Lect.7 Classification of Animal Viruses

RNA Viruses Families

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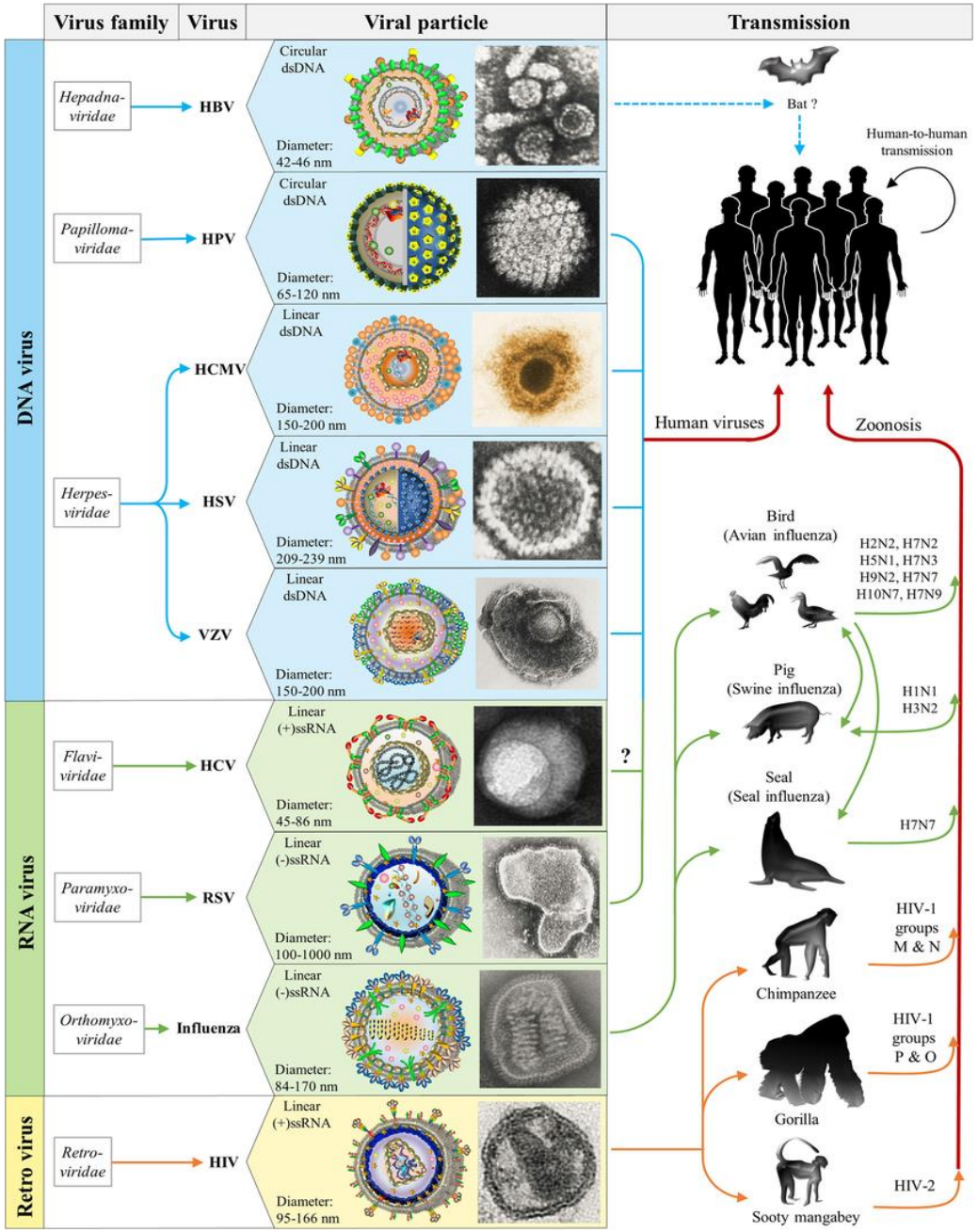


Classification of Animal Viruses:

Animal viruses can be classified into two families according to the following characters:

A-Characters of viral nucleic acid (N.A):

1. Type of N.A if it is DNA or RNA.

2. Shape of N.A strand if it is ring or straight, single or double strand, segmented or not

3. Molecular weight (size &diameter of N.A).

4. Replication site of N.A if it is in the cytoplasm or nucleus of infected cells.

5. Presence of transcriptase enzyme.

B- Characters of viral capsid:

1. Shape & size of capsid.

2. Symmetry of capsid with N.A (Helical, Cubical, Binal, Complex).

3. Site of capsid assembly inside the infected cells.

4. Lipid solvent sensitivity.

5. Number of capsomeres which consisting the capsid.

According to all above characters recently animal viruses classified into two major groups which are RNA group & DNA group as following:

This lecture deals with:

Classification of Animal Viruses

RNA Viruses families:

I. **Picornaviridae**
II. **Orthomyxoviridae**
III. **Paramyxoviridae**
IV. **Reoviridae**
IV. **Retroviridae.**
V. **Birnaviridae**
VI. **Rhabdoviridae.**

RNA Viruses Families:

I. Picornaviridae :- Pico = small in size.

General characters:

1. **Virions are nonenveloped, <30 nm in diameter and have icosahedral symmetry.**
2. **Replicate in cytoplasm.**
3. **Resistant to many organic solvents (ether, chloroform).**
4. **The genome consists of a single molecule of linear, positive-sense, single-stranded RNA, 78.8 kb in size.**
5. **Individual members differ in their susceptibility to pH change.**
6. **Genomic RNA is infectious(The viral RNA is infectious and serves as a template for replication and as mRNA**

Genera of Picornaviridae:

Viruses of veterinary importance in five genera of the family Picornaviridae:

1.General characters :

