myocarditis, encephalitis, *etc.*
- *L. caulleryi*, which causes severe disease in young chickens in south and eastern Asia, is classified as *Akiba caulleryi*
 - Vectors are biting midges of genus *Culicoides*
 - Lesions are similar to ducks
- Leucocytozoon-like infection has been described in budgerigars, parakeets, Nankeen kestrels and a buzzard
 - Myositis, myocarditis, encephalitis and hemorrhages in skin, pericardium, pancreas, hepatosplenomegaly, *etc.*
 - Granulomatous meningoencephalomyelitis, pectenitis and proliferative arteritis associated with endothelial parasitic cysts in Nankeen Kestrels

j. AVIAN MALARIA

- Hemoprotozoal infection of canaries, penguins and raptors caused by species of Plasmodium
 - Ducks, pigeons, chickens, grouse, pheasants, sparrows, blackbirds, robin, canary, tern, *etc.* are susceptible
 - Three species of *Culicoides* are vectors
- Etiology: *P. relictum*, *P. elongatum*, *P. circumflexum*, *etc.*
 - Infect red blood cells and cells of MPS
- Lesions: anemia, interstitial pneumonia, hepatitis, splenitis, encephalitis, *etc.*
 - Brown-black pigment (malaria pigment) of RBC's in MPS cells

k. HAEMOPROTEUS

- Hemoprotozoa of some significance primarily in columbiformes
 - Common in raptors, water fowl, passerines, *etc.*
 - Also seen in psittacines
- Etiology: *H. columbae* in pigeons and doves
 - Biting flies of hippoboscids and *Culicoides* are vectors
 - Infects red blood cells and endothelial cells
- Lesions: anemia, hepatitis, splenitis, myositis, pneumonia, *etc.*
 - Schizonts and megaloschizonts can be seen

- Hepatic hemorrhage, hemocoelom and sudden death due to *Haemoproteus* infection in passerine birds
 - In oropendola, different species of tanagers, cardinal, birds of paradise
 - Hepatocellular necrosis associated with megaloschizonts
- Disseminated myositis, myocarditis, splenitis, hepatitis, encephalitis, *etc.*, associated with protozoa of *Parahaemoproteus lophortyx* is common in quail in California
 - Anemia and other organs can also be involved

l. GIARDIA, SPIRONUCLEUS (HEXAMITA)

- *Giardia psittaci* cause of enteric disease in budgerigars
 - Others: cockatiels, lovebirds, parrots, conures, many wild birds, herons, egrets, sparrows, *etc.*
- *Hexamita meleagridis* an enteric protozoa of turkeys
 - Others: pheasants, pigeons, quail, partridge, ostrich, peafowl, *etc.*
- Lesions
 - Emaciation, fluid filled intestine, catarrhal enteritis

m. OTHER ENTERIC PROTOZOA

- *Cochlosoma anatis/ Cochlosoma. sp.*, a flagellate enteric protozoon of small intestine is associated with catarrhal enteritis in turkeys, ducks, geese and finches
- *Entamoeba gallinarum* common in large intestine of turkeys, significance?
- Others: *Balantidium* spp. in ostriches, *Wenyonella philiplevinei* in ducks, *etc.*

n. MISCELLANEOUS PROTOZOA

- Amoeba of undetermined spp. associated with meningoencephalitis in a cockatiel
- Besnoitia: Cyst stages of Besnoitia-like protozoa causes arteritis and endarteritis in shore birds like knots with severe mortality.
- Caryopsisora: coccidia with raptor-mouse cycle. Cysts found in the intestine, and other organs. Disease?
- Chilomastix: cyst forming flagellate seen in the intestine of chickens, turkeys, ducks, geese and bustards. Disease?
- *Babesia shortii*: causes anemia in Kestrels
- Others: trypanosomes, aegyptianella, *etc.*

Others:

i. Rhinosporidiosis (Protista – Mesomycetozoea. Parasites of fish and amphibians)

- Due to *R. seeberi* in swans and ducks
- Granulomatous conjunctivitis and cutaneous lesions

j. Blastocystis (Chromista/Protista)

Commonly found in the intestine (ceca) of chickens, turkeys, geese, ducks, pheasants, partridges, peafowl, ostriches, *etc.*

Vary in size from 3 to 200 um and exist in various forms (vacuolar, granular, cystic, *etc.*)

Significance in causing disease is unknown.

Blastocystis hominis has been associated with gastrointestinal disease in humans.

Nematodes

a. ASCARIASIS

- Common intestinal parasitism of many birds
 - Chickens, turkeys, pigeons, partridges, raptors, psittacines (Australian parakeets), passerines, *etc.*
- Etiology: *Ascaridia galli* (chicken), *A. dissimilis* (turkey), *A. columbae*, *A. hermaphrodita*, species of *Porrocaecum* and *Contraecum*, *etc.*
- Lesions: loss of weight, intussusception, mild enteritis if in large numbers
 - Eosinophilic enteritis in turkeys
 - Granulomas and or necrosis in livers due to larval migration in turkeys, psittacines, *etc.*
 - Bile duct hyperplasia and pericholangitis associated with larvae in bile ducts in parakeets

b. CAPILLARIASIS

- Significant disease primarily of upper digestive tract in many species of birds
 - Quail, pheasants, partridges, guinea fowl, turkeys, pigeons, chickens, raptors, ducks, psittacines, *etc.*
- Etiology: *C. contorta*, *C. annulata*, *etc.*
- Lesions: hyperplastic mucosa, fibrinonecrotic esophagitis, ingluvitis, *etc.*
- *C. obsignata*, *C. caudinflata* may cause enteritis in galliformes and columbiformes

