Mineral Metabolism and Abnormalities

CALCIUM

Total body calcium ? 1–1.2 kg.

Distribution:

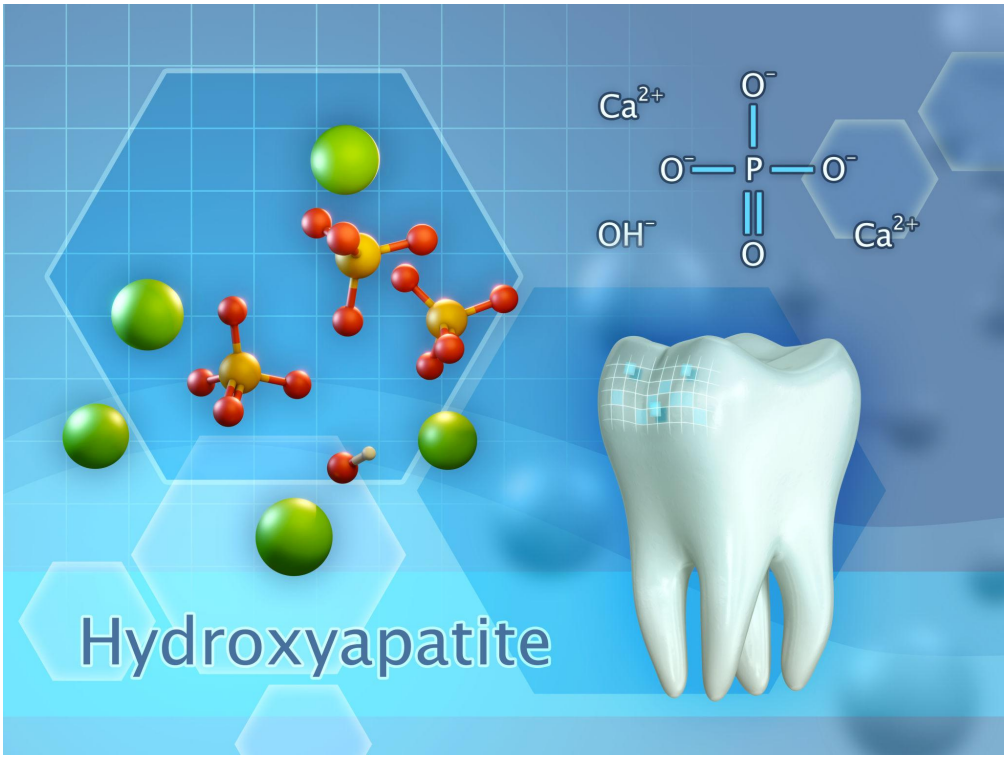
- 99% in bone (as hydroxyapatite)
- 1% in ECF and cells

