# Excretory Products & their Elimination : Introduction

Course on Human Physiology: Excretory Products & their Elimination

**Dr Amit Gupta** • Lesson 1 • Aug 10, 2021

Excretion :- Removal of cellular Nitrogenous waste from body

Homeostasis :- Maintenance of steady state

Temp, pH, osmolarity, glucose conc, water balance

# Osmolarity

Human Blood = 300 mosm $L^{-1}$

## Osmoconformer

Adapt their osmolarity acc to surroundings.

Eg- invertebrates.

(Exception = Hagfish)

## Osmoregulator

Maintain their osmolarity constant irrespective of surroundings

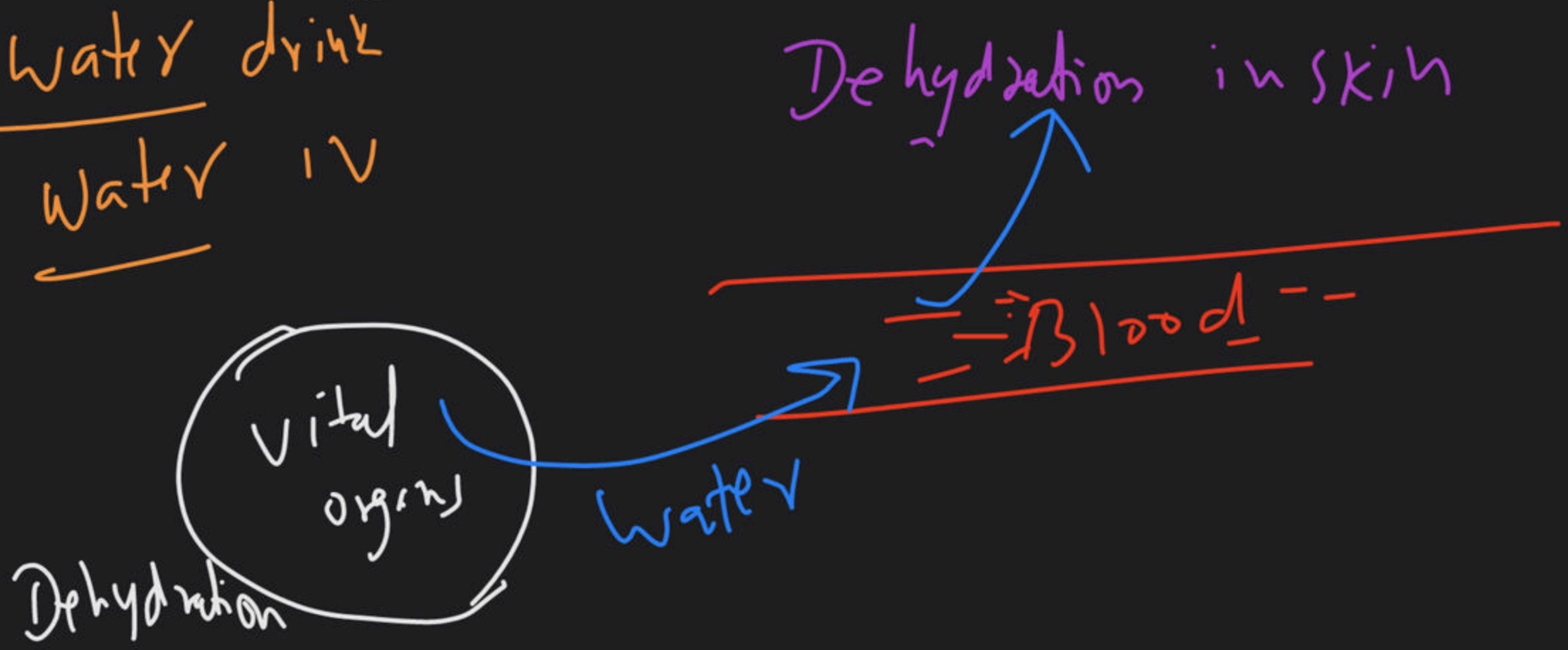
Eg- vertebrates

Human beings = Strict osmoregulator (300 mosmL$^{-1}$)

