PRINCIPALS OF RECOMMENDED NUTRITION

- Quantitative aspect
- Qualitative aspect
- **Special components of diet**
- Aesthetic aspect
- Socio-economic aspect

WATER, VITAMINS, MINERALS IN NUTRITION

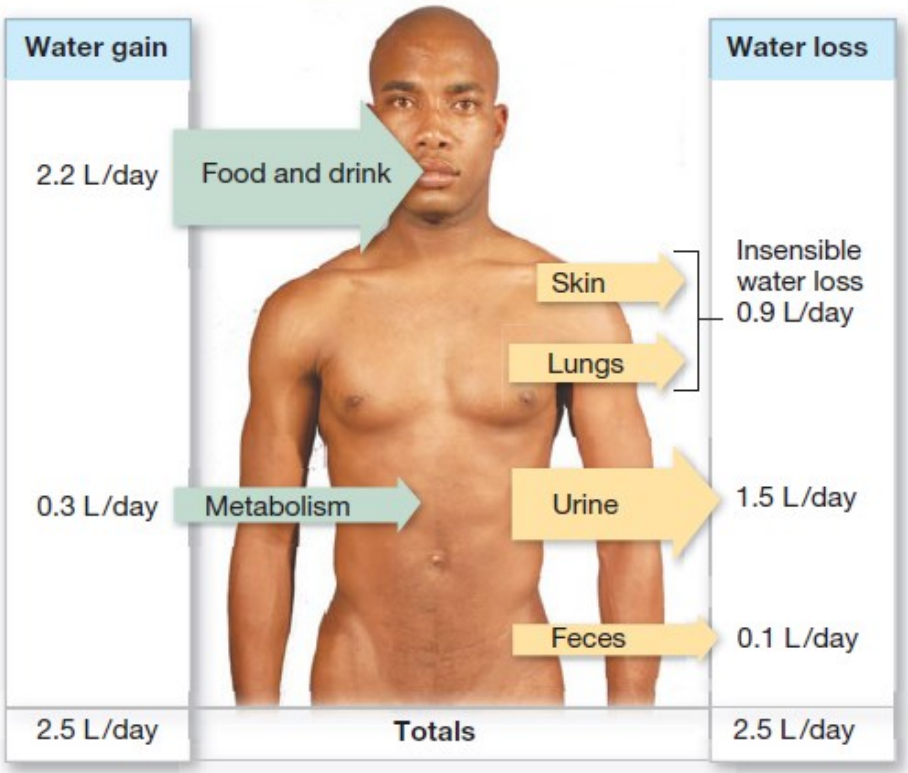
WATER

- 50-70% of body mass, newborns
- 2/3 intracellularly, 1/3 extracellularly
- metabolism
- compartmentalisation
- phylogenetic view

Water and its functions in the human body

- The transport medium, solvent, wetting and protection of the mucous membranes
- Age, sex, weight

