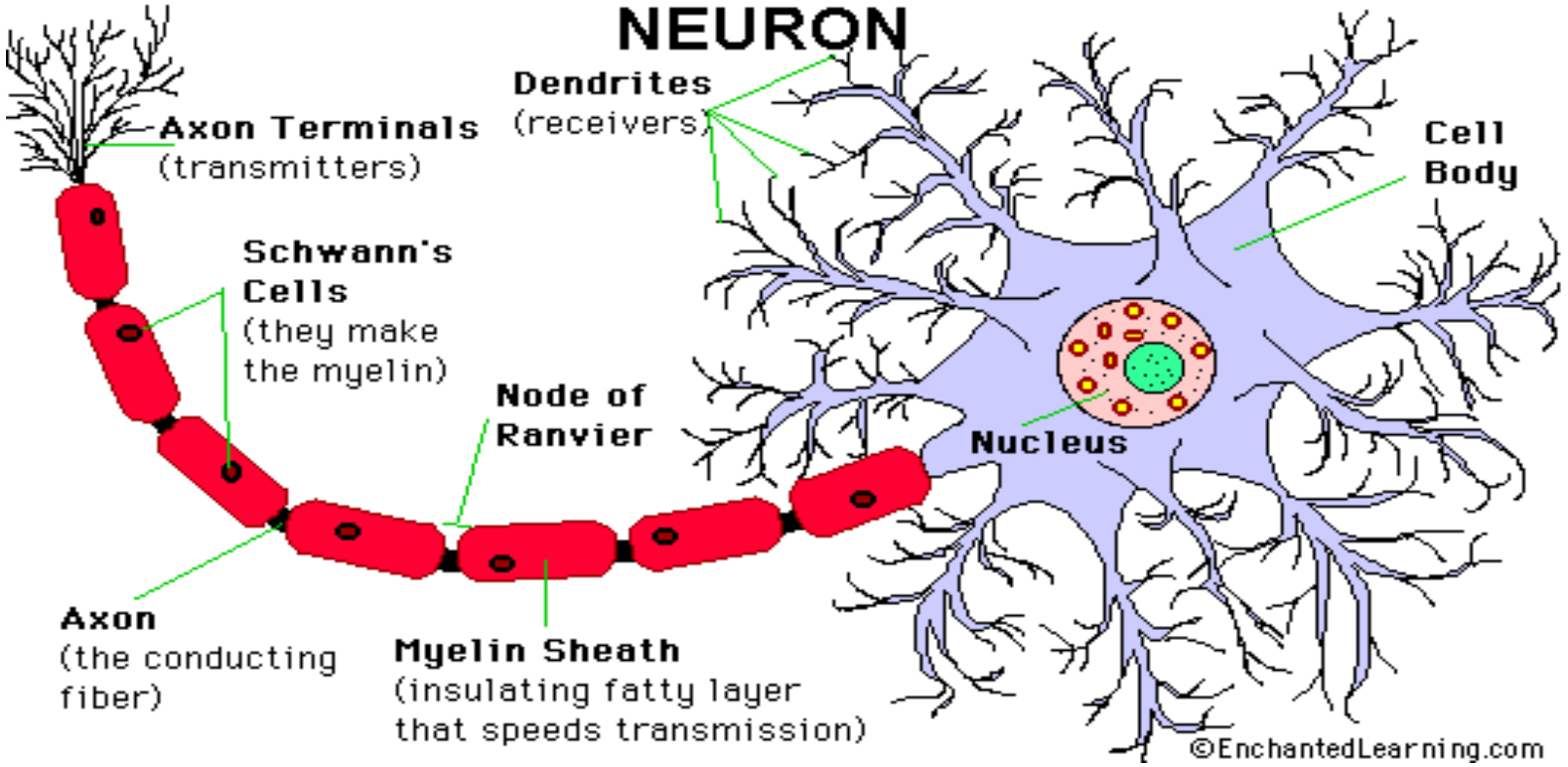
# NERVOUS SYSTEM

- The **nervous system** is an organ system containing a network of specialized cells called neurons that coordinate the actions of an animal and transmit signals between different parts of its body.

- In most animals the nervous system consists of two parts, central and peripheral.

- The nervous system is primarily made up of two categories of cells: **neurons and glial cells.**
- **Neurons** -most fundamental property is that they communicate with other cells via synapses
- Synapses are membrane-to-membrane junctions containing molecular machinery that allows rapid transmission of signals, either electrical or chemical.
- Neurons possess an **axon**, a protoplasmic protrusion that can extend to distant parts of the body and make thousands of synaptic contacts.
- Axons frequently travel through the body in bundles called nerves.


NEURON
Dendrites
(receivers)
Axon Terminals
(transmitters)
Cell
Body
Schwann's
Cells
(they make
the myelin)
Node of
Ranvier
Nucleus
Axon
(the conducting
fiber)
Myelin Sheath
(insulating fatty layer
that speeds transmission)
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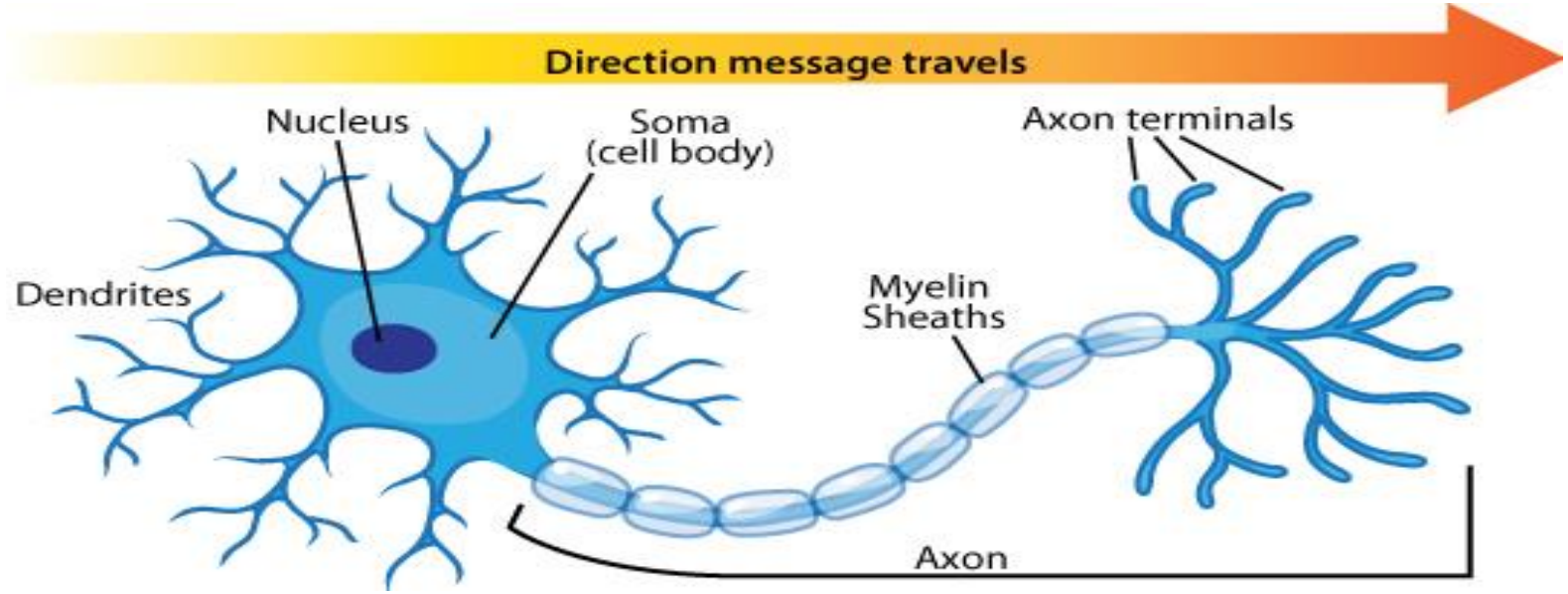
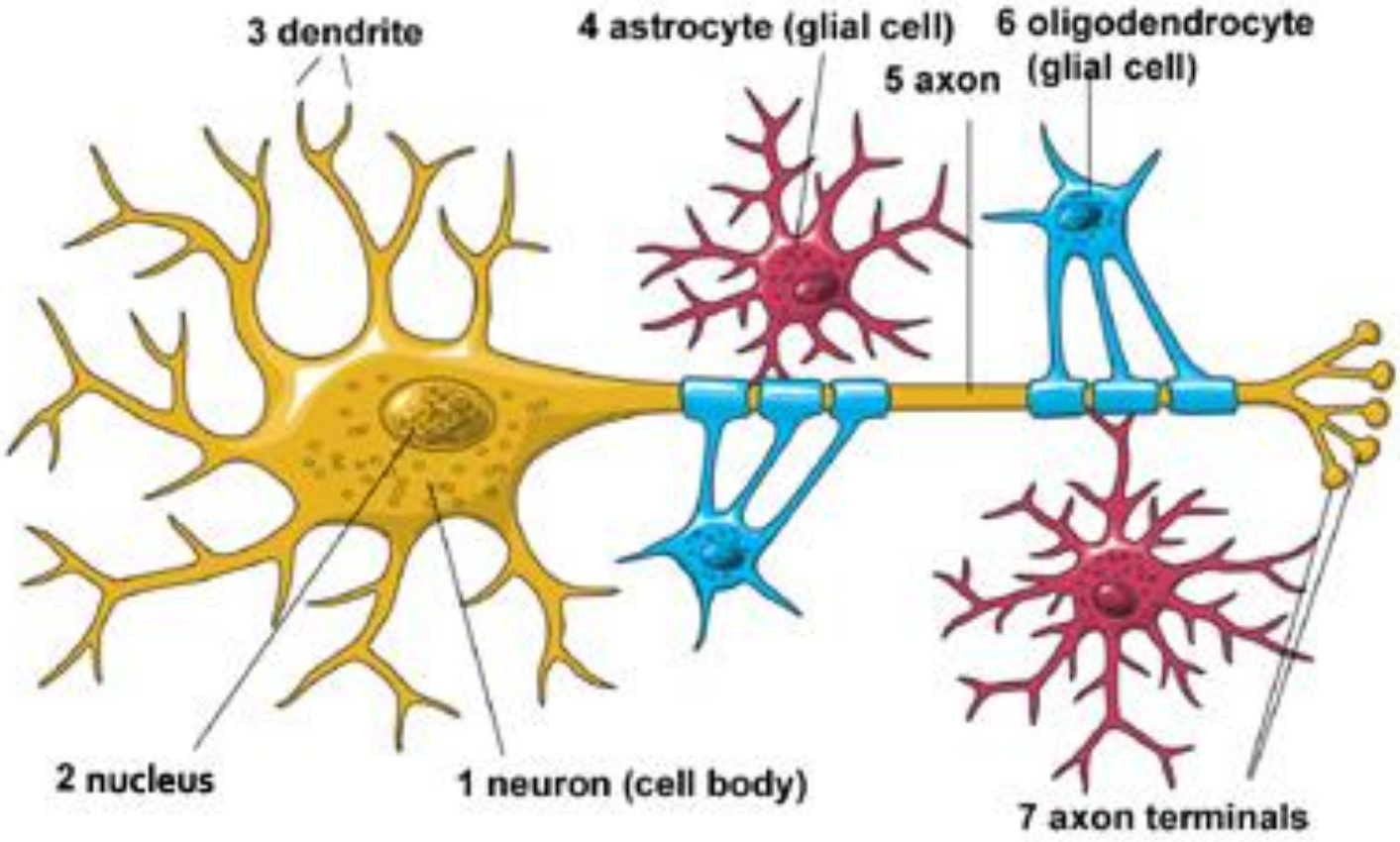

