มหาวิทยาลัยมหิดล
คณะแพทยศาสตร์ศิริราชพยาบาล

Laboratory Tests in Mineral and Bone Disorders

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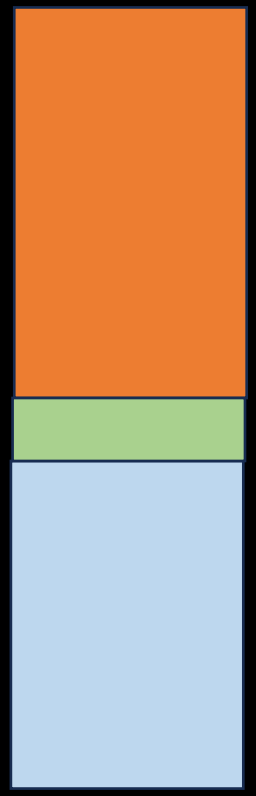
“เอกสารและสื่อนี้ ใช้เพื่อ
ประกอบการเรียนการสอน ใน
หลักสูตรแพทยศาสตรบัณฑิต
คณะแพทยศาสตร์ศิริราชพยาบาล
ห้ามผู้ใดนำไปใช้ในวัตถุประสงค์อื่น
หากฝ่าฝืนอาจมีความรับผิดตาม
พระราชบัญญัติลิขสิทธิ์”

Outline

- Calcium
- Phosphate
- Magnesium
- Parathyroid hormone
- Vitamin D
- Bone markers

CALCIUM

Serum (plasma) total calcium



Free	50%	Maintain ~ 1.25 mmol/L
Complex	10%	
Protein-bound	40%	

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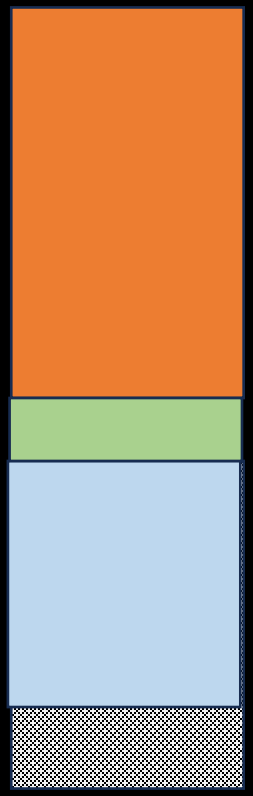
Adjusted (Corrected) calcium



Free

Complex

Protein-bound

Corrected calcium = Measured total calcium + [(4-albumin)*0.8]

Hypoalbuminemia

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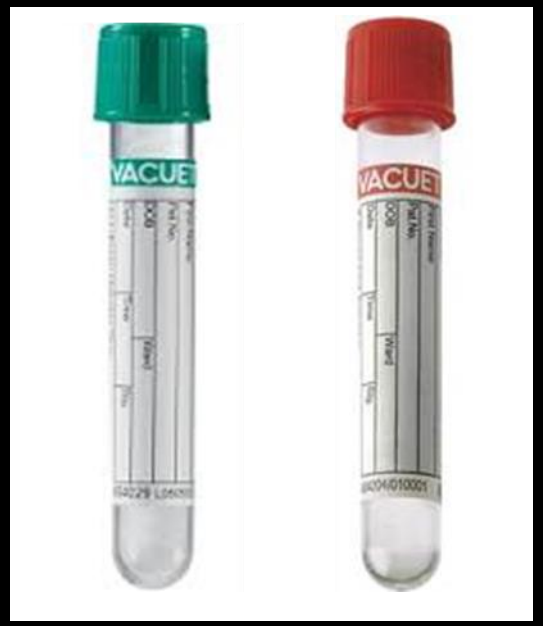
Specimen: total calcium