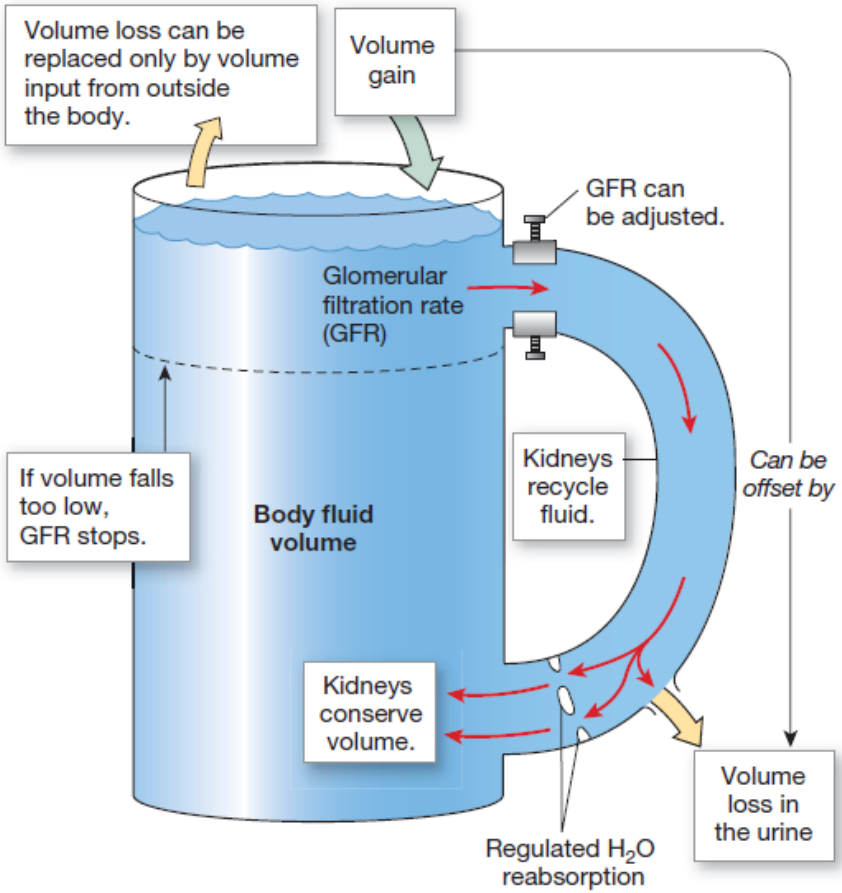
WATER BALANCE IN THE BODY



Intake 2.2 L/day + Metabolic production 0.3 L/day − Output 2.5 L/day = 0

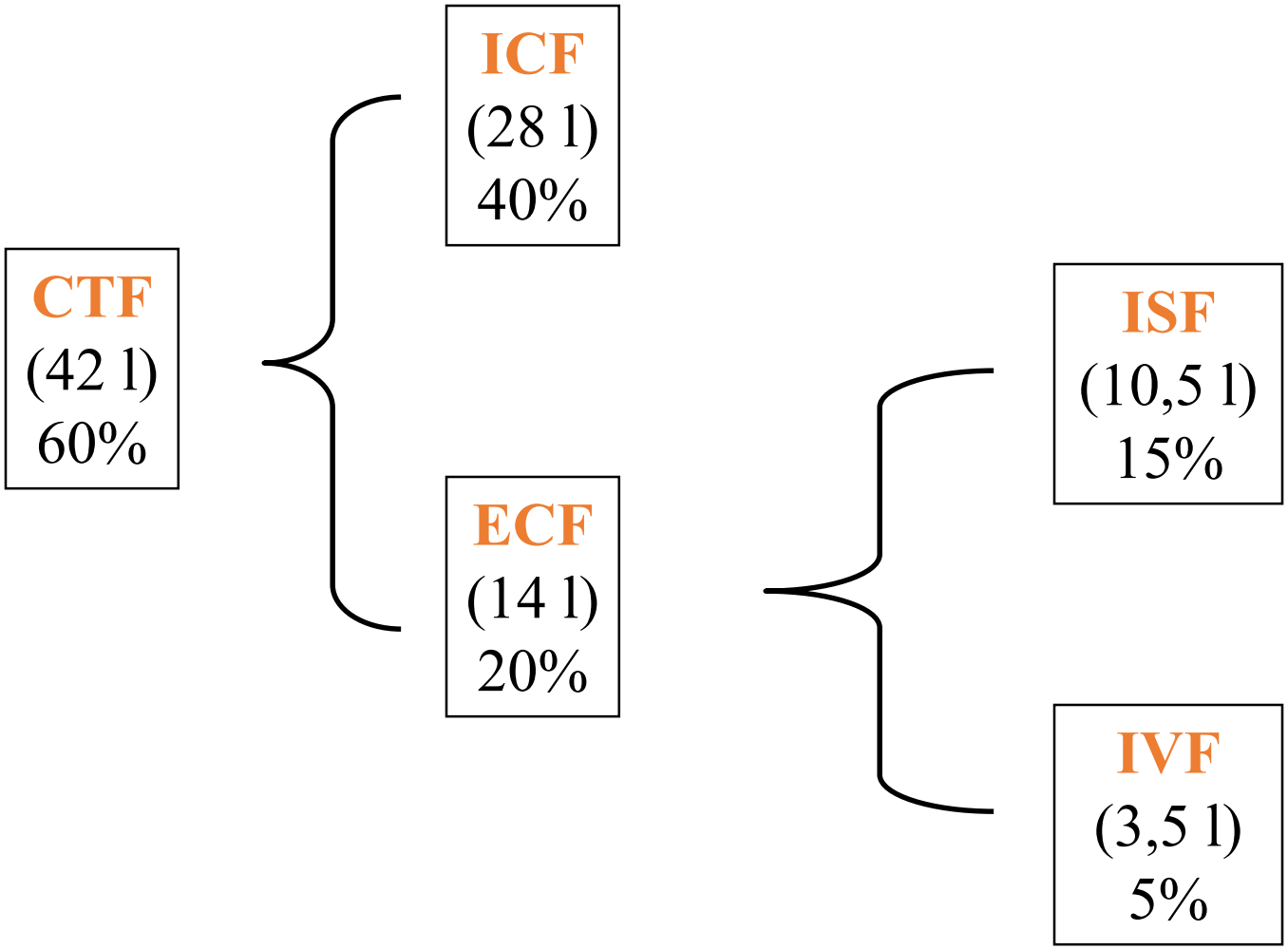
THE KIDNEYS CONSERVE VOLUME

Kidneys cannot restore lost volume. They only conserve fluid.