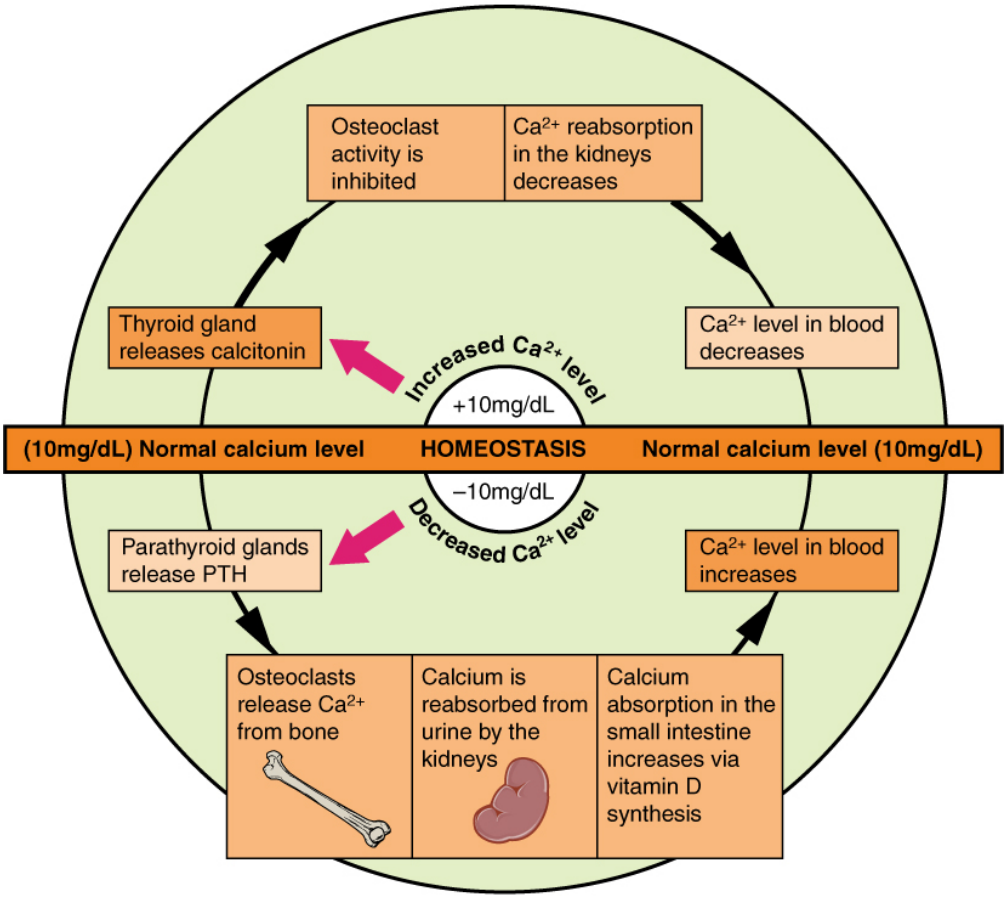
Serum calcium (normal):
8.5–10.5 mg/dL

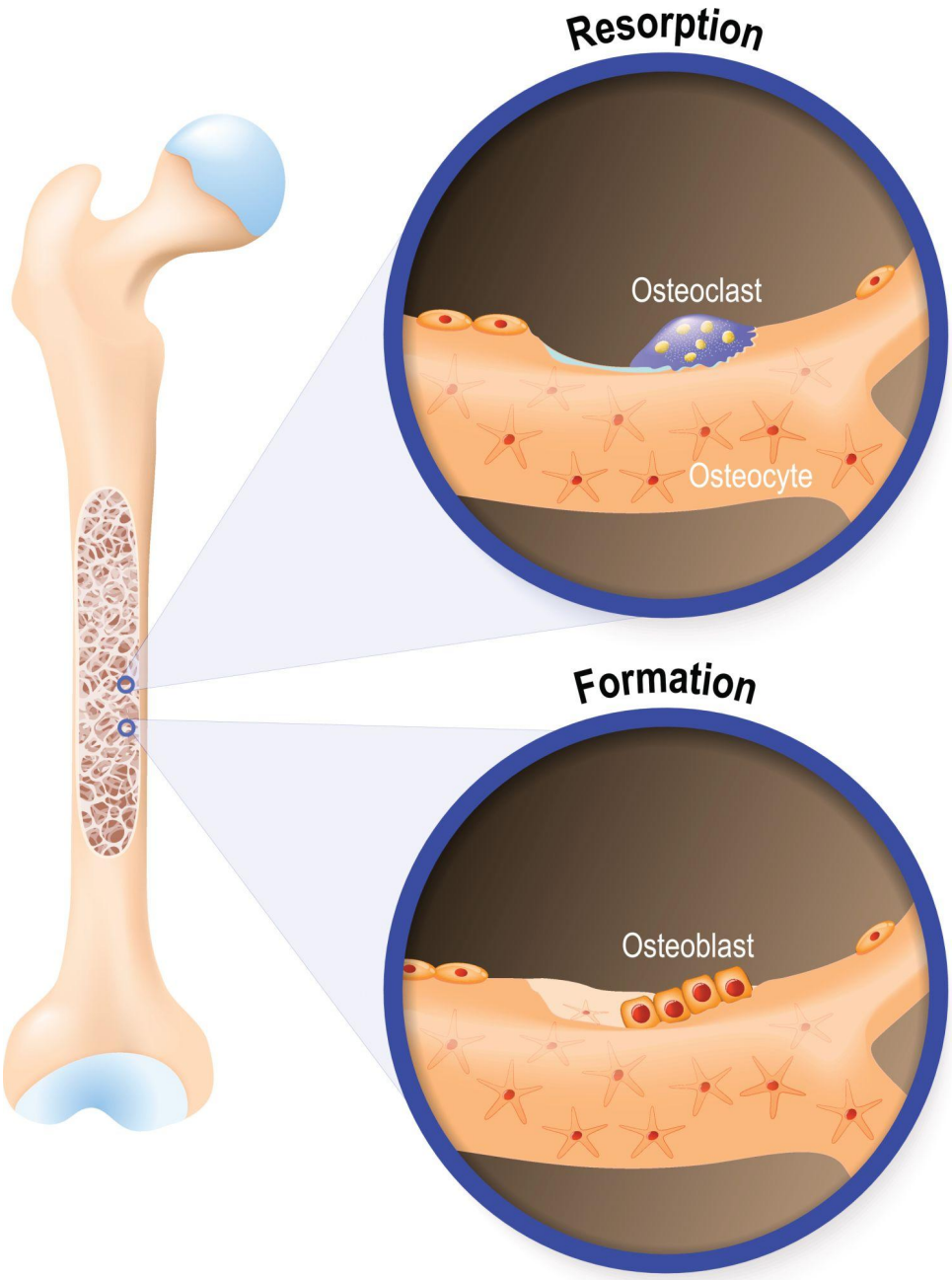
Forms in plasma:

- Ionized (active) ~50%
- Protein-bound ~40%
- Complexed ~10%

Ionized calcium is physiologically active.


Ca2+
O−
O−
P
O−
O
OH−
Ca2+
Hydroxyapatite


Osteoclast activity is inhibited
Ca2+ reabsorption in the kidneys decreases
Thyroid gland releases calcitonin
Ca2+ level in blood decreases
Increased Ca2+ level
+10mg/dL
(10mg/dL) Normal calcium level
HOMEOSTASIS
Normal calcium level (10mg/dL)
−10mg/dL
Decreased Ca2+ level
Parathyroid glands release PTH
Ca2+ level in blood increases
Osteoclasts release Ca2+ from bone
Calcium is reabsorbed from urine by the kidneys
Calcium absorption in the small intestine increases via vitamin D synthesis



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FUNCTIONS OF CALCIUM

- Muscle contraction
- Nerve transmission

- Blood clotting
- Enzyme activation
- Hormone secretion

CALCIUM HOMEOSTASIS

Maintained by:

1. Parathyroid hormone (PTH)
2. Vitamin D (Calcitriol)
3. Calcitonin

Three organs involved:

- Bone
- Kidney
- Intestine

PARATHYROID HORMONE (PTH)

Secreted by:
Parathyroid glands.

Stimulus:
Low serum calcium.

Actions of PTH

1. Bone

Stimulates osteoclast activity indirectly ? releases calcium.

2. Kidney

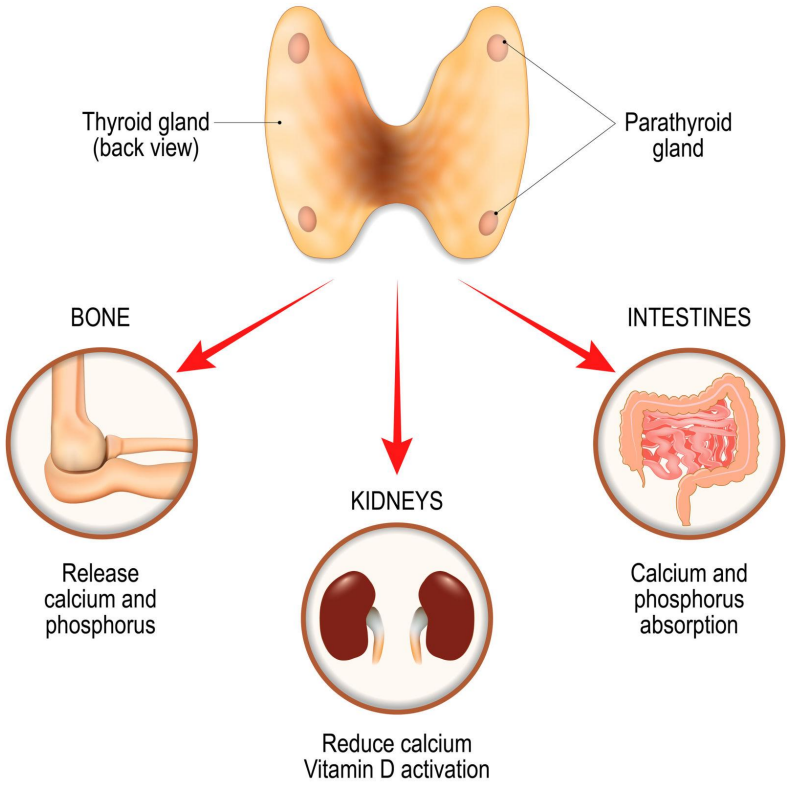
- Increases calcium reabsorption
- Decreases phosphate reabsorption
- Stimulates 1?-hydroxylase ? ? Calcitriol