c. CEREBROSPINAL NEMATODIASIS

- Common condition in a variety of birds
- Chickens, emus, ostriches, psittacines, raptors, quail, partridges, wild birds, *etc.*
- Etiology: *Baylisascaris procyonis* (raccoon) most common, occasionally *B. columnaris* (skunk) and badger
- Lesions: non-suppurative encephalitis associated with or with out larva/e. Brain stem most commonly involved
- Larvae of *Chandlerella quisicali*, a filarid nematode of grackle has been associated with encephalitis in emu

d. SYNGAMUS

- Common tracheal worm (gape worm) of pheasants
 - Others: turkeys, geese, quail, peafowl, chickens

- Etiology: *Syngamus trachea*
 - Lesions: granulomatous tracheitis and occasionally bronchitis
 - *Cyathostoma bronchialis* can cause bronchitis and pneumonia in geese
 - Also been associated with tracheitis in emus
- e. NEMATODES OF PROVENTRICULUS AND GIZZARD**
- *Dispharynx nasuta*, *Cyrnea colini*, *Tetrameres americana*, *Cheilospirura hamulosa* and species of *Acuaria*, *Synhimantia*, *Habronemia*, *Amidostomum*, *Hadjelia*, etc.
 - Occur in pigeons, chickens, quail, ducks, turkeys, pheasants, psittacines, passerines, etc.
 - Lesions: proventriculitis and ventriculitis
 - *Geopetitia aspiculata* (*Habronemia*) causes severe proventriculitis in passeriformes and others
 - *Libyostrogylus douglassii* causes severe proventriculitis in ostriches
 - *Eustrongylides ignotus* causes severe proventriculitis and peritonitis in fish eating birds such as herons, egrets and mergansers.

f. MISCELLANEOUS NEMATODES

- *Heterakis isolonche*: granulomatous typhlitis in pheasants
- *Trichostrongylus tenuis*: enteritis in young grouse and geese
- *Oxyspirura mansoni*: conjunctivitis in galliformes
- *Thelazia* sp. have been associated with conjunctivitis in psittacines
- *Pelecitus calamiformis* (filarid): tenosynovitis associated with adult nematodes in parrots
- Microfilariae are common in psittacines, especially cockatoos, not pathogenic
- Microfilariae associated with severe pneumonia in magpies
- *Serratospiculoides amaculata*, parasite of air sacs and airways in raptors. Associated with airsacculitis, peritonitis and necrotizing myelitis in a Prairie Falcon
- *Serratospiculum* sp. nine species known in raptors, some associated with airsacculitis and pneumonia
- *Paronchocerca ciconarum* (filarid): myocardial degeneration with adult nematodes in a Marabou Stork
- Cardiofilaria - heart worm in psittacines

Cestodes

- Common intestinal tapeworms of many species of birds
 - Chickens, turkeys, ducks, geese, pigeons, psittacines, passerines, wild birds, etc.
- Etiology and lesions:
 - *Davainea proglottina* (smallest); enteritis in chickens

- *Raillietina echinobothridia*: granulomatous enteritis in chickens
- Species of *Raillietina*, *Hymenolepis*, *Amoebotaenia*, *etc.* are common in psittacines and finches
 - ✓ Pathogenic in large numbers, obstruction, enteritis, *etc.*

Trematodes

- **Schistosomiasis**: common in waterfowl
 - *Dendritobilharzia* sp.
 - Medial hypertrophy of vessels in the intestinal wall
 - Rarely hepatitis, encephalitis, nephritis, enteritis
 - Encephalitis common in swans
- *Dicrocoeliidae*: been associated with dilated bile ducts and severe cholangiohepatitis in cockatoos and an amazon parrot
- *Gigantobilharzia* sp. associated with hemorrhagic ulcerative colitis and cloacitis in a nanday conure
- *Sphaeridiotrema globulus*: causes severe ulcerative hemorrhagic enteritis in swans and cygnet and chickens (experimental)
- *Philophthalmus gralli*: associated with conjunctivitis in ostriches
- *Collyriclum faba* cause cysts in the skin of poultry, wild birds including robins
- *Prosthogonimus* sp. oviduct fluke of poultry
- *Tanaisia bragai* in collecting tubules of kidney in poultry, pigeons, *etc.*
- *Cathaemasia hians* in the upper esophagus of storks
- *Athesmia heterolecithodes* causes severe hepatitis in guinea fowls

Arthropods

MITES

- Most common ectoparasites of a variety of species of birds
 - Chickens, canaries, finches, psittacines, pigeons, turkeys, pheasants, wild birds, *etc.*
- **Etiology** (see table 3): species of *Dermanyssus*, *Ornithonyssus*, *Knemidocoptes*, *Sternostoma*, *etc.* Numerous other species known.
- **Lesions**
 - Anemia
 - Hyperkeratosis, acanthosis, epidermitis, dermatitis
 - Blockage, granulomatous tracheitis, airsacculitis, pneumonia
 - Cysts in skin, poor feather growth, loss of feathers, *etc.*

LICE

- Most common in poultry; chicken body louse (*Menacanthus stramineus*) and shaft louse (*Menopon gallinae*). Female lice glue their eggs (nits) to host feathers but pathology is minimal.

FLEAS

- In poultry, stick tight flea also known as tropical chicken flea (*Echidnophaga gallinaceae*) can cause dermatitis.