The water content in different tissues (male, 70 kg)

	% of water
blood	83%
muscle tissue	76%
skin	72%
bones	22%
fats	10%
tooth enamel	2%



Clinical examination: evaluation of extracellular (plasmatic) levels of electrolytes (Na, K)

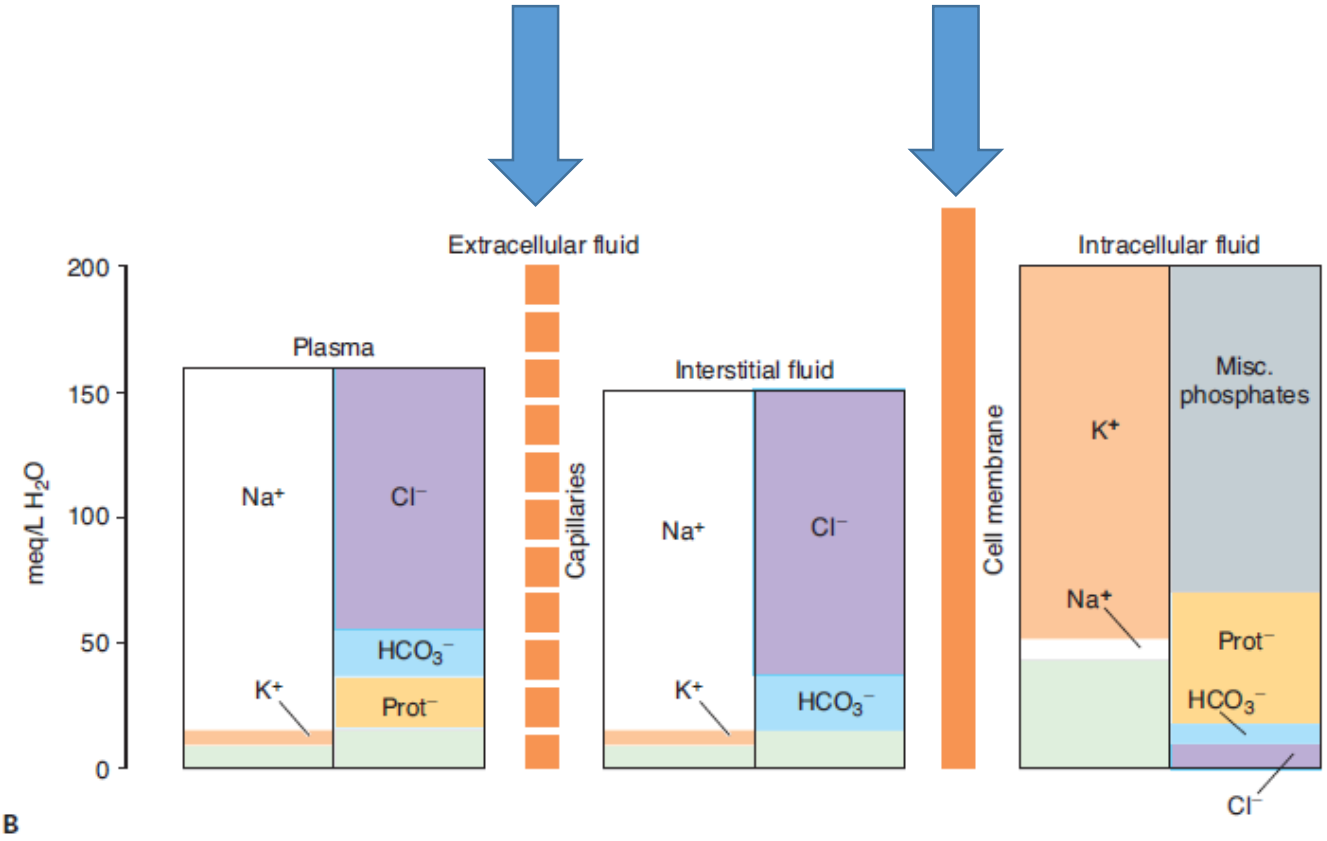


FIGURE 1–1 **Organization of body fluids and electrolytes into compartments. A)** Body fluids are divided into Intracellular and extracellular fluid compartments (ICF and ECF, respectively). Their contribution to percentage body weight (based on a healthy young adult male; slight variations exist with age and gender) emphasizes the dominance of fluid makeup of the body. Transcellular fluids, which constitute a very small percentage of total body fluids, are not shown. Arrows represent fluid movement between compartments. **B)** Electrolytes and proteins are unequally distributed among the body fluids. This uneven distribution is crucial to physiology. $Prot^-$, protein, which tends to have a negative charge at physiologic pH.