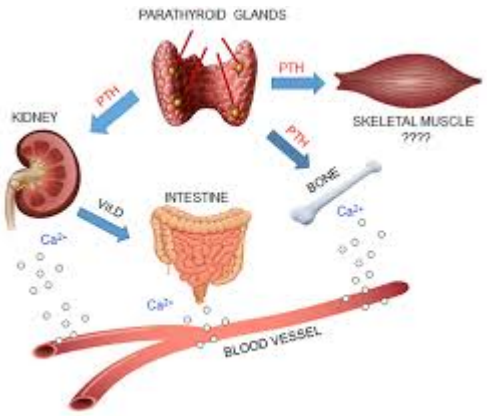
3. Intestine

Indirectly increases calcium absorption via calcitriol.

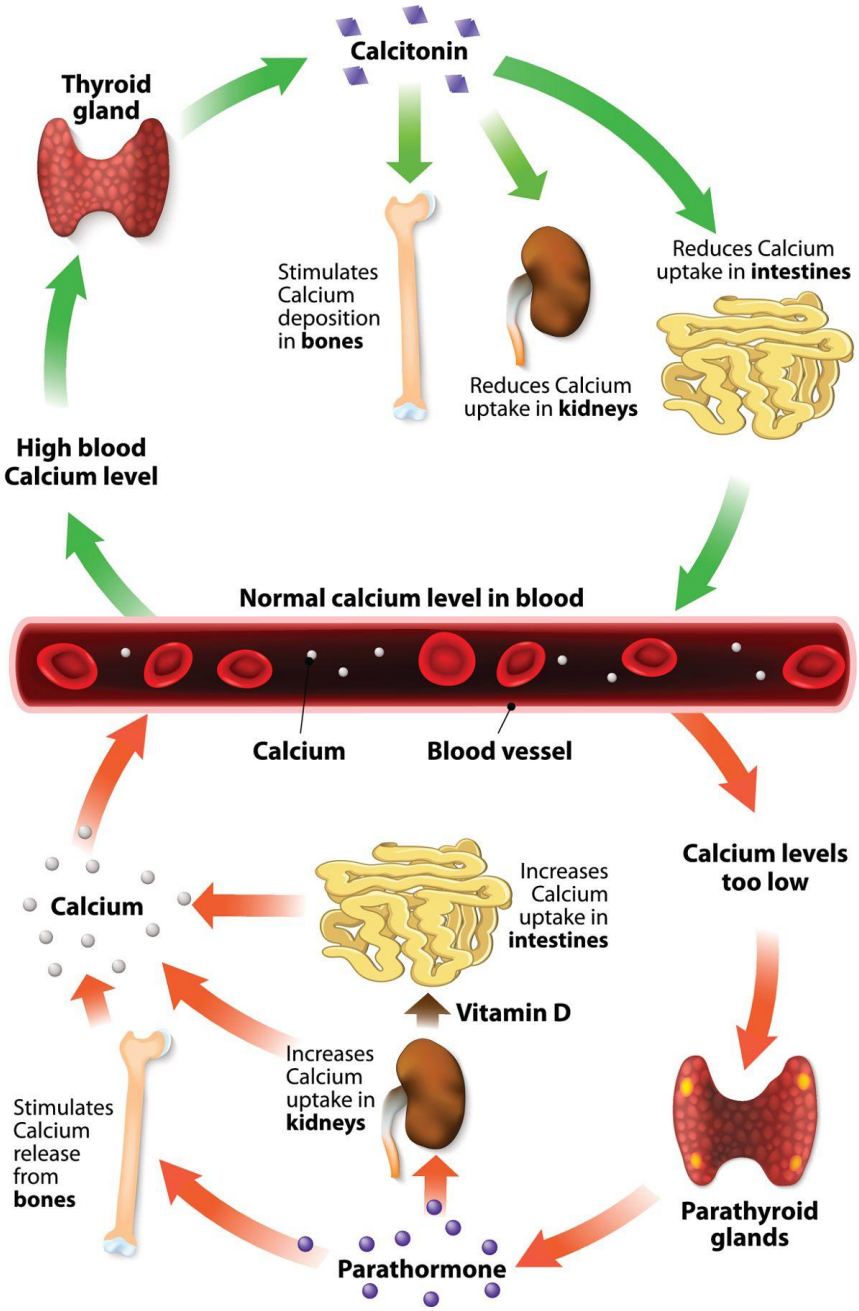
Net effect:
Raises serum calcium.

