URINARY CRYSTALS

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WHY URINARY CRYSTALS ?

- Urinary crystals are very common, they are almost always present in every routine urine analysis
- They are simply diagnosed by microscopic examination during routine urine analysis
- Their pathophysiology and clinical significant is not clear
- Children with urinary crystals are rarely taken optimal care

AGENDA

I- Pathophysiology

II- Solutes forming crystals

Oxalic acid

Uric acid

III- Clinical significance of urinary crystals

Diagnosis

Treatment

DEFINITIONS

- Crystalluria is defined as “presence of *crystals* in *urine*”
- It results from *supersaturation* of some *urinary solutes*

AGENDA

I- Pathophysiology

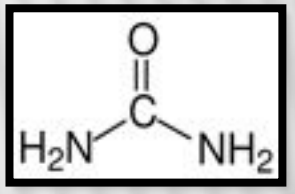
- Urine
- Urinary solutes (non volatile waste products)
- Crystals
- Solubility and supersaturation

What is the main function of the kidney ?

- **The main function of the kidney is *urine formation***

FUNCTION OF THE KIDNEYS

- **By urine formation the kidneys**
  - *Regulate water, electrolytes and acid base balance.*
  - *Excrete non-volatile waste products (urinary solutes), mainly nitrogenous compound in addition to other compounds.*



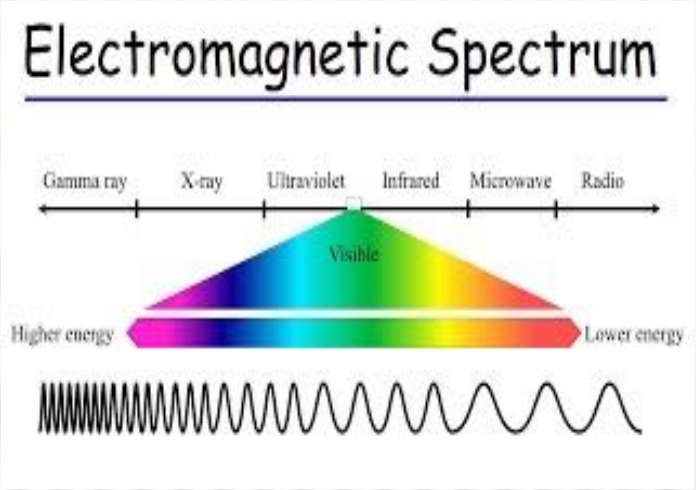
- **Other functions include:**
  - *Erythropoietin secretion.*
  - *Regulation of blood pressure through renin.*
  - *Activation of Vit. D*

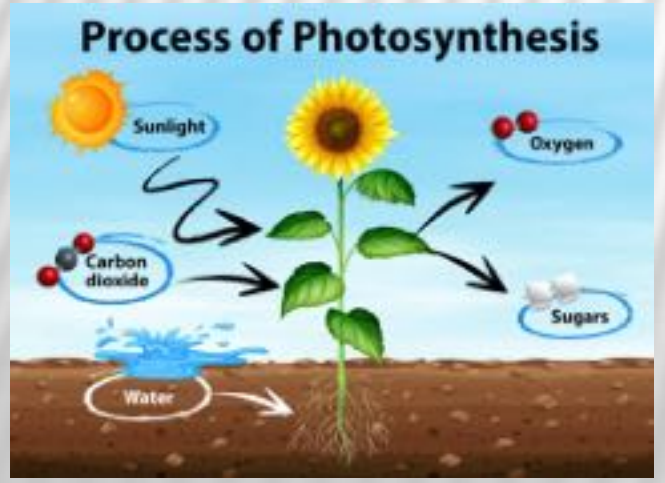
URINE

- From the chemical point of view, urine is solution
- It is formed of :

Solvent (water) + solutes (non volatile waste products)

SUN, PLANTS AND ENERGY





$6\ H_2O + 6\ CO_2 \ldots\ldots\ldots C_6H_{12}O_6 + 6\ O_2$

METABOLISM IN HUMAN

- ***Digestion*** **of thousands of complex foodstuf leads to few small soluble molecules**
  - **Carbohydrates …… Monosaccharides**
  - **Fat …… Fatty acids and glycerol**
  - **Proteins …… Amino acids**

- **These molecules are formed from hydrocarbons (C, H and O) in addition to N**

- **These molecules have potential energy**

METABOLISM IN HUMAN

- *Oxidation* of these small molecules leads to
  - Release potential energy …… stored in ATP ….. It is used
  - Heat production
  - Waste products

    * volatile waste products
      - CO_2 …… is excreted by lung (volatile waste products)
      - H_2O……. endogenous water

    * Non-volatile waste

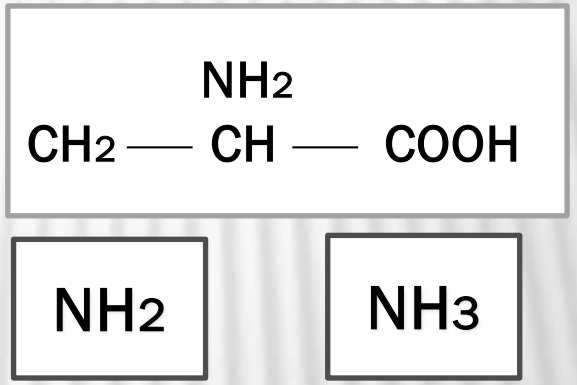
NON-VOLATIL WASTE PRODUCT

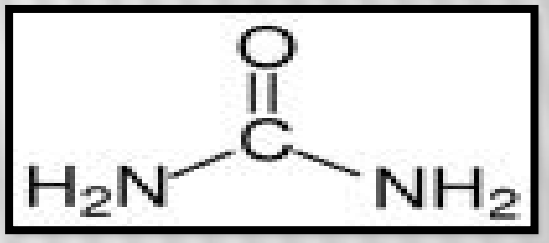
- Non-volatile waste products (urinary solutes).

I- Organic compound

1- Nitrogenous compounds

- Urea.
- NH4 salts





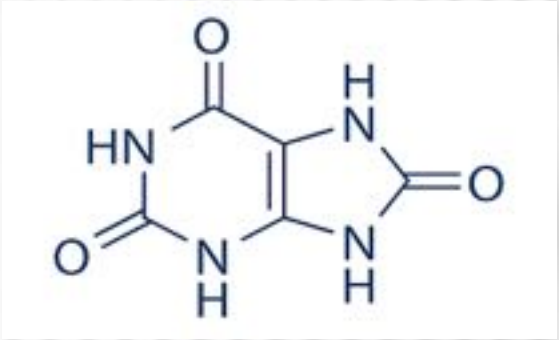
2- Other organic compounds

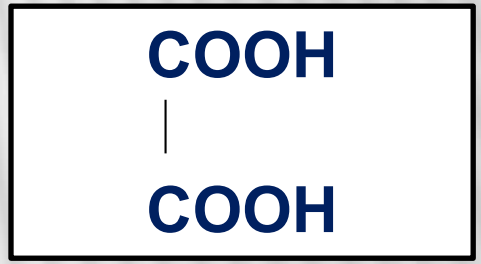
- Organic acids, amino acids, vitamins, hormone, ……

NON-VOLATILE WASTE PRODUCTS

3- End product of organic compounds

- ***Oxalic acid***
- ***Uric acid***
- ***Creatinine***





II- Non organic compound

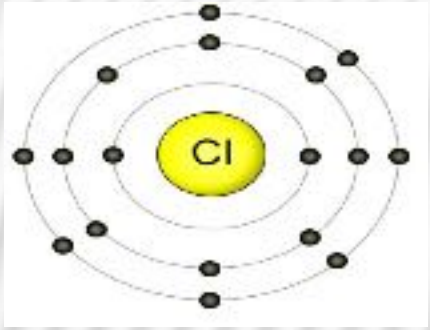
Electrolytes, minerals, inorganic acids, trace elements, ……

- ***Calcium***
- ***Phosphate***
- ***Carbonic acid***

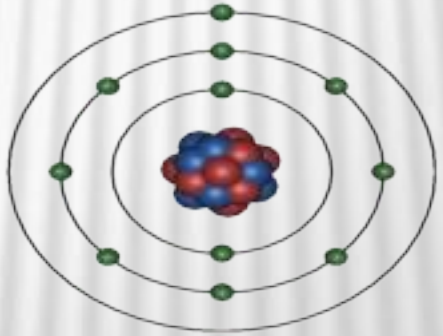
CRYSTALS

- Chemical bonds
  - *Ionic*
  - *Covalent*
  - *Hydrogen*

Ionic bond - Ion Exchange



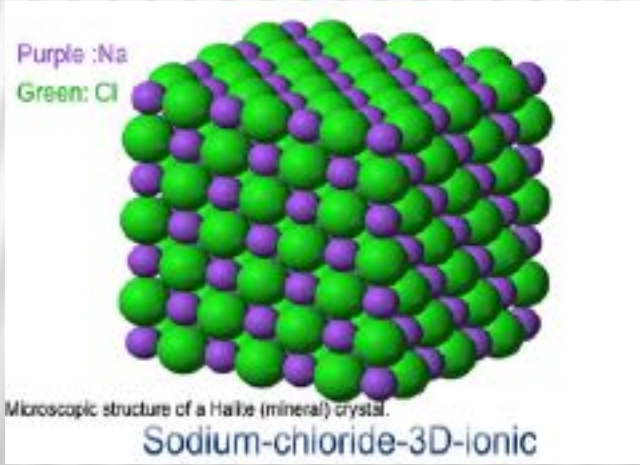
Chloride atom
Anion -ve



Sodium atom
cation +ve

CRYSTAL

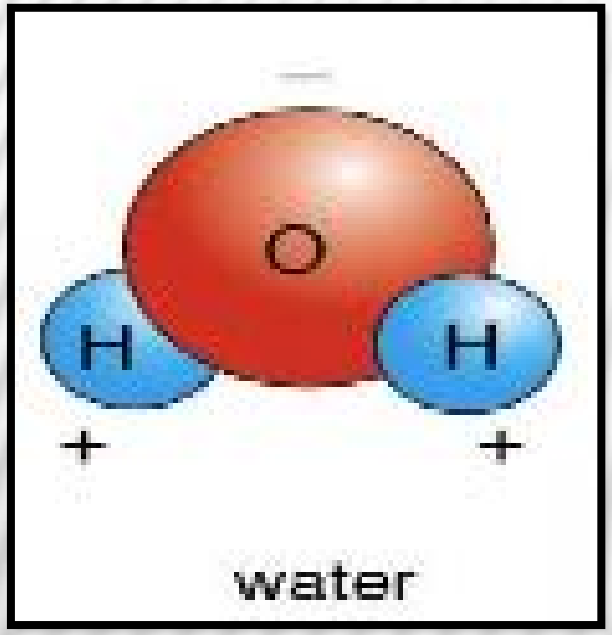
- A crystal is a solid material that is formed from ions
- It is formed by cohesion (تماسك) of these ions due to their electrostatic activity
- It is arranged in a highly geometric, well organized microscopic structure



WATER AS SOLVENT

- Water molecule is formed by *covalent bond (رابطه تساهميه)* between 2 hydrogen atoms and 1 oxygen atom.
- Water molecules stick to each other (*cohesion* تتماسك) to form chemical compound
- Water molecules have partial +ve charge at [H+] and partial –ve charge at [O- atom]
- Water is a polar molecule

WATER AS SOLVENT



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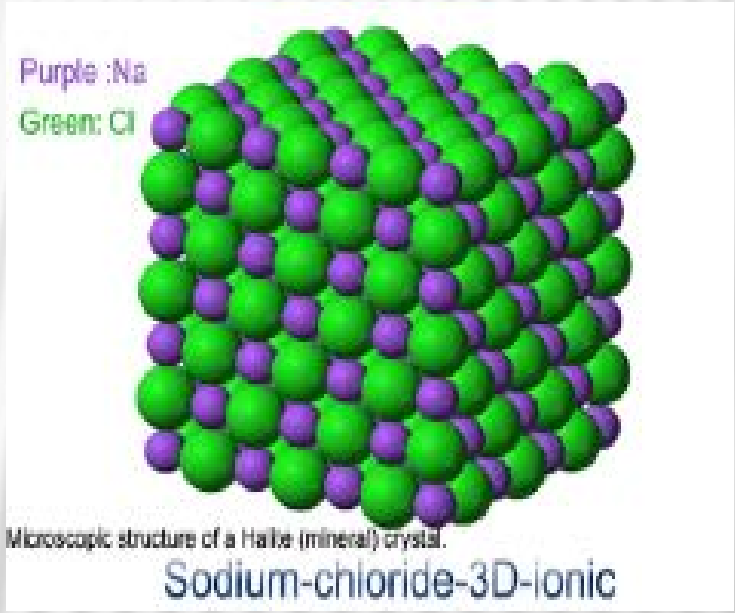