table 5-1 Body Water and Body Fluid Compartments

Body Fluid Compartment	Fraction of TBW*	Markers Used to Measure Volume	Major Cations	Major Anions
TBW	1.0	Tritiated H_2O D_2O Antipyrene		
ECF	1/3	Sulfate Inulin Mannitol	Na^+	Cl^- HCO_3^-
Plasma	1/12 (1/4 of ECF)	RISA Evans blue	Na^+	Cl^- HCO_3^- Plasma protein
Interstitial	1/4 (3/4 of ECF)	ECF–plasma volume (indirect)	Na^+	Cl^- HCO_3^-
ICF	2/3	TBW–ECF (indirect)	K^+	Organic phosphates Protein

*Total body water (TBW) is approximately 60% of total body weight, or 42 L in a 70-kg man. ECF = extracellular fluid; ICF = intracellular fluid; RISA = radioiodinated serum albumin.

HOMEOSTASIS

- **Izoionia** – concentration of ions
- **Izotonia** – osmotic concentration
- **Izohydria** – ratio between acids and bases
- **Izovolemia** –ECL volume (volumoreceptors or baroreceptors, RAS, ADH)

- Izovolemia
- **Hypovolemia (dehydratation)**
- Hypervolemia (hyperhydratation)

Cause – result

Complex disorders!

EXAMINATIONS AT HYDRATATION DISORDERS

1. **Anamnesis** – diseases of kidneys, GIT, DM, DI, drugs, intake and output=balance, body mass changes, etc.

2. **Laboratory examinations**: electrolytes, blood osmolality, RBCC, total plasmatic proteins; Astrup examination

OBJECTIVE EXAMINATIONS

1. Skin changes
2. Body mass changes
3. Diuresis changes (oliguria, anuria, polyuria)
4. Respiration disorders (respiratory acidosis, alkalosis; secondary changes – Kussmaul breathing)
5. CNS disorders (changes of reflexes, muscle tonus, paresthesias, changes of consciousness, coma)
6. Central venous pressure changes (filling of neck veins)
7. Circulation changes: dehydratation – tachycardia, hypotonia

CAUSES OF HYDRATATION DISORDERS

1. Disturbance of normal intake of water and ions
2. Disturbance of normal circulation of water and ionts between ECL and GIT
3. Disturbance of cell metabolism
4. Disturbance of loss of water and ions
5. Excessive loss of water (and ions) by skin

DEHYDRATATION

= decreased volume of body fluids accompanied by lack of sodium

HYPERTONIC DEHYDRATATION = loss of (only) water

Bigger lack of water than sodium. Disorders of intake and big losses.
Cell dehydratation.
Thirst. Decreased skin turgor. CNS symptoms.
Hydratation.