Direction message travels
Nucleus
Soma
(cell body)
Axon terminals
Dendrites
Myelin
Sheaths
Axon

**Glial cells**

**Non-neuronal cells that provide support and nutrition, maintain homeostasis, form myelin, and participate in signal transmission in the nervous system**

- Support neurons and hold them in place
- Supply nutrients to neurons
- Insulate neurons electrically
- Destroy pathogens and remove dead neurons
- Provide guidance cues directing the axons of neurons to their targets.
- Oligodendrocytes in the central nervous system, and schwaan cells in the peripheral nervous system generates layers of a fatty substance called myelin that wraps around axons and provides electrical insulation which allows them to transmit action potentials much more rapidly and efficiently.


3 dendrite
4 astrocyte (glial cell)
5 axon
6 oligodendrocyte (glial cell)
2 nucleus
1 neuron (cell body)
7 axon terminals

- **Loss of consciousness-** complete- coma

  - animal lies outstreched and motionless, reflexs are absent, pupils dilated, slow and irregular respiration, weak heart beat and cool skin.

- **Nervous depression-** results from pressure upon the brain (hemorrhage, brain tumor, collection of fluid within ventricles)

  - loss of feeling, sleepiness and muscular incoordination

- **Nervous excitement-** results from congestion and inflammation of the brain and its coverings.

  - delirium, mania, and even convulsions

- **Muscle spasm-** there are sudden violent involuntary contractions

  *Tonic*- when they are continuous

  *Clonic*- when intermittent

- **Tremors-** when spasms are mild and confined to groups of muscles

- **Convulsions-** when muscle spasms are widespread and involve the whole body, including the limbs

- **Epilepsy-** when tonic and clonic spasms alternate and are accompanied by loss of consciousness

- **Paralysis-** complete immobility of a muscle due to defective innervation
- **Paresis-** incomplete loss of motion due to defective innervation

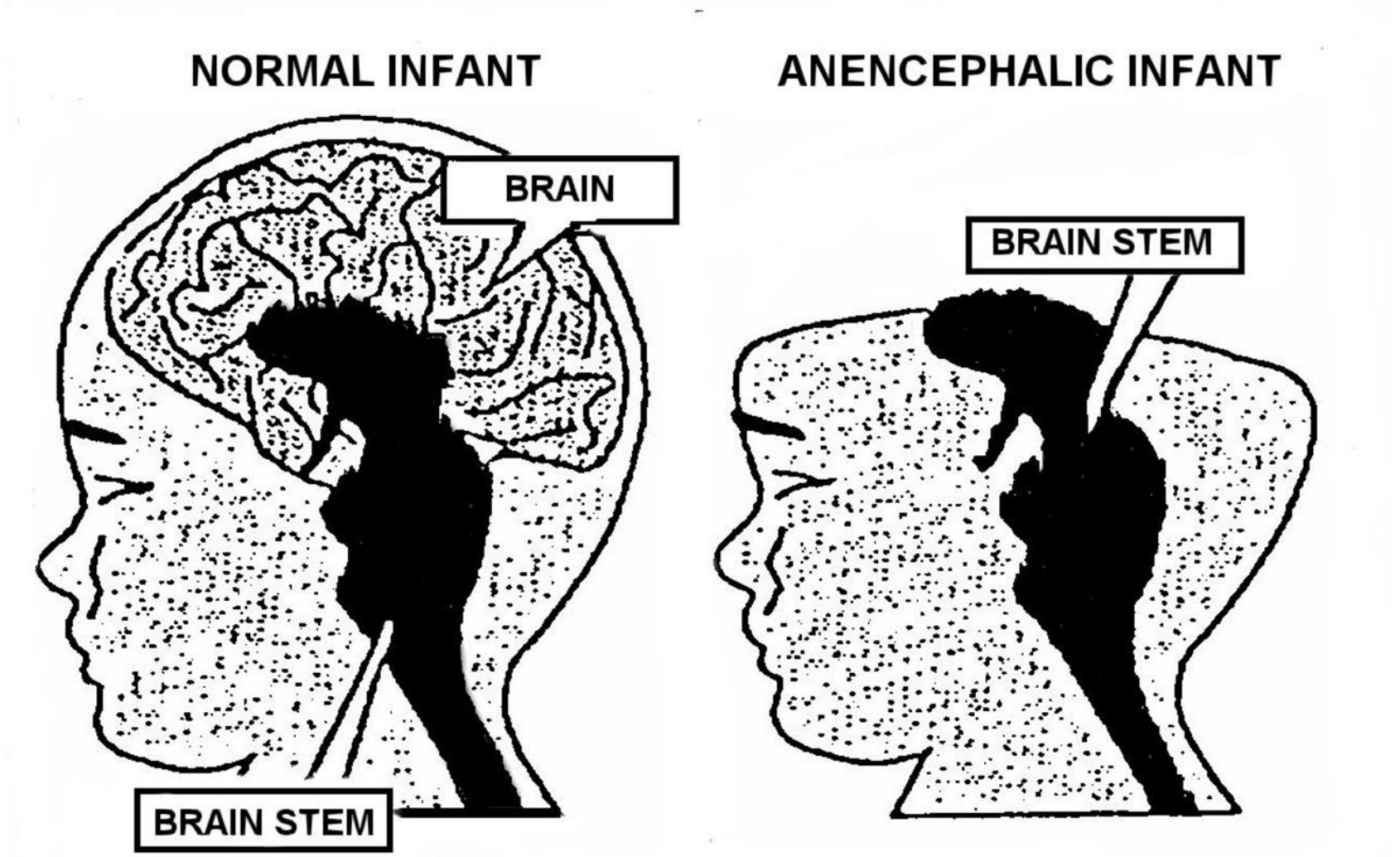
- **Hemiplegia-** paralysis arising in the brain cortex and in the peripheral nerves and is unilateral (paralysis of one side of the body)

- **Paraplegia-**bilateral paralysis of the posterior parts of the body and hind limbs resulting from injury to the spinal cord

# Congenital anomalies

# Anencephaly

- Absence of the brain
- In many cases only rostral part of the brain is absent or very rudimentary (prosencephalic hypoplasia)
- It occurs due to abnormal development of the rostral aspect of the neural tube.