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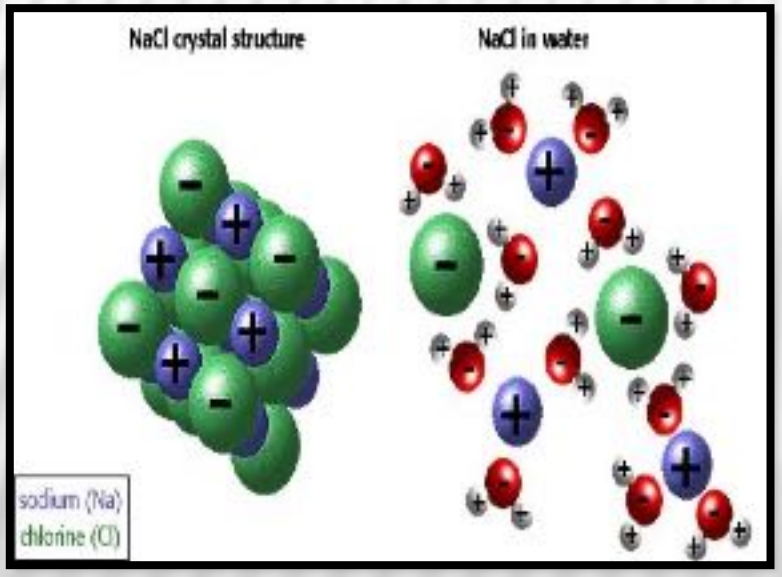
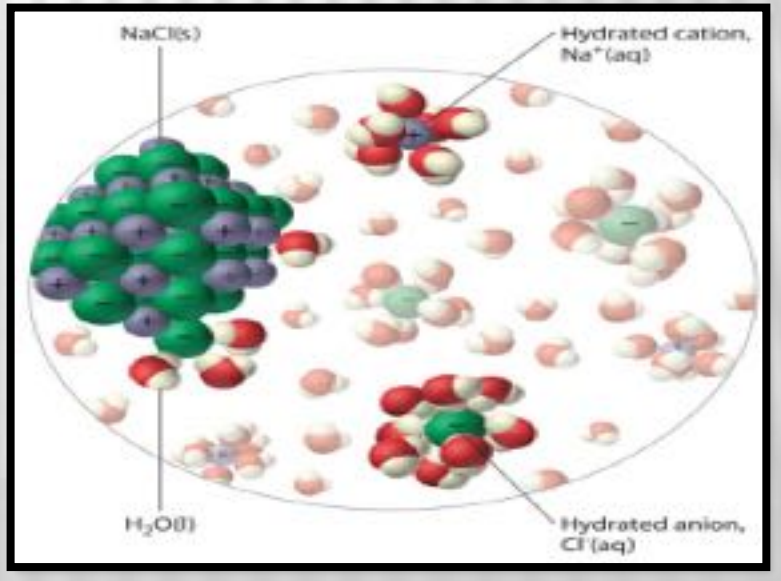
WATER AS SOLVENT

- **Water molecules due their polarity attract ions from crystals to form solution**
- Solubility depends on electrostatic activity between molecules of crystals
- **Water is universal solvent "*solvent of life***





SOLUBILITY AND SUPERSATURATION

- Solubility is a chemical property referring to the ability for a given solvent (water) to dissolve a solutes (crystals)
- It is measured the maximum amount of solute (gm) that dissolve in a solvent (1 liter) at standard condition.
- The resulting solution is called saturated solution.
- Addition of more solute can not be dissolved and remains in solid form supersaturation

SOLUBILITY AND SUPERSATURATION

- Solubility of solutes in water.
  - In neutral pH, at 25^0C and sea-water atmospheric pressure , one litter of water can dissolve:
    - Glucose ..... 909 gm/L
    - Na CL .... 350 gm/L
    - Uric acid ..... 60 mg /L ..... 6 mg / dl
    - Calcium oxalate ..... 6.1 mg /L ..... less than 1mg /dl
  - It depends on electrostatic activity of crystal molecules
- Crystallization of solutes in water:
  - It occurs if solute concentration exceeds supersaturation level :
    - Water ↓.
    - Solute ↑.

RISK FACTORS

The most important independent risk factor of urinary crystals formation is

Supersaturation

- Other risk factors
  - Urinary pH
  - Decrease natural inhibitors of crystals formation (citrate, Mg.....)

RISK FACTORS FOR STONE FORMATION

- In addition to crystals formation, which is the initial step for nephrolithiasis, risk factors for stone formation include
  - Urinary tract obstruction
  - UTI
  - Renal tubular abnormality or injury
  - Medications

AGENDA

I- Pathophysiology

II- Solutes forming crystals

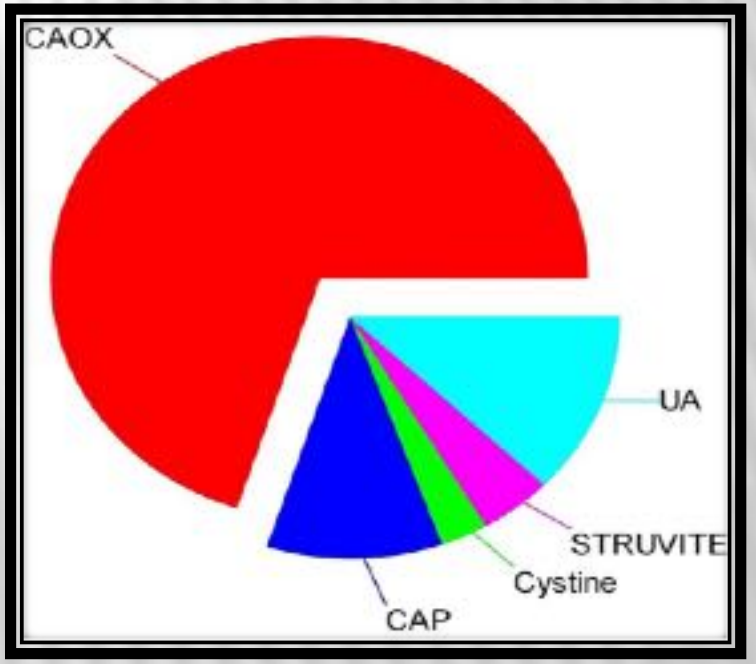
III- Clinical significance of urinary crystals

SOLUTES FORMING CRYSTALS

- *Most of urinary crystals are formed from normal constitutes of urine.*

- *Solutes responsible for normal crystals formation are:*
  - Calcium
  - Oxalic acid
  - Uric acid
  - Phosphorous

- *Pathological crystals*
  - Cysteine, cholesterol, bilirubin, tyrosine,leucine, sulfonamide



HYPERCALCIURIA

- Causes
  - **With hypercalcemia:**
    - **Hyperparathyroidism.**
    - **Hypervitaminosis D and A.**
    - **Immobilization in malignancies.**
    - **Hypo and hyperthyroidism.**
    - **Malignancy**
  - **Without hypercalcemia:**

Idiopathic (primary) most common :

Gain function mutation of CaSR ….. Hypocalcemic hypercalciuric

Secondary

Renal tubular disorders:

Dent disease.

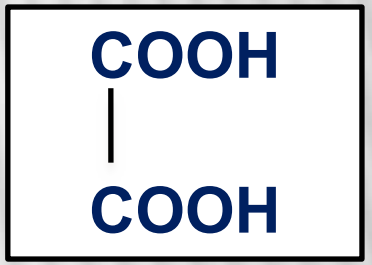
Lowe syndrome.

Bartter syndrome

d-RTA.

OXALIC ACID

- Oxalic acid is dicarboxylic acid
- It is widely distributed in plants (1-100 gm /kg dry weight)
- In plants, oxalic acid has many functions
  - Antifungal, antibacterial and antiviral effect
  - Calcium and iron hemostasis
  - pH regulation
  - Source of CO_2 in photosynthesis



OXALIC ACID METABOLISM

- Exogenous sources:
  - **Plant diets …green vegetables, spinach, tea, chocolate, nuts, ….**
  - **Average daily oral intake is 100 - 300 mg / day**
  - **Bioavailability 3-5%**
  - **Net absorption …. average 8-12 mg / day**
  - **Exogenous sources reprsent about 30 - 50 % of total daily intake**

OXALIC ACID METABOLISM

- Endogenous sources:.

They represent about 50-70% of total daily intake

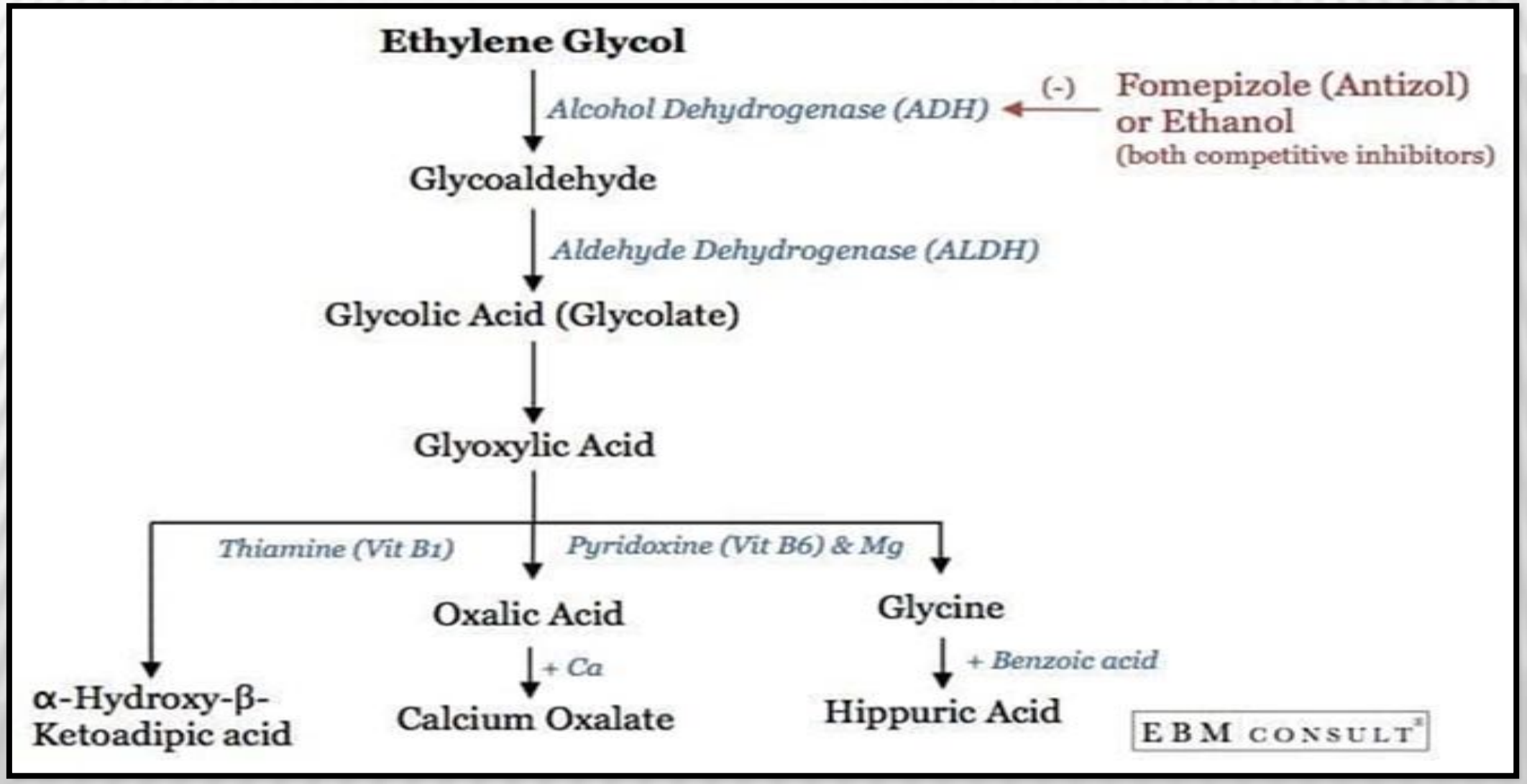
Sources

1- It is an end product in glycine metabolism

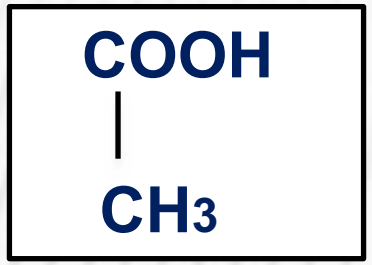
2- Non-enzymatic oxidation of ascorbic acid (vit. C)

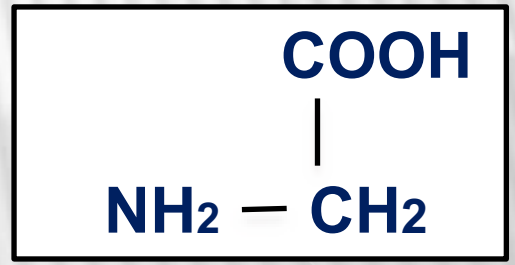
3- Less than 1% from inversion the action of AGT enzyme