TICKS

- Fowl tick, *Argus persicus* can cause anemia. May transmit bacterial and rickettsial diseases.

11. Toxicosis

a. *Mycotoxins*

- Generally ducklings, turkey poults and pheasants are more susceptible
- **Aflatoxins** (B1, B2, G1 and G2): B1 most toxic, liver has congestion, necrosis, fatty change, karyomegaly, numerous mitotic figures, bile duct hyperplasia, fibrosis, *etc.*
 - Immunosuppression, myocardial, kidney degeneration, impaired blood coagulation, *etc.*
 - Turkey X disease due to aflatoxin B1 + cyclopiazonic acid
 - Model for hepatocarcinogenesis
- **Citrinin, Ochratoxin, Oosporein:** renal tubular necrosis and visceral urate deposition
 - In addition vacuoles, bile duct hyperplasia, *etc.* in liver associated with citrinin and ochratoxin
 - Ochratoxin can cause glycogen storage disease in chickens
 - Ochratoxin is embryocidal at low levels
- **Trichothecenes** (T2, DAS, Vomitoxin = DON): radiomimetic effect, oral, proventricular and gizzard erosions, lymphoid necrosis and depletion, hepatic necrosis, *etc.*
- **Fumonisin:** poultry are relatively resistant, hepatic necrosis, biliary hyperplasia, widening of growth plates, myodegeneration, *etc.*
- **Moniliformin:** Cardiomegaly in broilers, myocardial degeneration, hepatic necrosis
- **Fusarochromanone:** tibial dyschondroplasia
- **Cyclopiazonic acid:** skeletal muscle, heart, liver, GI degeneration
- **Zearalenone:** mycotoxin with estrogen activity
 - Cystic oviduct with inflammation, cysts in vent, *etc.*
- **Ergotism:** beak and toe necrosis

b. *Heavy metals*

- **Lead:** one of the most commonly reported toxic compounds of waterfowl and companion birds

- Lesions: anemia, hemorrhagic enteritis, myocardial degeneration, hyalinosis of cerebral vessels with hemorrhage, nephrosis, demyelination of nerves, *etc.*
- Acid fast intranuclear inclusions in renal tubular epithelial cells
- **Zinc**: common in companion birds, waterfowl
 - Lesions: gizzard erosion, pancreatic acinar necrosis, enteritis, nephrosis
- **Iron**: seen in a variety of birds
 - Lesions: hepatic necrosis, hemolysis of RBC, hemosiderosis (in Lorikeets)
- c. Ionophore toxicity**
 - Ionophores widely used as anticoccidials in poultry
 - Toxicity most common in turkeys and chickens
 - Also described in quail, guinea fowl, *etc.*
 - Monensin, Lasalocid, Salinomycin, Narasin
 - Various compounds including antibiotics interact and influence toxicity
 - Lesions: degeneration of skeletal muscles (pectoral muscles not affected) and occasionally heart (in chickens). Sartorius, adductor, semimembranous, semitendinosus, intercostal muscles most commonly affected
 - In addition demyelination and axonal degeneration of peripheral nerves and spinal cord have been associated with lasalocid toxicity
- d. Selenium, salt, calcium**
 - Selenium: hepatopathy, alopecia of the scalp and dorsal cervical midline, broken or lost digit nails, necrosis of the tip of the beak in ducks
 - pulmonary congestion and edema in an ostrich chick
 - Salt: Low to moderate levels causes right heart hypertrophy, dilation and ascites in turkey poults and broiler chicks and occasionally encephalomalacia
 - Water high in salinity causes conjunctivitis, myocardial degeneration, hyperemia of brain, hyperplasia or atrophy of salt glands, cataracts (reversible if not severe) in wild waterfowl
 - Cystic testes in poultry
 - Symmetrical encephalomalacia in young turkey poults and occasionally in chicks
 - Calcium: nephrosis in young poultry
- e. Vitamins**
 - Vitamin D: common in psittacines
 - Soft tissue mineralization, proventriculus, heart, air sacs, *etc.*
 - Vitamin A: conjunctivitis and rickets in chickens
 - Hepatic degeneration, Ito-cell hyperplasia?
- f. Gases; PTFE, Ammonia, CO**
 - Polytetrafluoroethylene (PTFE): Teflon coated pans when overheated release toxic gases
 - Seen in companion birds, also in free flying birds
 - In poultry from PTFE-coated light bulbs

– Pulmonary congestion and edema

- Carbon monoxide: pulmonary congestion and edema, bright red colored blood
- Ammonia: conjunctivitis, corneal erosions and ulcers and sinusitis and tracheitis in poultry
- Oxygen: in budgerigars, edema and interstitial pneumonia

g. Rodenticides

- Diphacinone, Brodifoum, Bromodiolone: blood in abdominal cavity, hemorrhage in liver
- Zinc phosphide: hydropericardium, pulmonary edema, congestion and hemorrhage in liver, congestion in kidney

h. Antibiotics

- Gentamicin, Amikacin - nephrosis
- Sulfa drugs - disseminated hemorrhages, nephrosis
- Tetracyclines - nephrosis
- Furazolidone - round heart, hepatocellular vacuoles
- Polymyxin E-1. in ostriches, congestion of meningeal vessels, vacuolization of the plexus of Auerbach, edema in the heart and intestinal serosa