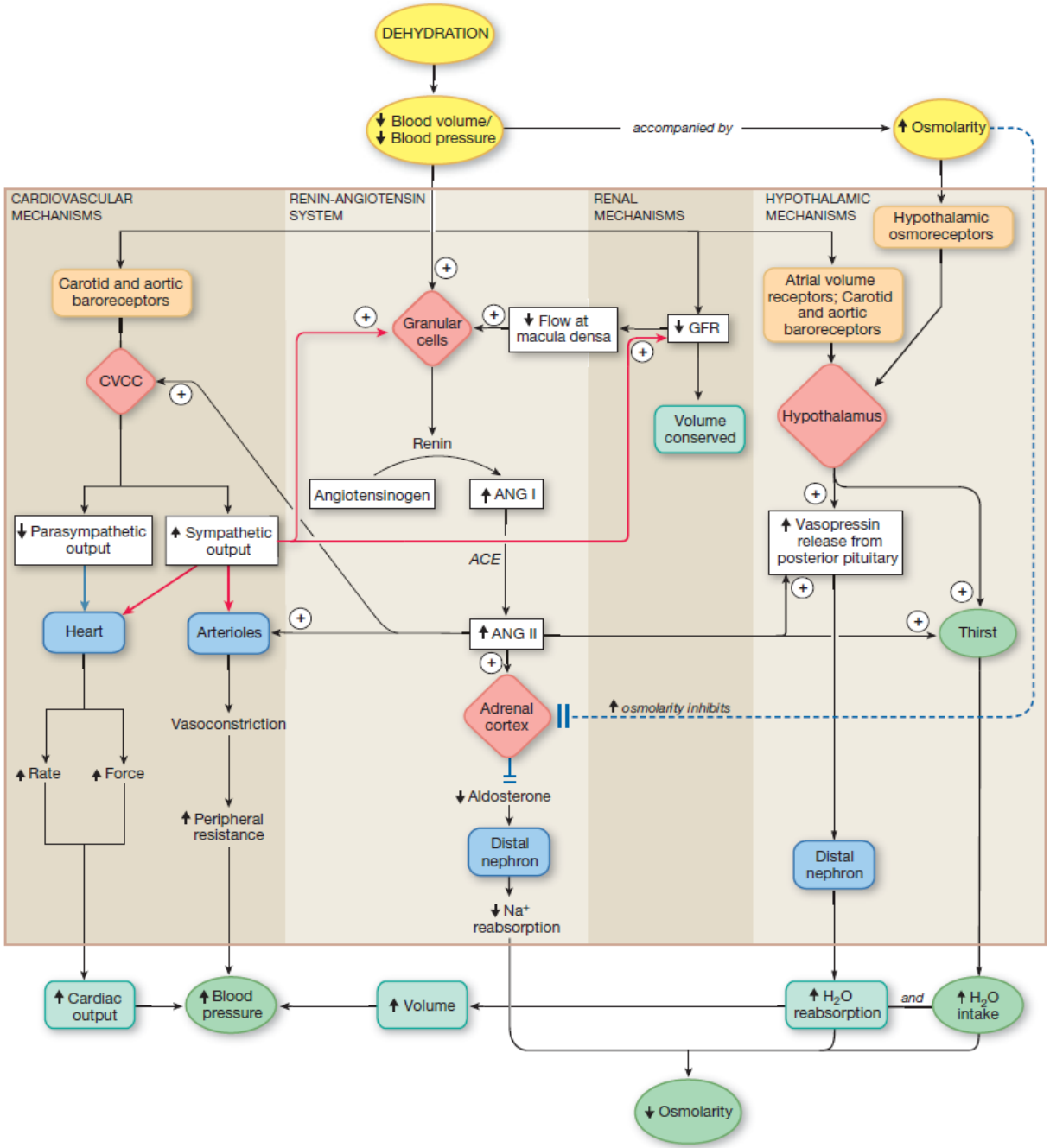
IZOTONIC DEHYDRATATION = isonatremic

Causes – bleeding, diuretics, „blind spaces“
Hypovolemic syndrome: decreased diuresis, symptoms of dehydratation.

HYPOTONIC DEHYDRATATION

Always bigger deficiency of sodium than water.
Cell hyperhydratation.
Losses by GIT, kidneys.
Hypovolemic syndrome, CNS symptoms.

HOMEOSTATIC COMPENSATION FOR SEVERE DEHYDRATION



HYPERHYDRATATION

= increased volume of extracellular fluid

HYPOTONIC HYPERHYDRATATION – **water intoxication**

Cell hyperhydratation. Decreased osmolality.
Excessive intake of liquids (dialysed patient, patient with kidney disorders), hyperproduction of ADH

IZOTONIC HYPERHYDRATATION

Increased volume of ECF. Osmolality stabile.
Heart failure, nefrotic syndrome, liver cirrhosis.
Oedemas and water withholding in serose cavities.

HYPERTONIC HYPERHYDRATATION = hypernatremic

Rare. Increase of ECF caused by sodium abundance. Osmolality increases.
Primary hyperaldosteronism.

table 5-2 Changes in Volume and Osmolarity of Body Fluids

Type	Key Examples	ECF Volume	ICF Volume	ECF Osmolarity	Hct and Serum [Na^+]
Isosmotic volume expansion	Isotonic NaCl infusion	↑	No change	No change	↓ Hct –[Na^+]
Isosmotic volume contraction	Diarrhea	↓	No change	No change	↑ Hct –[Na^+]
Hyperosmotic volume expansion	High NaCl intake	↑	↓	↑	↓ Hct ↑ [Na^+]
Hyperosmotic volume contraction	Sweating Fever Diabetes insipidus	↓	↓	↑	–Hct ↑ [Na^+]
Hyposmotic volume expansion	SIADH	↑	↑	↓	–Hct ↓[Na^+]
Hyposmotic volume contraction	Adrenal insufficiency	↓	↑	↓	↑ Hct ↓[Na^+]

– = no change; ECF = extracellular fluid; Hct = hematocrit; ICF = intracellular fluid; SIADH = syndrome of inappropriate antidiuretic hormone.