water gain = water loss

>12 % water loss is fatal

Rx - water drink / water IV



# Death due to Drowning occurs Early in

(A) fresh water

(B) Sea water

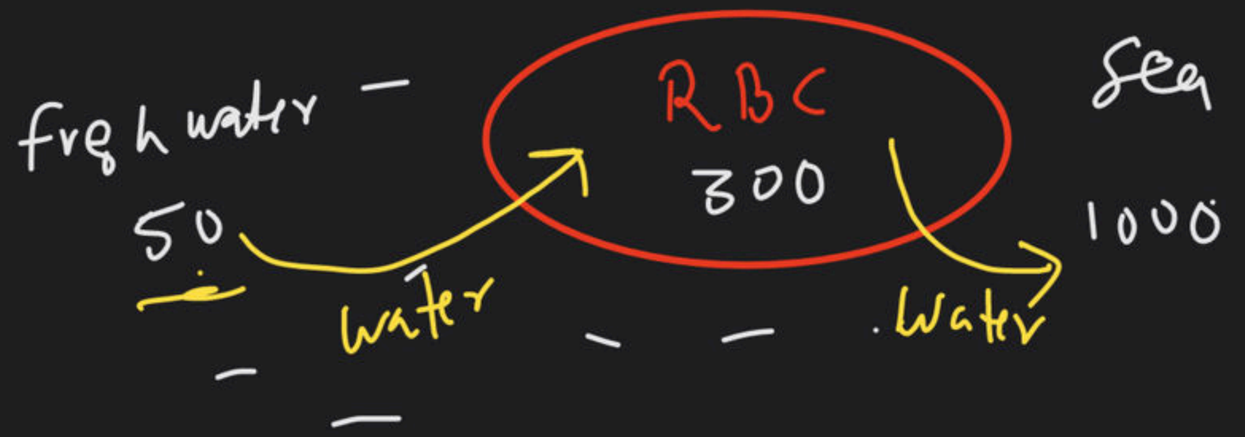
(C) Anybody / Equal time

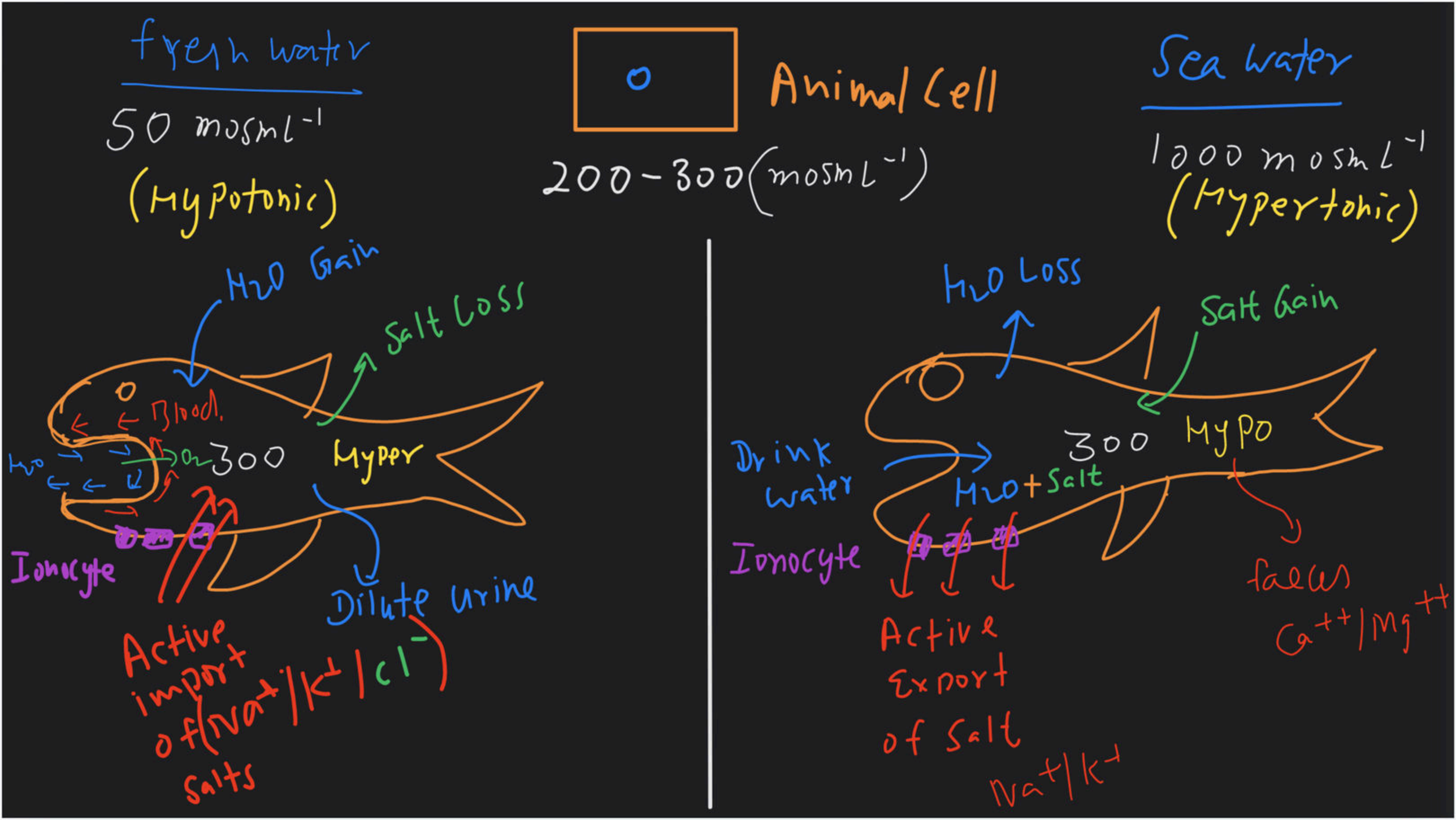
IV fluid

0.9% NaCl

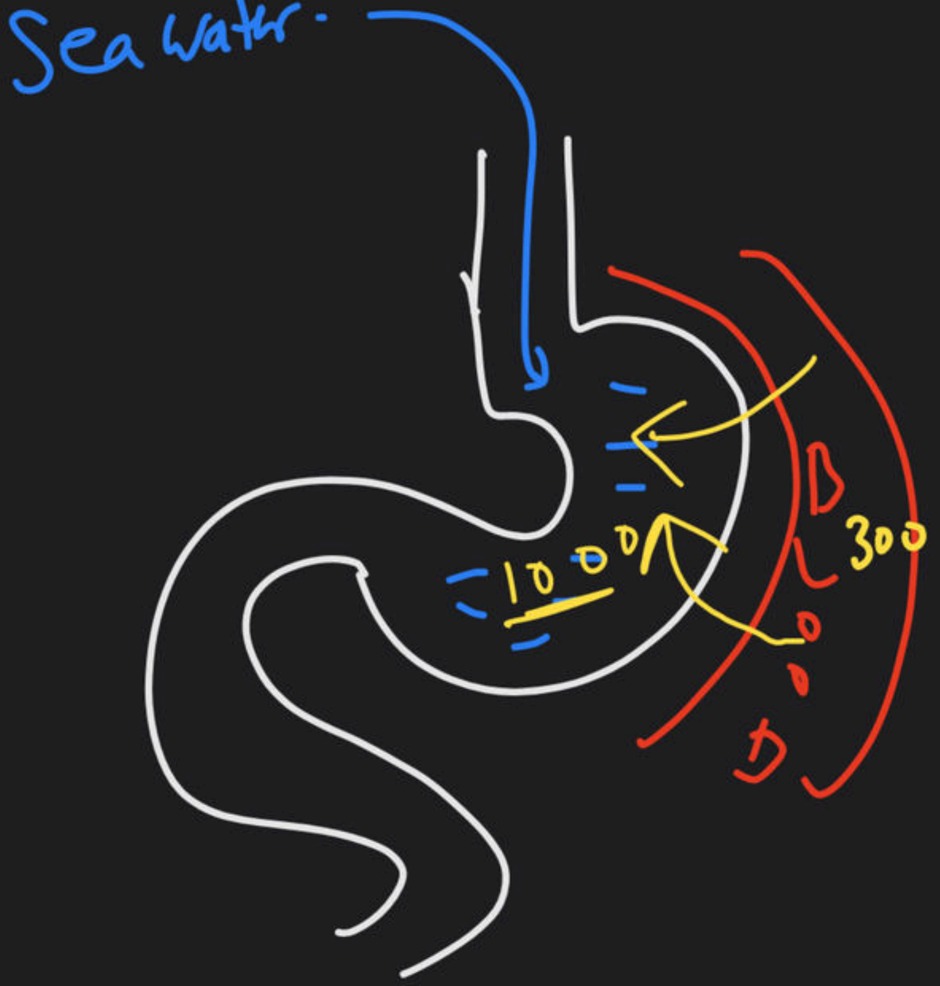
300 mosmol

~~Distilled Water~~



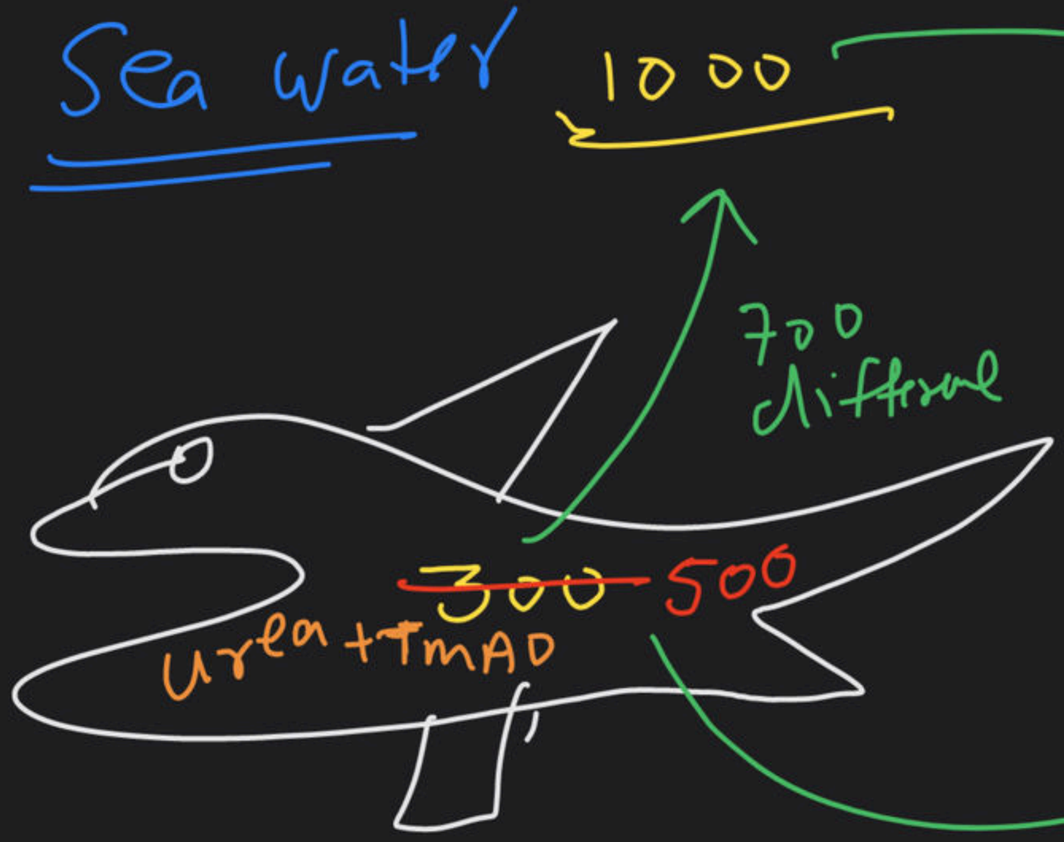