i. Plants

- Avocado and oleander: myocardial degeneration
- Oak: nephrosis
- Green acorns (pyrogallol): gastroenteritis, congestion and edema of organs
- Coffee senna: degeneration of muscles
- Gossypol: hepatic necrosis, biliary hyperplasia, perivascular inflammation
- Spring Parsley (*Cymopterus watsonii*), celery: photosensitization, dermatitis
- Blue green algae (Microcystin): Hepatic necrosis
- Onion: hemosiderosis in liver in White Chinese geese.
- Yew: no significant lesions

j. Others

- Organophosphates - acute and delayed neurotoxicity
 - Acute, inhibition of acetyl cholinesterase, no lesions
 - Delayed, axonal degeneration in peripheral nerves and spinal cord, adult chicken is the (test) animal model, young birds are resistant
- Nitrate, Nitrite: Brown mucus membranes, methemoglobinuria
- Arsenic acid, nitro-phenyl-arsenic acid: demyelination of peripheral nerves
- Sodium Sesquicarbonate: nephrosis, visceral gout, fluid in intestine

- Quaternary Ammonium: erosions and ulcers in upper GI tract
- Domoic acid (marine neurotoxin):
 - In pelicans and cormorants
 - Hemorrhage and necrosis in skeletal muscles
- Diclofenac (NSAID) – caused high mortality (due to 2^o poisoning) in vultures in the Indian subcontinent. Nephrosis and visceral urate deposits
- **Avian vacuolar myelinopathy**
 - Cause: toxicity due to Cyanotoxins (metabolites of cyanobacteria – blue green algae) is suspected
 - In bald eagles, coots, geese, owls and others
 - Spongy degeneration of the white matter of CNS but most prominent in optic lobes and swollen axons in spinal cord. Optic nerve also affected.

12. Metabolic diseases

a. *Goiter*

- In male mature buff Cochin chickens (Dr. D. Webb, IL)
- Severely enlarged cystic thyroid glands with follicles lined by flattened epithelial cells
- Genetics suspected

b. *Hemochromatosis*

- Abnormal accumulation of iron in tissues associated with tissue disturbance such as cirrhosis
- Most common in mynahs, toucans, crows, starlings, ducks, fruit doves, horn bills, psittacines (Lorikeets), *etc.*
- Hepatic degeneration, fibrosis, myocardial degeneration, ascites, *etc.*
- Genetics, nutrition (iron), hemorrhagic syndromes, starvation, *etc.*

c. *Diabetes mellitus*

- Poorly understood
- It has been described in psittacines, toco toucans and a red-tailed hawk
- Glucagon is the major glucose - regulating hormone in granivorous birds
- Carnivorous birds are similar to mammals
- Lesions
 - Hyperplasia of islet cells
 - ✓ Decrease in insulin secreting cells (by IHC)
 - Enlarged islets with eosinophilic cytoplasm in toco toucans
 - Islet cell tumor

d. *Amyloidosis*

- Most common in ducks and finches

- Also in other water fowl, game birds, turkeys, chickens, psittacines, ratites, canaries, flamingos, touracos, pigeons, doves, *etc.*
- Can be associated with chronic infections
- Genetics probably plays a major role in its occurrence in commercial ducks, as young as 3-4 week-old ducklings may have severe amyloidosis in the spleen with out apparent co-infections.
- Accumulation of amorphous eosinophilic material in various tissues
- Liver, spleen, intestine, adrenal, kidney, synovium, heart, pancreas, thyroid, skin, brain, lung, proventriculus, *etc.*
- Lesions
 - **Gross:** ascites (water belly) in commercial ducks, firm enlarged and waxy liver sometimes with nodules, enlarged mottled white spleen, pale or brownish kidneys, *etc.*
 - **Microscopic:** interstitial accumulation of amyloid in liver with hepatocellular atrophy in severe cases, kidney, adrenal, thyroid, pancreas, spleen, in the lamina propria of intestine and proventriculus, in subepithelium of synovium, bronchus, in myocardium, brain, skin, vessels, *etc.*
 - ✓ Severe hepatic capsular fibrosis and nodules made up of hyperplastic hepatocytes
- Amyloid arthropathy in Brown Leghorn chickens
 - Cause: *Enterococcus faecalis*, *Mycoplasma synoviae*, *M. gallisepticum*, *S. aurues* and others
 - Lesions: Orange colored exudate in the synovium
- Amyloid associated with Hepatitis-splenomegaly syndrome in mature broiler and laying-type chickens
 - Cause: Hepatitis E virus
 - Lesions: enlarged mottled pale spleen and enlarged and hemorrhagic liver. Amyloid primarily in the spleen

e. Gout (*visceral and articular urate deposits*)

- Uric acid is the end product of protein and purine metabolism (uricotelic) in birds, where as in mammals' urea is the end product (ureotelic)
- Birds lack the enzyme carbamyl phosphate synthetase to dispose of ammonia and the enzyme uricase to decarboxylate uric acid to allantoin
- Gout is a metabolic condition where abnormal accumulation of white chalky or white semifluid-like urates in soft tissues of various organs in the body
- Gout occurs as two distinct syndromes, visceral and articular gout urate deposits
 - The term “gout” has been replaced with the term “urate deposits”
- These two syndromes differ in age of onset, frequency, sex predilection, gross and microscopic lesions, pathogenesis and causes
- Great deal of confusion exists between the two syndromes because urate deposition takes place in joints in visceral urate deposits (gout) also