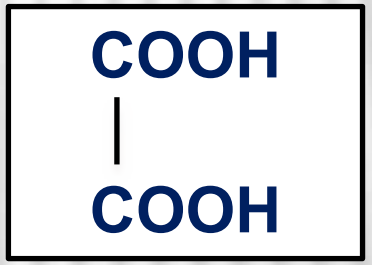
OXALIC ACID METABOLISM

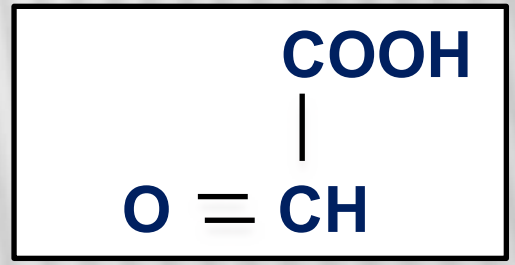


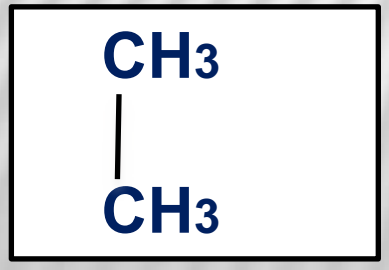
OXALIC ACID METABOLISM

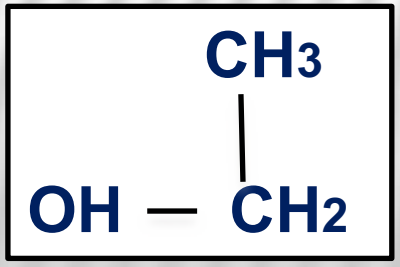


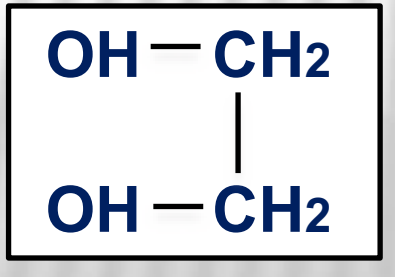


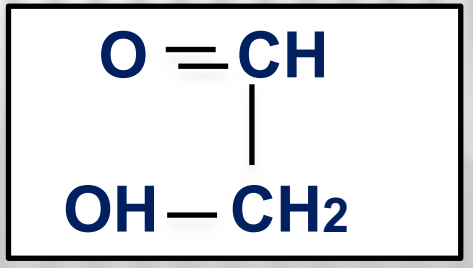


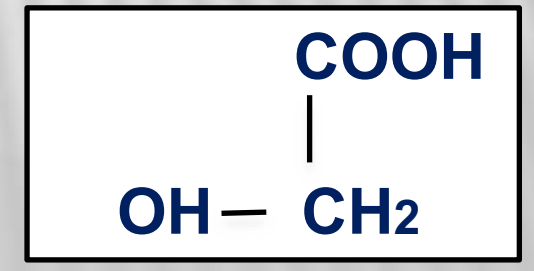












OXALIC ACID METABOLISM

- Normal plasma level
  - 1 - 2.4 mg /L
- Metabolism
  - In humans oxalic acid is an end product (not more oxidized)
  - Colonic anaerobic bacteria *(oxalobacter formigenes)* oxidized oxalic acid to CO_2 and water by *oxalic acid oxidase enzyme*
- Function
  - It has a role in uracil synthesis (nitrogenous base of RNA)

OXALIC ACID METABOLISM

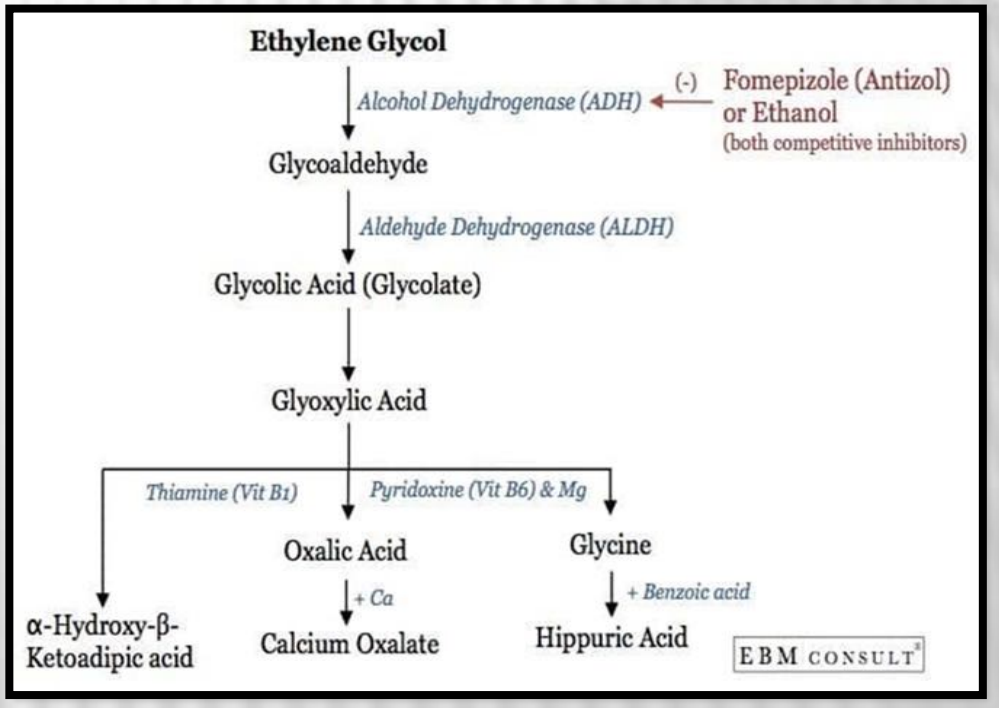
- Elimination:
  - **Kidney**

    About 90% of oxalates are excreted by the kidney

    - **Normal value ……15 -35 mg /24 h**
    - **Enteric hyperoxaluria …….60 mg /24 h**
    - **Primary hyperoxaluria ……. 250 mg / 24h**
  - **Colon…. *oxalobacter formigenes***

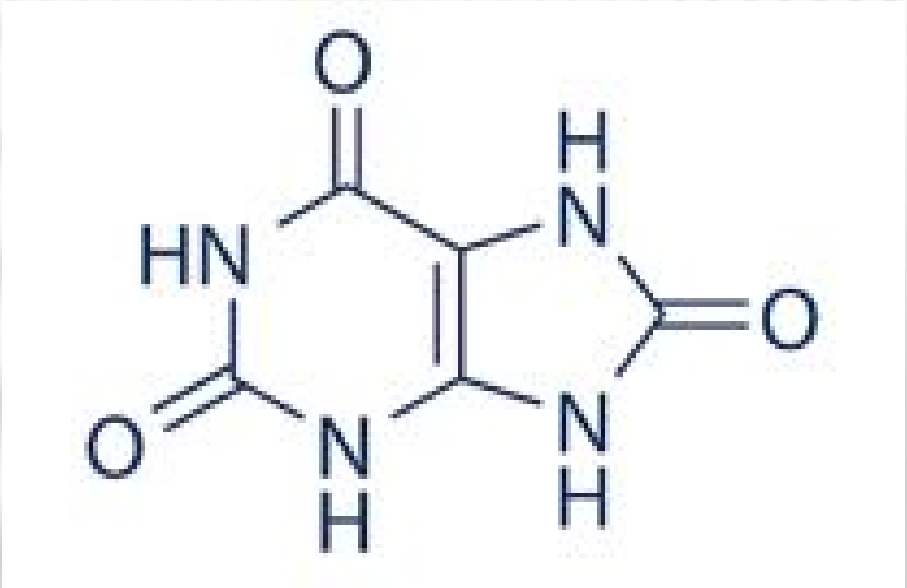
HYPEROXALURIA

- Causes:
  - **Primary:**
    - **Type I .. Alanine glyoxylate aminotransferase**
    - **Type II .. Glyoxylate reductase**
  - **Secondary:**
    - **Diet rich in oxalate.**
    - **Low Ca diet**
    - **Enteric hyperoxaluria**
      - **Malabsorption (IBD, cystic fibrosis…etc.)**
      - **Oxalobacter foremigenes deficiency**



URIC ACID

- Uric acid is a heterocyclic nitrogenous organic compound
- It is the end product of *purines* metabolism.



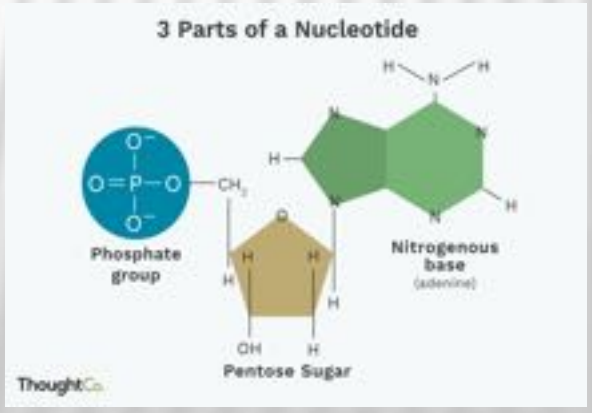
Uric acid

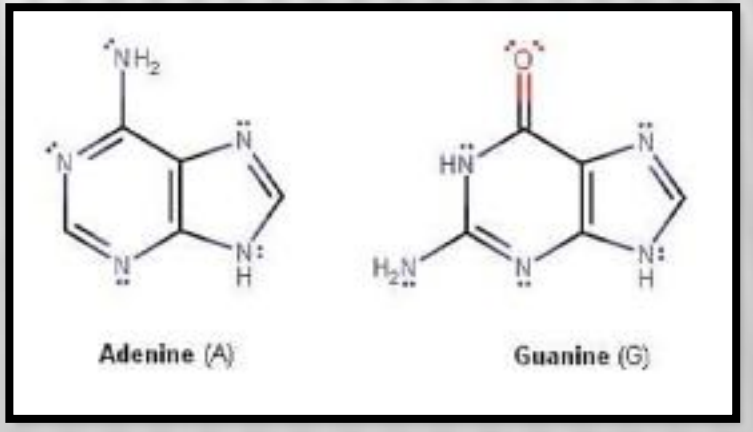
$C_5 H_4 N_4 O_3$

Molecular weight
168 gm/mole

PURINES

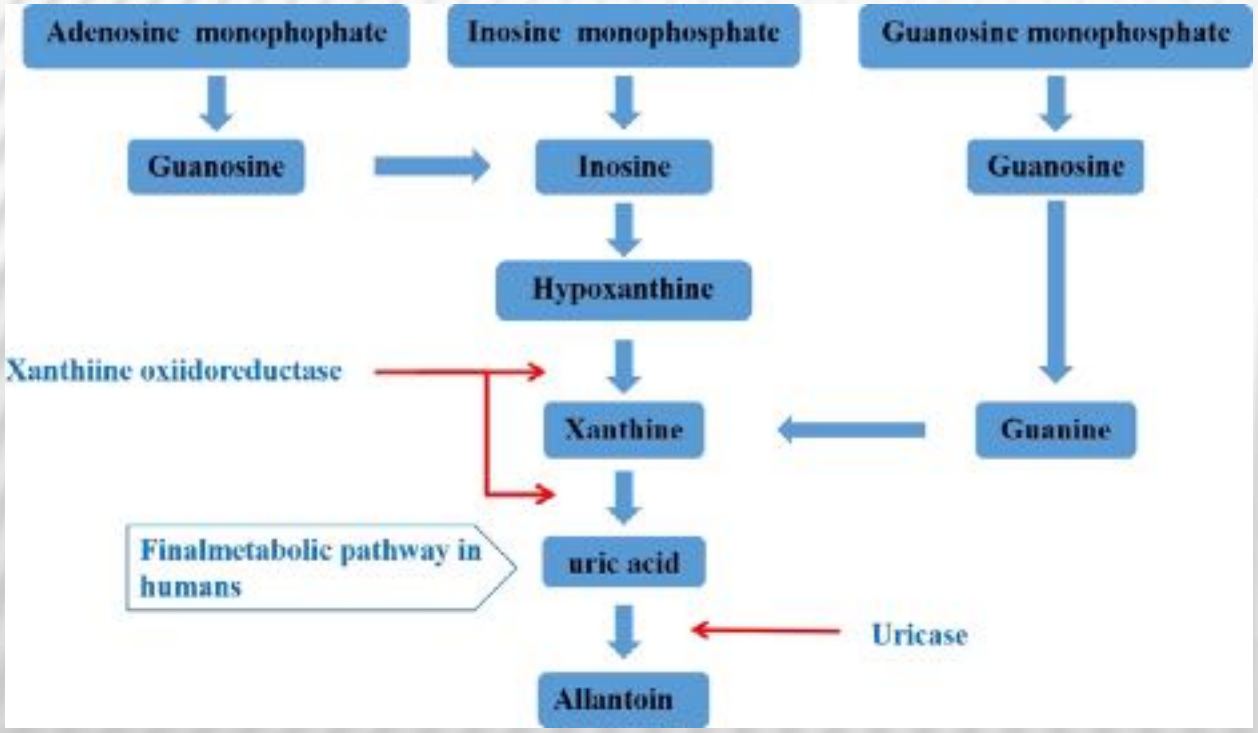
- Purine is heterocyclic nitrogenous organic compound.
- Purines (adenine & guanine) together with pyrimidines (cytosine & thymine), in addtion to ribose and phosphates provide the source for DNA and RNA structure
- Purines are essential for other important biochemical structures ….ATP, Co-enzyme NAD and NADH, cyclic AMP, cyclic GMP ….

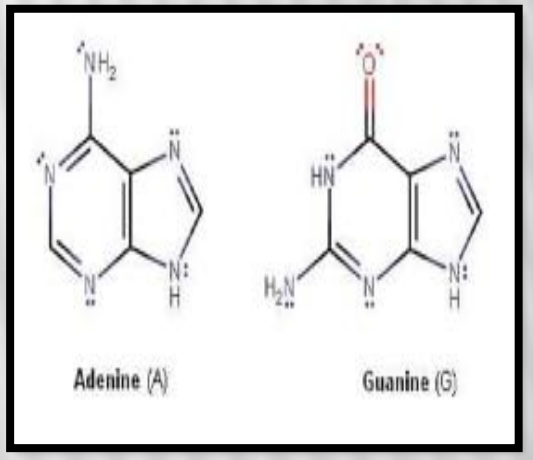




PURINE METABOLISM

- Pyrimidine is completely oxidized to CO_2 and water
- Uric acid is the end product of purines metabolism in human





Uric acid $\xrightarrow{\text{Uric acid oxidase}}$ allantoin

URIC ACID METABOLISM

- Uric acid oxidase enzyme is founded in nearly all organism from bacteria to mammals
- It is inactive in human due to nonsense evolutional mutations of it`s gene
- Uric acid is a potent antioxidant, protect endothelium from oxidative damage …… prolongation of life and protect against cancer

URIC ACID METABOLISM

- Sources

  Endogenous 400 mg /day

  Exogenous 300 mg / day …….. diet reach in purines

- **Normal serum level 3 - 7 mg/ dl …. Optimum < 6 mg / dl**

- **Normal 24 h urinary uric acid is < 700 mg**

HYPERURICOSURIA

- Causes:
  - Primary type:
    - It is a rare inherited deficiency of purine salvage enzymes.
  - Food rich in purine.
  - Tumor lysis syndrome.
  - Drugs (analgesics, diuretics …etc.)
  - Metabolic syndrome.