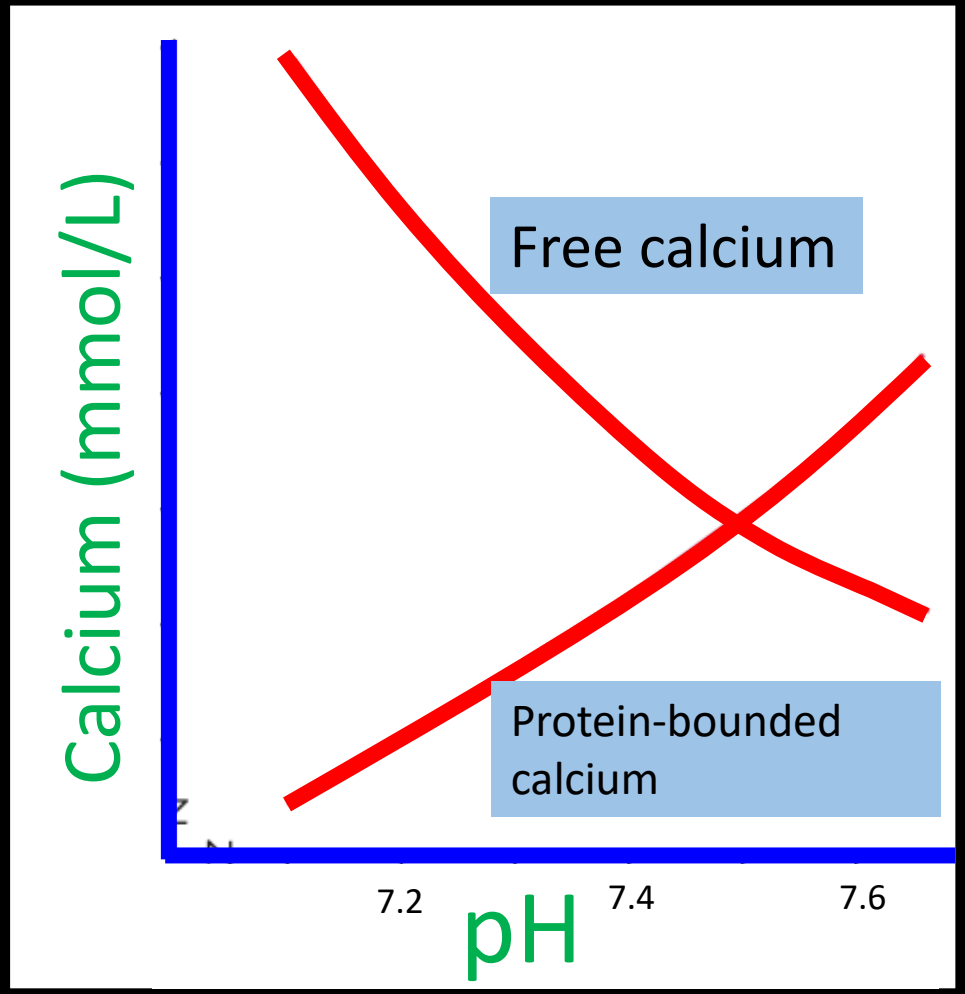
citrate

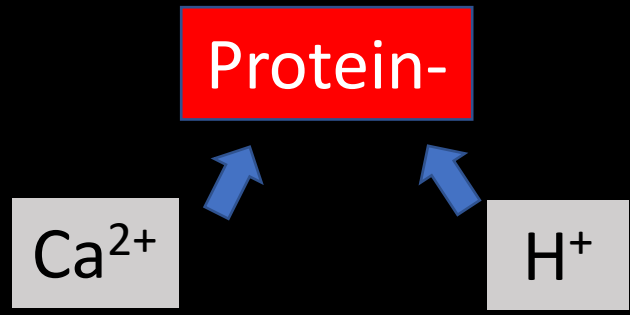
oxalate

EDTA

Can form complex with calcium

Free calcium





Distribution of 3 forms of Ca

pH dependent

Specimen: free calcium

Heparin

High concentration

Bind calcium

Liquid heparin

dilution

Lower free calcium

Specimen: free calcium

1 2 3

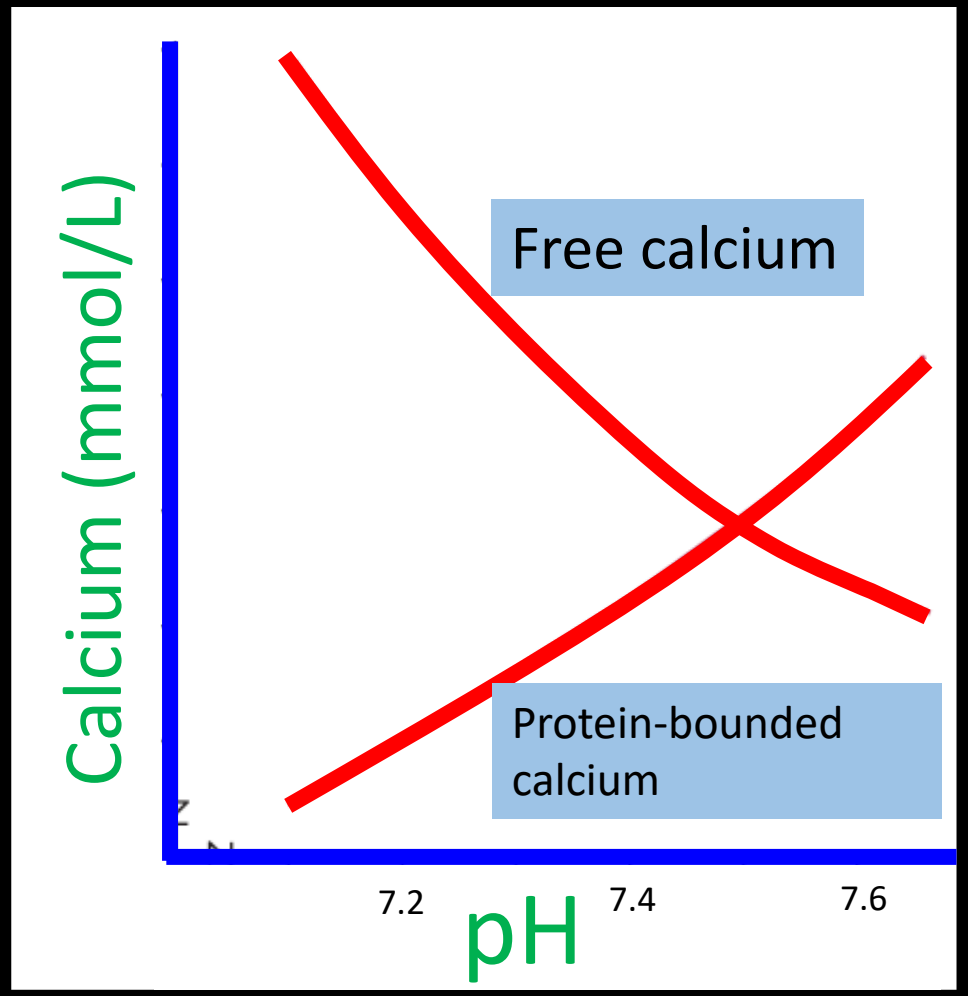
citrate

oxalate

EDTA

Can bind calcium

Specimen: Free calcium

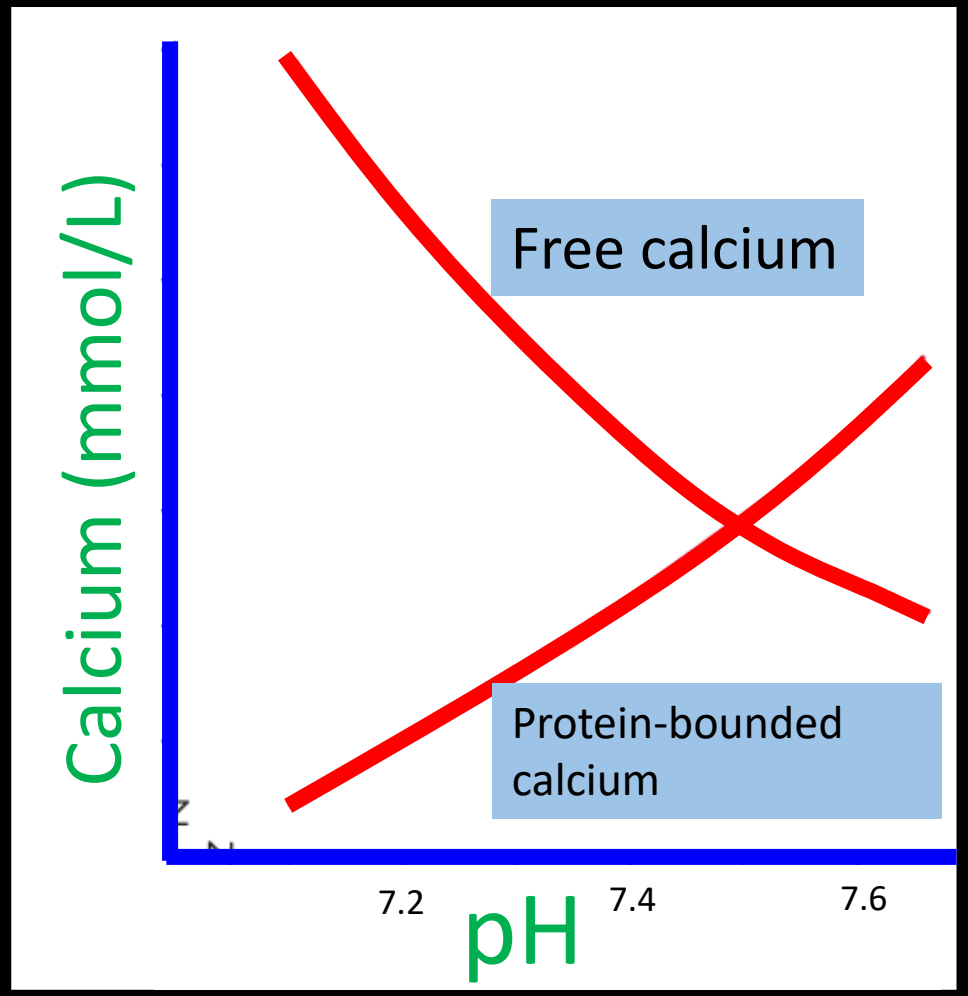


Handle anaerobically

Loss of CO_2

pH ↑

Specimen: Free calcium



Analyze within 30 min

If delay > 30 min

Chill in an ice-water slurry

CLSI C31A2E

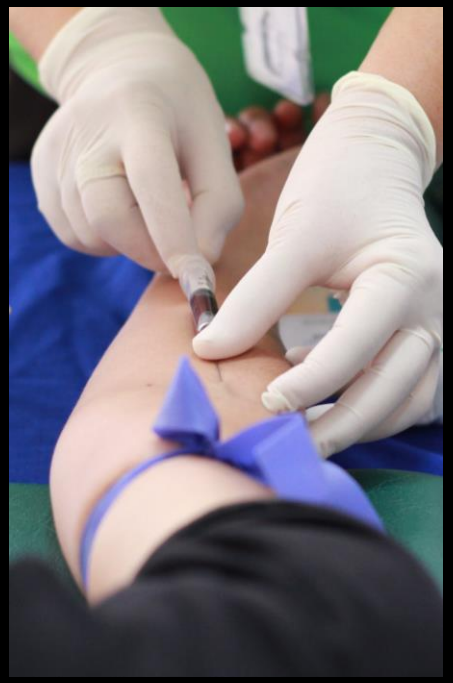