- **It is a highly infectious, gains access to the animal domestic cloven-hoofed and many wild animals through the mucosal epithelium, viremia ensues.(Infectious diseases are diseases caused by microorganisms. such as bacteria, viruses, fungi, or parasites. They can sometimes be caught from other people, the environment, from animal contact, or from insect bites)**
- **the virus localizes to epithelial sites throughout the body.**
- **Lesions are most evident in the oral mucosa and feet.**
- **Necrotizing myocarditis has been reported to affect primarily young animals.**
- **Immunity conferred by infection is fairly short-lived (a few years), and cross-protection against other strains is poor.**

Aphthovirus or Foot and mouth disease(FMD virus) :

1. Genus Aphthovirus:

7 serological types: Seven serotypes of foot-and-mouth disease virus have been identified by cross-protection and serologic tests, they are designated : Type A , O, C, South African Territories (SAT) 1,South African Territories (SAT) 2,South African Territories (SAT) 3,and Asia 1. more than 60 subtypes that vary in virulence and species specificity.

b) Animal Transmission:

1. **Respiratory aerosols. is through Inhalation of droplets, 2) Inoculation with contaminated vaccines. 3) Insemination with contaminated semen. 4) Contact with contaminated clothing,veterinary instruments.**

c) Clinical signs :

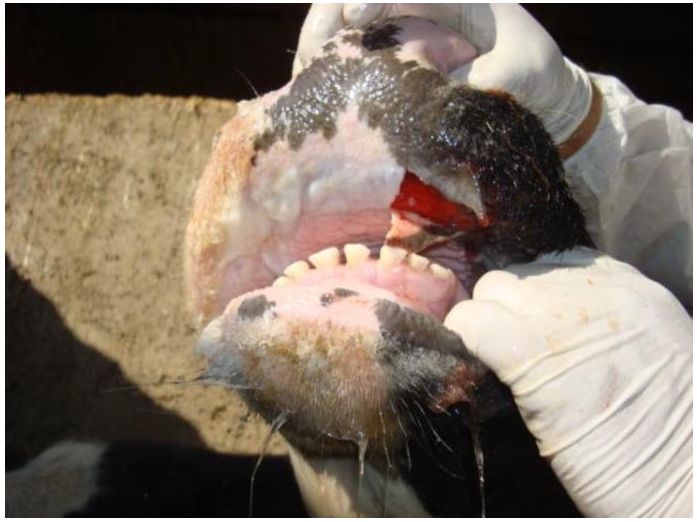
1)Incubation period: 2 to 14 days. 2)Fever and vesicles in Feet, mouth, nares, muzzle, teats, Progress to erosions. 3)Lameness(unwillingness to move, sloughing of hooves. 4) Abortion. 5) Death in young animals. **In cattle: roughly 11 days after vesicle formation. Vesicles on the feet take longer to heal and are susceptible to bacterial infection leading to chronic lameness. Secondary bacterial mastitis is common due to infected teat vesicles resulting in resistance to milking. Young calves may die without prior clinical signs of illness because of virus-induced damage to the developing myocardium.**

d) Diagnosis:

1. Samples should include vesicular fluid, epithelial tissue from the edge of recently ruptured vesicles, blood (in anticoagulant), milk, and serum.
2. Serum neutralization,Complement fixation test, ELSA, Viral isolation, PCR(Polymerase chain reaction)

e) Prevention and Control

Movement of animals and animal products from endemic areas is regulated. Vaccination, quarantine and slaughter are practiced in outbreaks in endemic areas.



Lesions in mouth, including ruptured vesicles and necrotic membrane in hard palate

Separation of horn tissue in a case of FMD

2. **Enterovirus:** **A) Avian enterovirus cause avian encephalomyelitis (Encephalomyelitis is inflammation of the brain and spinal cord) and nephritis in chickens.** **B) Bovine entero viruses Most cattle show no clinical signs when infected with the virus. However abortion, stillbirth, infertility, and neonatal mortality can occur following infection of the reproductive tract**. Enteric signs include diarrhea and weight loss, and respiratory infection can produce a mucoid nasal discharge. C) **Swine vesicular disease virus.**

3.Cardiovirus: Encephalomyocarditis in Rodents.

4. **Hepatovirus**: Avian encephalomyelitis-like virus.

5. **Teschovirus** encephalomyelitis (previously Teschen/Talfan diseases, and later enterovirus encephalomyelitis) is **an acute condition of pigs characterised by central nervous system (CNS) disorders**

II. Orthomyxoviridae:- Orthomyxo = Classical mucous

General characters

1. **Orthomyxoviruses have enveloped virions (virus particles) that measure between 80 and 120 nm (1 nm = 10−9 metre) in diameter.**
2. **The nucleocapsid, which consists of a protein shell, or capsid, and contains the viral nucleic acids, has helical symmetry.**
3. **The orthomyxovirus genome contains six to eight segments(10-14.6 kb in overall size) of single-stranded negative-sense RNA, and an endogenous RNA polymerase is present for the transcription of the negative-sense strand into a positive-sense strand to enable protein synthesis.**
4. **Genome is segmented facilitating genetic reassortment.**

- **The lipoprotein envelope of the virion contains two glycoproteins: Hemagglutinin glycoprotein (HA) (major antigen) has rod shaped, consisting of homotrimers (three different macromolecules) are responsible for virus attachment and envelope fusion.**
- **The neuraminidase protein(NA) has mushroom shaped, consisting of homotetramers(have four identical subunits) capable of cleaving viral receptors & promoting both entry of virus into cells & release of virions from infected cells.**

Genera of Orthomyxoviridae:-

Six genera: Influenzavirus A, Influenzavirus B, Influenzavirus C, Thogotovirus, Isavirus, and Quaranjavirus

The main genra are:

1. **Influenza type A. This type includes influenza A viruses of human and also widespread in animals, particularly aquatic birds, chickens, ducks, pigs, horses, and seals. Influenza type A is responsible for pandemic and for most cases of epidemic influenza (antigenically highly variable).**

- **Influenza A viruses are divided into subtypes based on two proteins on the surface of the virus: hemagglutinin (H) and neuraminidase (N).**
- **There are 18 different hemagglutinin subtypes and 11 different neuraminidase subtypes (H1 through H18 and N1 through N11, respectively). While more than 130 influenza A subtype combinations have been identified in nature, primarily from wild birds,**

Epidemic: is defined as an outbreak of a contagious disease that is rapid and widespread, affecting many individuals at the same time.(able to be passed from one individual to another through contact

A pandemic: is an epidemic that becomes so widespread that it affects a region, continent, or the world.