AGENDA

I- Pathophysiology

II- Solutes forming crystals

III- Clinical significance of urinary crystals

- Diagnosis
- Treatment

DIAGNOSIS OF URINARY CRYSTALS

- Routine urine analysis is the most commonly performed laboratory test in clinical practice

- Urinary crystals are diagnosed by routine urine analysis

Urine Analysis

Physical Examination

Volume	Sample
Colour	Yellow
Aspect	Clear
Reaction	Acidic
Sp.Gr	

Physical Examination

Albumin	Nil
Sugar	Nil
Keton	Nil
Nitrite	Nil
Bilirubin	Nil
Bile Salts	Nil
Urobilinogen	Normal

Microscopic Examination

R.B.Cs	0 - 1 /	H.P.F
Pus Cells	1 - 3 /	H.P.F
Epithelial Cells	Nil	H.P.F
Casts	Nil	
Crystals	Uric acid (Few)	
Amorphous Material	Nil	
Bilharzial Ova	Nil	

DIAGNOSIS

- Urine sample collection
  - First morning voided urine
  - Clean-catch, mid stream voided urine
  - Urine sample must be stored at 37C not refrigerated
  - Examination should be done within two hours following voiding

DIAGNOSIS

- Procedure
  - 10 ml urine (fresh, morning sample)
  - Centrifuged for 5 minutes at 1500 rpm
  - Supernatant is discarded (poured of)
  - Resuspend in 0.5 ml urine
  - Drop of this solution is placed on glace slide and covered with cover slip
  - The slide is examined immediately under the microscope using first the low power and then the high power field

DIAGNOSIS

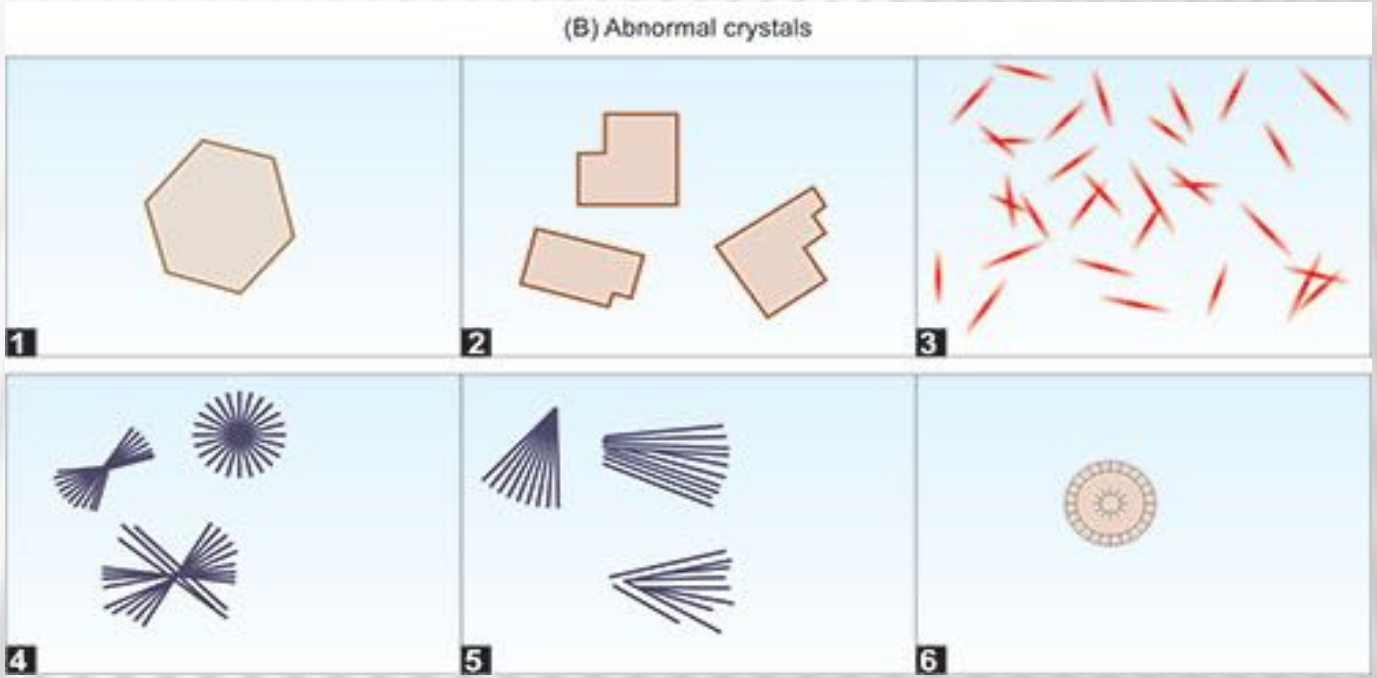
- Examination
  - Urinary crystals should be examined according to the following criteria:
    - Chemical nature
    - Urine pH
    - Morphology
    - Crystal abundance
    - Crystal size
    - Crystal aggregation
    - Solubility
    - Persistent crystaluria

URINARY CRYSTALS

- Chemical structure
  - Crystals are *refractile* structure with a definite geometric shape due to orderly arranged their atoms and molecules
  - Crystals can be identified microscopically by their specific *morphology*
  - First step for diagnosis of urinary crystals is to:
    - Identify and recognize abnormal urinary crystals
    - Confirm their diagnosis by additional chemical test (solubility test)

URINARY CRYSTALS

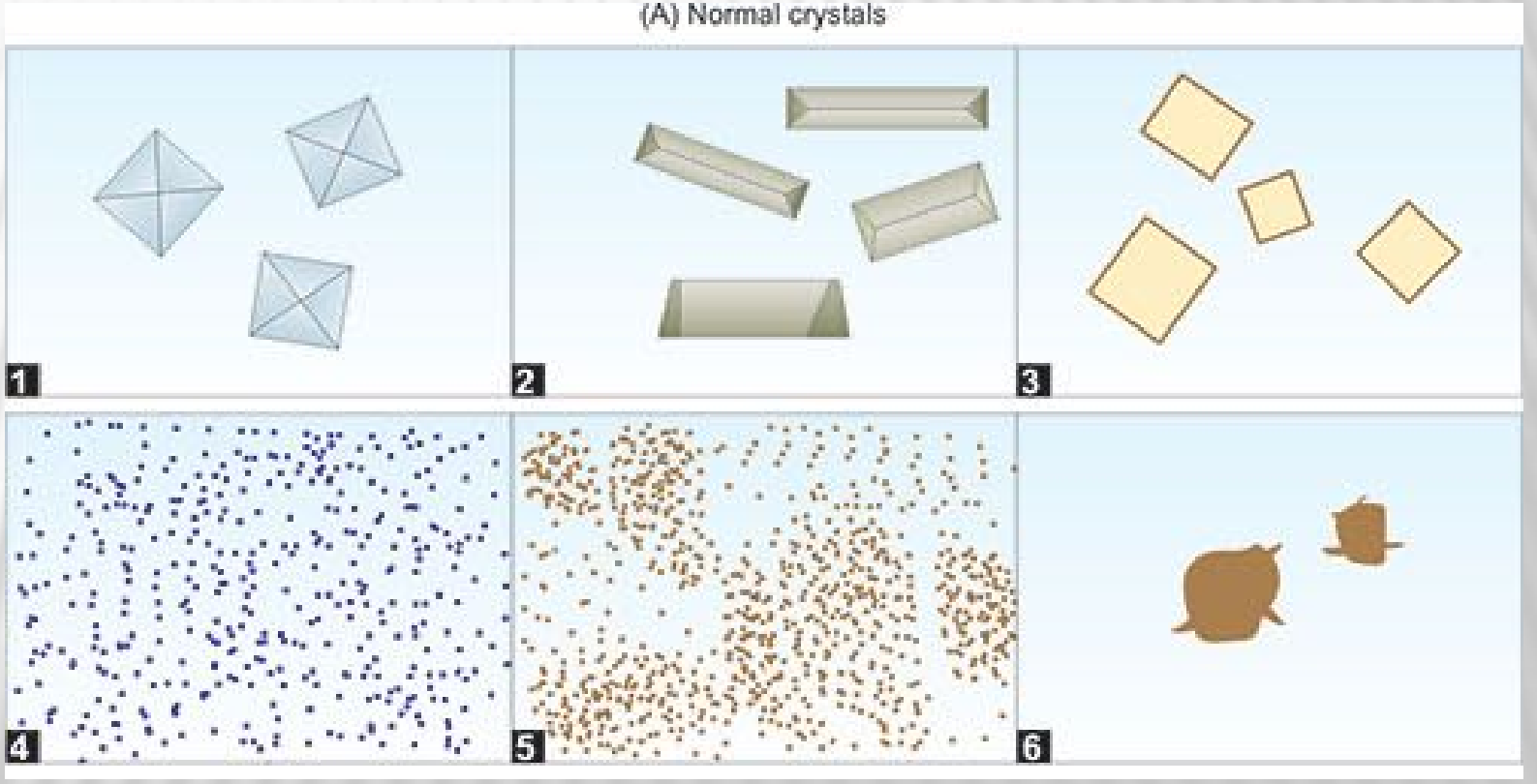
- Abnormal urinary crystals
  - 1- Cysteine
  - 2- Cholesterol
  - 3- Bilirubin
  - 4- Tyrosine
  - 5- Sulfonamide
  - 6- Leucine



URINARY CRYSTALS

- Normal urinary crystals

1- Calcium oxalate
2- Triple phosphate
3- Uric acid
4- Amorphous phosphate
5- Amorphous urates
6- Ammonium urate



URINARY CRYSTALS

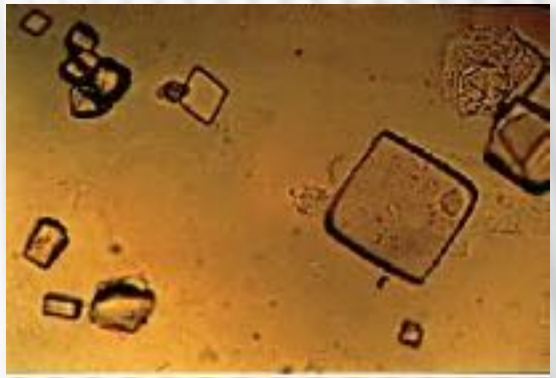
- Crystal and pH of urine
  - Normal crystals in acidic urine
    - Uric acid
    - Calcium oxalate
    - Amorphous urates
  - Normal crystals in alkaline urine
    - Calcium carbonate
    - Phosphates
    - Ammonium urate crystals
  - Most of abnormal crystals occur in acidic urine

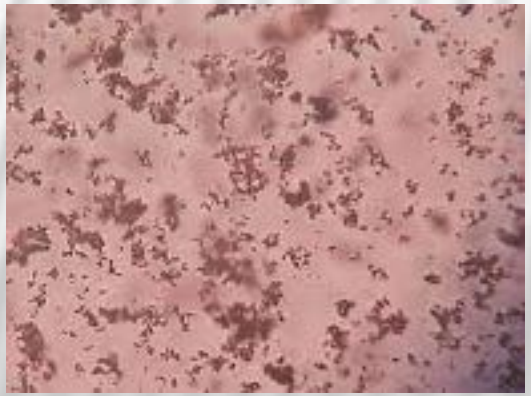
URINARY CRYSTALS

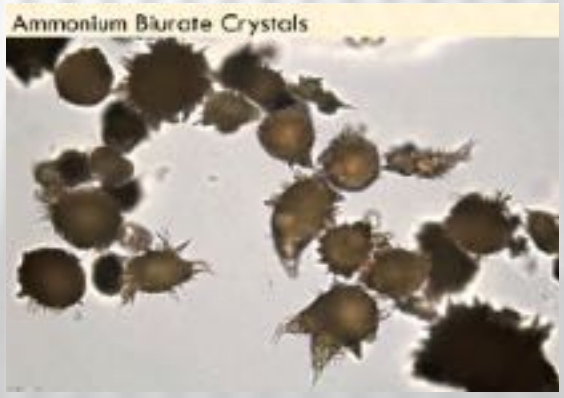
- Crystal morphology
  - Calcium oxalate according to number of water molecules
    - tri hydrate
    - dihydrate ..... envelop shaped
    - monohydrate ... dumbbled, needle, or oval shaped
    - anhydrous

URINARY CRYSTALS

- Crystal morphology
  - Uric acid
    - Plates, rosette, diamond shped
  - Urates
    - k, Mg, Ca .....amorphus
    - ammonium..... cactus







URINARY CRYSTALS

- Abundance
  - In routine urine analysis, crystals are subjectively quantified as:
    - few (+)
    - moderate (++)
    - many (+++)

URINARY CRYSTALS

- Abundance
  - In special situations ….(stone former)
    - Counting crystals in urine sediment (> 200 CaO crystals /mm3 highly suggestive of primary hyperoxaluria)
    - Global crystal volume ……. (oxalate and cysteine)
    - Urine flow cytometry is an automated methods to detect and quantify different urinary components including crystals

URINARY CRYSTALS

- Abundance

  Chemical analysis of solutes concentration in 24 h urine collection or solute/creatinine ratio give accurate value of different solutes and replaces these techniques

URINARY CRYSTALS

- Crystal size

  Increase size of calcium oxalate crystal > 35 microns (normal size <20)

  is indicative of simultaneous hypercalciuria and hyperoxaluria

- Crystal aggregation

  It is defined as more than 3 crystals tightly joint together is suggestive risk of stone formation