Free calcium

Orderable Item	Value	Units	H/L	Ref Range
Ionized calcium				
Measured pH	7.522			
Measured Ca++	**4.0**	**mg/dl**	**L**	**4.6 - 5.2**
Corrected Ca++(pH7.4)	4.2	mg/dl		

Corrected ionised calcium = Measured iCa (mmol/L) x (1 - 0.53 x (7.4-pH))

Preanalytical factors

↑Total calcium



Tourniquet

Postural change

Food-Mild elevation

Preanalytical factors

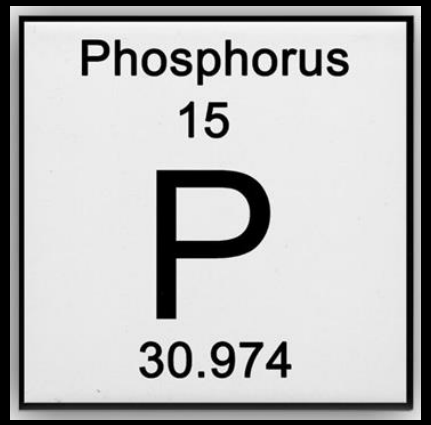
- Free calcium ↑: pH change

Fist clenching

Exercise

PHOSPHATE

Phosphate vs Phosphorus



Mineral

Combine with other substances to form organic and inorganic phosphate compounds

The amount of inorganic phosphate in the blood is measured.