fresh water
50 mosmL⁻¹
(Hypotonic)
Animal Cell
200-300 (mosmL⁻¹)
Sea water
1000 mosmL⁻¹
(Hypertonic)
H2O Gain
Salt Loss
Blood
300
Hypo
Ionocyte
Active import of (Na+/K+/Cl−) salts
Dilute urine
H2O Loss
Salt Gain
300
Hypo
Drink water
H2O + Salt
Ionocyte
Active Export of Salt
Na+/K+
faeces
Ca++/Mg++


1000


Sea water.
1000
300

Osmoregulator ⇒ Shark

behaves as temporary osmoconforming




Sea water

1200

good differ.

700

urea behaving as osmolyte

Animal Cell

O

$NH_3$

large amount of water.

$NH_4^+$

Ammonotelic

- Most Aquatic Animals
- Tadpole
- Bony fish

Liver

Urea

Ureotelic

- Mammals
- Cartilagenous fish
- Adult Amphibia

Uric Acid.

Uricotelic.

- Most Reptiles
- Most insects
- Land Snails
- Aves

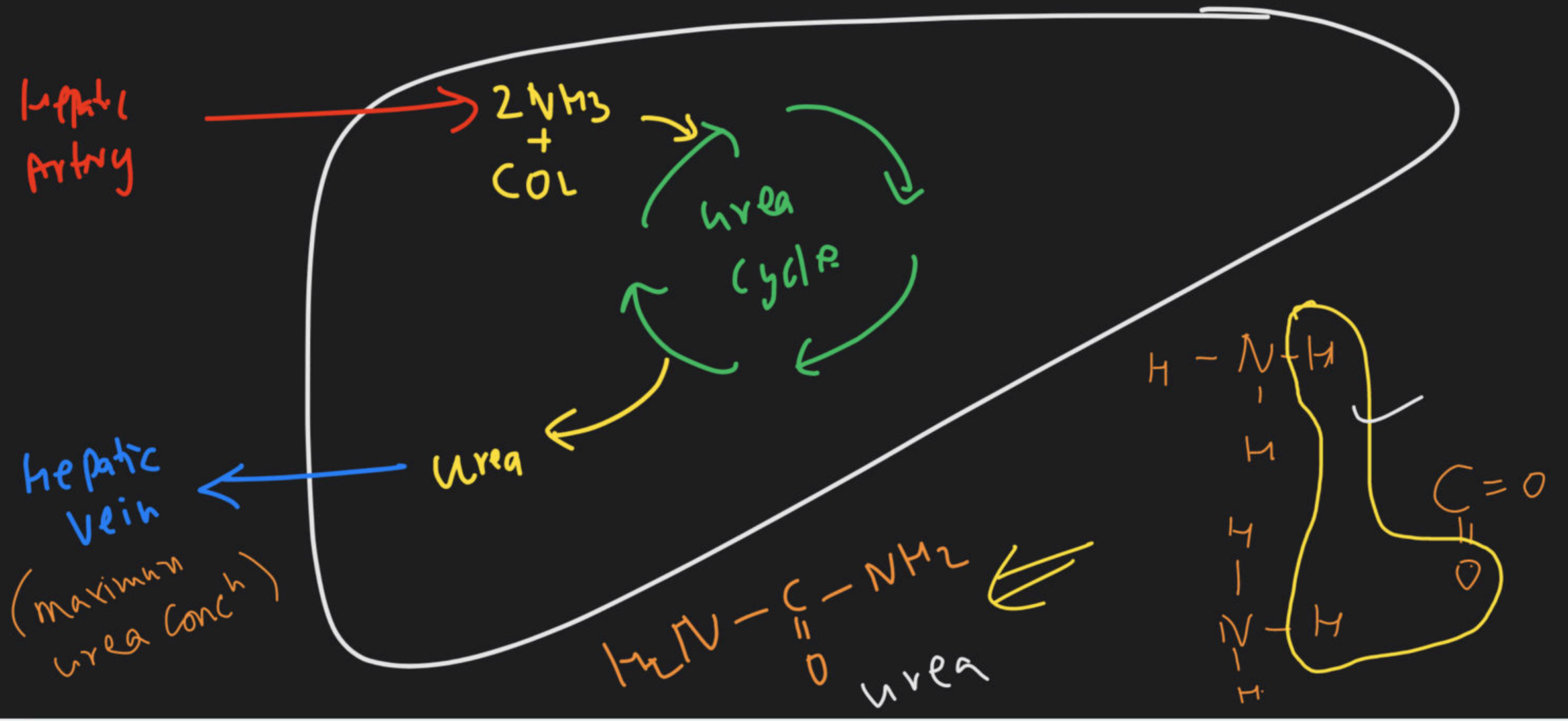
$NH_3$ > Urea > Uric Acid.