Parathyroid hormone





CALCITONIN and PARATHORMONE
(hormonal regulation of blood calcium levels)



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CALCITONIN

Secreted by:

Parafollicular (C) cells of thyroid.

Stimulus:
High serum calcium.

Action:
Inhibits osteoclast activity.

Net effect:
Lowers serum calcium.

Clinical importance limited in adults.

HYPERCALCEMIA

Serum calcium > 10.5 mg/dL.

Common causes:

- Hyperparathyroidism
- Malignancy
- Vitamin D excess
- Immobilization

Symptoms of Hypercalcemia

Mnemonic:
“Bones, stones, groans, psychiatric overtones”

- Bone pain
- Kidney stones
- Abdominal pain
- Confusion

ECG:
Short QT interval.

HYPOCALCEMIA

Serum calcium < 8.5 mg/dL.

Causes:

- Hypoparathyroidism
- Vitamin D deficiency
- Chronic kidney disease

Symptoms

- Tetany
- Muscle cramps
- Seizures
- Positive Chvostek sign
- Positive Trousseau sign

ECG:
Prolonged QT interval.

BONE METABOLISM

Bone is dynamic.

Two main cell types:

- Osteoblasts (build bone)
- Osteoclasts (resorb bone)

Bone remodeling is continuous.

Bone Matrix Components

- Collagen (organic)
- Hydroxyapatite (inorganic)

Hormonal Control

PTH:
Promotes bone resorption.

Calcitriol:
Promotes mineralization (but supports resorption if calcium low).

Calcitonin:
Inhibits resorption.

Bone Disorders

Osteoporosis

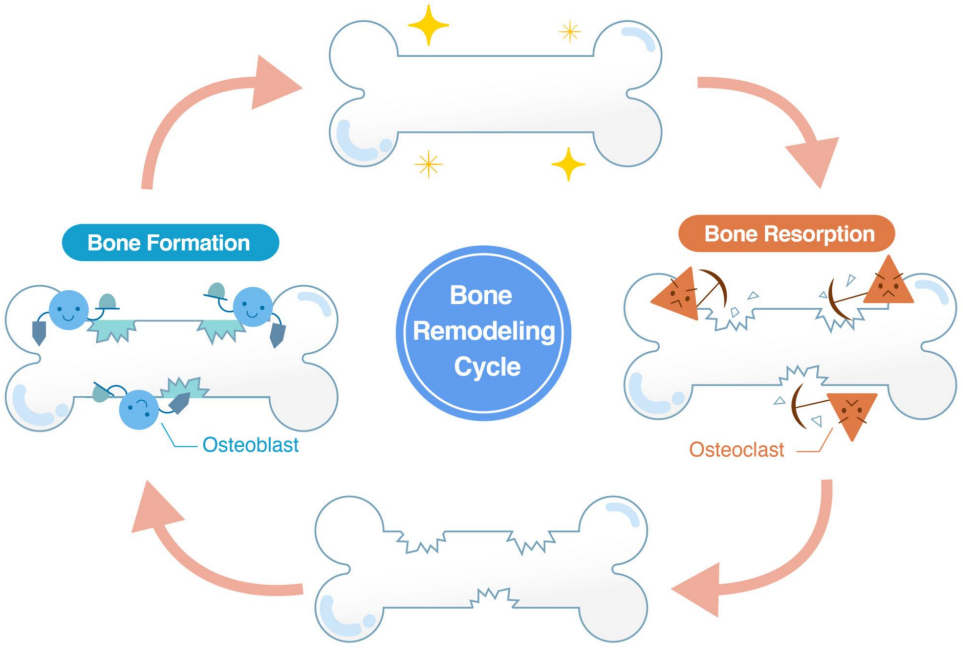
Low bone mass.