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Plasma/serum phosphate

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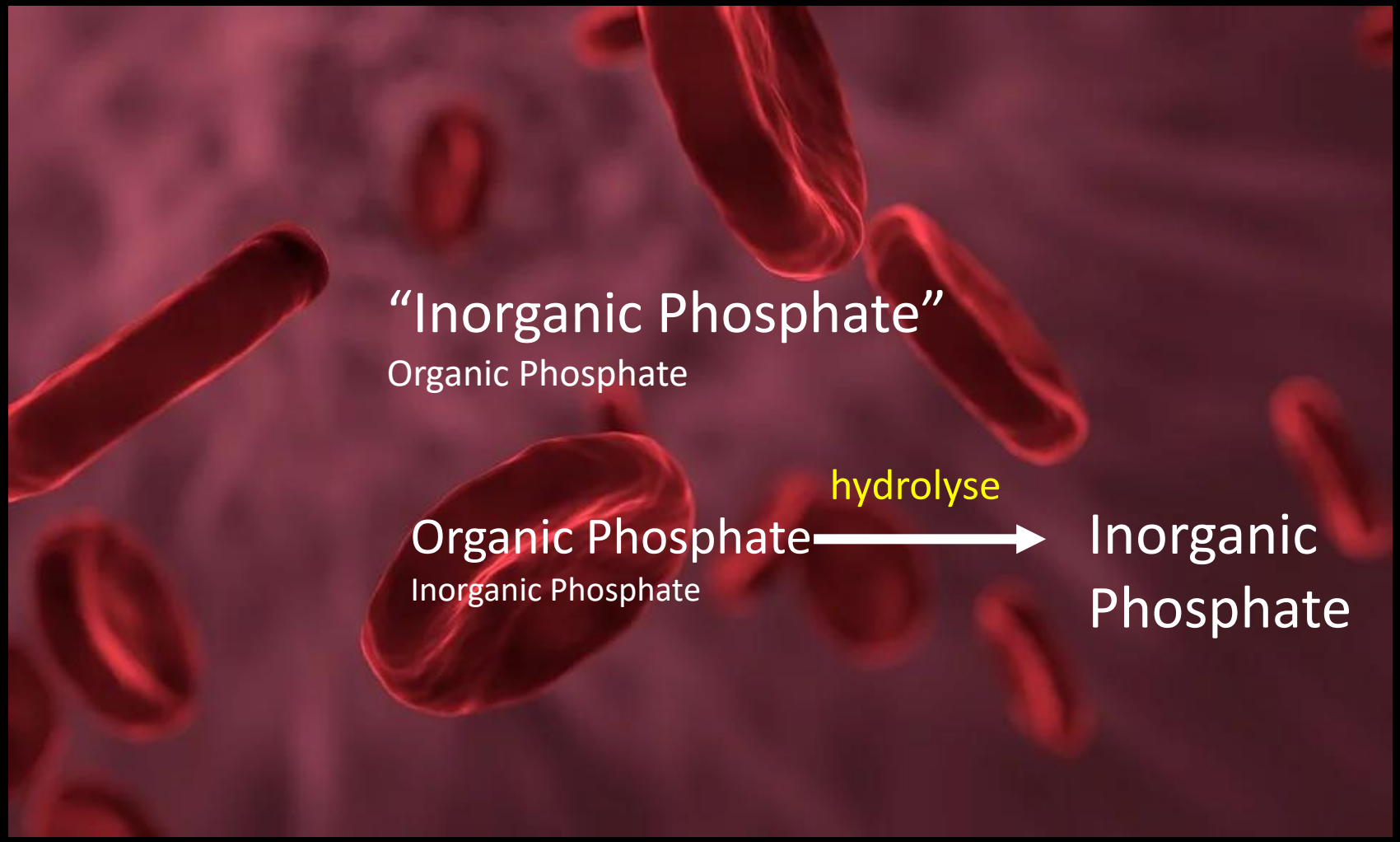
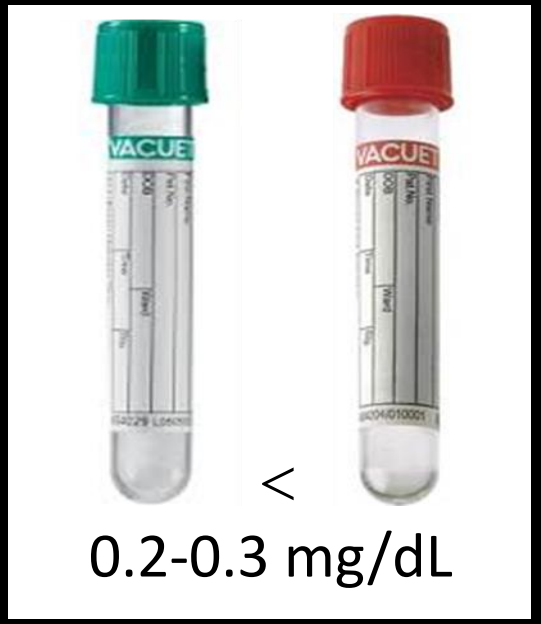
Plasma/serum phosphate: hemolysis