- See **table 4** to help clarify differences between the two syndromes

f. *Hepatic Lipidosis*

- Common in some psittacines; budgerigars, amazons, rose breasted cockatoos, shell parakeets, lorikeets, *etc.*
- Diet, environment, toxicities, hormones, genetics (shell parakeets) influence lipidosis
- Lesions: obesity, hepatic lipidosis, and lipidosis in liver and other organs in shell parakeets

g. *Hemorrhagic fatty liver syndrome (chickens)*

- Condition of obese layer-type chickens
- Fat in abdominal cavity, fatty livers, hemorrhagic or ruptured livers

h. *Atherosclerosis*

- Very common in psittacines especially in amazons and African Greys
- Others: ducks, geese, chickens, turkeys, ostriches, flamingoes, herons, vultures, falcons, pigeons, *etc.*
- Etiology: diet, environment, genetics, virus, age, *etc.*
 - Marek’s disease virus (herpesvirus) can induce atherosclerosis in chickens
 - White Carneaux pigeon used as model
- Lesions
 - Thickened walls or plaques in brachiocephalic, carotid, abdominal aorta, *etc.*, coronary arteries and other arteries are rarely involved, myocardial degeneration and fibrosis
 - Thickening of intima and media with lipid laden cells

i. *Mucopolysaccharidosis type IIIB (emu)*

- Also called Sanfilippo B syndrome
- First description in any animal
- Deficiency of N-acetyl- α -D-glucosaminidase
- Probably inherited as a autosomal recessive trait
- Signs and lesions
 - Sudden death, neurological signs
 - Ruptured liver or subcutaneous hemorrhages
 - Accumulation of membrane bound substance in neurons of nervous tissue and visceral organs

j. *Storage disease in Costa’s Hummingbirds*

- Neurologic signs; flying backwards, swaying, head tilt, flying in circles, head tremors
- Vacuoles in swollen neurons, cells of bone marrow, spleen, gland of Harder, uropygeal gland and inner nuclear layer of retina

k. *Inherited Muscular dystrophy in chicken*

- Seen in New Hampshire breed and similar dystrophy-like myopathy has been described in Cornish breed

- Clin. signs: unable to elevate wings beyond horizontal plane and unable to right themselves when placed on their backs
- Lesions: grossly enlargement of pectoral muscles initially and later atrophy, microscopically variation in fiber size, increased nuclei, vacuoles, necrosis, fragmentation and replacement by adipose tissue
- l. *Myotonic dystrophy in mutant (LWC strain) Japanese Quails***
 - As early as 28 days of age generalized myotonia, muscle stiffness, muscle weakness
 - Lesions: ring fibers, sarcoplasmic masses, internal migration of sarcolemmal nuclei, variation in fiber size, replacement by fat cells and lenticular cataracts
- m. *Type II Glycogen storage disease in Japanese Quail***
 - Acid maltase deficiency
- n. *Aortic aneurysm/rupture***
 - Most common in male turkeys but also seen in ostriches and emus
 - Most common in the abdominal aorta at the origin of the celiac artery
 - Longitudinal slit in the posterior abdominal aorta or rarely at the origin of aorta
 - Medial degeneration and loss of elastic fibers, subintimal thickening, displacement of elastic lamina, increased amount of collagen, necrosis, rupture
 - Genetics, hypertension, low copper, *vasa vasorum* defect?
 - Aortic rupture in psittacines due to invasion of *Aspergillus* sp.
 - **Coronary artery aneurysm** (turkeys)
 - In male turkeys, 15 -16 weeks-old, 1.5-3.5% mortality
 - Hemopericardium, hemorrhage across base of heart, subintimal thickening, medial degeneration of coronary artery, rupture
 - Genetics, hypertension, low copper, increased body weights?
- o. *Round heart disease (turkeys)***
 - Also called spontaneous cardiomyopathy
 - Common condition in young commercial turkeys
 - Dilated ventricles, chronic passive congestion of liver
 - Cause has been determined to be due to genetics
 - Been used as a model to study cardiomyopathy
- p. *Ascites syndrome (chickens)***
 - Common condition in broiler chickens
 - Right heart hypertrophy later dilation, passive congestion of liver and ascites. Pulmonary congestion and edema
 - Rapid growth coupled with insufficient pulmonary capillary capacity aggravates pulmonary hypertension leading to right heart failure
- q. *Tibial dyschondroplasia (TD)***
 - Common condition in broiler chickens and turkeys and ducks

- Abnormal masses of cartilage below the growth plate primarily in the proximal tibiotarsus but occurs also in the tarsometatarsus
 - Presence of prehypertrophic cartilage with no vascular channels
 - Etiology: multifactorial, nutrition, genetics, mycotoxin, *etc.*
- Similar picture as TD can be seen grossly in the long bones of ratites but it is **not** TD nor it is pathologic
 - In ratites it is normal embryonic cartilage which gets resorbed by 6-8 weeks of age

r. *Deep pectoral myopathy*

- Seen in well muscled broilers and turkeys
- Green discoloration of primarily supracoracoideus muscle due to ischemic necrosis

s. *Perirenal hemorrhage*

- Seen in rapidly growing turkeys, 8-14 weeks of age
- Hemorrhage over portion or entire kidney
- Underlying vascular problems? Probably due to small ruptures or tears in the posterior abdominal aorta and its branches?