URINARY CRYSTALS

- Solubility

  Abnormal crystals should not be diagnosed on microscopic examination alone

  Solubility test should be performed ex

  cysteine crystals are soluble in 30% HCl

  cholesterol crystal are soluble in ether or alcohol

- Frequency

  Persistent crystalluria of first morning sample is the most reliable marker for detecting the risk of stone recurrence in stone formers

CLINICAL SIGNIFICANCE

- Normal crystalluria is not, per se, a marker of a pathological condition, it is a marker of super saturation in both normal and pathological conditions
- In stone former, it is the best marker for predicting stone recurrence during their follow-up
- It offers the opportunity to adjust dietary and drug management, and thus control stone formation

TREATMENT

- Presence of normal urinary crystals in urine analysis is normal, is normal, is normal
- They need no treatment, no treatment, no treatment
- Treatment is just assurance

- When do to treat urinary crystals

TREATMENT

- Indication of treatment
  - Stone former
  - Family history of metabolic stone diseases
  - Risk factors of urinary crystals
    - Abundant crystalluria (heavy, increase count, increase global volume)
    - Increase crystal size
    - Crystal aggregation
    - Persistent crystalluria

TREATMENT

- Increase water intake
- Decrease exogenous sources of
  - Oxalate reach food
  - Urate reach food
- Normal calcium intake
- Avoid excessive intake of vit. C, vit D supplement
- Avoid excessive salt and protein intake
- Natural inhibitors of crystal formation (K citrates)

TAKE HOME MESSAGES

1. Urinary crystals are very common, they are almost always present in every routine urine analysis
2. They are simply diagnosed by microscopic examination depending on crystals morphology
3. Urinary crystals are divided into normal and abnormal crystals
4. Normal urinary crystals are formed from normal urinary constitutes

TAKE HOME MESSAGE

5- Normal crystalluria is not, per se, a marker of a pathological condition, it is a marker of supersaturation in both normal and pathological conditions

6. In stone formers, crystalluria is a marker for predicting stone recurrence during their follow-up

7. Treatment of normal urinary crystals, after exclusion of risk factors, is assurance

8- In human, absence of two enzymes oxalic oxidase and uric acid oxidase is responsible for most of urinary crystals and stones

Thank you

CALCIUM SENSING RECEPTORS

- **They are a class of G-protein coupled receptors**
- **They** are expressed in
  - Parathyroid gland
  - Brain
  - Renal tubules
    - Proximal tubules ..... (luminal)
    - Loop of Henle ..... (basolateral)
    - Connecting duct ..... (basolateral)
    - Collecting duct ..... luminal)
  - Others

CALCIUM SENSING RECEPTORS

- They sense extracellular calcium level
- They regulate ionized serum calcium level
- Calcium sensing receptor gene has 2 types of mutations:
  - Gain function mutation
  - Loss function mutation

CALCIUM SENSING RECEPTORS

- **Mechanism of action**

↑ Serum calcium level

parathyroid gland → ↓PTH

kidney → ↑calcium excretion in urine

↓ Serum calcium level

parathyroid gland → ↑ PTH

Kidney → ↓ Calcium excretion in urine

CALCIUM SENSING RECEPTORS

- **Gain function mutation**

  Calcium (normal or low)

  1- ↓ PTH ⟶ ↓ calcium level ⟶ hypocalcemia

  2- ↑ urinary calcium excretion ⟶ hypercalciuria

- **Loss function mutation**

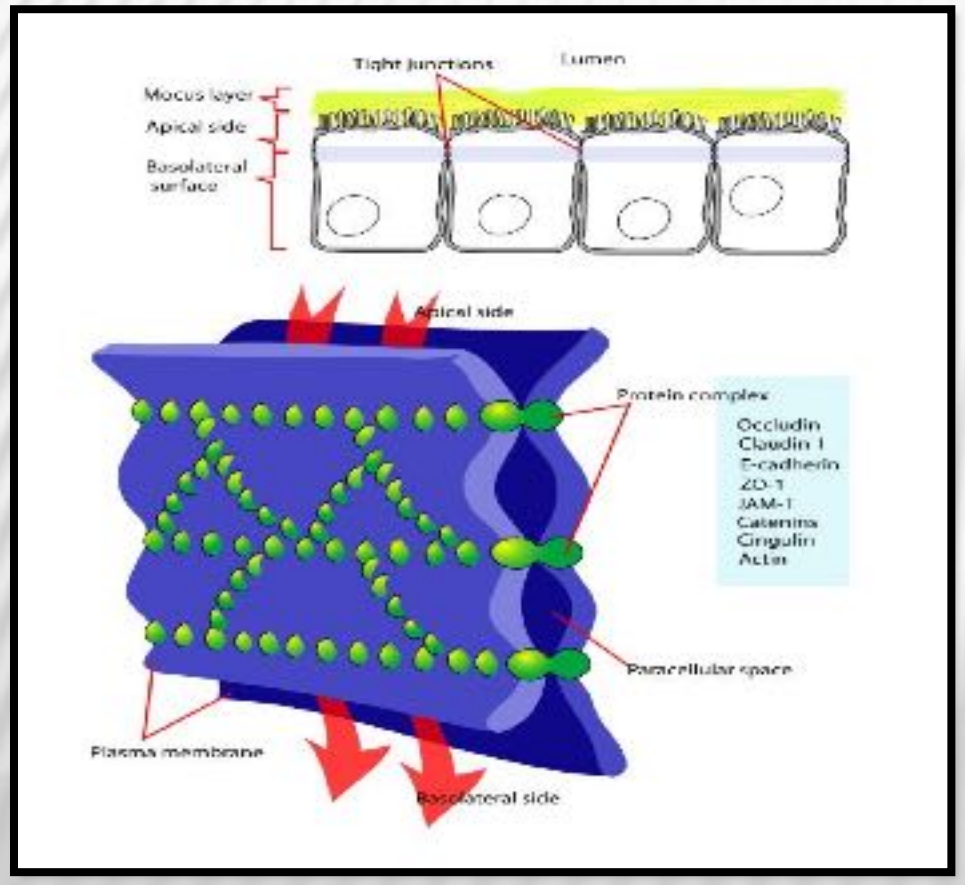
  Hypercalcemic hypocalciuric

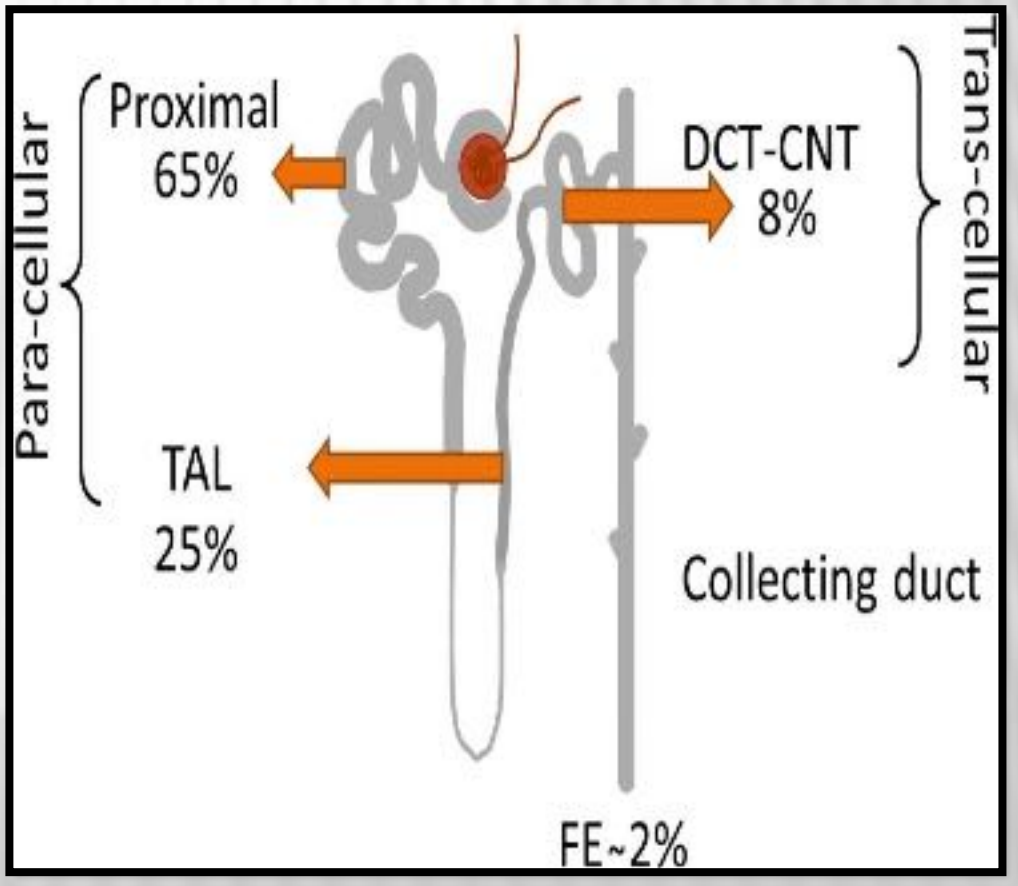
- **Calcimimetic agents**

  Cinacalcet … mimpara

CALCIUM HOMEOSTASIS

- **Calcium ions have intracellular signaling activity, so most of its reabsorption occurs paracellular.**

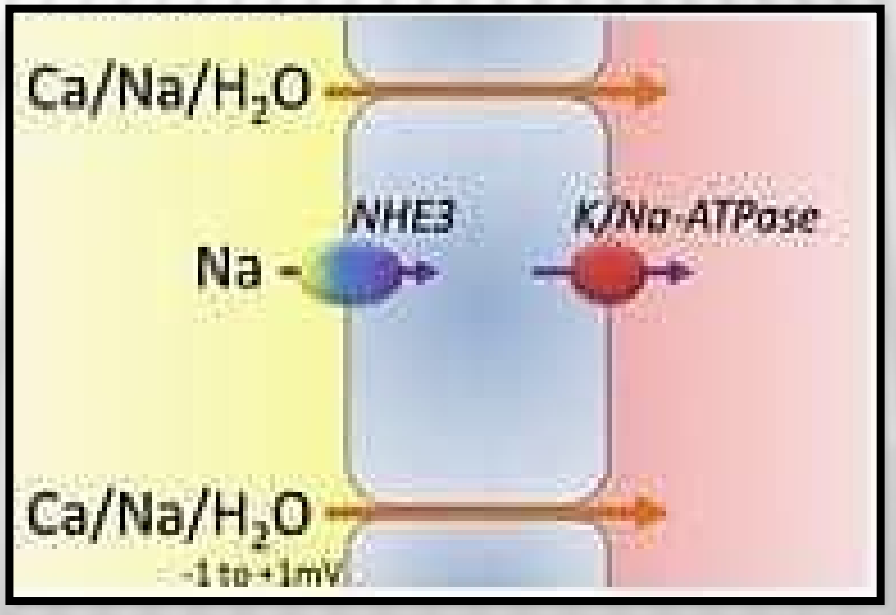




CALCIUM HOMEOSTASIS

Proximal tubules:

- Ca is reabsorbed by passive hormone-independent paracellular transport through freely permeable epithelium of proximal tubules.
- Driving force for Ca reabsorption is provided by Na-H exchanger.
- CaSR (luminal) have no role in calcium reabsorption, but may have a role in activation of vit D and Pi excretion.



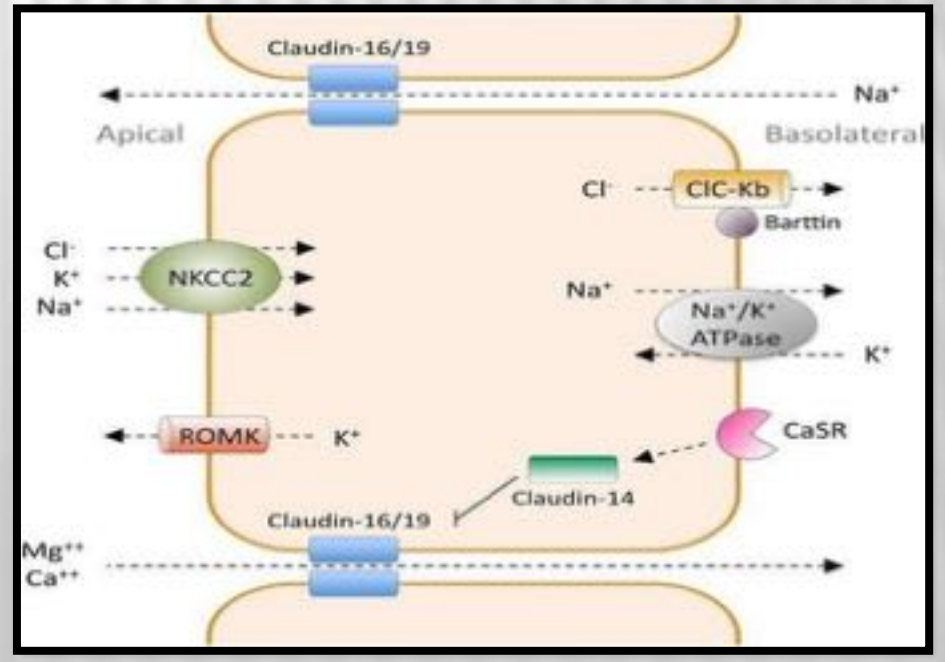
CALCIUM HOMEOSTASIS

Loop of Henle:

- Calcium is reabsorbed by controlled paracellular pathway involving claudin 16, 19, 14.
- The driving force is provided by Na-K-2Cl cotransporter, ROMK and Na –K-ATPase
- Paracellular permeability is controlled by CaSR (basolateral) which express either:

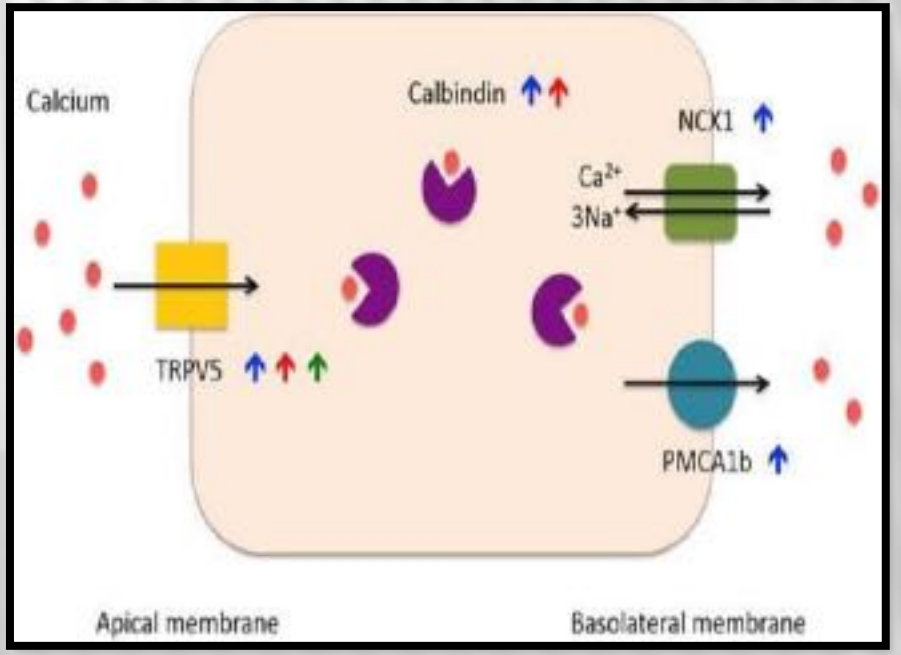
  (16 & 19) claudin .... Permeable

  (14) claudins ..... Block



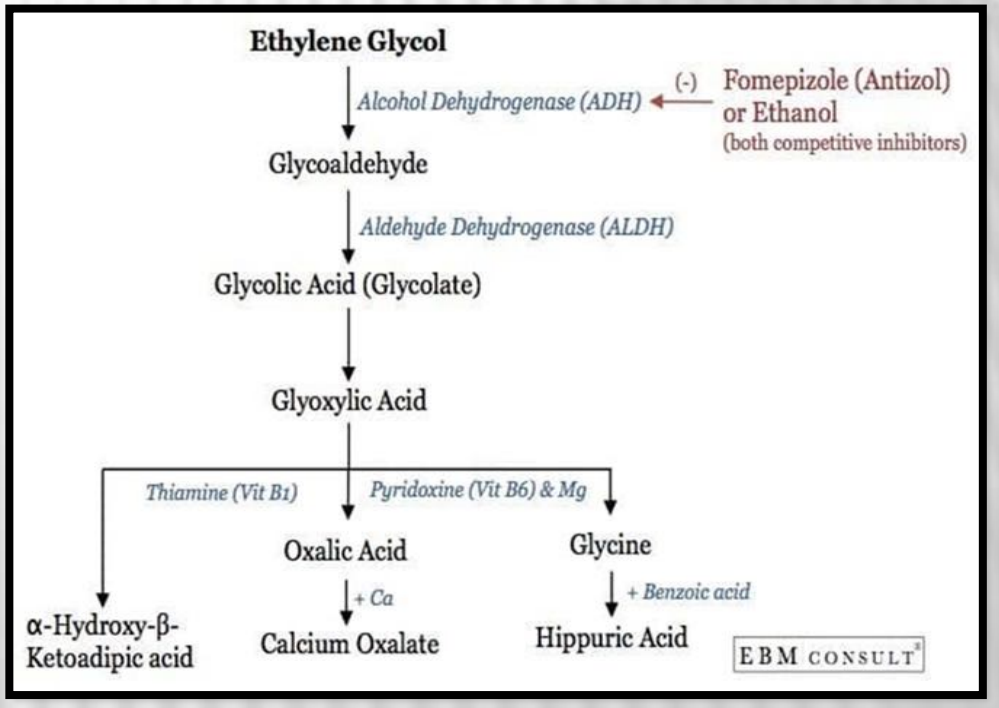
CALCIUM HOMEOSTASIS

- Distal tubules and connecting ducts
- **Calcium enters the cell at apical side through transient receptor potential V5 (TRPV5) channels.**
- **Inside the cell, it binds intracellular calbindin.**
- **At the basolateral side, it exits by sodium calcium exchanger (NCX1) and calcium ATPase**
- **TRPV5 is activated by vit D and PTH.**
- **Thiazides activate TRPV5, calbindin and NCX1**



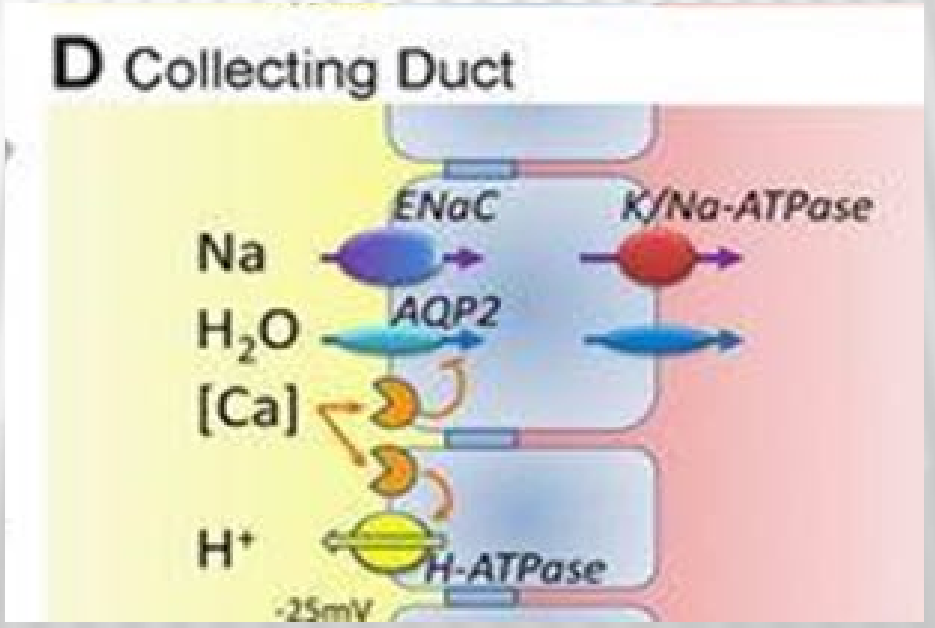
HYPEROXALURIA

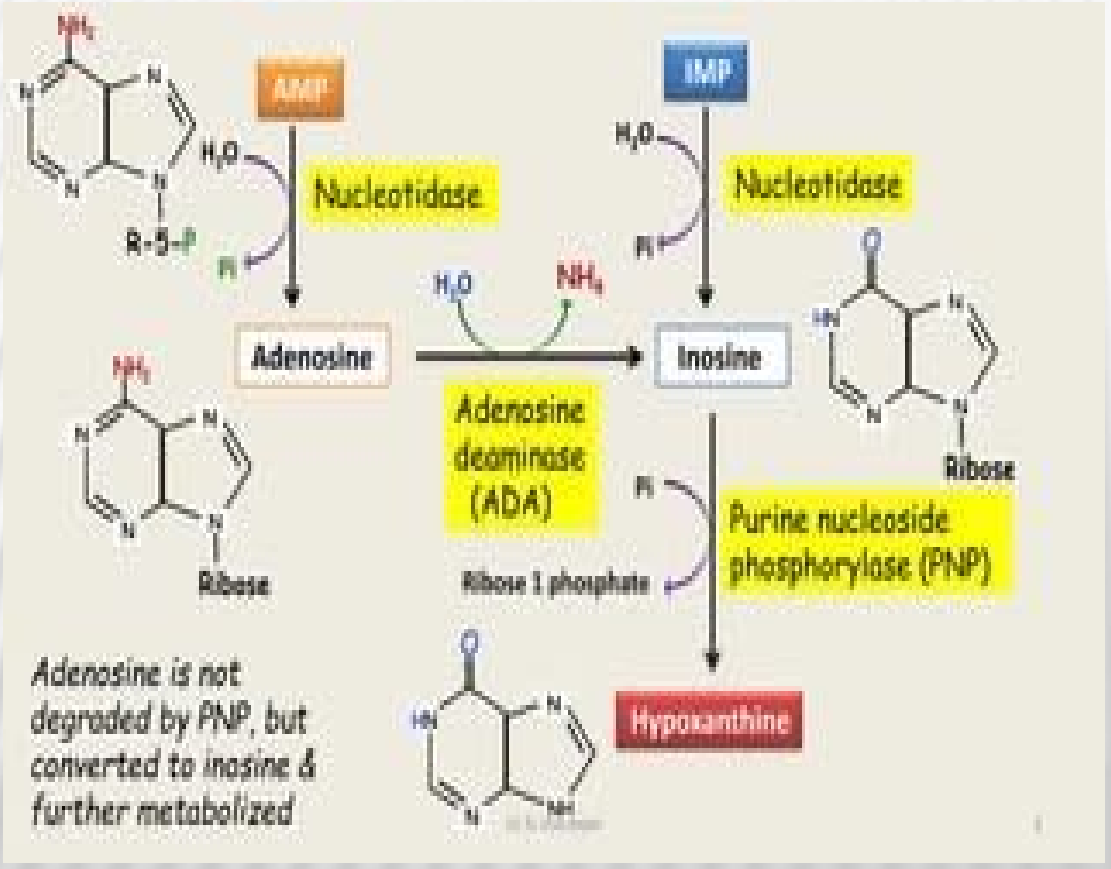
- Causes:
  - **Primary:**
    - **Type I .. Alanine glyoxylate aminotransferase**
    - **Type II .. Glyoxylate reductase**
  - **Secondary:**
    - **Diet rich in oxalate.**
    - **Low Ca.**
    - **Enteric hyperoxaluria**
      - **Malabsorption (IBD, cystic fibrosis…etc.)**
      - **Oxalobacter**
- Effect:
  - **Nephrocalcinosis and nephrolithiasis**



CALCIUM HOMEOSTASIS

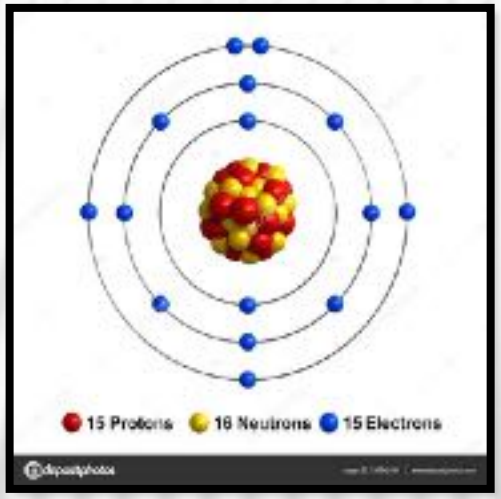
- Collecting ducts
  - **Collecting ducts are absolutely impermeable to Ca reabsorption, neither transcellular nor paracellular.**
  - **In case of hypercalciuria, CaSR at the luminal side inhibits water reabsorption and stimulates urine acidification.**

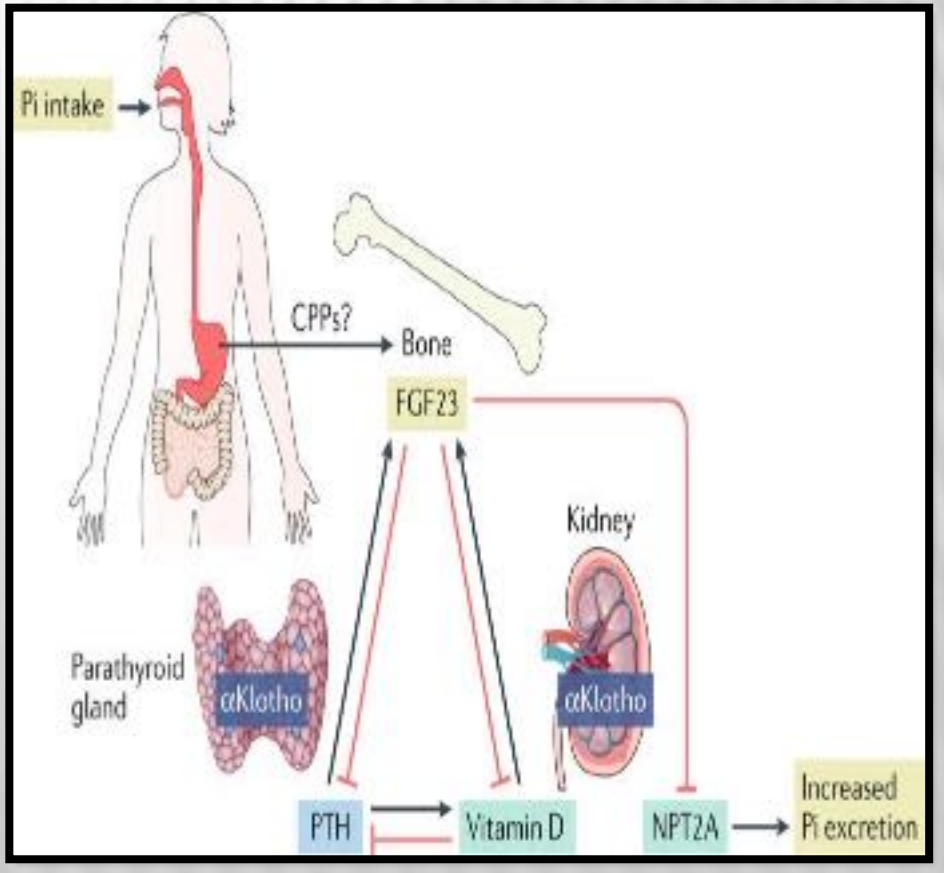



AMP
IMP
Nucleotidase
Nucleotidase
R-5-P
Adenosine
Inosine
Adenosine deaminase (ADA)
Ribose
Ribose
Ribose 1 phosphate
Purine nucleoside phosphorylase (PNP)
Hypoxanthine
Adenosine is not degraded by PNP, but converted to inosine & further metabolized

PHOSPHORUS

- It is the most common intracellular anion.
- Distribution:
  - Bone 85%
  - Soft tissue 14%:
    - Nucleic acid
    - ATP-AMP
    - Phospholipid
  - Extracellular fluid 1%





HYPER PHOSPHATURIA

- Excretion:
  - **It is freely filtered at glomerular level.**
  - **Reabsorption mainly occurs at PT by:**
    - Na dependent Pi co-transporter
    - PTH and FGF 23 inhibits reabsorption of Pi.
- Hyper phosphaturia not lead to stone formation except in presence of:
  - **Hypercalciuria**
  - **Alkaline urine**
  - **Other risk factors**

MECHANISM

❑Crystal formation:

- ❑Supersaturation.
- ❑pH.
- ❑Absence of naturally inhibitors substances (citrate).