Toxicity

Solubility in water

$CaCO_3$ Shell

# Urea cycle.


Hepatic Artery
2 NH3 + CO2
Urea cycle
Urea
Hepatic Vein
(Maximum Urea Conc^n)
H2N – C(=O) – NH2
Urea
H – N – H
H
C=O
O
N – H
H

# EXCRETORY SYSTEM

**Homeostasis :** *Maintenance of steady state* (Walter Cannon).

Homeostatic mechanism are important for normal life as they maintain condition within a range in which, the animals metabolic processes can occur. The process which is concerned with removal of nitrogenous waste materials (e.g.. urea, uric acid, $CO_2$, Ammonia, salts, excess water etc.) is termed excretion.

## OSMOCONFORMERS & OSMOREGULATORS

The regulation of solute movement and hence water movement (which follows solutes by osmosis) is called osmoregulation.

On the basis of osmoregulation, animals are either osmoconformer or osmoregulators.

**Osmoconformers :**

These animals can not actively control the osmotic condition of their body fluids. Instead of this, they change or adapt the osmolarity of body fluids according to the osmolarity of the surrounding medium.

Example :

- All marine invertebrates and some fresh water invertebrates.
- Hagfish (myxine) which is a marine cyclostome fish, is the vertebrate osmoconformer.

**Osmoregulators :**

These animals maintain an internal osmolarity different from the surrounding medium in which they inhabit. Osmoregulator animals must either eliminate excess water if they are in hypotonic medium or they should continously take in water to compensate for water loss if they are in hypertonic medium.

Due to this the osmoregulator animals have to spend energy

eg. most vertebrates (except Hag fish and elasmobranch like **shark** & **rays fish**)

# ELIMINATION OF NITROGENOUS WASTES

Ammonia, urea and uric acid are the major forms of nitrogenous wastes excreted by the animals. Ammonia is the most toxic form and requires large amount of water for its elimination, whereas uric acid, being the least toxic, can be removed with a minimum loss of water.

On the basis of type of excretory products (ammonia, urea or uric acid) three types of animals are present.

(1) **Ammonotelics** : Most aquatic animals excrete nitrogenous waste as ammonia, the water soluble ammonia molecules diffuse across the body surface into surrounding water. In fishes most of the ammonia ($NH_3$) is lost as ammonium ions ($NH_4^+$) across the gill epithelium.

eg of ammonotelic animals are teloest (modern bony fish), aquatic amphibians (tadpoles), aquatic reptiles and aquatic insects.