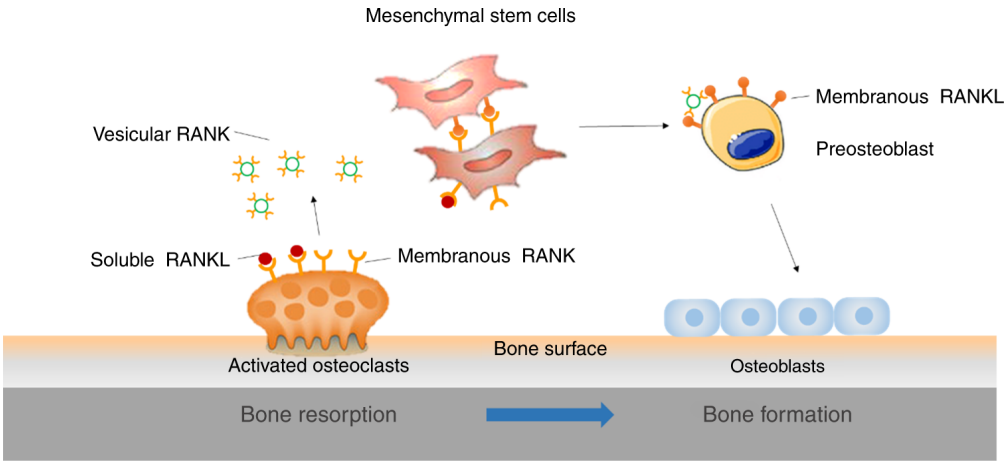
Osteomalacia

Defective mineralization.

Hyperparathyroidism

Bone resorption.





HIGH-YIELD INTEGRATION

Low calcium ? ? PTH ? ? bone resorption + ? calcitriol
High calcium ? ? calcitonin

Ionized calcium is active.
Albumin affects total calcium but not ionized calcium.

Corrected calcium formula:
Corrected Ca = Measured Ca + 0.8 × (4 ? serum albumin)

Examiner favorite.

RAPID MEMORY MAP

- PTH ? calcium, ? phosphate
- Calcitonin ? calcium
- Vitamin D ? calcium absorption
- Hypercalcemia ? short QT
- Hypocalcemia ? tetany
- 99% calcium in bone

Calcium metabolism is a balancing act between bone and blood.
Bone is storage. Blood is function.

Markers of Bone Formation

1. Serum Alkaline Phosphatase (ALP)
2. Osteocalcin
3. Procollagen type 1 N-terminal peptide (P1NP)

Raised in:

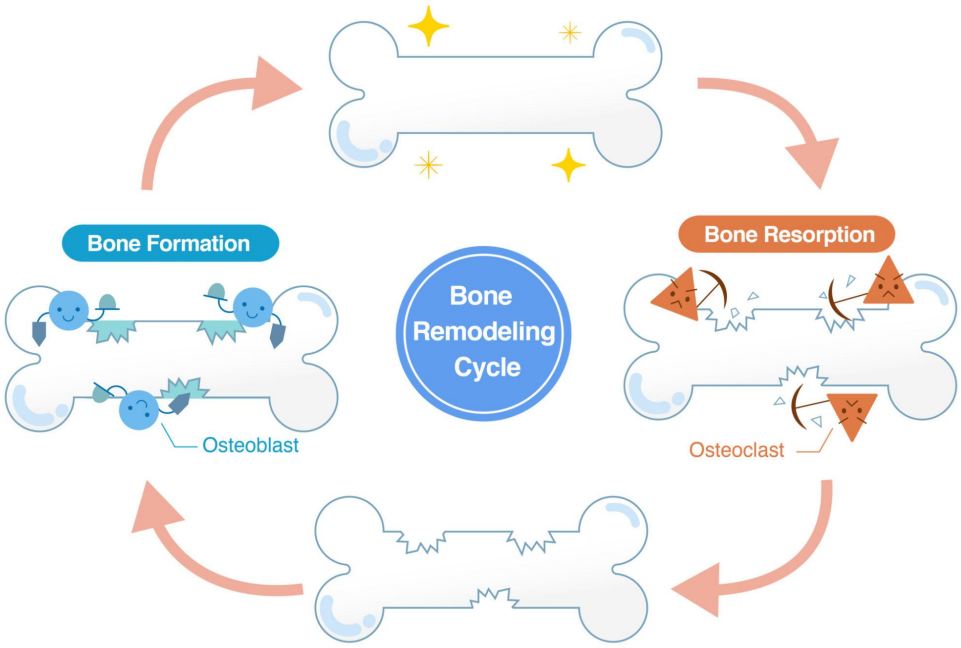
- Rickets
- Osteomalacia
- Hyperparathyroidism
- Paget disease