NORMAL INFANT
BRAIN
BRAIN STEM
ANENCEPHALIC INFANT
BRAIN STEM

- **Acrania-** complete failure of development of cranium
- **Amyelia-** absence of spinal cord

- **Cranioschisis-** congenital fissure of the cranium
- **Encephalocele-** protrusion of meninges, alone or with part of the brain, through a defect in the cranium
- **Exencephalus-** absence of cranial vault exposing the fully developed brain
- **Microcephaly-** presence of an abnormally small brain

- **Meningocele-** hernia of the meninges, which protrude through an opening of the skull or spinal column
- **Rachicele-** hernia of the spinal cord

# Cranium bifidum

- Midline cranial defect through which meninges & brain may protude
- Protruded material forms a sac & is covered by skin
- If lined by meninges- meningocele
- Meninges accompanied by a part of the brain- meningo-encephalocele

# Spinal bifida

- Myeloschisis & Rachischisis
- Spinal counter part of cranium bifidum
- Congenital defect in the dorsal spinal column (lack of union between the laminae of the vertebrae)
- Reported in horses, calves, sheep, dogs, & cats
- Lesions result from defective closure of neural tube.
- If there is no herniation- Spina bifida occulta
- Herniation of only meninges- Meningocele
- Herniation of both meninges & spinal cord- meningo-myelocele

# Hydrocephalus

- “hydro”- water and “cephalus” - head
- it is a condition in which there is excessive accumulation of fluid in the brain.
- This results in an abnormal dilatation of the spaces in the brain called ventricles.
- This dilatation causes potentially harmful pressure on the tissue of the brain.

# Types of hydrocephalus

- **Congenital hydrocephalus** - present at birth, and may be caused be either environmental influences during fetal development or genetic predisposition.
- -e.g. vitamin A deficiency during intrauterine life may cause internal hydrocephalus in calves and pigs

- **Acquired hydrocephalus** develops at the time of birth or at some point afterwards.

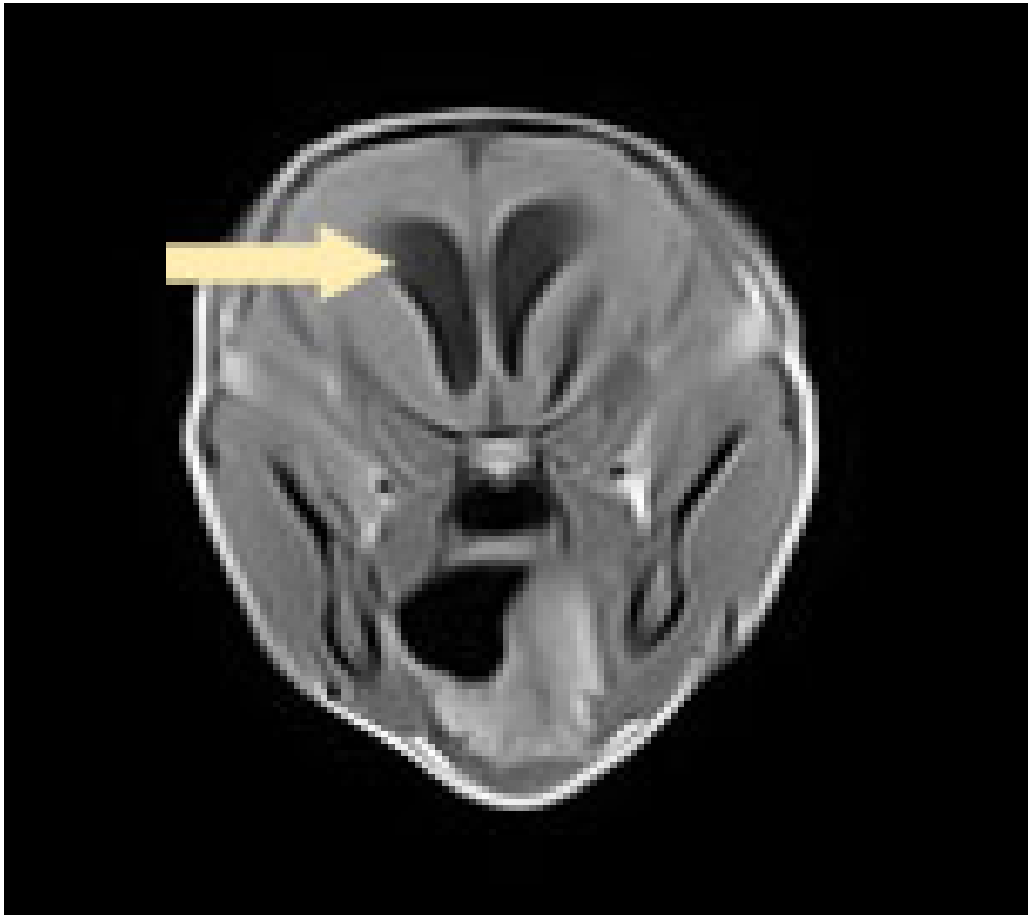
# Causes of Hydrocephalus

- Hydrocephalus results when the flow of CSF is disrupted when the animals body doesn't absorb it properly.
- **Function of CSF** - acts as a cushion for protection and transporting nutrients to the brain.
- Two main causes- obstructive and non-obstructive.

# Obstructive (non-communicating)

## Internal hydrocephalus

- This type of hydrocephalus results from an obstruction within the ventricular system of the brain that prevents CSF from flowing or “communicating” within the brain
- (at foramen of Monro, aqueduct of sylvius, foramina of Luschka)
- Obstruction may occur due to inflammation or neoplasm, cysts
- Enlargement proximal to the site of obstruction.
- Atrophy of adjoining nervous tissue



MRI which demonstrates dilation of the ventricles of the brain (arrow points to the left ventricle)

# Non-obstructive (communicating)

## External hydrocephalus

Less common form.

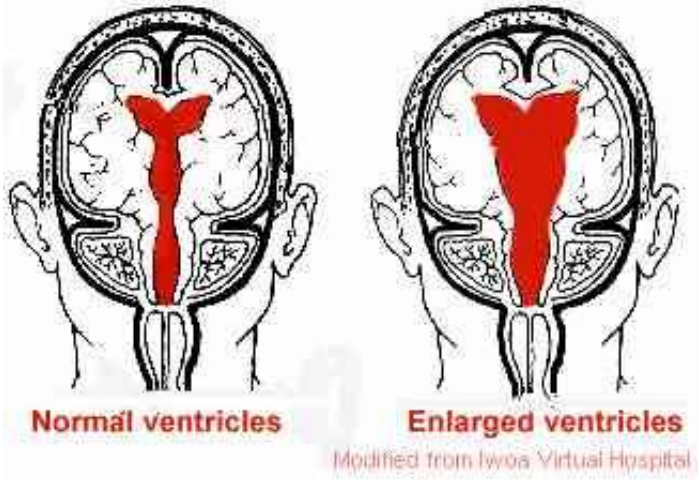
CSF accumulates in within both ventricles & subarachnoid space

This type results from problems with the production or absorption of CSF.