2. **Influenza type B:** This type includes influenza B viruses which are mainly found in humans. Influenza type B may exhibit antigenic changes and sometimes causes epidemics.
3. **Influenza type C :**This type includes influenza C viruses of human and swine. Influenza type C is antigenically stable.

Genetic variation in influenza viruses.

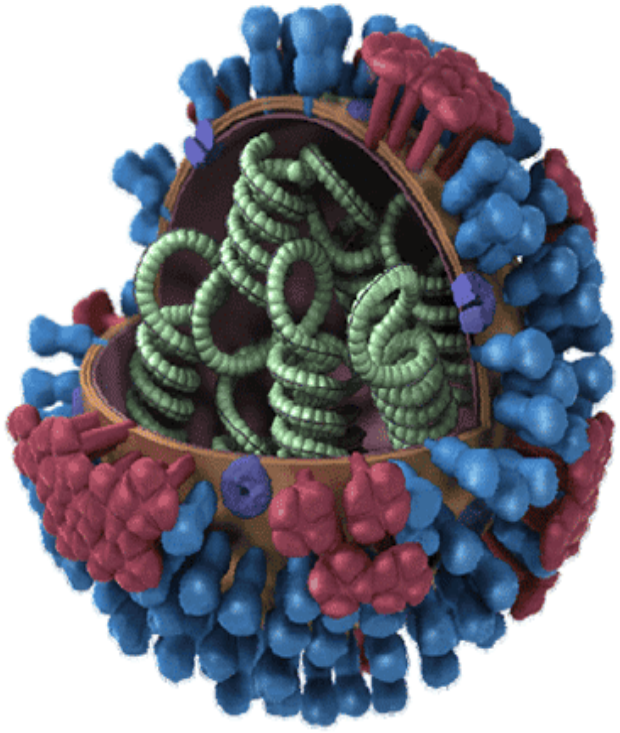
A. Events leading to different subtypes:

- **Reassortment or Antigenic shift: Major antigenic changes in one or both surface glycoproteins (HA and/ or NA) in influenza A viruses. This can occur when two influenza viruses infect a host at the same time and swap genetic information**
- **This results completely in new viruses having surface antigens different from the antigens of the old viruses circulating in the population ,**

Every 10-40 years when a new subtype of influenza A appears, a pandemic results.

- This happened in : 1918 H1N1 (Spanish flu), 1957 H2N2 (Asian flu) , 1968 H3N2 (Hong Kong flu) , 1977 H1N1 (Russian flu). **2013** Asian-lineage avian influenza A (H7N9) virus ("Asian H7N9") in China.

B. Events leading to variation within subtypes by **Antigenic drift : These are small changes (or mutations) in the genes of viruses that can lead to changes in the surface proteins of the virus,** which means they are recognized by the immune system and are capable of triggering an immune response, including production of antibodies that can block infection. The changes associated with antigenic drift happen continually over time as the virus replicates