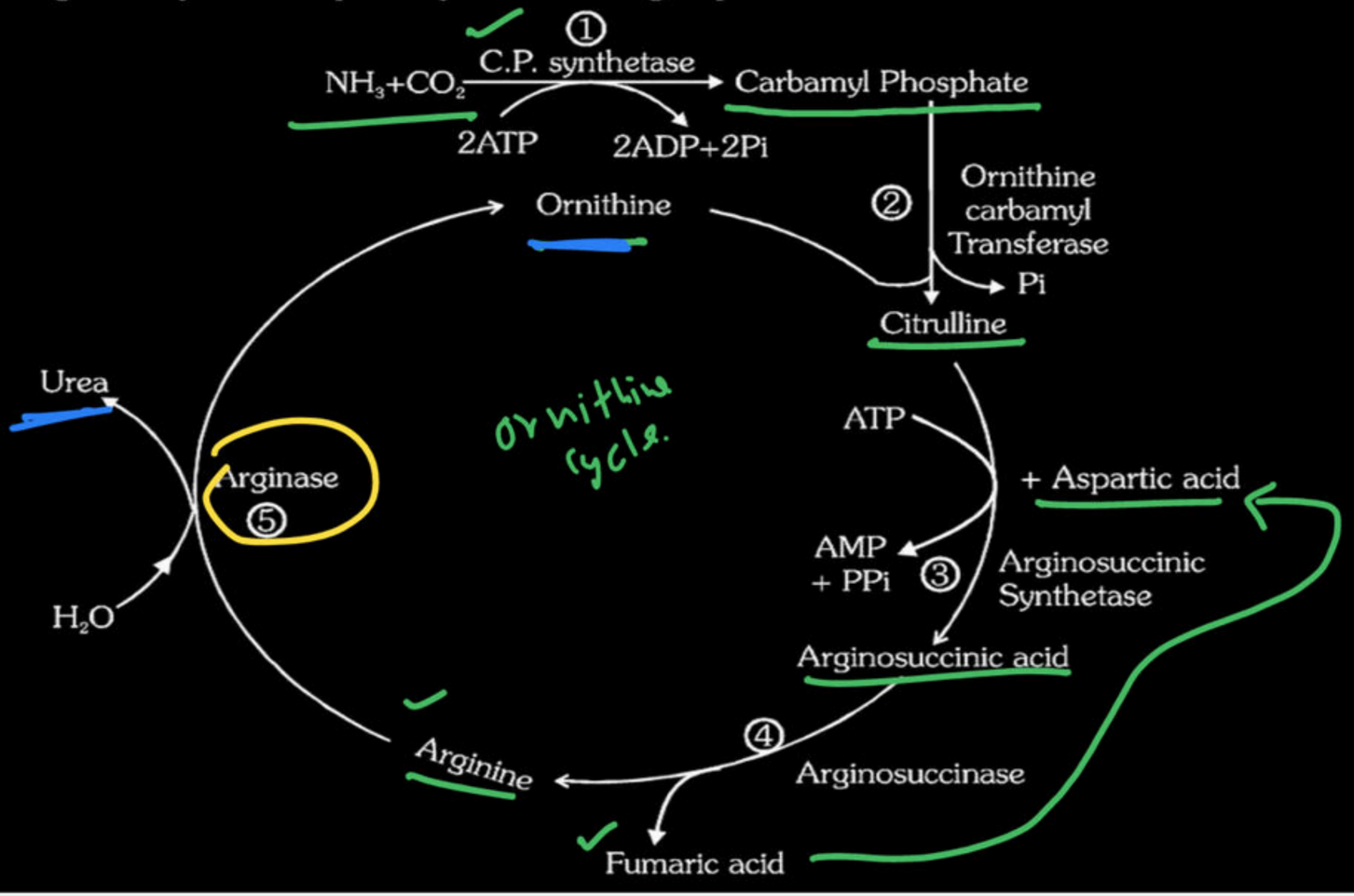
(2) **Ureotelics** : Animals like mammals, many terrestrial amphibians, marine fish excrete urea and are called Ureotelic. Ammonia produced by metabolism is converted into urea in the liver of these animals and released into the blood which is filtered and excreted out by the kidneys. Excretion of urea is benefical forthese animals than ammonia because of following reason.

(1) Urea can be tolerated in much more concentrated form because it is 100000 times less toxic than ammonia.

(2) Urea excretion helps to sacrifice less water while disposing off the nitrogenous wastes.
In mammals urea is excreted by kidney. However entire amount of urea produced is not excreted immediately but some portion of it is retained in the kidneys for osmoregulation. (important for water reabsorption)

- Sharks retain some amount of urea produced to balance the osmolarity of body fluids with surrounding sea water. Thus urea here acts as an osmolyte.
Urea is produced in the liver by urea cycle.

**Ornithine Cycle :-** It is also termed as the **Kreb-Henseleit cycle**. In this cycle, 2 molecules of $NH_3$ react with 1 molecule of $CO_2$, resultants a molecule of urea is formed. The formation of urea through this cycle takes place by the following steps -