-Either too much fluid formed

-Hindrance to the drainage of normally produced fluid

Result in atrophy of brain and widening of sulci

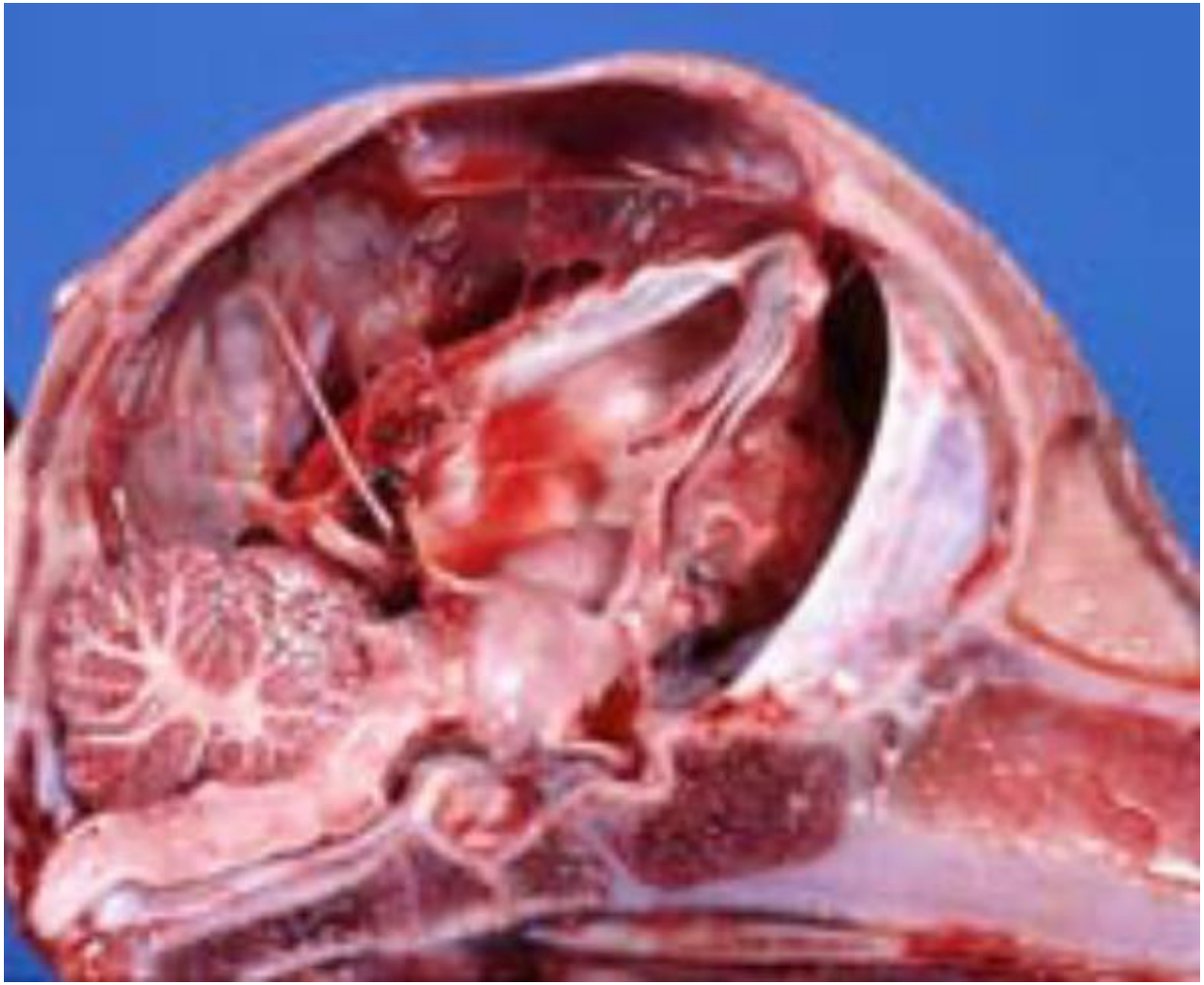


# Hydrocephalus ex vacuo

- Increase in size of the lateral ventricles is secondary to absence or loss of cerebral tissue
- Cause- lack of development/destruction & loss of cerebral tissue surrounding the lateral ventricles.
- E.g.- hydranencephaly, lysosomal storage disease in sheep, aging of CNS(cerebral atophy)

# Hydraencephaly

- Formation of big spaces in the central part of the cerebral hemispheres.
- It results from lack of proper development
- The ventricles extend into this space
- Causes may be- foetal viral infection & nutritional copper deficiency



Hydraencephaly

# Syringomyelia

- Tubular cavity in the spinal cord
- Humans, sometimes dogs
- Separate from central canal but may communicate with it
- The cavity may contain fluid
- Causes- trauma, infection & neoplasia that leads to parenchymal degeneration & cavitation

# Dysraphic anomalies

- Dys- abnormal
- Raphia- fusion
- It means abnormal fusion or failure of fusion of parts which normally fuse.
- Defective closure of neural tube during embryonic development
- Anencephaly & prosencephalic hypoplasia, cranium bifidum & spina bifida.

# CIRCULATORY DISTURBANCE

- Hyperemia
- Anemia
- Thrombosis and embolism
- Hemorrhage
- Edema of CNS
- Infarction
- Vascular disease
- Specific disease
- decreasing order of susceptibility are neurons, oligodendroglia, astrocytes, microglia & blood vessels

# Hyperemia

- Acute general passive- rabies, viral equine encephalomyelitis and hog cholera
- Acute focal active- abscess, tumors and infarcts
- Chronic general passive- when lesion in heart or lungs, or obstruction to flow of blood from brain
- Chronic focal passive- tumor or abscess

# Anemia

- General-
- Brain and spinal cord –whiter than normal
- Blood vessels less prominent
- Presence of areas of liquefactive necrosis, gliosis and neuron degeneration
- Local/Ischemia- deficiency of arterial blood in a local area of the brain and spinal cord.

# Hemorrhage

- Rupture of an artery give rise to large areas of hemorrhages with clots in brain – **apoplexy**
- **Causes-** trauma, atherosclerosis, arteriosclerosis, infection and bursting of aneurysm
- Initially shock and later coma, terminating in death.
- Animals that survive shock, suffer from some degree of paralysis due to pressure on damage to neurones.
- When hemorrhage is present in the ventricles- the CSF may be blood tinged

- Blood clot in the brain – contracts- serum separates- absorbed; remaining clot is liquified and cyst is formed with a clear fluid- this is known as ‘apoplectic cyst’.
- The capsule of the cyst is formed by the neuroglial
- Hyperemia, petechial hemorrhages and edema of brain and meninges is found in- electrocution, lightning stroke, and sunstroke.

# Edema

- Local- neoplasm, trauma along with hemorrhage and laceration, meningitis, focal necrosis,hemorrhages
- General- diffuse meningitis, viral encephalitis, enterotoxemia, lead poisoning, organic mercury poisoning, shock, ANTU poisoning, sunstroke, salt poisoning in pigs

# Grossly

- Brain- more moist and heavy
- Gyri are widened and the sulci are narrowed
- Swollen gyri that press againt the skull appear flattened
- On section- grey matter-  wider
- White matter- softer
- Ventricles- narrowed

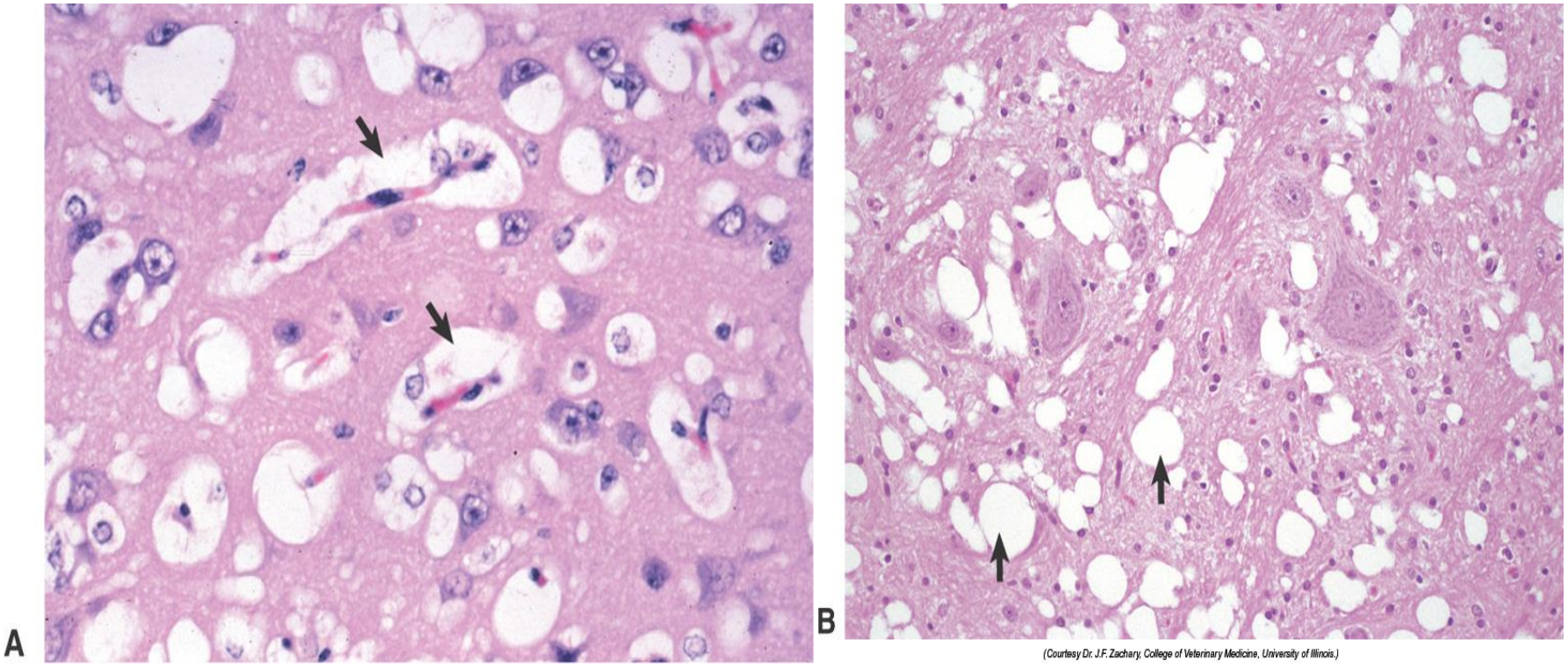
# Microscopically

- Loose tecture of grey and white matter
- Interfibrillar space is widened
- Neurones and glial appear swollen
- Edema in peri-vascular space.