Specimen: phosphate



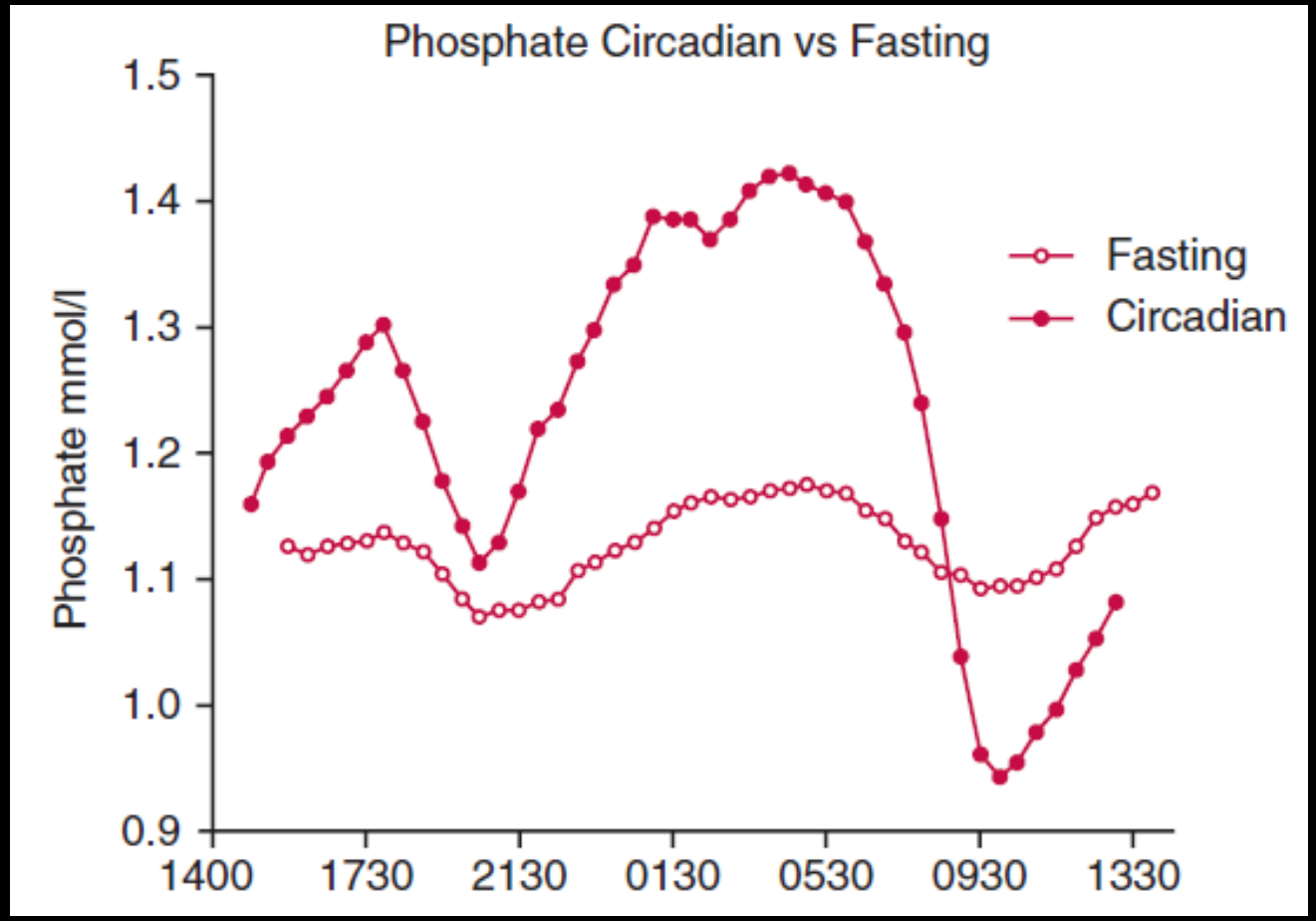
citrate

oxalate

EDTA

Interfere with formation of phosphomolybdate complex

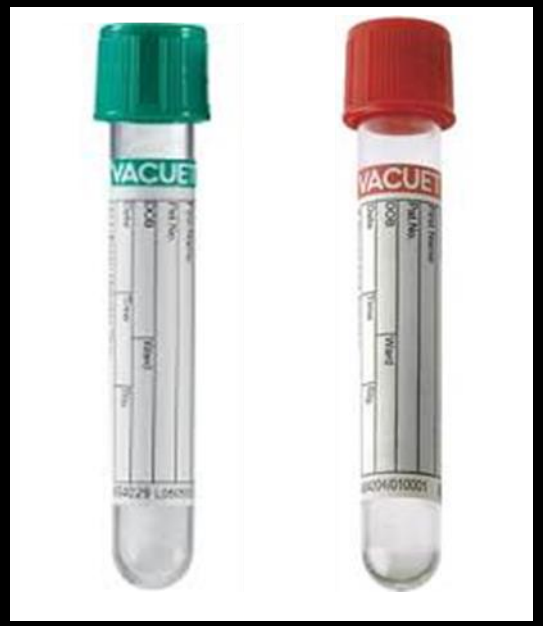
Phosphate: circadian variation



Phosphate ↑: meal & exercise

MAGNESIUM

Specimen: magnesium



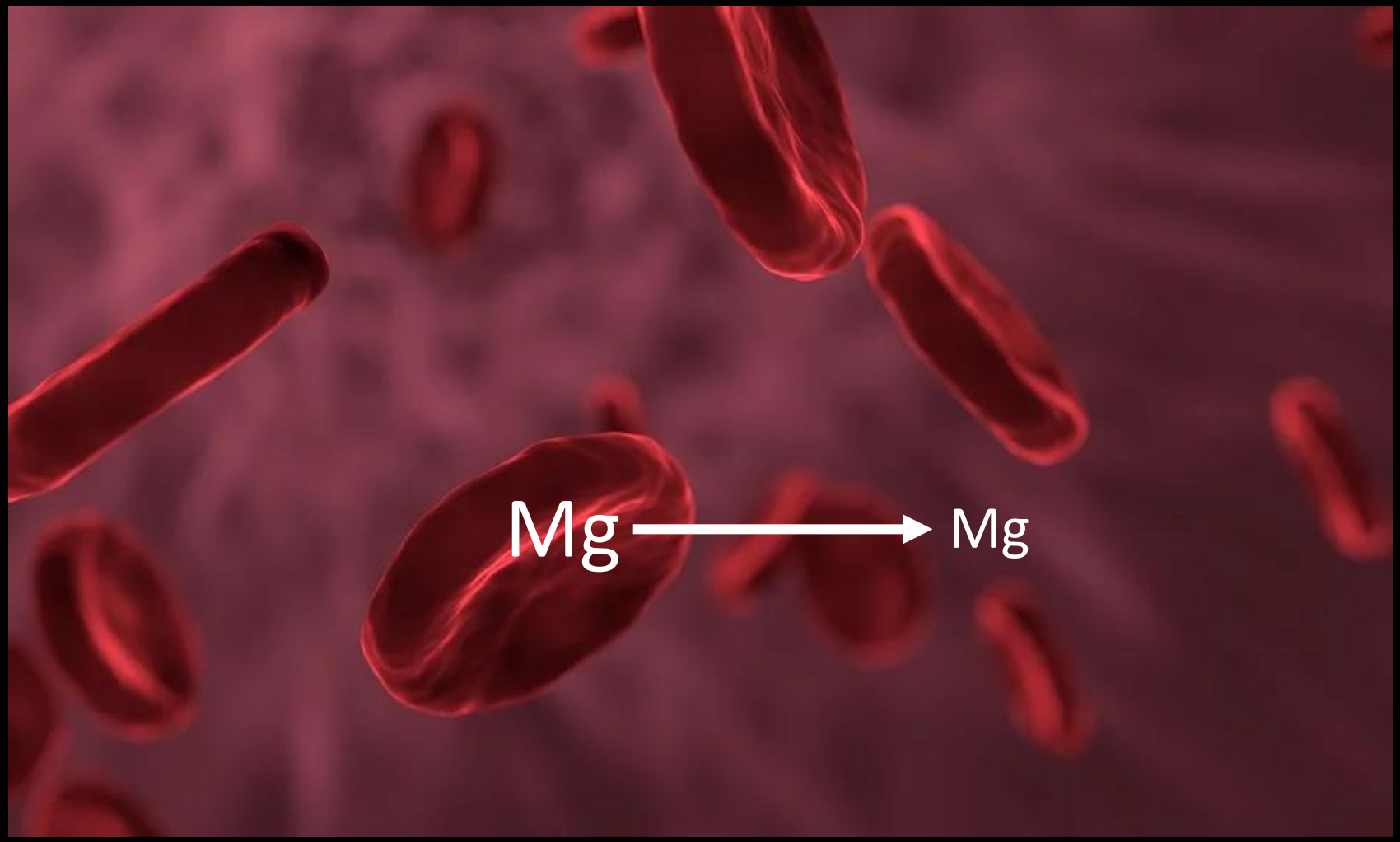
citrate

oxalate