❑Crystal adhesion:

- ❑Tubular renal disorders
- ❑Injured renal tubules by infections and drugs.
- ❑Rapidly proliferating tubular epithelium (newborn).

MECHANISM

- Crystal endocytosis:
  - **It leads to formation of interstitial suburothelial crystals that become apatite (Ca phosphate) plaques.**
- Crystal aggregation:
  - **stone**
- Stone migration:
  - **Papillary tip of the kidney or moves down.**

CONCLUSIONS

- Nephrolithiasis is common and serious medical problem dating since ancient times, with unclear pathophysiology.
- Water is the solvent of life.
- Kidney stones are formed from normal urinary constitutes.
- Supersaturation of stone forming solutes is the most important independent risk factor in stone formation.

CONCLUSIONS

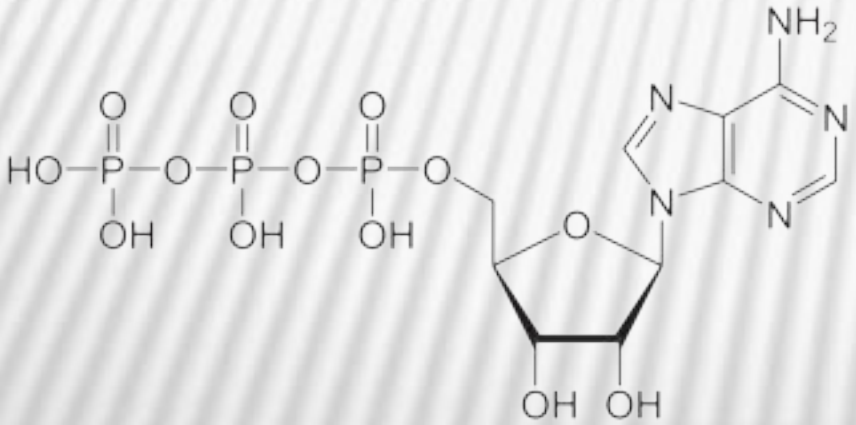
- Other risk factors include urinary pH, UTI, stasis, decrease natural inhibitors, medications and renal tubular abnormalities.

- Updates in renal handling of Ca may declare some of the pathophysiologic mechanism of nephrolithiasis in the future.

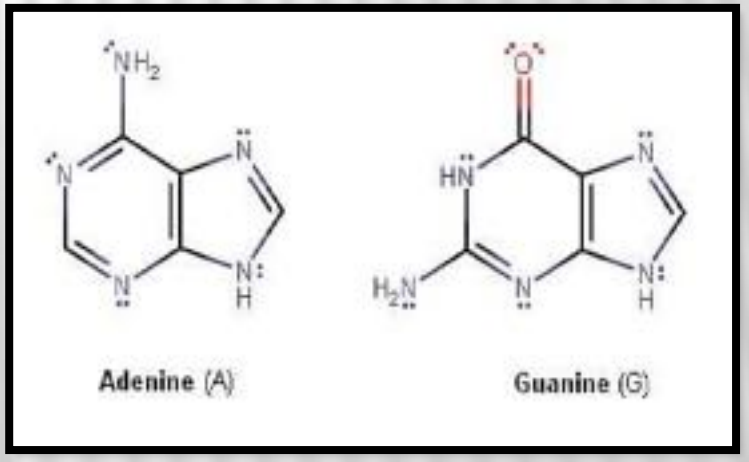
THANK YOU

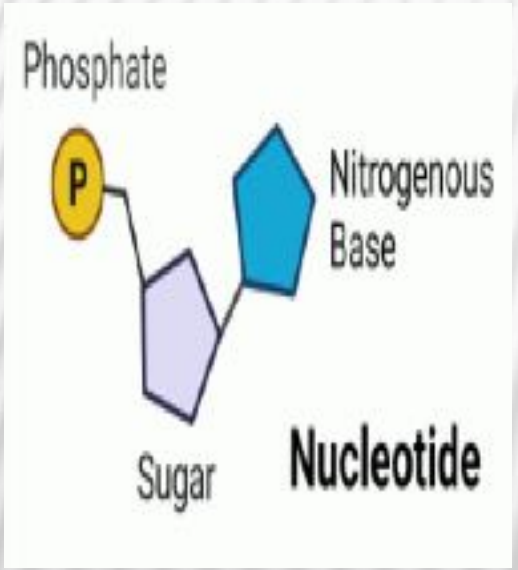
PURINES

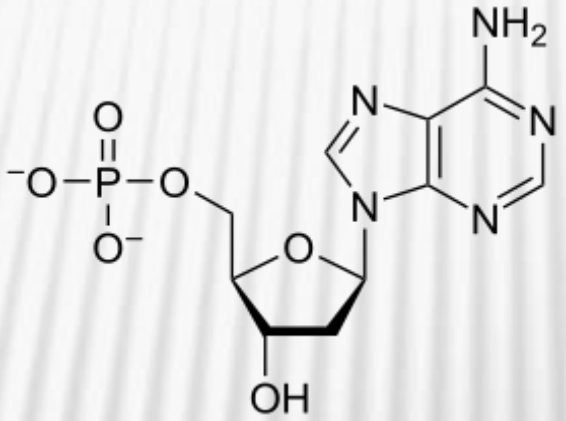
- Purine (adenine) provides primary source of cellular energy through ATP
- Purine is essential for other important biochemical structures ….ATP, Co-enzyme NAD and NADH, cyclic AMP, cyclic GMP ….

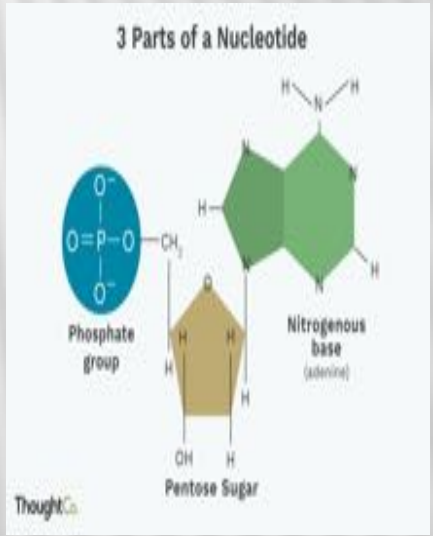


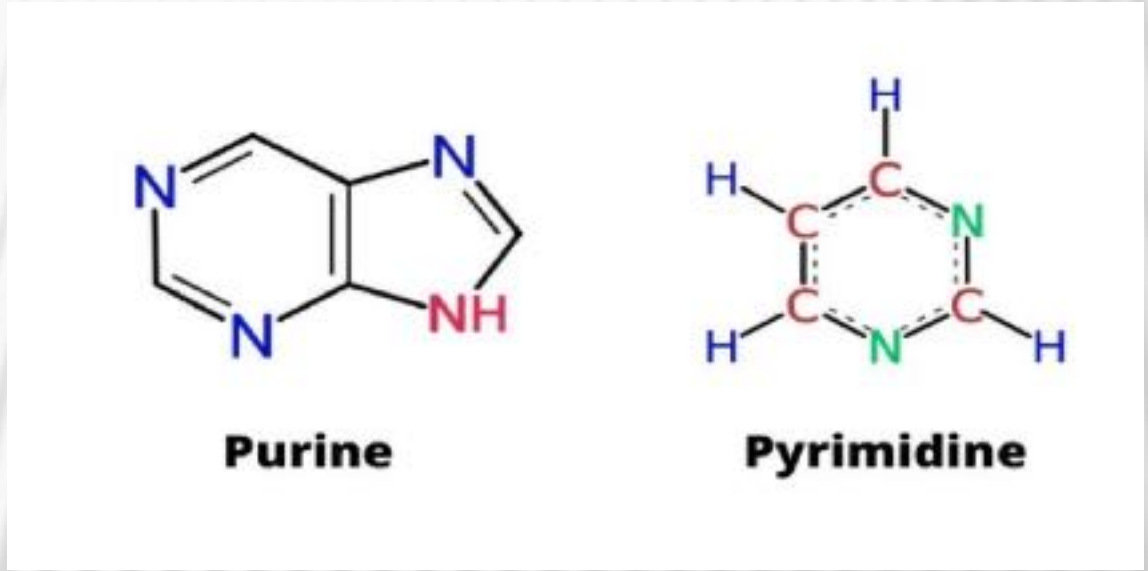
ATP




Phosphate
P
Nitrogenous Base
Sugar
Nucleotide


NH2
O
⁻O—P—O
O⁻
O
N
N
N
N
OH

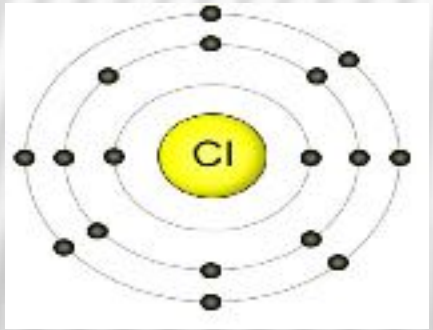

3 Parts of a Nucleotide
Phosphate group
Nitrogenous base
(adenine)
Pentose Sugar
ThoughtCo


N
N
N
NH
Purine
H
H
C
C
N
C
C
H
N
H
Pyrimidine

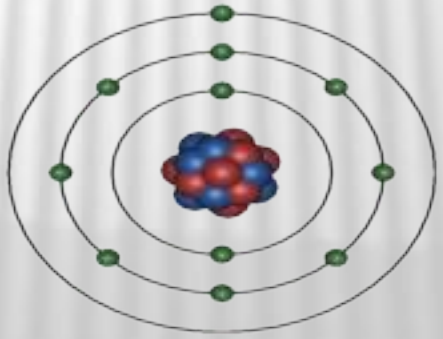
CHEMICAL COMPOUNDS

- *Elements* **are devided to**
  - 1- *Metal* **is element that easily loss electron to be stable (Na, K, Ca, Mg, ….), after electeron loss it become cataion (ion bears +ve charge)**
  - 2- *Non- metal* **is element that easily gain electron to be stable (O2, Cl, C,….), after electron gain it become anion (ion bears –ve charge)**

Ionic bond Ion Exchange



Non-metal {Chloride}



Metal {Sodium}

Chemical reaction is the process that occurs when two or more molecules interact to form new product

Chemical reaction requires energy

The new product store this energy (potential energy)

For human being, food is the source of this potential energy

WASTE PRODUTS

- **Definition**
  - **Waste products are useless materials and usually toxic, that are produced from biological processes in the body and should be eleminated**

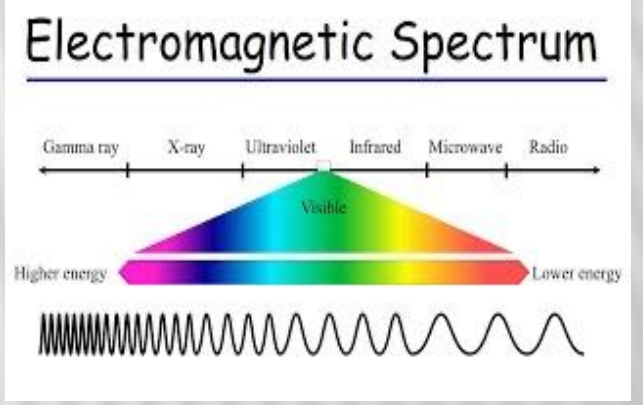
- **Types**
  - **Volatile waste products**
  - **Non – volatile waste products**