SIADH = syndrome of inappropriate antidiuretic hormone secretion)

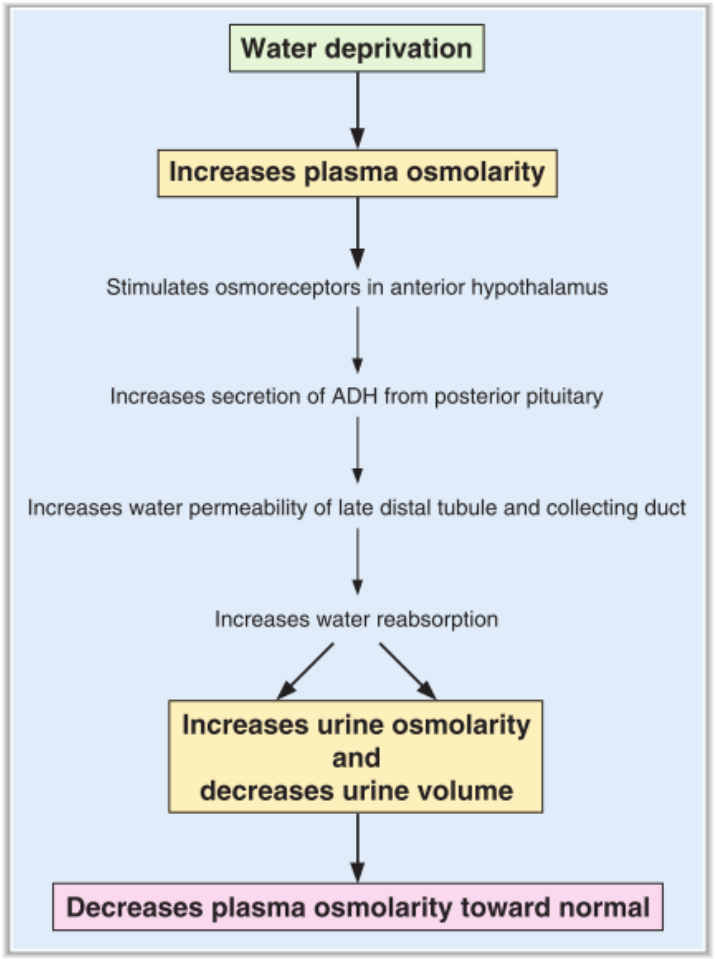


FIGURE 5-14 Responses to water deprivation. ADH = antidiuretic hormone.

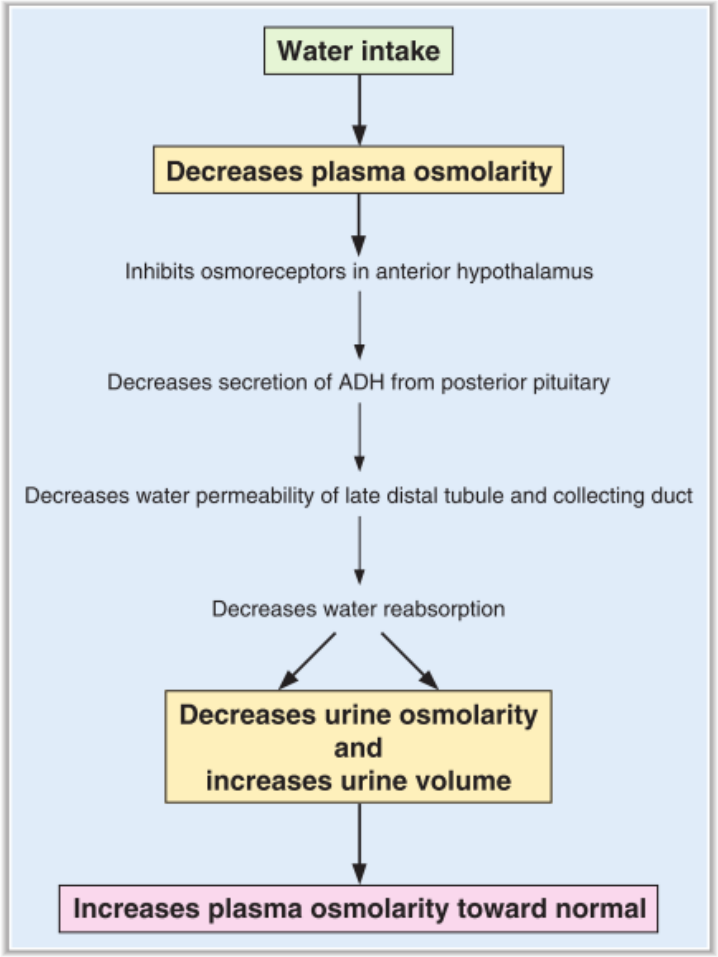


FIGURE 5-15 Responses to water intake. ADH = antidiuretic hormone.