EDTA

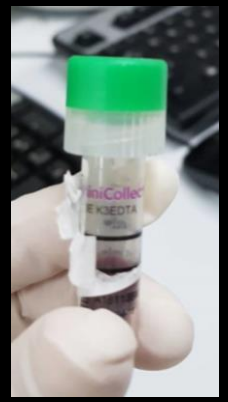
Can form complex with magnesium

Plasma/serum magnesium: hemolysis: unacceptable



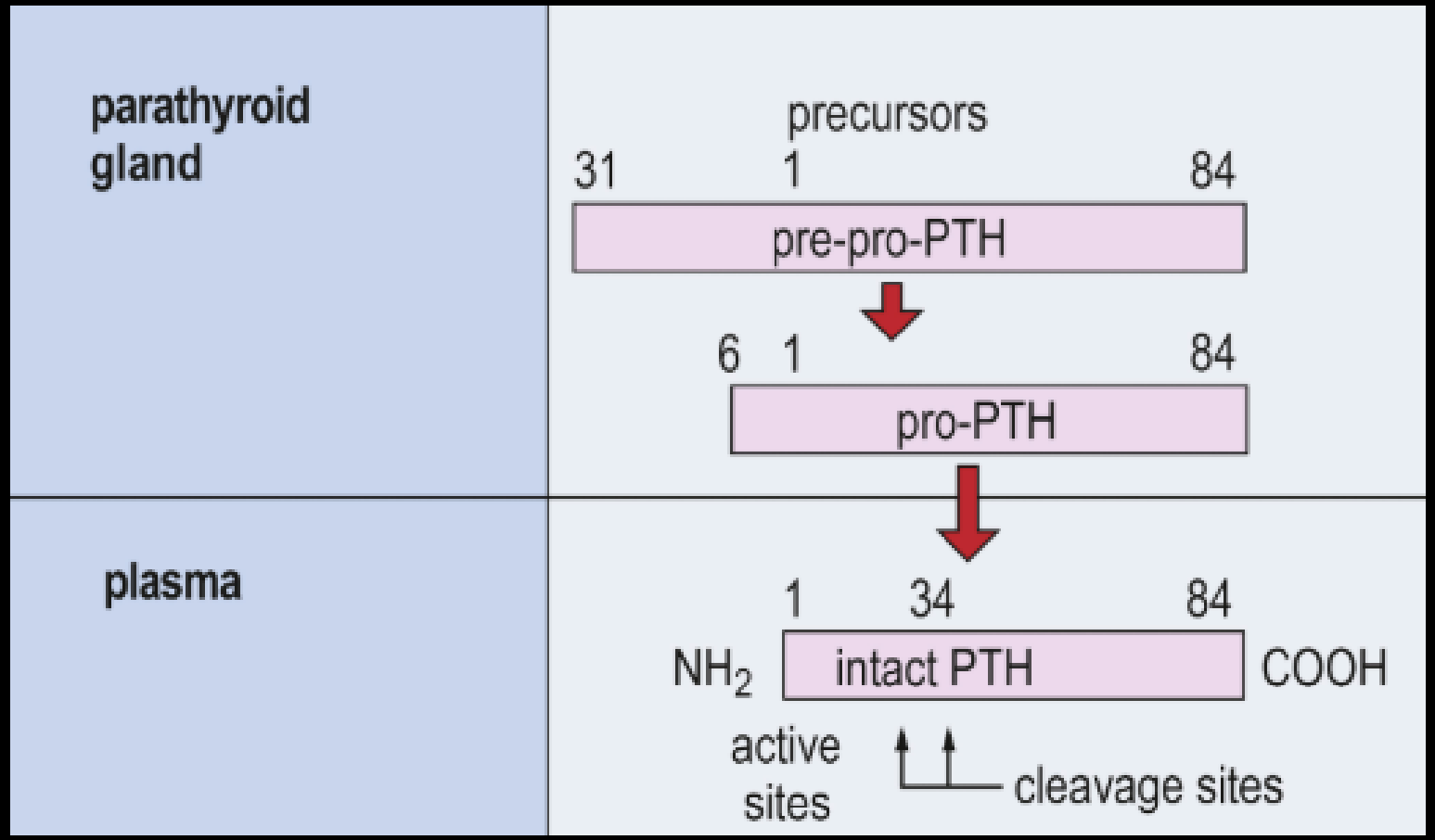
หญิงอายุ 6 เดือน

			Heparinized tube
K	27.75	mmol/L (3.4-4.5)	4.5
Total Calcium	-0.19	mg/dL (9-11)	8.7
P	5.01	mg/dL (3.7-6.5)	5.9
Mg	0.01	mg/dL (1.7-2.3)	2.2