Markers of Bone Resorption

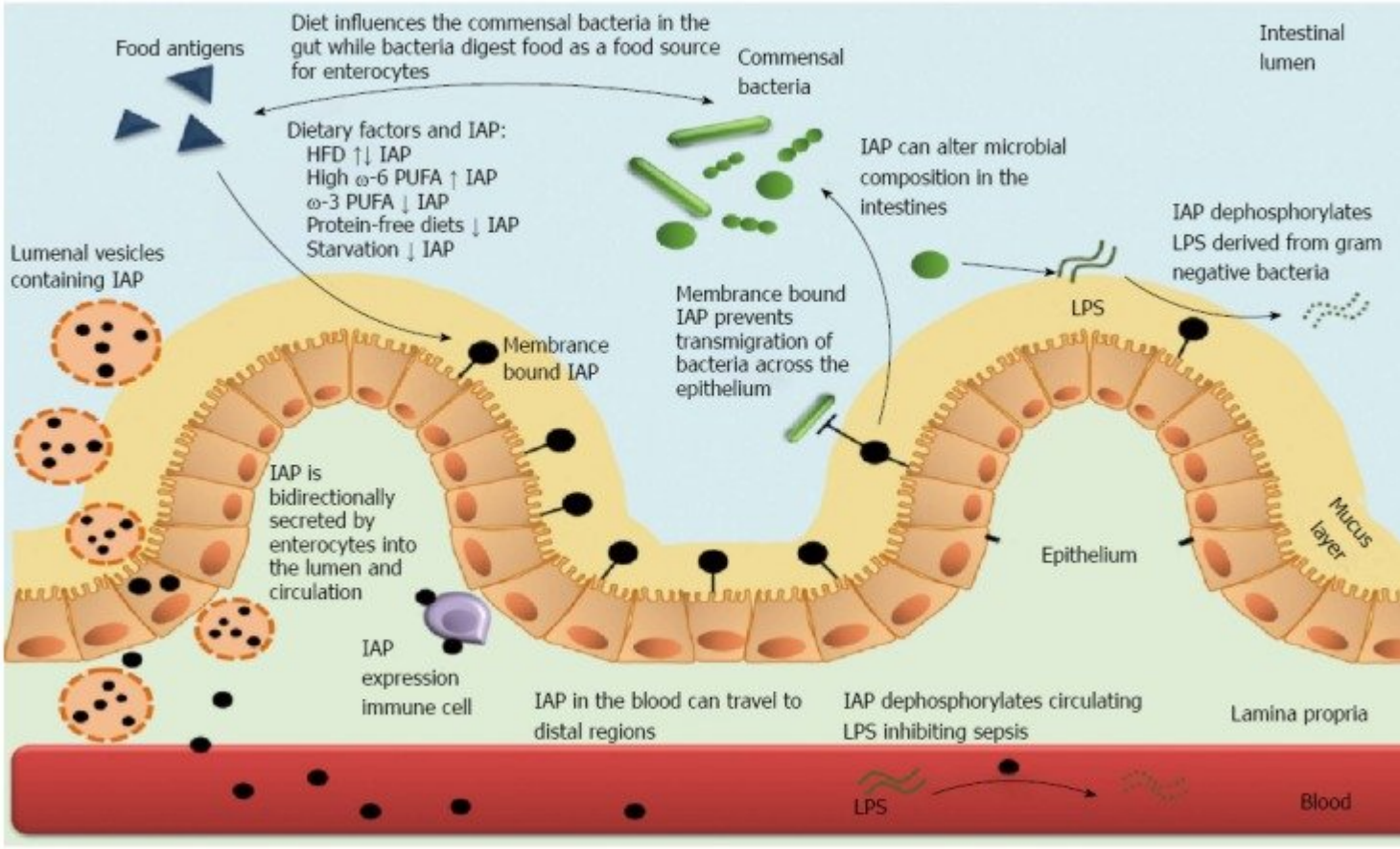
1. Urinary hydroxyproline
2. C-terminal telopeptide (CTX)
3. N-terminal telopeptide (NTX)