t. *Xanthomatosis*

- Common in psittacines and occasionally in chickens
- Yellow subcutaneous swelling or nodules in the body cavity
- Giant cells, lymphocytes, macrophages with cholesterol clefts
- Very common in the bone marrow of many species of birds

u. *Auto immune thyroiditis (chicken)*

- Occurs spontaneously in obese strain of chicken
- Used as model to study Hashimoto's thyroiditis
- Birds have long and silky feathers, large amount of abdominal fat
- Thyroids become small gradually as the bird matures and atrophies
- Lymphocytic infiltration with few macrophages and lymphoid nodules, loss of architecture, thyroid gland
- Antibodies to thyroglobulin
- Hyperlipidemia, low T3 and T4 and IgA deficiency
- Been described in Fayoumi breed of chickens with feather amelanosis

13. Diseases of Malnutrition

a. *Xerophthalmia*

- In non-commercial poultry, psittacines, *etc.*

- Etiology: vitamin A deficiency
- Lesions: pustule-like nodules in upper GI tract, exudate in conjunctiva, nasal cavity, nephrosis, opaque dry cornea, hyperkeratosis of plantar surfaces
 - Microscopic lesions: squamous metaplasia of epithelium and hyperkeratosis in esophagus, conjunctiva, salivary and salt glands, respiratory tract (sinus/turbinates, larynx, trachea, syrinx, bronchus/parabronchus), bursa of Fabricius, proventriculus, ureter, feather follicles, *etc.*

b. Polyneuritis

- Rarely seen in poultry
- Etiology: vitamin B1 (thiamin) deficiency
- Lesions: prominent peripheral nerves with edema and infiltration of mononuclear cells
- Malacia of the brain in fish eating birds

c. Rickets/osteomalacia

- Rickets in younger birds and osteomalacia in older birds
 - In poultry, ratites, psittacines, zoo birds, *etc.*
 - Etiology: deficiency of calcium, phosphorus and vitamin D3 or an imbalance in calcium to phosphorus ration (normal 2:1)
 - Lesions: soft and pliable beak, claws and keel, beading of ribs ('rickety rosary'), enlarged epiphysis, fractures of long bones, enlarged parathyroid glands
 - ✓ **Microscopic**:
 - Calcium deficiency - lengthened Proliferating Prehypertrophied Zone and short Degenerating Hypertrophied Zone (DHZ), hyperplasia of parathyroid glands
 - Phosphorus deficiency/calcium excess: lengthened DHZ
 - Vitamin D3 deficiency - similar to calcium deficiency

d. Encephalomalacia

- In young chickens, turkeys, pheasants, geese, ducks, *etc.*
 - Can also be seen in older birds
- Etiology: vitamin E deficiency. (**Note: not** associated with Selenium deficiency)
- Lesions: soft and enlarged cerebellum, petechiae, hemorrhages especially in turkey poults
 - **Microscopic**: malacia, hemorrhage, vascular thrombosis, demyelination in brain
 - Occasionally spinal cord involved, poliomyelomalacia
- Yellow fat disease in wild birds: herons, *etc.*
 - Fat is brownish yellow, steatitis

e. Muscular dystrophy/exudative diathesis

- In chickens, quail, turkeys, pelicans, ducks, *etc.*
- Etiology: vitamin E/Selenium deficiency
- Lesions
 - Subcutaneous green-tinged fluid

- Pale streaks in skeletal muscles, gizzard and heart (ducks and pelican)
- Degeneration of skeletal muscle, heart, gizzard, pancreatic acinar necrosis
- f. *Curled-toe paralysis***
 - Seen in chicks, turkey poults, ducklings
 - Etiology: vitamin B2 (riboflavin deficiency)
 - Lesions: swelling of peripheral nerves, axon and myelin degeneration, Schwann cell proliferation, mononuclear cell infiltration, *etc.*
- g. *Pyridoxine (B6) deficiency***
 - Perosis, neurological signs in chicks and ducks and reduced egg production and hatchability in laying chickens and turkeys
 - Microcytic hypochromic anemia in ducks
- h. *Perosis/slipped tendon (chicks, poults)***
 - Etiology: manganese and choline deficiency
 - Lesions: deformity of hocks, enlargement of condyle, bowing of tarsometatarsus, slipping of gastrocnemius tendon
 - Deficiency of pantothenic acid, biotin, folic acid, niacin can cause similar lesions
 - In addition dermatitis can be seen in birds deficient in biotin and pantothenic acid and poor feathering and anemia in niacin deficiency
- i. *Goiter***
 - Common in psittacines especially in budgerigars
 - Also seen in pheasants, geese, chickens, *etc.*
 - Etiology: Iodine deficiency
 - Lesions: enlarged thyroid glands, some times cystic
 - Micro: severe hyperplasia of follicle epithelium with papillary projections, pale or lack of colloid, hemorrhage and severe effacement of the gland in extreme cases

14. Neoplasia

- Most common in chickens and psittacines especially budgerigars among birds
 - Historic significance; retroviruses and chickens have served as models to study various phenomenon of neoplasia
- In chickens most are caused by viruses such as retroviruses (see Leucosis/Sarcoma group, Reticuloendotheliosis group) and herpesvirus (Marek's Disease)
- Tumors of unknown etiology in chickens include Squamous cell carcinoma (Keratoacanthoma) of the skin, ovarian/oviductal Adenocarcinoma (carcinomatosis), leiomyoma of the mesosalpinx, teratoma of testes, multicentric histiocytosis, *etc.*