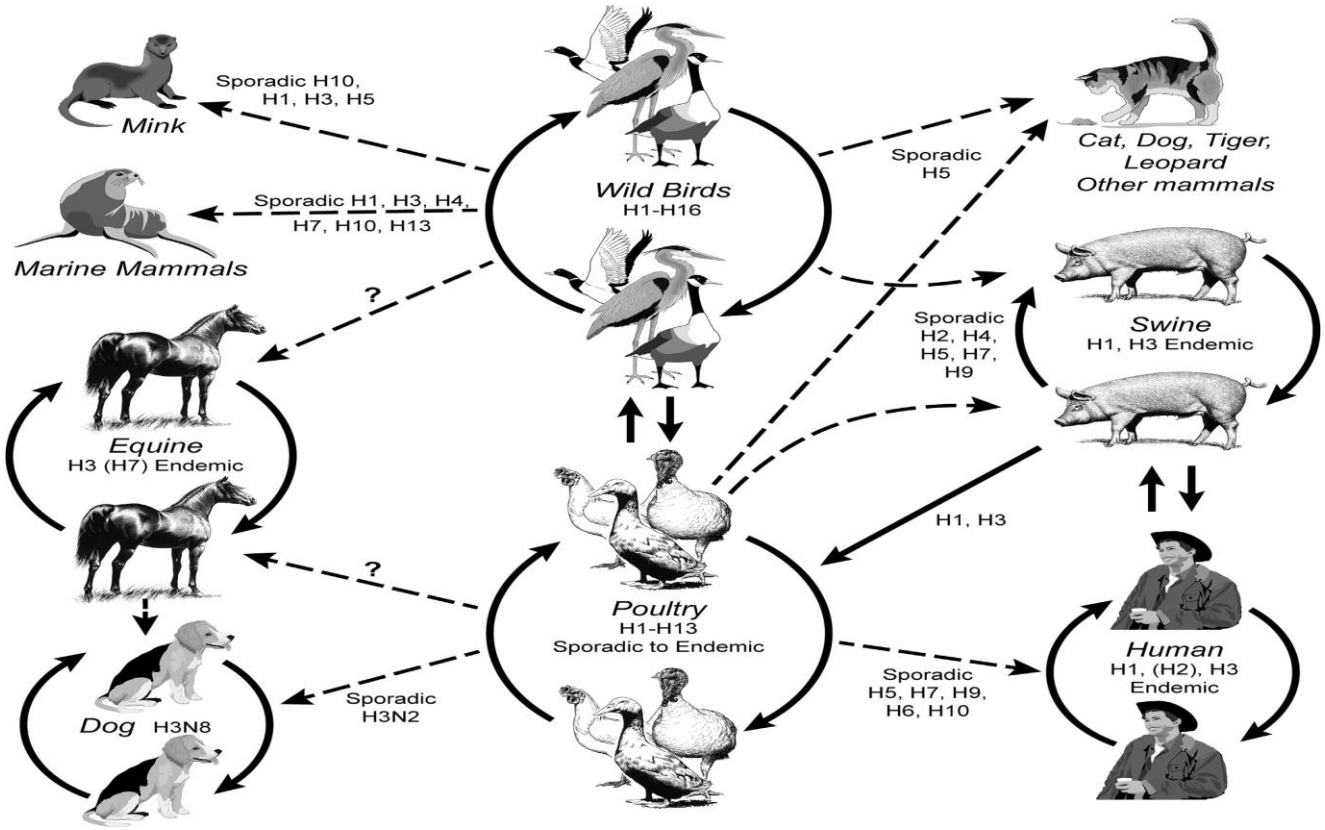


Hemagglutinin- protein the virus uses to attach to the host cells

Neuraminidase- enables the virus to be released from the host cell

M2 Ion Channel- allows protons to move through the viral envelope and is essential for the virus replication process

RNP- Ribonucleoprotein containing the virus RNA genome



Interspecies transmission of influenza A viruses. Diagrammatic representation of the source and movement of influenza A viruses or their genes within avian and mammalian ecological and epidemiological situations

Avian influenza (AI)

Avian influenza (AI) viruses infect domestic poultry as well as pet, zoo, and wild birds. In domestic poultry, AI viruses are typically of low pathogenicity (LP), causing subclinical infections, respiratory disease, or drops in egg production. However, a few AI viruses cause severe systemic infections with high mortality. This highly pathogenic (HP) form of the disease has historically been called fowl plague .

i. Etiology

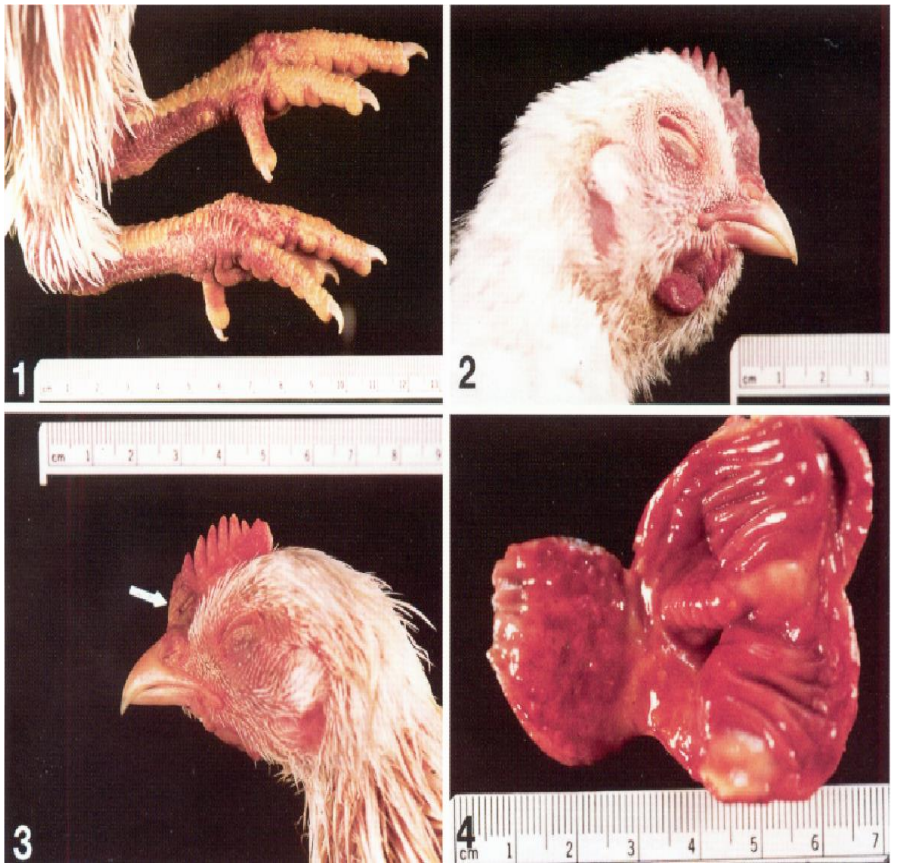
AI viruses are type A orthomyxoviruses characterized by antigenically homologous nucleoprotein and matrix internal proteins,

AI viruses are further divided into 16 hemagglutinin (H1-16) and 9 neuraminidase (N1-9) subtypes based on hemagglutinin inhibition and neuraminidase inhibition tests, respectively. Most AI viruses (H1-16 subtypes) are of low pathogenicity, but some of the H5 and H7 AI viruses are highly pathogenic for chickens, turkeys, and related gallinaceous domestic poultry.

ii. Transmission: by Fecal oral route water

iii. Clinical Findings

Clinical signs, severity of disease, and mortality rates vary depending on AI virus strain and host species.



Leg, 4-week-old chicken Severe subcutaneous suffusive hemorrhage of leg shanks.