# Vasogenic edema-

- It is most common type
- Occurs following vascular injury
- **Mechanism** - breakdown of the blood-brain barrier movement of plasma constituents such as water, sodium & plasma proteins into the extracellular space particularly that of white matter.
- It is often adjacent to hematomas, contusions, infarcts, inflammatory foci, neoplasms & in certain toxicities.
- Cellular swelling may be present in astrocytes.

# Brain edema




The perivascular spaces are wide as a result of fluid leakage through the blood-brain barrier

Variably sized fluid-filled spaces within the white matter- spongy change

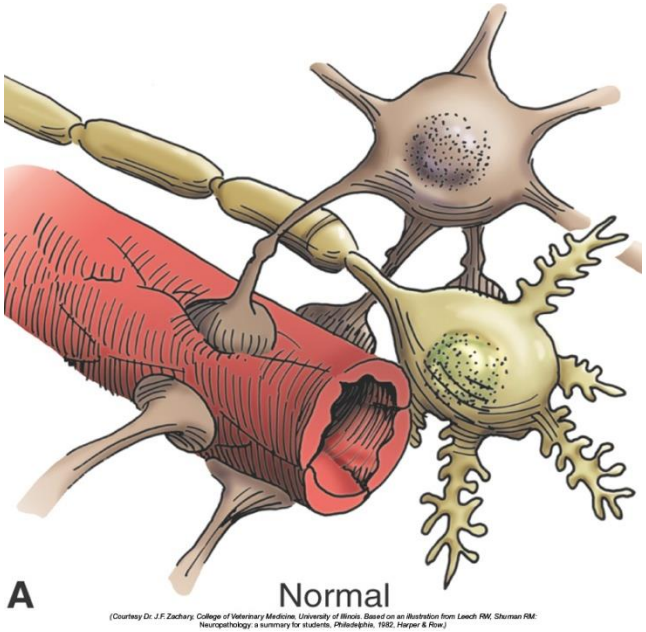
# Cytotoxic edema

- As a result of altered cellular metabolism often due to ischemia
- Accumulation of fluid intracellularly in neurons, astrocytes, oligodendroglia, & endothelial cells.
- Mechanism - an energy deficit that interferes with normal function of the ATP-dependent sodium-potassium pump.
- Both the grey & white matter of the brain is affected.
- The blood-brain barrier remains intact so fluid does not enter the brain by a disturbance in vascular permeability.
- The fluid taken up by swollen cells is primarily derived from the extracellular space, which becomes reduced in size and has an increased concentration of extracellular solutes.

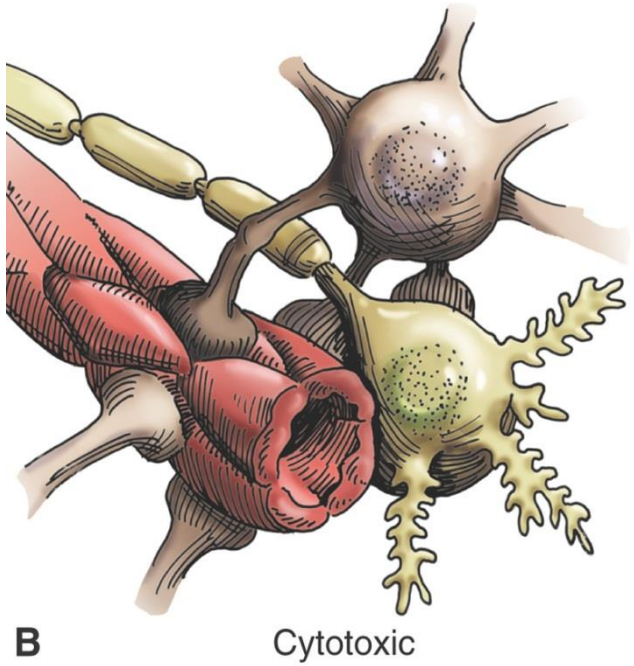
# Hydrostatic edema-

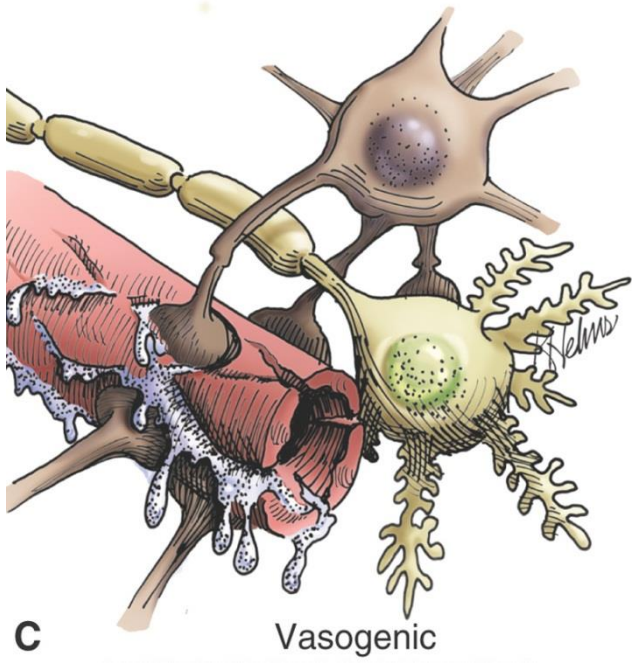
- Accumulation of a protein free fluid in the extracellular space of the brain because of elevated ventricular hydrostatic pressure that accompanies hydrocephalus.
- It causes variable degeneration & loss of the periventricular white matter.
- The blood-brain barrier remains intact.

# Blood-brain barrier, cytotoxic & vasogenic edema




(Courtesy Dr. J.F. Zachary, College of Veterinary Medicine, University of Illinois. Based on an illustration from Leech RW, Shuman RM: Neuropathology: a summary for students, Philadelphia, 1982, Harper & Row.)



# Osmotic cerebral edema

- It is associated with water intoxication which results from increased body hydration.
- Hypotonic plasma & an osmotic gradient between the hypotonic plasma & the relatively hypertonic state of the normal cerebral tissue.
- The blood-brain barrier remains intact.
- Fluid accumulation occurs primarily intracellularly, but can also be present extracellularly.