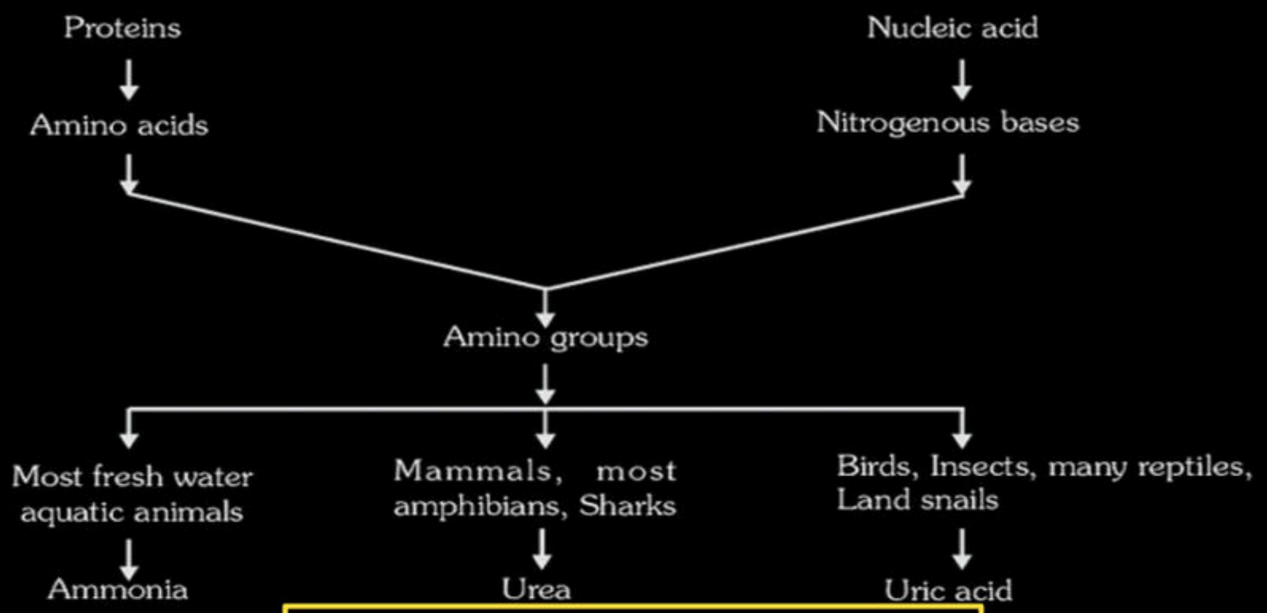


**(3) Uricotelics** : Reptiles, birds, land snails and insects excrete nitrogenous wastes as uric in the form of pellet or paste with a minimum loss of water and are called Uricotelic animals.

Excretion of wastes in the form of uric acid is particularly advantageous for land vertebrates which lay shelled eggs. This is because shelled eggs of reptiles & birds possess many fine pores which are permeable to gases only.

If the embryo would have produced ammonia or urea inside the shelled egg, the soluble nitrogenous waste would have accumulated to toxic concentration levels. But because the wastes are in the form of uric acid which is thousand times less soluble than $NH_3$ or urea, this uric acid precipitates out of the solution and can be stored in the shell as a solid waste which is left behind when the animal hatches.

- Most terrestrial reptiles excrete uric acid but crocodiles excrete ammonia in addition to uric acid.




## Some Other Excretory Products

**Tri-methyl amine-oxide** - Some animals convert the ammonia into non-toxic tri-methyl amine oxide and excrete it. It has a typical fishy-smell. e.g. Marine body fish, Marine molluscans and Marine crustacians etc.

**Guanine** :- Spiders convert ammonia into guanine and then excrete it. It is similar to uric- acid; its structure is same as that of uric acid. It is insoluble in water. Guanine is excreted in the form of crystals. It is also an adaptation to check the water-loss.

**Allantonin**- Majority of mammals convert the Purines and Pyrimidines to Allantonin and then excrete it. In man purines are excreted in the form of uric-acid and pyrimidines in the form of alanine and Iso-butyric acid.

**Hippuric-acid** :- In mammals, the Benzoic-acid is excreted out in the form of Hippuric acid.

$$\text{Benzoic - acid} + \text{Glycine} \longrightarrow \text{Hippuric - acid}$$

But in birds, the benzoic acid is treated with Ornithine amino-acid, and ornithuric acid is excreted.

$$\text{Benzoic acid} + \text{Ornithine} \longrightarrow \text{Ornithuric acid}$$

**Creatine** :- In normal urine, creatine is absent. But in new-born infants, pregnant and lactating females the urine contains creatine. Creatine is obtained in the liver from amino-acids.

**Creatinine** :- Creatinine is the break down metabolic product of creatine. It is formed in the muscles from high energy compound creatinine phosphate. It is excreted along with urine.

**Animals on the basis of excretory matter are divided into three categories :-**

| | Characters | Type of animals | | |
|---|---|---|---|---|
| | | **Ammonotelic** | **Ureotelic** | **Uricotelic** |
| **1.** | Excretory matter | Ammonia | Urea | Uric acid |
| **2.** | Requirement of water | Very large | Less than ammonia | Least |
| **3.** | Mechanism of excretion | By diffusion across body surfaces or through gill surfaces (in fish) as ammonium ion. | Ammonia produced by metabolism is converted into urea in the liver and released into the blood which is filtered and excreted out by the kidneys. | |
| **4.** | Toxicity | Highest | Less than ammonia | Least |
| **5.** | Examples | Teloests, Tadpoles, Aquatic insects | Mammals, Sharks, | Birds, Insects, Land snails, many reptiles |

AGSIR

# HUMAN EXCRETORY SYSTEM

Excretory organ are also termed as organs of homeostasis.

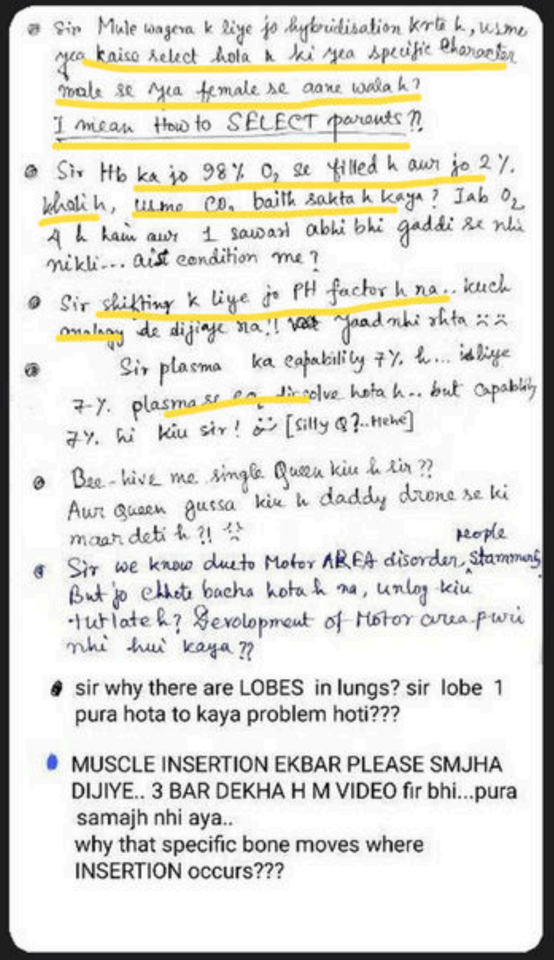
The main excretory organ in humans is kidney.