Low Pathogenicity Avian Influenza Viruses:

1)Sub clinical infection

2)respiratory signs such as sneezing, coughing, ocular and nasal discharge, and swollen infraorbital sinuses in poultry.

3)decreased egg production or fertility.

High Pathogenicity Avian Influenza Viruses:

HP AI viruses cause severe, systemic disease with high mortality in chickens, turkeys, and other gallinaceous poultry.

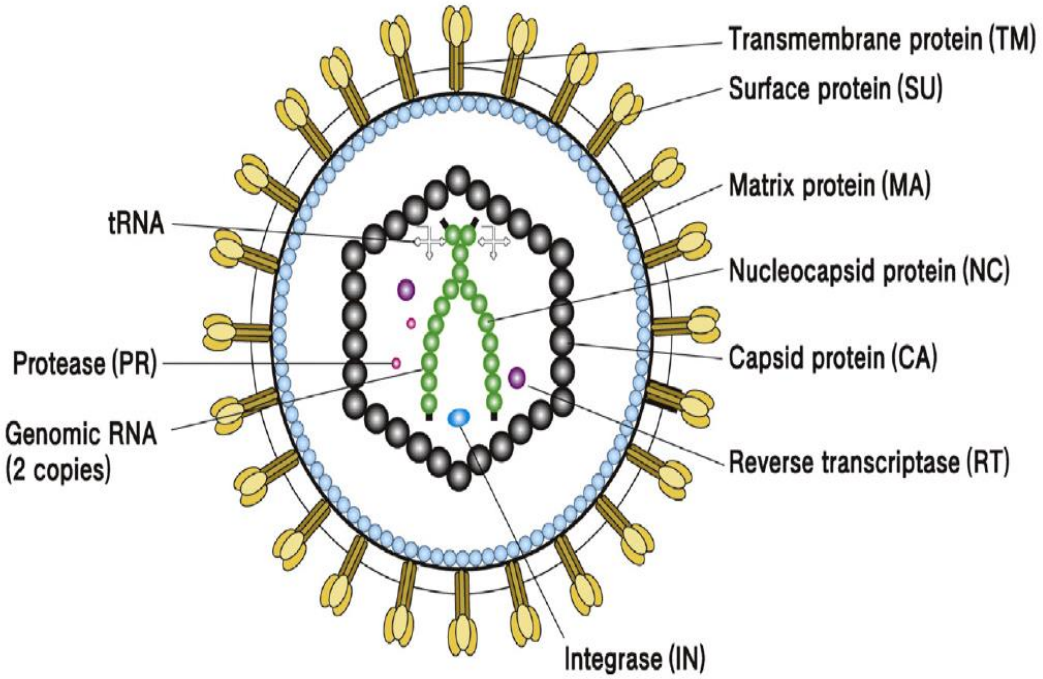
1. Mortality can be as high as 100% in a few days.
2. In peracute cases, clinical signs or gross lesions may be lacking before death.
3. However, in acute cases, lesions may include cyanosis and edema of the head, comb, wattle, and snood (turkey); cyanosis refers to a bluish-purple hue to the skin
4. Edema and red discoloration of the shanks (A chicken's shank is the bottom part of her leg, above the foot, but below the hock) and feet due to subcutaneous ecchymotic hemorrhages; (form when blood vessels near the surface of the skin are damaged)
5. Petechial hemorrhages on visceral organs and in muscles;(pinpoint red or brown macules of the skin. The soft internal organs of the body, including the lungs, the heart, and the organs of the digestive, excretory, reproductive, and circulatory systems
6. Blood-tinged oral and nasal discharges.
7. In severely affected birds, greenish diarrhea is common.

Retroviridae:-Reverse transcriptase

Retroviruses infect a wide variety of animal species including mammals, reptiles, birds, and fish; these viruses are associated with many economically important diseases. Retrovirus infections are typically narrowed to a single host species (host-adapted).

1. **Retroviruses (family Retroviridae) are enveloped (about 100 nm in diameter) and icosahedral viruses**
2. **The genome of retroviruses is unique in being comprised of two 7-12 kbp copies of positive-sense RNA that makes retroviruses effectively diploid.**
3. **Most members of this family possessing a reverse transcriptase which transcribes Viral RNA to double-stranded DNA and Mutation and recombination occur with high frequency.**
4. **Retroviruses are divided into two classes: simple retrovirus and complex retrovirus (ie, lentivirus or HIV)**:

5. The simple retroviruses encode three polyproteins, termed Gag (matrix (MA), capsid (CA), and nucleocapsid (NC)), Pol (the reverse transcriptase (RT) and integrase enzyme functions) , and Env (the antigenic surface glycoproteins (SU) and transmembrane protein (TM)). complex retroviruses encode six accessory proteins, in addition to the polyproteins.



The virion structure of retrovirus. Two envelope glycoproteins (SU and TM) are found in the viral envelope, in which SU is attached to TM by a disulfide bond. An icosahedral capsid (CA) is found inside of the viral envelope. Two RNA genomes encapsidated by nucleocapsid protein (NC) are found inside the capsid. Two tRNA molecules attached to the viral RNAs are indicated.

Replication

1. The first step of replication is the binding of the glycoprotein to the receptor protein of the host cell.
2. Once these have been bound, the cell membrane degrades and the RNA strands and enzymes enter the cell.
3. Within the cell, reverse transcriptase creates a complementary strand of DNA from the retrovirus RNA and the RNA is degraded; this strand of DNA is known as cDNA.
4. The cDNA is then replicated, and the two strands form a weak bond and enter the nucleus.
5. Once in the nucleus, the DNA is integrated into the host cell's DNA with the help of integrase.
6. This cell can either stay dormant(inactive), or RNA may be synthesized from the DNA and used to create the proteins for a new retrovirus.
7. Ribosome units are used to transcribe the mRNA of the virus into the amino acid sequences which can be made into proteins in the rough endoplasmic reticulum. This step will also make viral enzymes and capsid proteins.
8. Viral RNA will be made in the nucleus. These pieces are then gathered together and are pinched off of the cell membrane as a new retrovirus.