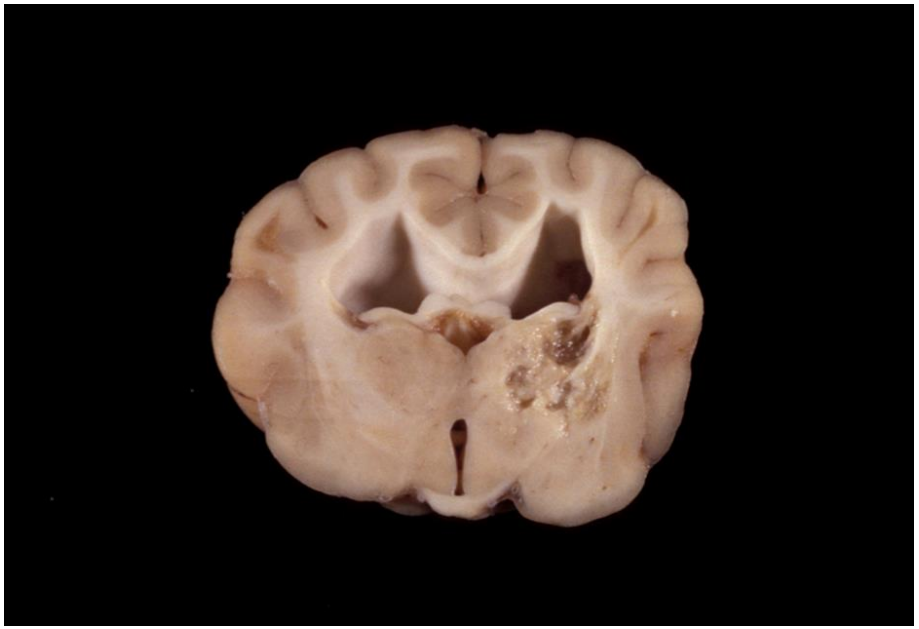
# Infarction

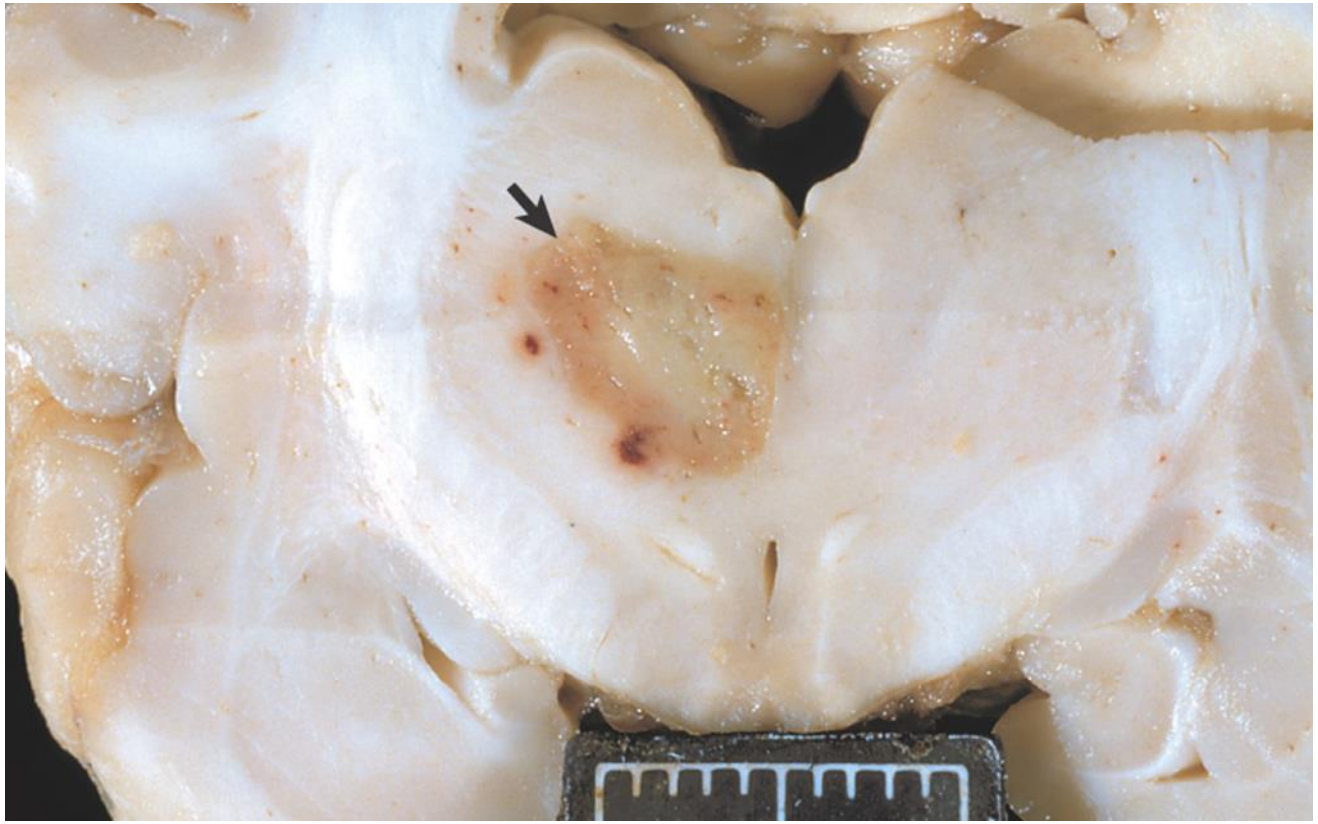
means necrosis of a tissue following obstruction of its arterial supply. Causes -

- Cessation of cerebral circulation (cardiac arrest)
- Sudden hypotension (reduced cardiac output)
- Reduced or absent oxygen in inspired air
- Altered function of hemoglobin (carbon monoxide poisoning)
- Inhibition of tissue respiration (cyanide poisoning)
- Toxic substances & poisons
- Nutritional deficiencies

- The gross appearance of infarction differs according to location-

- Infarctions of grey matter tend to be hemorrhagic while that of white matter it is often pale





# Mechanism

- An artery supplying the CNS is suddenly occluded and blood supply to cells at the center of the infarcted area is rapidly stopped.
- The axonal terminals of degenerated ischemic neurons in the core of infarct releases excessive amount of the neurotransmitter glutamate, causing injury to still viable neurons
- This increases the extent of injury that can occur with infarction.
- This results in increase in intracellular calcium ion concentration which contributes to multifunctional cascade that lead to neuronal death.