- Squamous cell carcinoma (keratoacanthoma) of skin occur as small nodular or ulcerative lesions in broiler chickens leading to condemnations, no evidence of metastasis
- Ovarian carcinoma in hens used as model to study ovarian cancer in women. Ovarian carcinomas appear as multiple to numerous pale nodules in the coelomic cavity and on the serosa of the intestine with adhesions between loops of intestine and ovary and oviduct. Ascites common
- Leiomyoma of mesosalpinx – very common in hens and appears as a small to large (2x2 cm) pale nodule in the mesosalpinx and occasionally as small nodules in the coelomic cavity and abdominal viscera
- Birds in the order Passeriformes have the lowest incidence
 - Lymphoma in canaries and finches are common
 - Cutaneous papilloma's associated with papillomavirus associated in chaffinch and brambling finches
- Incidence in budgerigars range from 16 to 24 %
- Etiology of tumors is not known in psittacines and other species of birds
- Some of the mammalian markers (IHC) to identify tumors do work in birds
- Some of the common tumors in psittacines include renal tumors, fibrosarcoma, squamous cell carcinoma, lymphoma, papillomas, tumors of the gonads (testes, ovary, and oviduct), gastric carcinoma, osteoma, osteosarcoma, leiomyosarcoma, rhabdomyoma/sarcoma, pituitary adenoma, air sac, *etc.*
 - Integument: lipoma/sarcoma, myelolipoma, hemangioma/sarcoma, squamous cell carcinoma, fibroma/sarcoma, lymphoma, basal cell tumors, mast cell tumors, melanoma, granular cell tumor, uropygial gland tumors, folliculoma, *etc.*
 - GI tract: gastric carcinoma, papillomas, bile duct carcinoma, *etc.*
 - ✓ Gastric carcinoma most commonly arising from proventriculus. Tumors extend in to the submucosal and muscular layers. Desmoplastic reaction common
 - ✓ Papilloma's are most common in cloaca but can involve tongue, pharynx, esophagus, and crop. Often birds have bile duct and occasionally pancreatic duct tumors in birds with cloacal papillomas. Herpesvirus sequences have been associated with cloacal papillomas but does not prove cause and effect relationship. Papillomavirus has been demonstrated in the cutaneous papilloma in an African Gray parrot
 - Urinary tract: renal tumors are most common in psittacines and have been extensively studied to demonstrate virus but none so far.
 - ✓ Various forms; adenoma, cystadenoma, Adenocarcinoma, nephroblastoma, *etc.*, have been described. Size can vary but some impinge on sciatic nerve causing paresis. Some can compromise renal function.
 - Hemopoetic tumors: multicentric lymphosarcoma is most common involving liver, spleen, kidneys, bone marrow, skin, thymus, pancreas, *etc.* The tumors can be diffuse or nodular.
 - Pituitary adenoma: one study described a high incidence but the cases were solicited. Chromophobe adenomas are most common often presented with exophthalmus and/or neurological signs. Carcinoma's with metastasis can occur

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Table 1: Oncogenes originally identified through their presence in transforming retroviruses

Oncogene	Protein	Source of virus	Tumour
<i>abl</i>	Kinase	Mouse, cat	Pre-B-cell leukaemia
<i>akt</i>	Kinase	Mouse	T-cell lymphoma
<i>crk</i>	Kinase activator	Chicken	Sarcoma
<i>erb-A</i>	TH-R	Chicken	Erythroleukaemia
<i>erb-B</i>	EGF-R	Chicken	Erythroleukaemia
<i>ets</i>	TF	Chicken	Myeloid leukaemia
<i>fes/fps</i>	Kinase	Chicken/cat	Sarcoma
<i>fgr</i>	Kinase	Cat	Sarcoma
<i>fms</i>	Kinase	Cat	Sarcoma
<i>fos</i>	TF	Mouse	Osteosarcoma
<i>jun</i>	TF	Chicken	Fibrosarcoma
<i>kit</i>	Kinase	Cat	Sarcoma
<i>mil/raf</i>	Kinase	Chicken/mouse	Sarcoma
<i>mos</i>	Kinase	Mouse	Sarcoma
<i>myb</i>	TF	Chicken	Myeloid leukaemia
<i>myc</i>	TF	Chicken	Myelocytoma, lymphoma, carcinoma
<i>H-ras</i>	G-protein	Rat	Sarcoma
<i>K-ras</i>	G-protein	Rat	Sarcoma
<i>rel</i>	TF	Turkey	Reticuloendotheliosis
<i>ros</i>	Kinase	Chicken	Sarcoma
<i>sea</i>	Kinase	Chicken	Sarcoma, leukaemia
<i>sis</i>	PDGF	Monkey	Sarcoma
<i>ski</i>	TF	Chicken	Carcinoma
<i>src</i>	Kinase	Chicken	Sarcoma
<i>yes</i>	Kinase	Chicken	Sarcoma

Abbreviations: EGF-R, epidermal growth factor; PDGF, platelet-derived growth factor; TH-R, thyroid hormone receptor; TF, nuclear transcription factor. Chicken genes are shown in **bold**.

Ref: R. A. Weiss. The oncologist's debt to the chicken. Avian Path. 27:S8-S15, 1998.

Table 2. Relative frequency of microscopic lesions in various organs of psittaciformes diagnosed of having PDD

Organ	# Examined	# With Lesions	%
Prov/Gizzard	112	112	100
Adrenal	56	50	89.3
Intestine	89	77	86.5
Heart	87	69	79.3
Brain/spinal cord	66	52	78.8
Esophagus/crop	61	44	72.1
Peripheral nerves	28	20	71.4
Eye	12	8	66.7
Skin	24	6	25.0
Pancreas	64	11	17.2
Thyroid	31	3	9.6
Liver/lung/spleen/kidney	102	0*	0.0

* Incidental findings not included.