Genera of Retroviridae:

1. **Alpha retrovirus causing : avian leucosis and avian sarcoma**.
2. Beta retrovirus: mouse mammary tumor virus.
3. Gamma retrovirus: feline leukemia feline sarcoma. affecting domestic cats worldwide;
4. Delta retrovirus: bovine leukemia.
5. Epsilon retrovirus: fish tumor virus.
6. Retroviruses infect cells that mediate the immune response:

a) Human immunodeficiency virus 1,2 HIV (AIDS)

b) Equine infectious anemia virus.

c) Feline immunodeficiency virus.

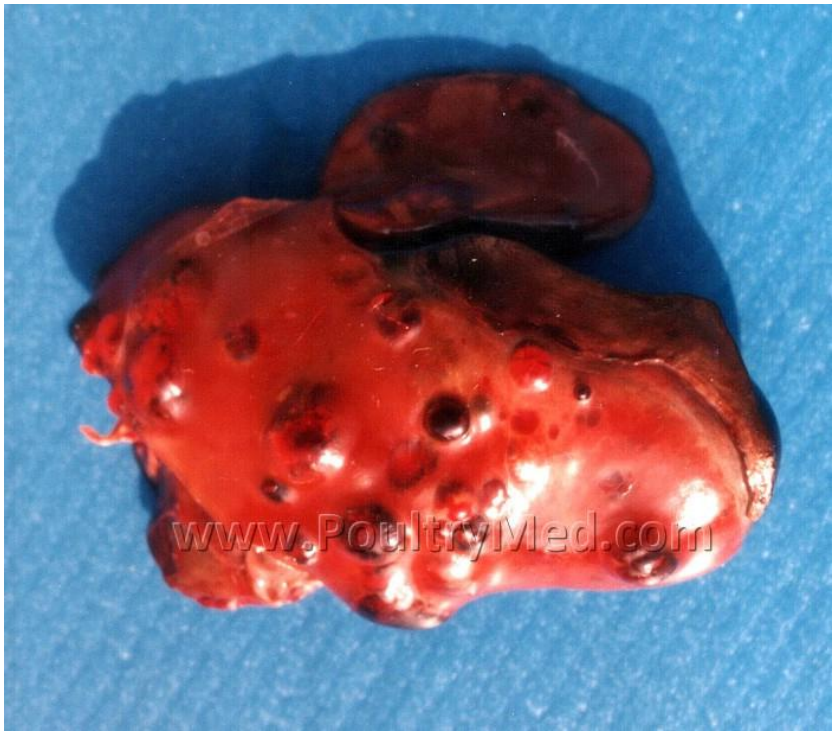
d) Bovine immunodeficiency virus.

Avian leucosis:

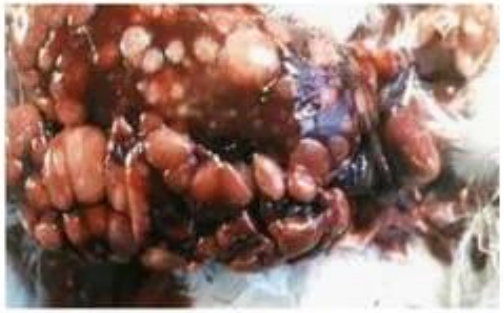
- **leukosis/sarcoma group or historically called avian leukosis complex viruses (ALV).**

In the first part of the 20th century, infections with avian leukosis virus caused great economic losses to the poultry industry. Tumors resulting from avian leukosis/sarcoma virus infections were the first virus-induced tumors to be identified in any species.

- **(ALV) induces bursal lymphomas after a long latent period. These tumors develop within the follicles of the bursa of Fabricius**, a specialized organ required for normal B lymphocyte differentiation, and are clonal in nature.
- They subsequently metastasize into the viscera intestines, gut, bowels, resulting in the death of the chicken.
- lymphoid leukosis has been the most common form of the leukosis/sarcoma group of diseases seen in chicken flocks.



The internal organs of a chicken affected by lymphoid leukosis



Etiology:

On the basis in their viral envelope glycoproteins, which determine antigenicity , ALV are grouped into 10 subgroups designated A-J, of which chickens are the natural hosts for the subgroups A, B, C, D, E and J .

Transmission:

1. **Endogenous Transmission:**

Endogenous ALVs are permanently incorporated into the host cellular genome, do not produce virus copies, and are transmitted to progeny as the infected cells are passed to the offspring, i.e., genetic transmission.

2. **Exogenou Transmission: ALVs are transmitted as infectious virus particles.**

Exogenous ALV's are transmitted vertically or horizontally:

In vertically or Congenitally, from hen to progeny through the eggs . Eggs become contaminated with the virus within the oviduct leading to the infection of embryos during development. This route of congenital infection results in the birds becoming viremic carriers with shedding of virus in vaginal swabs, egg albumen, and embryos.

a) **In horizontally from hen to progeny through the egg and from bird to bird by direct or indirect contact.**

Clinical Findings

1. These may include inappetence, weakness, diarrhea, dehydration, and emaciation(Infected chickens become depressed before death).
2. Palpation often reveals an enlarged bursa and sometimes an enlarged liver. Infected birds may not necessarily develop tumors, but they may lay fewer eggs.
3. Diffuse or nodular lymphoid tumors are common in the liver, spleen, and bursa and are found occasionally in the kidneys, gonads, and mesentery.

Diagnosis:

1-Clinical signs . 2-virus isolation and PCR . 3- ELISA kits.

Bovine leukemia.