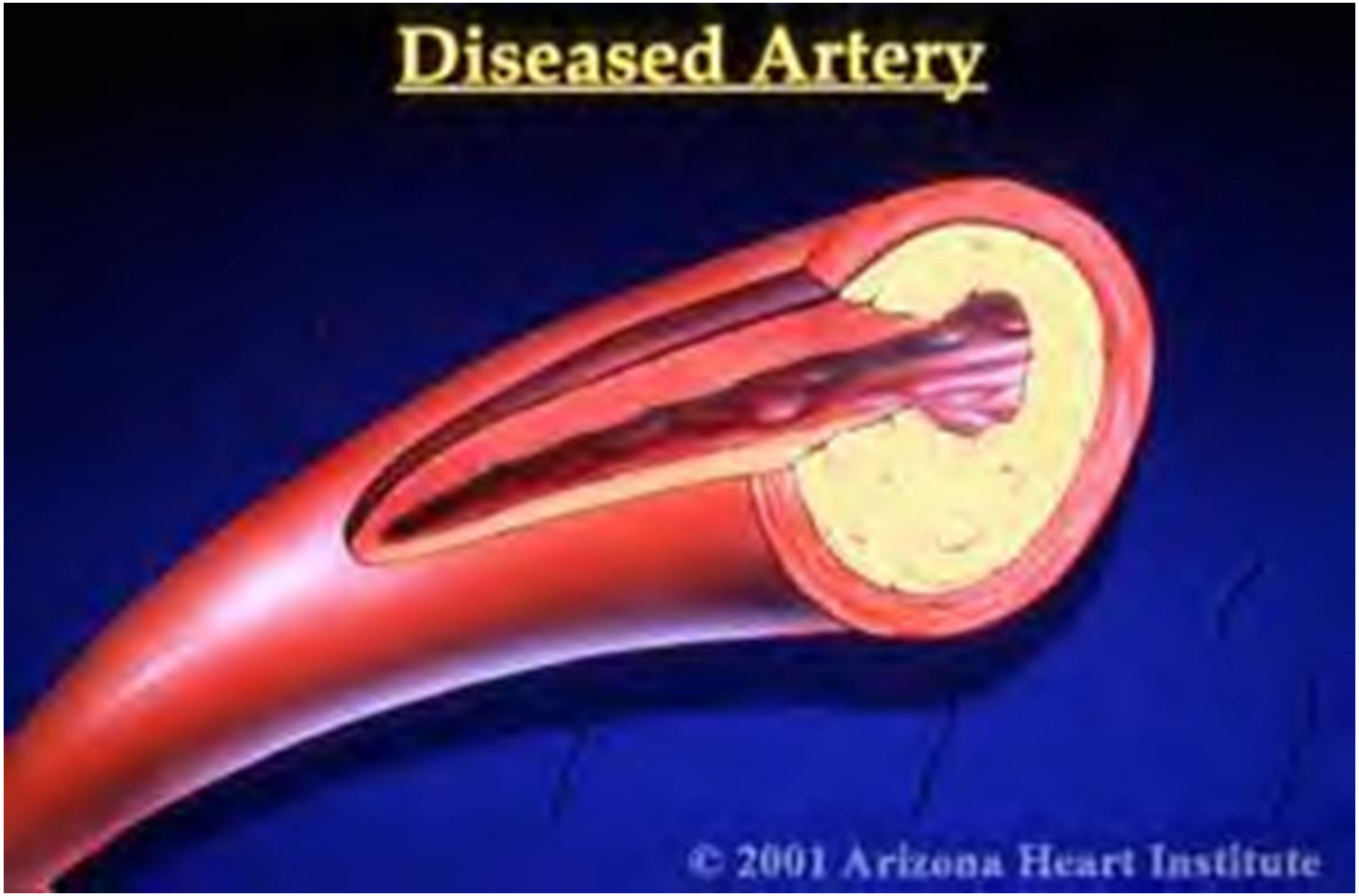
# Vascular disease-

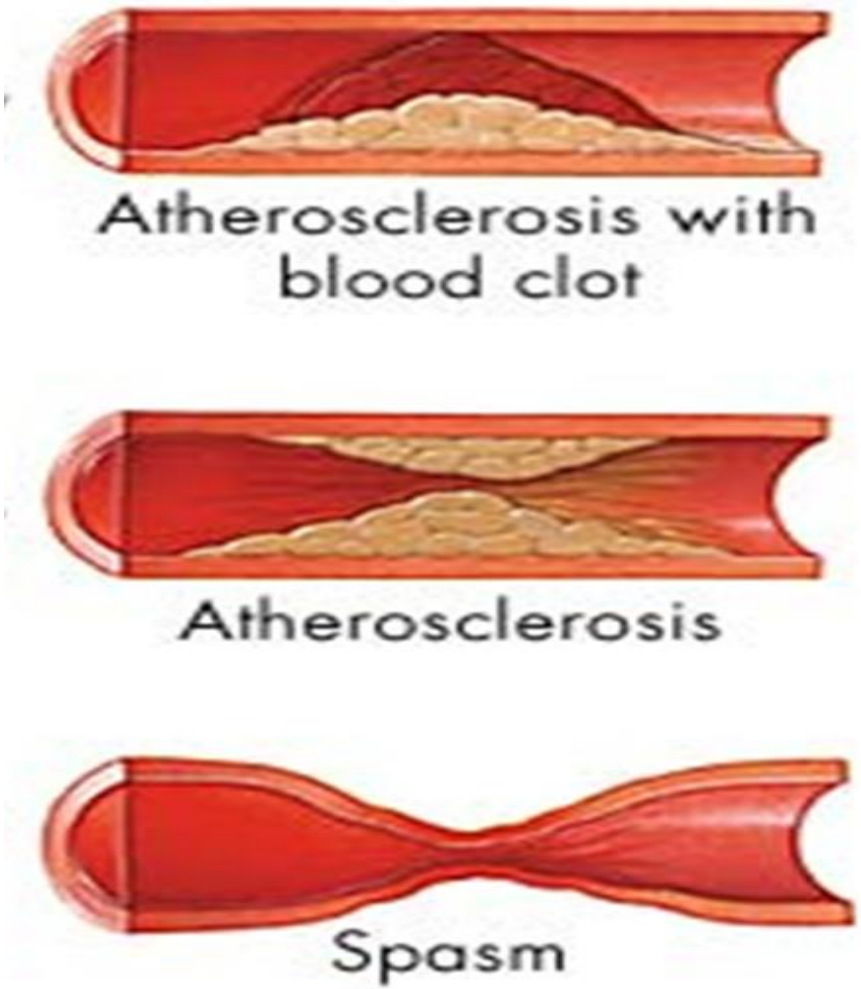
- The incidence is low in animals & neurological manifestation associated with this are uncommon.

- Arteriosclerosis- hardening of arteries. It is of 2 types-
- -Lipid arteriosclerosis (atherosclerosis)
- -Non-lipid arteriosclerosis

# Atherosclerosis

- Pigs, dogs, non human primates & several avian species.
- Older pigs are most commonly & severely affected.
- Affected arteries are rigid, irregularly thickened, narrow lumen & white to yellow white in color.
- Intimal thickening in intracranial arteries contain less lipid & have a greater tendency for fibrosclerosis than other vessels.
- Lesion are most severe in the intima & media.


Diseased Artery
© 2001 Arizona Heart Institute


Atherosclerosis with
blood clot
Atherosclerosis
Spasm

# Non-lipid arteriosclerosis

- Occurs frequently in older animals (dog, horse).

  - In dogs- fibrosis of intima, media or adventitia.
  - Collagenous thickening of arteries
  - Preferential site is choroid plexus.

  - In horses- similar pattern of fibrosis occurs in vessels & intima is preferentially affected.
  - Mineralization (calcium & iron salts) of cerebral blood vessels is common in adult horses.

# Disturbances in growth

- **Aplasia- failure of development** of portions of brain and spinal cord observed in young animals
- **Hypoplasia-** relatively more common
  - Failure of development of brain and spinal cord to full normal size **(incomplete development)**
  - E.g. congenital posterior paralysis in calves and swine; spastic paresis in cattle; cerebellar hypoplasia
- **Cerebellar hypoplasia-** mostly in calves and cats
  - Rudimentary or even absence of cerebellum
  - Animal die shortly after birth
  - Show **locomotor disturbances, and incoordination**
    - E.g. calves born of cow ( viral diarrhoea- mucosal disease)
    - Piglet-(modified hog cholera virus vaccine used in dam)

- **Atrophy-**
  - Atrophy of cerebrum may occur in hydrocephalus, tumors, abscesses, cysts and fractures.
- **Hypertrophy-**
  - result from increase in size of the glial cells, microglial cells show greatest degree of hypertrophy.
  - Neurons does not increase in size
- **Hyperplasia-**
  - results from increase in the number of glial cells, especially microglial (under vconditions of hypoxia)
  - Does not occur in neurons

**Metaplasia-**

- does not occur in nervous tissue proper.
- May occur in C.T. of the meninges and blood vessels- leading to the formation of cartilage or bone

# Disturbances of cell metabolism

- Cloudy swelling-
  - As a result of hypoxia, toxic substances, infectious agents
  - Cells become larger, cellular outline more round, and cellular structures indistinct
- Hydropic degeneration-
  - continuation of cloudy swelling, droplets of edematous fluid in the cytoplasm of the neurons and glial
- Fatty degeneration-
  - appear as fat droplets in the cytoplasm of the neurons
- Amyloid infiltration-
  - uncommon in CNS of most domestic animals
- Glycogen infiltration –
  - does not occur in the CNS

- Pigmentation-
  - Cattle and Sheep- melanin is most frequently encountered in the pia-mater of the anterior part of the brain, meninges, spinal cord.
- Calcification-
  - More commonly found in meninges than in the brain and spinal cord.
  - Occurs in presence of dead tissue and faulty circulation

# Traumatic injury

- Fractures-
  - Damage to meninges and brain, hemorrhage, disruption of nerve fibres, pressure atrophy from accumulated blood
- Concussion-
  - Skull recieves a sharp blunt blow suddenly not accompanied by fracture.
  - Loss of consciousness, not fatal, no morphological changes, recovery occur
  - Lesions- small hemorrhages in the brain and under the skin at the site of injury
- Laceration-
  - Discontinuity of the tissue and usually occurs in automobile accidents
  - Coutrecoup laceration- occur on the brain on the side opposite to that on which the injury is struck. Due to striking of the brain on the skull on the opposite side. Hemorrhages are common.
- Penetrating wounds-
  - Caused by gun-shot wounds, severe hemorrhages, fractures common , followed by secondary infections and are fatal.

# Necrosis

## Coagulative necrosis

- Involves neurons and glial cells

Causes-

Grossly – no clear change

H/P-

- **Satellitosis-** Glial cells accumulate around the necrotic neurons
- **Neuronophagia-** when the microglia phagocytose the necrotic neuron

# Liquefactive necrosis

- Most common type in brain and spinal cord
- Autolytic enzymes released from lysosomes of dead cells cause disintegration of myelin into a liquid mass that consists mainly of lipids.
- The lysosomal enzymes released from neutrophils induce liquefaction of myelin, neuroglia and other structures- **encephalomalacia**
- Softening of grey mater- **poliomalacia**
- Softening of white matter- **leucomalacia**

- E.g. Vit. E deficiency in young chicks (crazy chick disease); mouldy corn disease in horses; sway back, acute pancreatitis; enzootic marasmus, emterotoxemia; mulberry heart disease in pigs, vit. B deficiency, blue tongue; rift valley fever, distemper, toxoplasmosis, lead poisoning; infarction, thrombosis.

## Lesions-

- Thickening of blood vessels, endothelial hyperplasia and liquefaction, thrombosis and hemorrhage, proliferation of capillaries, astroglial proliferation, liquefaction of involved tissue, presence of serous tissue

## Caseous necrosis

- *Mycobacterium tuberculosis*
- Necrotic area is dry, crumbly, yellowish white mass, calcification may occur

- Necrosis of nerve fibres is first indicated by fatty degeneration of the myelin sheaths of the affected nerve fibres- **demyelination**
- Demyelination- Non-functional nerve fibres
- If demyelination alone occurs- regeneration is possible with restoration of function
- Ultimately axon disappears

# Reactive changes of neurons

- **Shrinkage-** irregular cells, nucleus pyknotic, clumping and condensation of nissl substance and tortuousness or sclerosis of processes. Seen in senility and chronic infections.
- **Swelling-** faint cytoplasm and only cell outline seen, fragmentation of processes. Seen in intoxications and systemic infections. It is reversible change.
- **Vacuolation-** seen in toxicities and viral encephalomyelitis
- **Chromatolysis-** nissl substance becomes fine and dispersed and later may disappear. The nucleus may be eccentric. Cytoplasm shows swelling and rounded contours.
- **Satellitosis-** whenever a neurone is damaged, oligodendroglial and microglial accumulate around it, without actually invading it, this phenomenon is known as satellitosis.
- **Neuronophagia-** when the nerve cell dies, microglial and oligodendroglial invade the cell and remove it by phagocytosis

# Blood vessels of the brain

- Veins do not have valves

- Blood vessels acquire a meningothelial sheath and a second outer sheath derived from the pia.

- A peri vascular space is formed between these sheaths- the **space of Virchow- Robin**. In this space the cells accumulate and give rise to "**perivascular cuffing**"

# Inflammation

- Encephalitis- brain
- Myelitis- spinal cord
- Encephalomyelitis- brain and spinal cord
- Meningitis- meninges
- Pachymeningitis- duramater
- Leptomeningitis- pia- arachnoid mater
- Meningoencephalomyelitis- meninges, brain and spinal cord
- Polioencephalitis- grey matter in brain
- Poliomyelitis- grey matter in the spinal cord

# INFLAMMATION

- Catarrhal inflam.- does not occur- since no mucous membranes
- Serous probably does not occur, resemble edema
- Hemorrhagic- rarely
- Fibrinous- often limited to meninges (Pasteurella infection of CNS in cattle and sheep)
- **Purulent and lymphocytic inflammations-** regularly encountered in the CNS.