PARATHYROID HORMONE

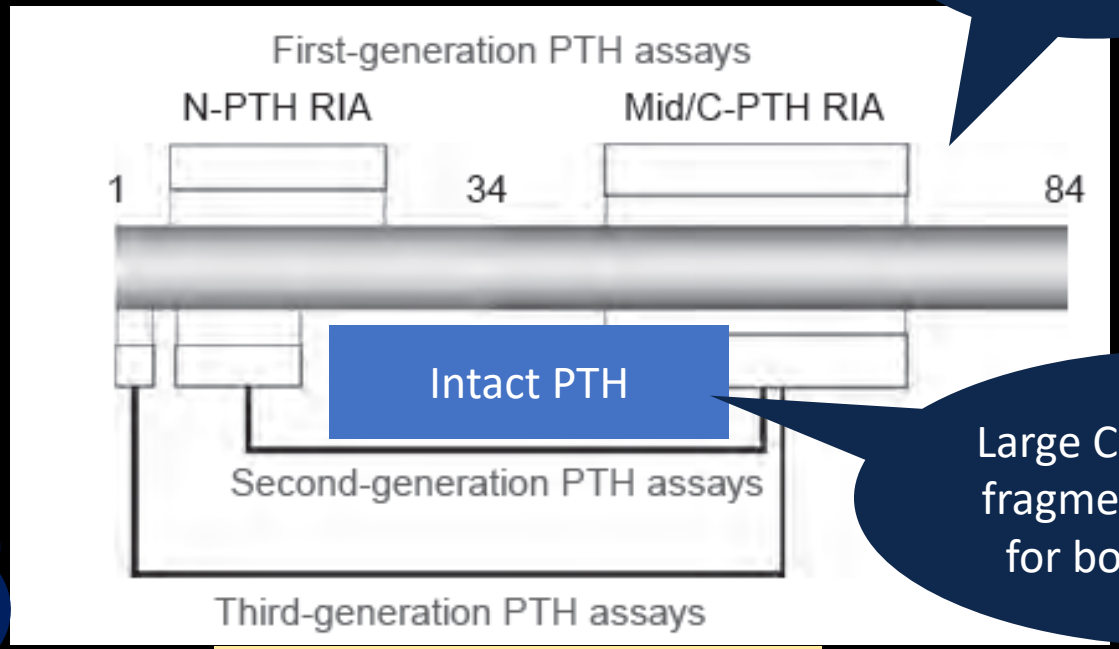
Parathyroid hormone



Marshall, Clinical Chemistry 2021.

PTH

Inactive fragment



Large C terminus: 7-84 fragments: antogonist for bone resorption

Not widely available

Whole/bioactive PTH

Kidney International (2009) 76 (Suppl 113), S22–S49

PTH

Pulsatile secretion

Circadian rhythm with nocturnal rise

PTH

Room temperature

↓PTH in a few hours

Kidney International (2009) 76 (Suppl 113), S22–S49
Tietz textbook of clinical chemistry 2023

VITAMIN D

	D_2	D_3	Total
Parent compound • Acronym • Full term • Synonym	 $vitD_2$ Vitamin D_2 Ergocalciferol	 $vitD_3$ Vitamin D_3 Cholecalciferol	 vitD Vitamin D (total)
Calcidiol • Acronym • Full term • Synonym	 25-(OH)D_2 25-hydroxyergocalciferol 25-(OH) vitamin D2	 25-(OH)D_3 25-hydroxycholecalciferol 25-(OH) vitamin D3	 25-(OH)D 25-(OH) vitamin D (total)
Calcitriol • Acronym • Full term • Synonym	 1,25-$(OH)_2D_2$ 1,25-dihydroxyergocalciferol 1,25-$(OH)_2$ vitamin D_2	 1,25-$(OH)_2D_3$ 1,25-dihydroxycholecalciferol 1,25-$(OH)_2$ vitamin D_3	 1,25-$(OH)_2$D 1,25-$(OH)_2$ vitamin D (total)

Kidney International (2009) 76 (Suppl 113), S22–S49
Lombardi, Clin Chem Lab Med. 2024 Nov 25;63(4):704-711.

25(OH)D

best measure of vitamin D status

long half-life about 3 weeks

Kidney International (2009) 76 (Suppl 113), S22–S49

$1,25(OH)_2D$

Half-life 4-6 h
Circulating level 1/1000 of 25(OH)D
Altered by exogenous calcitriol