Contrary to the name, bovine leukemia virus is the irregular cause of solid lymphoid tumors in cattle and is generally not associated with leukemia.

Bovine leukemia virus (BLV): Bovine immunodeficiency virus (BIV) is a retrovirus belonging to the *Lentivirus* genus. It is similar to the *human immunodeficiency virus* (HIV) and infects cattle. The cells primarily infected are lymphocytes and monocytes/macrophages.

Transmission

1. BIV is spread through exchange of bodily fluids.
2. Transmission via colostrum, milk, and *in utero*.
3. Contaminated needles used in vaccinations

Clinical signs of bovine leukosis

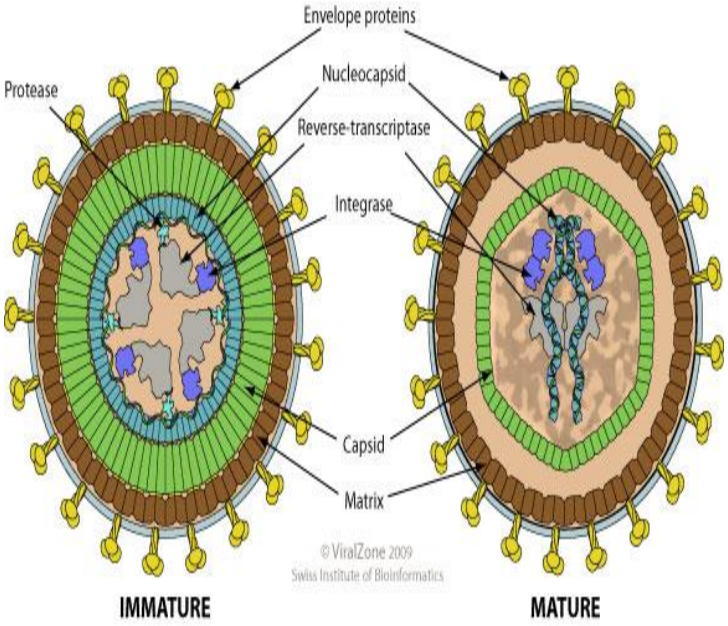
Enlargement of superficial lymph nodes, a digestive form, a cardiac form, a nervous form, a respiratory form, and others. Lymph node enlargement is often an early clinical sign.

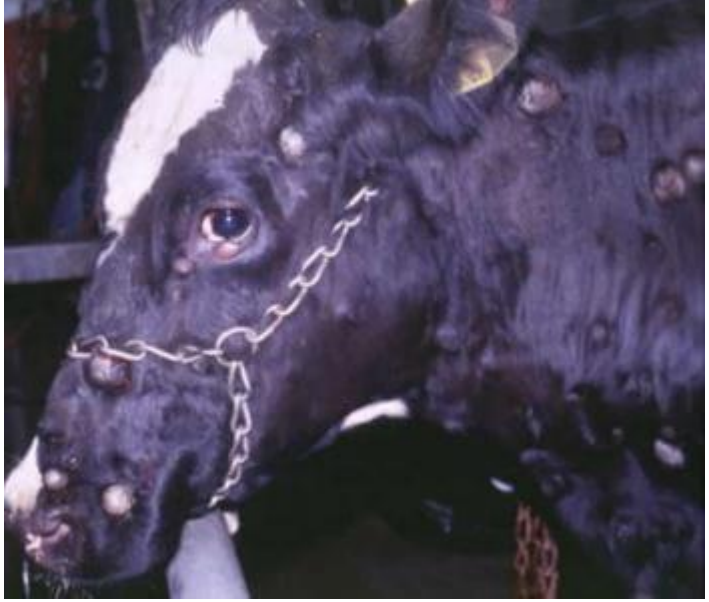
Diagnosis

1) clinical signs. 2) agar gel immunodiffusion, 3) ELISA and PCR. 4) Post-mortem findings are characteristic and include widespread white tumors in most organs.

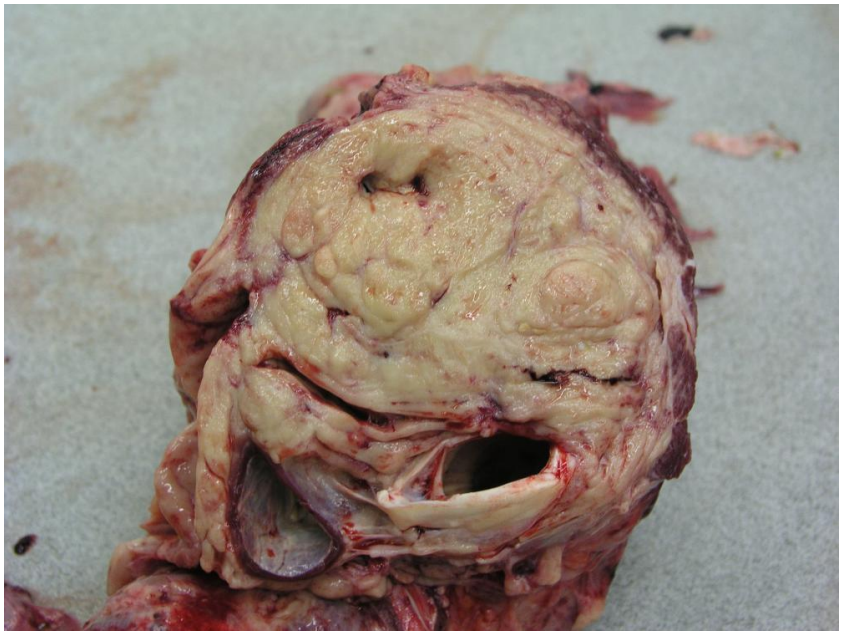
Treatment and vaccine:

1) No apparent treatment is available for the disease. 2) attenuated provirus vaccine for bovine.