4 common changes-

- Leptomeningitis
- Perivascular cuffing
- Microgliosis
- Neuronal degeneration

# Suppurative (purulent) inflammation

- Seen in all species of animals.
- Principal constituent of exudate is pus.
- It may be focal or diffuse.
- Cause- staphylococci, streptococci, corynebacterium, pasteurella, listeria & pleuropneumonia like organism.
- **Route of infection-**

1. Direct extension from suppurative conditions of the middle ear, nasal passage, cribriform plate or from meninges.
2. Through blood stream & lymphatic vessels accompanying nerves (Listeriosis).
3. Through infection of wounds.

**Lesions-** focal infiltration of neutrophils & lymphocytes. Pressure of pus causes destruction of local tissue. Abscesses do not have well developed capsule. Astroglia proliferate & form a poorly defined capsule around the cerebral abscess.

# Listeriosis

- *Listeria monocytogenes*
- Most frequent cause of purulent inflammation in brain in farm animals
- Suppurative meningoencephalomyelitis in cattle, sheep and goat.
- Presence of multiple microabscesses

# Lymphocytic inflammation:

- Most important form of inflammation of CNS in animals. There is perivascular lymphocytic infiltration. It is mainly caused by viruses.
  - **Neurotropic virus-** affect almost only the nervous system. E.g. rabies in dogs & borna disease in the horses.
  - **Organotropic virus-** affect other tissue & may also infect the nervous tissue by chance. E.g. canine distemper, hog cholera, malignant catarrhal fever, rinderpest & epidemic tremor of fowl.
  - Other causes are allergens, mycoplasma, rickettsia & trypanosoma.
  - **Route of infection-** blood stream- hog cholera; Nerves- rabies
  - **Grossly-** not significant. Hyperemia & edema of the pia-arachnoid. Occasionally localized areas of softening.
  - **Microscopically-** congestion & hemorrhages, perivascular cuffing both in the grey & white matter, edema, gliosis- diffuse proliferation of the astrocytes throughout the brain giving a dense & cellular appearance, satellitosis, neuronophagia, inclusion bodies may be seen in neurons or astroglia cells e.g. rabies, C.D, ICH, Borna disease.

## Lymphocytic meninoencephalomyelitis-

- **Rabies-** intracytoplasmic inclusions- hippocampus in dogs and cerebellum in cattle
- **Pseudorabies-** Herpes virus- pigs
- **Swine fever**
- **Canine distemper**
- **Equine encephalomyelitis**
- **Louping ill**
- **Epidemic tremor**
- **Ranikhet disease –pneumoencephalitis of poultry**
- **Parasitic-** *Hypoderma bovis* larvae, *Oestrus ovis* larvae- **Myiasis**
- *Coenurus cerebralis*- larvae of *Multiceps multiceps* – ***Gid or sturdy***
- Cerebral nematodiasis *(Neurofilariasis,* ***kumri****)*- *Setaria digitata*

# Meningitis

- Inflammation of meningis
- Characterised by infiltration of neutrophils & mononuclear cells,
- Pachymeningitis- dura mater
- Leptomeningitis- pia & arachnoid mater

- Etiology- virus(swine fever), trauma, Bacteria(Pasteurella, Listeria), Toxoplasma, Leptospira

**Grossly:**

- Congestion
- Thickening of meninges
- Petechial hemorrhage

**Microscopically:**

- Congestion
- Infiltration of neutrophils & lymphocytes
- Fibrosis

# Peripheral nervous system

- Both degeneration & regeneration can occur
- 3 basic degenerative processes:

- **Wallerian degeneration-** transection of the axon which then undergoes degeneration (both axis cylinder and myelin sheath) and remanants are removed by phagocytes
- **Axonal-** due to dysfunction, neuron is unable to maintain axon, which degenerates.
- **Segmental-** selective loss of myelin between 2 nodes of ranvier, with preservation of underlying axon
- Fat droplet – Marchi's method

# Neuritis

- Inflammation of nerves along with degenerative changes, and oedema & inflammatory changes in the C.T.
- Etiology: toxins, trauma, virus (MD), lead & mercury, bacteria(strangles), deficiency of vitamin E
- **Features-**
- Nerves swollen and reddened, soft flabby
- Wallerian degeneration
- Infiltration of neutrophils & lymphocytes
- More destruction of distal end of the neuron
- E.g. Marek’s Disease

# METABOLIC/TOXIC BRAIN INJURY:

Osmotic encephalopathies-

- **Sodium chloride (salt) poisoning:** "sodium ion toxicosis", "water deprivation syndrome"
- **Host-** pigs, poultry & occasionally in ruminants.
- The disease is due to hypernatremia caused by excessive intake of sodium salts or severe dehydration followed by rehydration
- And a rapid hypernatremic to normonatremic or hyponatremic shift.

# Pathogenesis

- During initial hypernatremic phase- the brain shrinks because of the osmotic loss of water.
- Then as an acute adaptive response, there is an influx of sodium, potassium, & chloride ions into the brain to equalize the sodium imbalance.
- More delayed adaptive response- influx or endogenous production of organic osmolytes e.g., certain amino acids, polyols, & methylamines to equalize the osmotic imbalance created by hypernatremia.

- When animals are given free access to fresh water, an acute hypernatremic to hyponatremic shift occurs.
- The brain attempts to offset this osmotic imbalance by eliminating sodium, potassium, & chloride ions.
- This however cannot offset the osmotic stress created by the increased organic osmolytes in the brain.
- The osmotic gradient develops and **water enters the brain with subsequent brain swelling**.

- **Grossly-** cerebral & leptomeningeal congestion & edema. Cerebro-cortical necrosis can be seen.
- **Microscopically-** cerebrocortical neuronal necrosis & astrocytic swelling.
- In pigs- perivascular accumulation of eosinophils in cerebral leptomeninges & adjacent cortex.
- In ruminants- arteriolar degeneration with neutrophilic infiltrate, cerebellar purkinje cell necrosis & edema of basal nuclei, thalamus & midbrain.

# Thiamine deficiency

- Function of thiamine: Vitamin B1 is a necessary cofactor for the enzyme transketolase
- Transketolase is the rate limiting enzyme in the hexose monophosphate shunt (pentose phosphate pathway)
- This is the major metabolic pathway for glucose utilization in the brain
- Also a co-factor for other enzymes (i.e. pyruvate decarboxylase) in the Kreb's cycle
- Neurologic disease is thought to represent an energy deficit due to the inhibition of these metabolic pathways.
- Also involved in neurotransmitter metabolism

# Thiamine deficiency

- **Carnivores** (dogs, cats) - Chastek's paralysis
- **Herbivores (including ruminants)** have no or little dietary requirement for thiamine.
- The disease in ruminants has been given the name polioencephalomalacia or laminar cerebrocortical necrosis.
- Estimated that the daily requirement of thiamine for sheep is 2-4 mg, slightly less than that produced by rumen microflora.

- In horses, thiamine deficiency encephalopathy has been associated with horses eating plants containing a thiaminase enzyme such as bracken fern (*Pteridium spp.*), horsetails (*Equisetum spp.*) or given the coccidiostat amprolium (a structural analog of thiamine – may inhibit uptake from the gut)
- **Clinical signs:**

– Ataxia, cardiac arrythmias, blindness, weight loss, dysuria (difficult urination), convulsions

– The brain has not been adequately studied in these cases

– Treatment – parenteral (injectible) thiamine

# Thiamine deficiency

Thiamin deficiency - Polyneuritis. Arched back & hyperextended legs, spastic gait, loss of balance.

Thiamine deficiency - Polyneuritis

# Copper deficiency

- Occurs worldwide in sheep producing areas.
- Is associated either with primary copper deficiency (absolute copper deficiency in the diet) or the deficiency may be secondary to other metals such as molybdenum and zinc that interfere with absorption.
- The type of food is also important. Copper is poorly absorbed from fresh herbage compared to cereal grains.

❖ Swayback

- Affects lambs, rarely kids
- Clinical signs are evident at the time of birth

– Dullness, depression, blindness, recumbency, flaccid limbs, may appear deaf

- Lesions

– Cavitation and cystic areas in cerebral cortex resembling porencephaly

❖ Enzootic ataxia

- Affects lambs & kids
- Normal at birth; after birth up to about 6 months of age

– Clinical signs are progressive incoordination, ataxia, may have some muscle atrophy

- Lesions

– Cortical lesions are absent

– Degeneration of neurons in cerebellum and spinal cord