VITAMINS

= all organic compounds of diet, necessary for life, health and growth; NO source of energy

HYPOVITAMINOSIS (AVITAMINOSIS)
HYPERVITAMINOSIS

1. Decrease supply in diet
2. Food intake disorders
3. Absorption disorders
4. Increased consumption
5. Store organ diseases

1. Increased supply in diet – usually **iatrogenic**

SOLUBLE

- in water: diffusion, D, J; **vit.B_{12}** - I
- in lipids: deficient absorption in disorders of lipids absorption (pancreatic enzymes or bile missing)

Vitamin	Species	Place of absorption	Transport mechanism	Maximal absorption capacity in humans / day	Daily dose
C	Humans, guinea pig	Ileum	Active	>5000mg	<50mg
Biotin	Hamster	Small intestine	Active	?	?
Cholin	Guinea pig, hamster	Small intestine	Facilitated diffusion	?	?
Folic acid (pteroylglutamate)	Rat	Jejunum	Facilitated diffusion	> 1000µg (dose)	100-200µg
Folic acid (5-methyltetrahydrofolate)	Rat	Jejunum	Diffusion	> 1000µg (dose)	100-200µg
Nicotinic acid	Rat	Jejunum	Facilitated diffusion	?	10-20mg
Pantothenic acid		Small intestine	?	?	(?)10mg
B_6 (pyridoxine)	Rat, hamster	Small intestine	Diffusion	> 50mg (dose)	1-2mg
B_2 (riboflavin)	Humans, rat	Jejunum	Facilitated diffusion	10-12mg (dose)	1-2mg
B_1 (thiamine)	Rat	Jejunum	Active	8-14mg	Approx. 1mg
B_{12}	**Humans, rat, hamster**	**Distal ileum**	**Active**	**6-9µg**	**3-7µg**