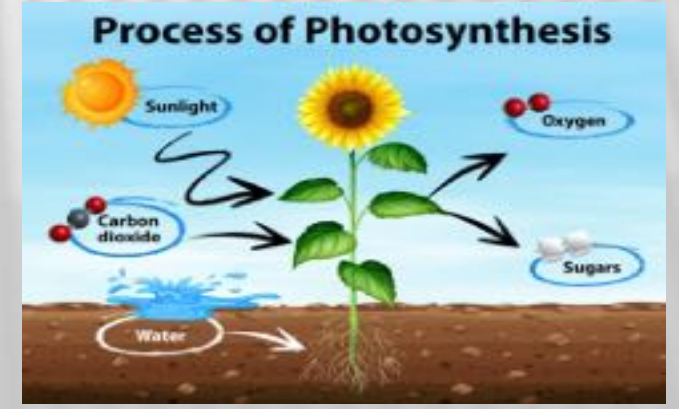
ENERGY AND CO_2 CYCLE

❑ Photosynthesis

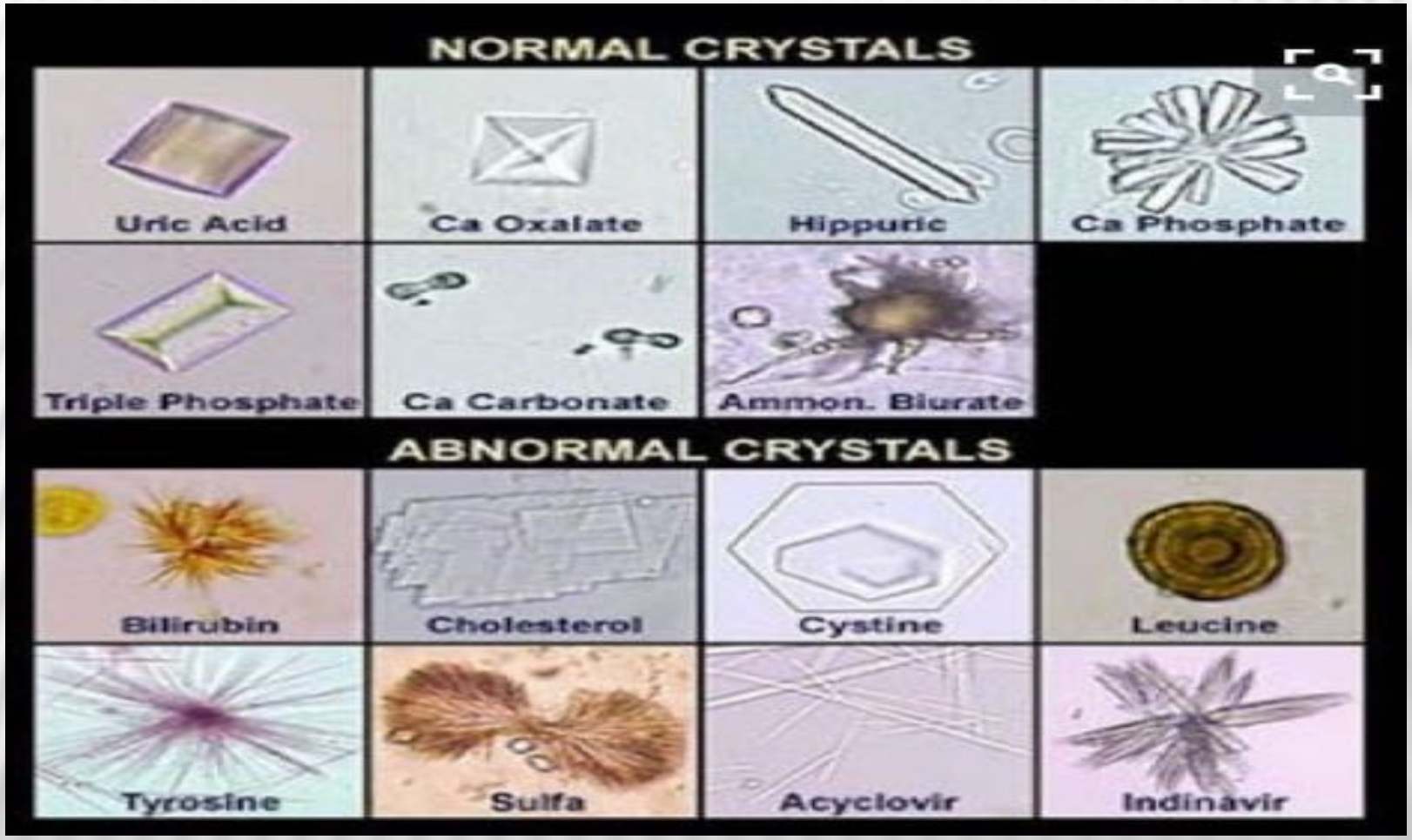
- More thane 99% of energy used on earth is provided by plants
- Chlorophyll of green plant uses part of electromagnetic radiation of sun for reduction of water ……. O2 + energy
- This energy is used for formation of glucose from water and CO2

  6 H2O + 6 CO2 ……. C6 H12 O6 + 6 O2
- End result, plant cells store solar energy in glucose
- Potential energy of glucose is consumed in biological reaction in plant cell



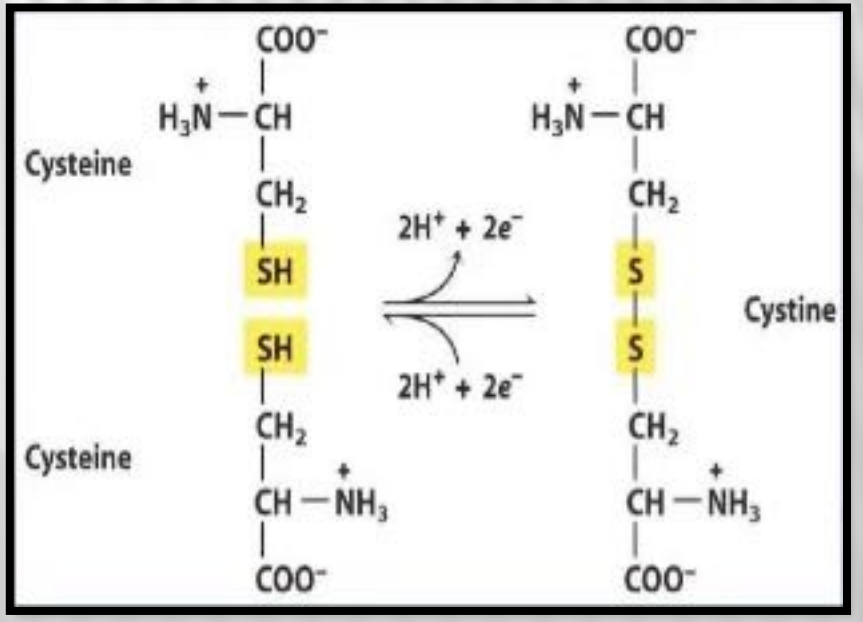


URINARY CRYSTALS



CYSTINE

- Cystine is essential dibasic amino-acid, it is formed by oxidation of 2 molecules of cysteine.
- It is insoluble in water.
- About 99% of filtered cystine is reabsorbed in the proximal renal tubules by a transporter formed by 2 subunits:
  - rBAT (Neutral Basic Amino acid Transport).
  - AGT 1 (alpha glucoside transporter 1)
- Gene mutation of either subtypes leads to cystinuria which in acid urine lead to cystine stone



OXALIC ACID

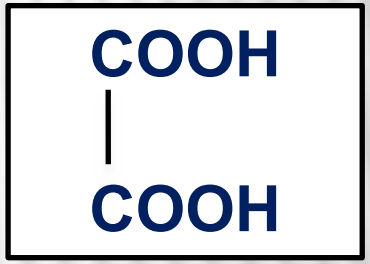
- Chemistry

Oxalic acid is organic dicarboxilic acid

Chemical formula C2 H2 O4

Molecular weight … 90 daltons

Highly soluable in water at temp. 20 C 1/10 (polar compound).. Ca oxalate???



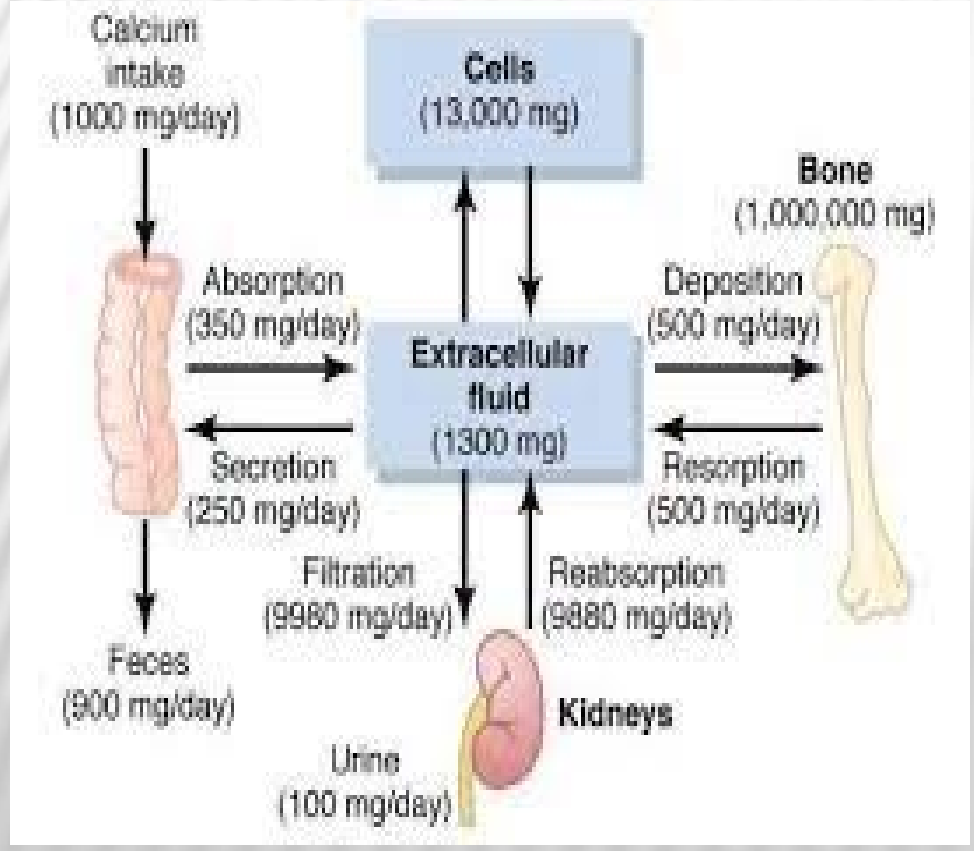
CALCIUM

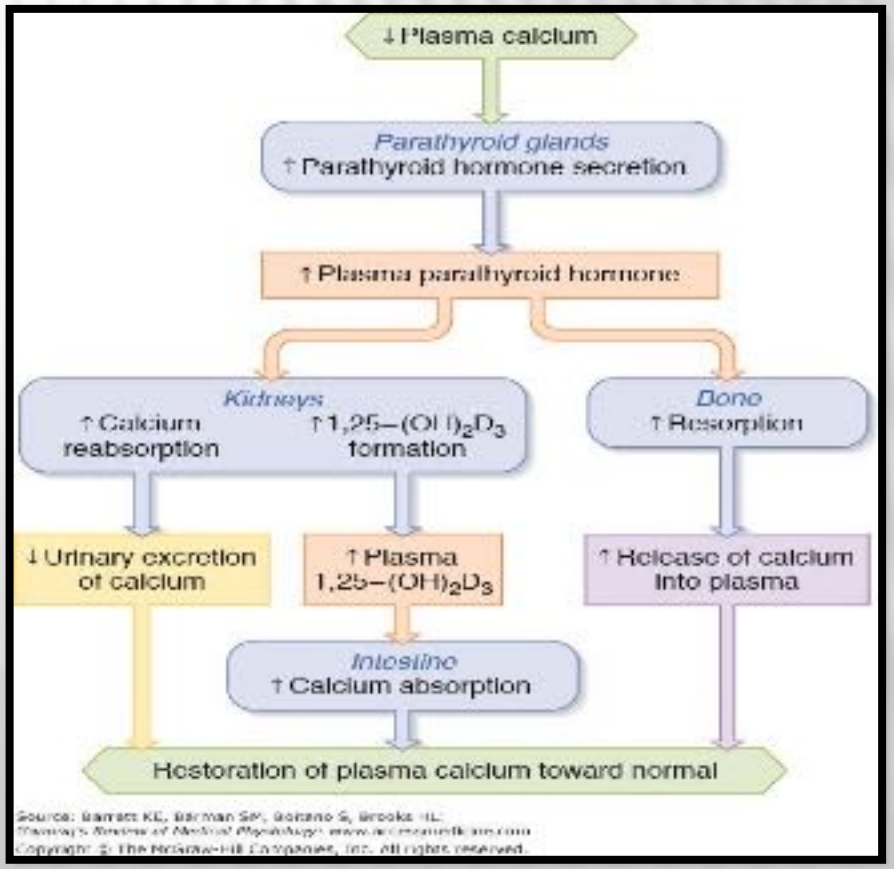
- About 99% of total body Ca resides in bone. Only 1% is found in soft tissues and extracellular spaces. Ionized calcium represents only 1%

- Calcium plays a crucial role in:
  - Intracellular signaling.
  - Neuromuscular junction.
  - Blood coagulation.
  - Bone formation.

CALCIUM HOMEOSTASIS

- Blessed were the days, when calcium homeostasis was regulated by calciotropic hormones (PTH and active vit D).





CALCIUM HOMEOSTASIS

- The role of the kidney in calcium homeostasis has been reshaped from the classic view to another view in which the kidney actively takes a part in regulation of calcium homeostasis.
- Update of calcium renal handling includes:
  - **Renal Ca sensing receptor…… *CaSR.***
  - **Paracellular Calcium transport …… *Claudine.***
  - **Transient receptors potential vanilloid type 5 channels …..*TRPV 5.***
  - **Calbindin.**

URIC ACID METABOLISM

- Uric acid is a potent antioxidant, 50% of plasma antioxidant is due to uric acid
- It's solubility is 60 mg / liter, it depends on pH, in alkaline urine it combines with sodium to form

  sodium hydrogen urate is more solubil by ten times than oxalic acid

  disodium urates is more solubile by ten times than sodium hdrogen urate