Evaluation of hyper/hypocalcemia

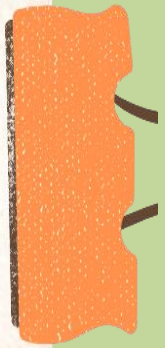
25(OH)D: specimen

Stable

Difference in measurement method

Kidney International (2009) 76 (Suppl 113), S22–S49

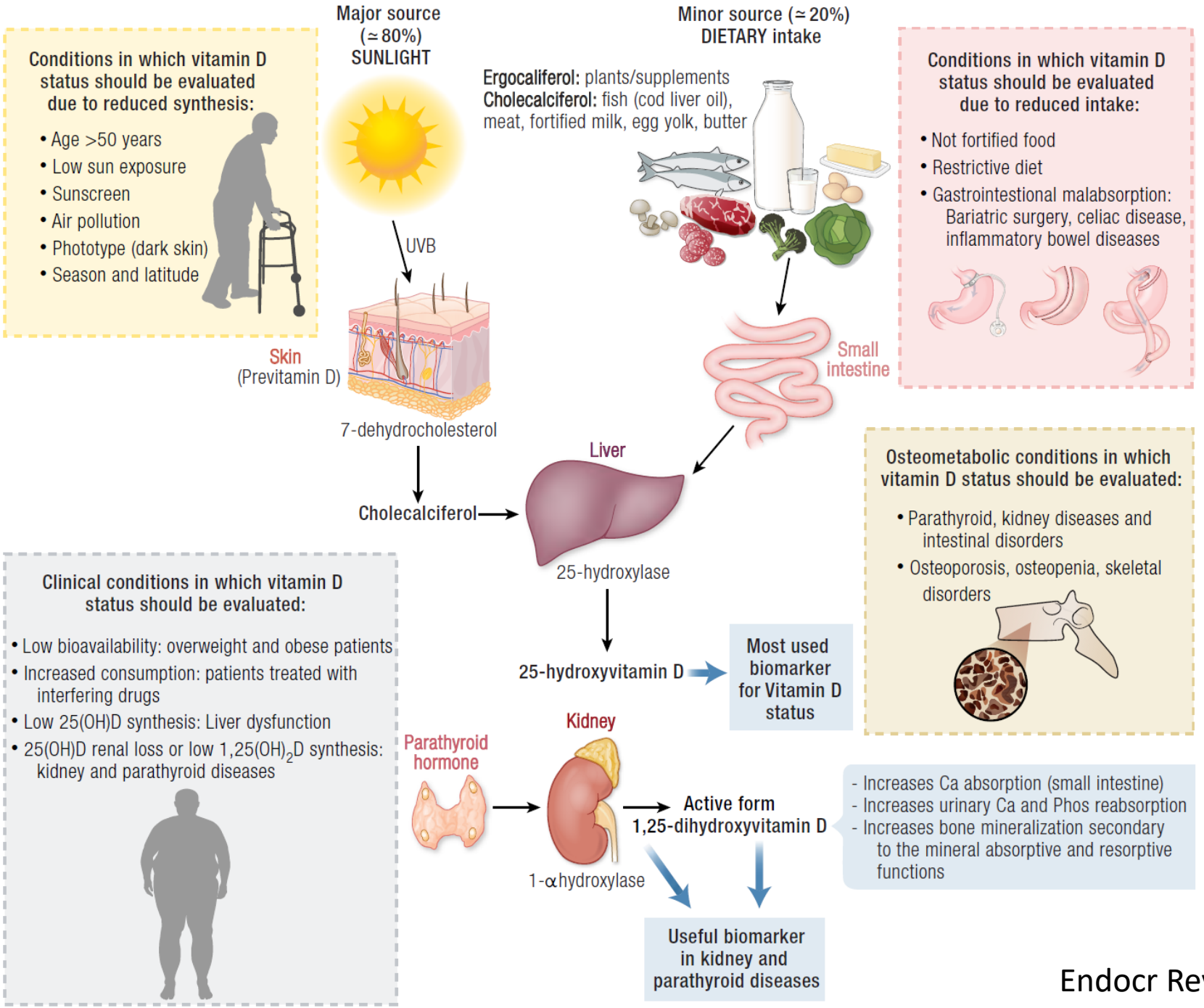
RATIONAL LAB USE



When to perform vitamin D (25-OHD) testing?

Screening for optimal vitamin D status in the general population should be avoided as it is not informative and has a considerable economic burden.

Endocr Rev. 2024 Sep 12;45(5):625-654.



Endocr Rev. 2024 Sep 12;45(5):625-654.

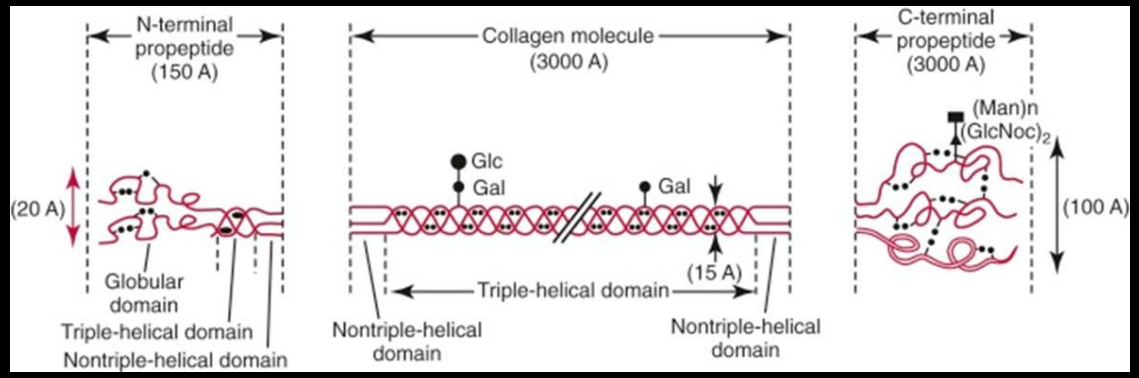
Biochemical Markers of Bone Turnover

Bone formation

Name	Abbreviation
Propeptides of type I procollagen	PINP and PICP
Bone alkaline phosphatase	BALP
Osteocalcin [bone gla protein (BGP)]	OC

Less sensitive, less diurnal variation

Noncollagenous protein in bone; degrade rapidly; N-terminal/midregion: more stable



Bone resorption

Name	Abbreviation
Type I Collagen Telopeptides	
N-telopeptide	NTx
C-telopeptide (formed by cathepsin K)	CTx, Crosslaps
C-telopeptide (formed by MMPs)	ICTP
Pyridinium Cross-links	
Tartrate-Resistant Acid Phosphatase 5b	TRACP5b

Breakdown product of bone resorption

Secreted by osteoclast during bone resorption

ICTP = collagen type I carboxy terminal telopeptide

RATIONAL LAB USE

Bone markers

Monitor the effectiveness of therapy:
earlier than measurements of bone mass

Measurement of bone mass e.g. dual energy X-ray absorptiometry: identify significant changes after 1-3 years of treatment

Bone marker: preanalytical variability

- Sampling time
  - Diurnal variation of bone resorption & formation
  - Peak in the early morning (4.00-8.00) and lowest in the afternoon (13.00-23.00)
  - BALP, TRACP5b: no significant diurnal variation
- Food intake: effect only on CTx

นึกถึง Rational Lab use

นึกถึง พยาธิวิทยาคลินิก ศิริราช