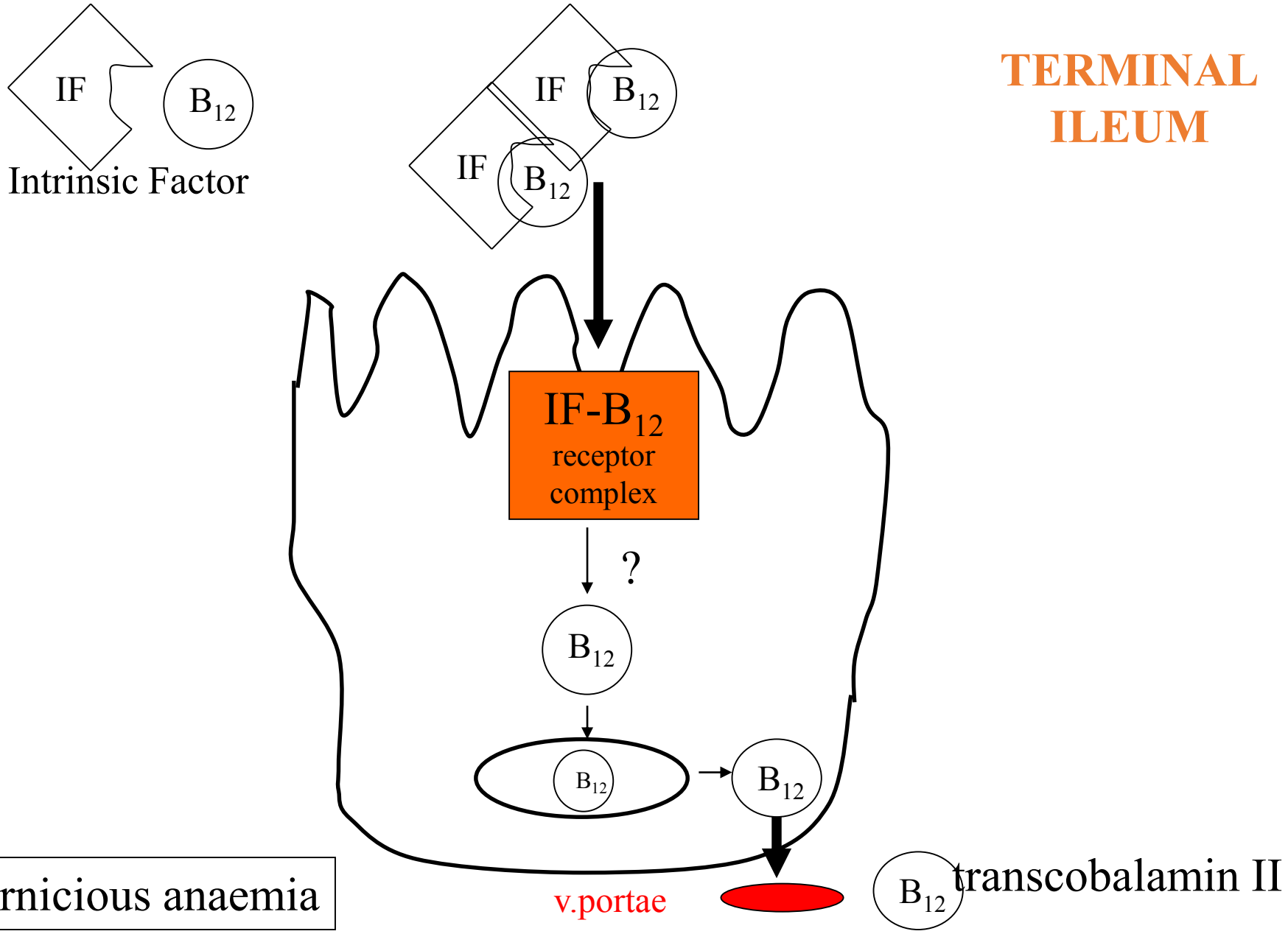
VITAMIN B_{12}

- Daily dose is close to absorption capacity
- Synthesised by bacteria in colon – BUT there is not absorption mechanism
- Store in liver (2-5mg)
- In bile 0,5-5µg / day, reabsorbed
- Daily loss – 0,1% of stores → stores will last for 3-6 years

ABSORPTION

1. **Gastric phase**: B_{12} is bound to proteins, low pH and pepsin release it; bound to glycoproteins – **R-proteins** (saliva, gastric juice), almost pH-undependable; intrinsic factor (**IF**) – parietal cells of gastric mucosa; most of vitamin bound to R-proteins
2. **Intestinal phase:** pancreatic proteases, cleavage of R-B_{12}, bound to IF (resistant to pancreatic proteases)

ABSORPTION OF B_{12} VITAMIN



Pernicious anaemia

HYPOVITAMINOSES

Folic acid – disorders of embryo development (clefts)
B_{12} – pernicious anaemia
C – scurvy (scorbutus)
D – rickets (rhachitis, English disease, English sickness)
E – fertility problems
K - haemorrhage

HYPERVITAMINOSES

A – teratogenic effects
D – kidney failure
K – anaemia, GIT disorders
B_6 – peripheral polyneuropathy

BERI-BERI (B_1)

"The first clinical descriptions of beriberi were by Dutch physicians, Bontius (1642) and Nicolaas Tulp (1652). Tulp treated a young Dutchman who was brought back to Holland from the East Indies suffering from what the natives of the Indies called beriberi or "the lameness." Tulp's description of beriberi was a detailed one, but he had no clues that it was a dietary deficiency disease. This discovery came more than two hundred years later. Nicholaas Tulp (1593-1674) is best remembered as the central figure in Rembrandt's famous painting, "The Anatomy Lesson" (1632).

PELAGRA (3 D disease):

Dementia, dermatitis, diarea

(niacin)

Mineral	Daily need (dose)
Na	3,0 g
K	1,0 g
Cl	3,5 g
Ca	1,2 g
P	1,2 g
Fe	18,0 mg
J	150,0 µg
Mg	0,4 g
Co	?
Cu	?
Mn	?
Zn	15 mg

Coenzyme of metabolic reactions of saccharides; deficiency – increased irritability of CNS, peripheral vasodilatation, arrhythmias; excess – suppresses electrical activity of CNS and skeletal muscle

Part of enzymes (carboanhydrase in erythrocytes, lactatedehydrogenase, peptidases)

MINERALS AND TRACE ELEMENTS

1. Arsenic
2. Chrome – experimental deficiency, glucose oral test is of diabetic character
3. Cobalt – part of enzymes, vit.B_{12}; poisoning by cobalt (beer), cobalt cardiomyopathy
4. Copper – impairment of cytochromoxidase (experiment), melanoma – increase of radiosensitivity when copper is depleted; vessel wall damage
5. Fluorine
6. Iodine
7. Iron
8. Manganese – catalyses similar reactions as Mg, stored in mitochondria, β1-globulintransmanganin
9. Molybdenum – in xantinoxidase and flavoproteins, defficiency in humans???
10. Nickell
11. Selenium – antioxidant, in diet bound to proteins (alcoholism, liver cirrhosis)
12. Silicon
13. Vanadium
14. Zinc – part of metalloenzymes, proteosynthesis (ribosomes);deficiency-Middle East (parasites, fytates in diet); testes atrophy, immune disorders; in DM 50% of stores Zn (insulin stored in pancreas together with Zn)

Iron: Factors Affecting Absorption

Physical State (bioavailability)	**heme > Fe^{2+} > Fe^{3+}**
Inhibitors	phytates, tannins, soil/clay (pica), laundry starch, iron overload, antacids
Competitors	lead, cobalt, strontium, manganese, zinc
Facilitators	ascorbate, citrate, amino acids, iron deficiency, stomach acid, high altitude, exercise, pregnancy