Other excretory organs are skin, liver, lungs & large intestine.

Human excretory system consists of :

- Two kidneys & their blood supplies.
- A pair of ureters.
- urinary bladder
- Urethra

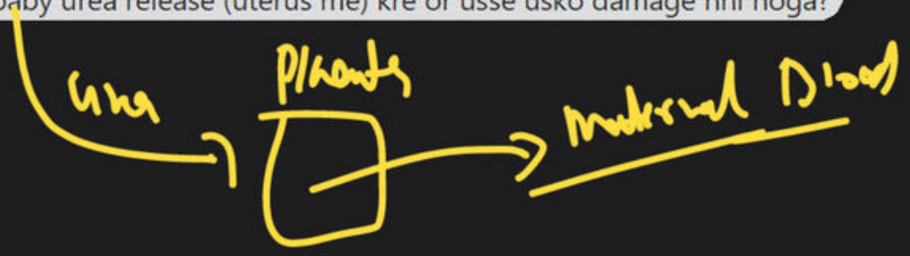
## Question
from Arjuna Muk...



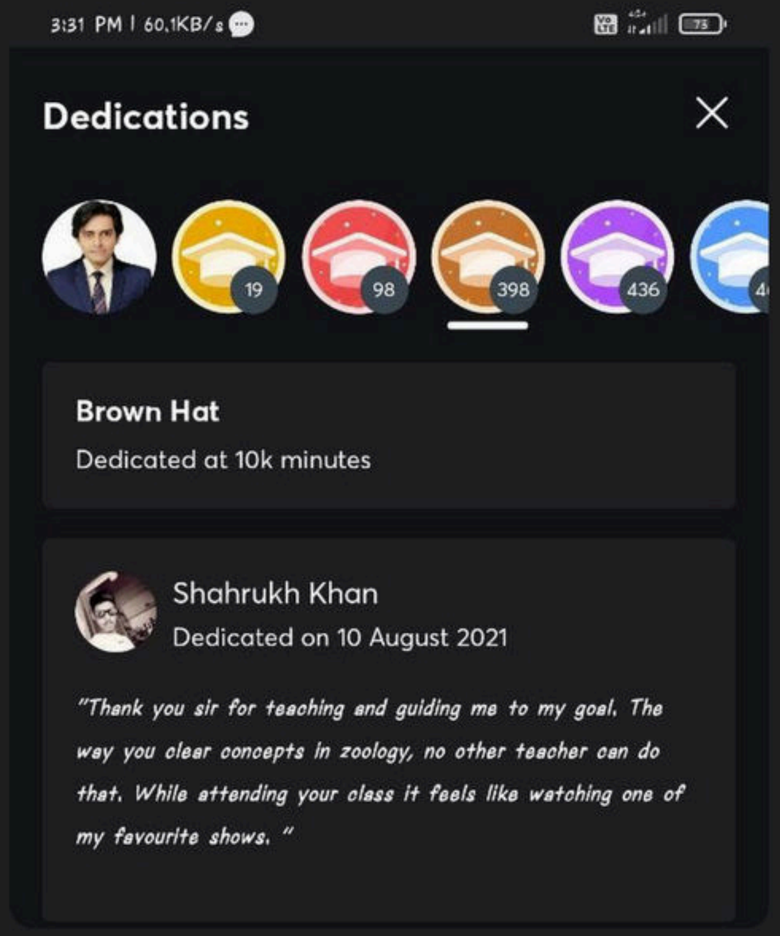
## Question

from Soham Sing...

sir birds ke jaise, human baby urea release (uterus me) kre or usse usko damage nhi hoga?



## Question
from Shahrukh



Question
from TanishkRaj

1-SIR AAPNE DIGESTION ME BATAYA HA KI ECL CELLS HISTAMINE SECRETE KARTE HAI JO VASODILATER HOTA HAI. PHIR BRONCHIAL ASTHMA ME WO BRONCHOCONSTRICTION KAISE KAR RAHA HAI??

SIR SPIROMETER ME HUM TO PURA VITAL CAPACITY EXHALE KARTE HAI, TO USME IRV BHI TO MEASURE HONA CHAHIYE?

SIR PTYALIN 30% OF TOTAL STARCH DIGEST KARTA HAI YA 30% OF COOKED STARCH?

SMJAG

IRV