Ref: Shivaprasad *et al.*, Pathology of Proventricular Dilation Syndrome, Vet Path 34:500, 1997.

Table 3. Mites in Birds

Name	Common Name	Species of birds affected
<i>Dermanyssus gallinae</i> *	Red mite (Roost mite, Poultry mite)	Chickens, turkeys, pigeons, canaries, wild birds
<i>Ornithonyssus sylviarum</i> *	Northern Fowl mite	Chicken, turkeys, wild birds
<i>O. bursa</i>	Tropical Fowl mite	Poultry, pigeons, Mynah
<i>Knemidocoptes mutans</i> *	Scaly-leg and scaly-face mites	Poultry
<i>K. pilae</i> *	Scaly-leg and scaly-face mites	Psittacines
<i>Procnemidokoptes janssensi</i>	Scaly-leg and scaly-face mites	Love birds
<i>K. jamaicensis</i>	Scaly leg mite	Canaries, finches, other passerines
<i>Knemidocoptes gallinae</i>	Depluming mite	Chickens, pigeons, pheasants
<i>K. laevis</i>	Depluming mite	Pigeons
<i>Neocnemidocoptes gallinae</i>	Depluming mite	Pheasants and others
<i>Epidermoptes bilobatus</i>	Skin mite	Chickens
<i>Myialges nudus</i>	Skin mite	Grey-cheeked parakeets
<i>Harpyrynchus sp.</i>	Skin and feathers	Passerines
<i>Syringophilus hipectinatus</i>	Feather and quill mites	Poultry, wild birds
<i>S. columbae</i>	Feather and quill mites	Pigeons
(<i>Dermoglyphus sp.</i> , <i>Analges sp.</i> , <i>Mengninia sp.</i> , <i>Freyana sp.</i>)	Feather and quill mites	Chickens, turkeys
<i>Paragloopsis sp.</i>	Feather and quill mites	Psittacines, finches
<i>Sternostoma tracheacolum</i> * (<i>Neonyssus</i> , <i>Rhinonyssus</i>)	Respiratory tract mite (trachea, lung, air sac)	Passerines (canaries, finches), psittacines, poultry, pigeon
<i>Cytodites nudus</i>	Air sac mite (bronchi, lungs, air sac)	Poultry, pheasants, pigeons, canaries, etc.
<i>Laminosioptes cysticola</i>	Cyst mite (skin, subcutis, muscle, abdominal viscera and lungs)	Chicken, turkeys, pigeons, pheasants geese
Hypopial mites	Areolar subcutaneous, connective tissue	Pigeons
Family Trombiculidae (<i>Neoschonagastia americana</i>)	Chiggers	Poultry (Southern US), turkeys, wild birds, chickens, pigeons, psittacines

* Most common

Table 4: Differences between Visceral urate deposition and articular urate deposition in Birds

	Visceral urate deposition (Visceral gout)	Articular urate deposition (Articular gout)
1. Onset:	It is usually an acute condition but can be chronic.	It is usually a chronic disease.
2. Frequency:	It is very common.	It is rare or sporadic.
3. Age:	1 day and above.	4-5 months and above. However, immature genetically susceptible chickens may be induced by high protein levels in the diet.
4. Sex:	Both males and females are susceptible.	Mostly males.
5. Gross lesions		
Kidney:	Kidneys are almost always involved and they look grossly abnormal with deposition of white, chalky precipitates.	Kidneys are normal grossly. Kidneys may become abnormal with white urate deposits if the bird gets dehydrated.
Soft tissues:	Visceral organs like liver, myocardium, spleen or serosal surfaces like pleura, pericardium, air sacs, mesentery, <i>etc.</i> are commonly involved.	Soft tissues other than synovium are rarely involved, however, comb, wattles, and trachea have been observed to be involved.
Joints:	Soft tissues around the joints may or may not be involved. Surfaces of muscles, synovial sheaths of tendons and joints are involved in severe cases.	Soft tissues around the joints are always involved, especially feet. Other joints of the legs, wing, spine, and mandible are also commonly involved.
6. Microscopic lesions:	Generally no inflammatory reaction in synovium or visceral surfaces. Kidney has inflammatory reaction around tophus.	Granulomatous inflammation in synovium and other tissues.
7. Pathogenesis:	It is generally due to failure of urate excretion (renal failure).	It is probably due to a metabolic defect in the secretion of urates by the kidney tubules.
8. Causes:	<ol style="list-style-type: none"> 1. Dehydration. 2. Nephrotoxicity: calcium, mycotoxins, (ochratoxins, oosporein, aflatoxins, <i>etc.</i>), certain antibiotics, heavy metals (lead), ethylene glycol, ethoxyquin <i>etc.</i> 3. Infectious agents: nephrotropic IBV and avian nephritis virus (chickens), polyomavirus, PMV-1 (pigeons), Salmonella sp., Yersinia sp., Chlamydia psittaci, Eimeria truncata, microsporidia, cryptosporidia, Aspergillus sp., <i>etc.</i> 4. Vitamin A deficiency 5. Urolithiasis 6. Neoplasia (lymphoma, primary renal tumors) 8. Immune mediated glomerulonephritis 9. Anomalies 10. Others? 	<ol style="list-style-type: none"> a. Genetics. b. High protein in the diet. c. Others?

Ref: Shivaprasad, H. L. An overview of anatomy, physiology and pathology of urinary system in birds, AAV Proceedings, pp. 201-205, 1998