Enveloped. Spherical to pleomorphic, about 80-100 nm in diameter.



Gross specimen: thymic lymphosarcoma in a cow. Ventral is down in this image; the trachea is seen on cross section at 6:00.

Birnaviridae:- Bi-RNA

General characters:

a. Double stranded RNA icosahedral symmetry.

b. Virions are 60 nm in diameter.

c. Virions stable over a wide pH range and 60 C° for 1 hour, resistant to ether and chloroform (Fig.4)

Genera of Birnaviridae:

1. Avibirna virus: - infectious bursal disease (Gumboro).
2. Aquabirna virus: - infectious pancreatic necrosis in salmonids (fish).
3. Entomobirna virus: - infect insects.

Infectious bursal disease (Gumboro).

Infectious bursal disease (IBD) is a viral disease infected domestic chickens. Characterized by present clinical or subclinical disease, but immune suppression and related secondary infections are typically seen. Severity of the immune suppression depends on the virulence of the infecting virus and age of the host.

Etiology

IBD is caused by avibirnavirus that is most readily isolated from the bursa of Fabricius but may be isolated from other organs.

Two serotypes of IBDV have been identified.

1. **Serotype 1 viruses cause disease in chickens and, within them, antigenic variation can exist between strains.** Antigenic drift is largely responsible for this antigenic variation, but antigenic differences can also occur through genome homologous recombination.
2. **Serotype 2 strains of the virus infect chickens and turkeys but have not caused clinical disease or immunosuppression in these hosts.**

Transmission

1-feces . 2-transferred from house to house by fomites(objects or materials which are likely to carry infection, such as clothes, utensils, and furniture)

Clinical Findings:

IBD is highly contagious; results of infection depend on age and breed of chicken and virulence of the virus.

Infections may be subclinical or clinical.

Chickens are most susceptible to clinical disease at 3–6 weeks of age when immature B cells populate the bursa and maternal immunity has decreased.

1. **In clinical infections, beginning of the disease occurs after an incubation of 3–4 days. Chickens may exhibit severe prostration, incoordination, watery diarrhea, and inflammation of the cloaca.**
2. **Subclinical infections before 3 weeks of age are usually subclinical. subclinical disease has no or minimally recognizable clinical findings.**
3. **Severe infections have occurred in Leghorn chickens up to 18 weeks of age.They cause severe, long-lasting immunosuppression due to destruction of immature lymphocytes in the bursa of Fabricius, thymus, and spleen. The humoral (B cell) immune response is most severely affected; Immunosuppression is a reduction of the activation or efficacy of the immune system.**

Diagnosis:

1) clinical signs. 2) Viral isolation. 3) PCR to identify the viral genome in bursa tissue. 4) Titration of the virus and virus-neutralization assays.

Control : Live vaccines of chicken embryo can be administered by eye drop, drinking water, or SC routes at 1–21 days of age 2-oil-adjuvanted, inactivated vaccine.

Rhabdoviridae:- Rod

General characters:

a. **Have characteristic rod shapes and bullet-shaped in vertebrates .**

b. Enveloped RNA viruses with helical symmetry.

c. Virions size (100-430 nm).

d. Stable in the pH range of 5- 10.

e. Rapidly inactivated by heating at 56 C°.

f. Sensitive to lipid solvents and UV light.

Genera of Rhabdoviridae:

1. Lyssavirus:Rabies virus .
2. Ephemero virus:Bovine ephemeral fever virus.
3. Vesiculovirus: vesicular stomatitis virus.

Rabies virus

Rabies virus is a neurotropic virus that causes rabies in humans and animals.

Transmission

1. **Usually the bite or scratch of an infected animal, which introduces the virus through the skin or mucous membrane. .**
2. **Aerosol transmission from an infected animal, usually a bat.**
3. **Tissue transplants (such as corneas) from infected humans.**

Clinical signs:

Most animals, the virus will spread through the nerves of the bitten animal towards the brain. The virus is relatively slow moving and the average time of incubation from exposure to brain involvement is between 3 to 8 weeks in dogs, 2 to 6 weeks in cats, and 3 to 6 weeks in people.

However, incubation periods as long as 6 months in dogs and 12 months in people have been reported.

After the virus reaches the brain it then will move to the salivary glands where it can be spread through a bite.

Diagnosis:

1. Clinical signs.
2. Microscopic examination.
3. Blood samples

Treatment

There is no treatment. Vaccination is the best way to prevent infection

After the virus reaches the brain the animal will show one, two, or all of the three different phases

I. Prodromal phase

The first phase is the prodromal phase and usually lasts for 2-3 days in dogs. Apprehension(fear,worry)
, nervousness, anxiety, solitude (isolation) the state or situation of being alone.
, and a fever may be noted. Friendly animals may become shy or irritable and may snap, whereas, aggressive animals may become affectionate and docile.

II. Furious phase

From the prodromal phase, animals may enter the furious stage; cats are particularly prone to developing this phase. The furious stage (angry) of the disease in dogs usually lasts for 1 to 7 days. Animals become restless and irritable and are hyperresponsive to auditory and visual stimuli. As they become more restless, they begin to roam and become more irritable and vicious. When caged, dogs may bite and attack their enclosures. Animals progress to become disoriented and then have seizures and eventually die.

III.Aralytic (dumb) phase

Animals may develop the paralytic phase either after the prodromal or furious stage. The paralytic phase usually develops within 2 to 4 days after the first signs are noted. Nerves affecting the head and throat are the first to be involved and animals may begin to salivate as a result of their inability to swallow.

Deep labored breathing and a dropped jaw may result as the diaphragm and facial muscles become increasingly paralyzed. Animals may make a choking sound and many owners think that there is something lodged in the dog's throat. The animal will get weaker and eventually go into *respiratory* failure and die.