High in:

- Osteoporosis
- Hyperparathyroidism



Bone formation markers	Bone resorption markers
Osteocalcin	C-Telopeptide of Collagen Cross-links (CTx)
Bone Specific Alkaline Phosphatase (BSAP)	N-Telopeptide of Collagen Cross-links (NTx)
Carboxyterminal propeptide of Type I Collagen (P1CP)	Pyridinolines
Aminoterminal propeptide of Type I Collagen (P1NP)	Deoxypyridinoline
	Tartrate-Resistant Acid Phosphatase (TRAP)



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PHOSPHORUS

Normal serum phosphate:
2.5–4.5 mg/dL

Major component of:

- Hydroxyapatite
- ATP
- Nucleic acids
- Phospholipids

Regulation

Controlled by:

- PTH (decreases phosphate reabsorption in kidney)
- Vitamin D (increases absorption)

Hypophosphatemia

Causes:

- Hyperparathyroidism
- Vitamin D deficiency
- Refeeding syndrome

Hyperphosphatemia

Causes:

- Renal failure
- Hypoparathyroidism

MAGNESIUM

Normal:
1.7–2.2 mg/dL

Functions:

- Cofactor for ATP-dependent enzymes
- Neuromuscular stability
- PTH secretion

Hypomagnesemia

Causes:

- Alcoholism
- Diarrhea
- Diuretics

Effects:

- Tetany
- Arrhythmia
- Hypocalcemia (due to impaired PTH)

SULPHUR

Derived from sulfur-containing amino acids:

- Methionine
- Cysteine

Functions:

- Disulfide bonds in proteins
- Detoxification reactions (sulfation)
- Structure of keratin

Deficiency rare.

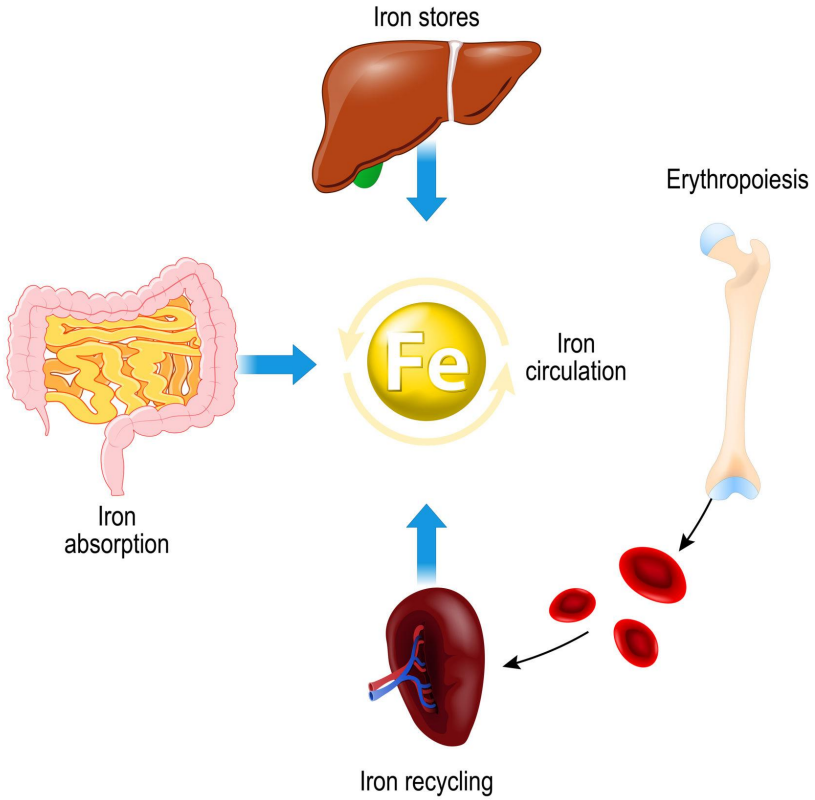
IRON

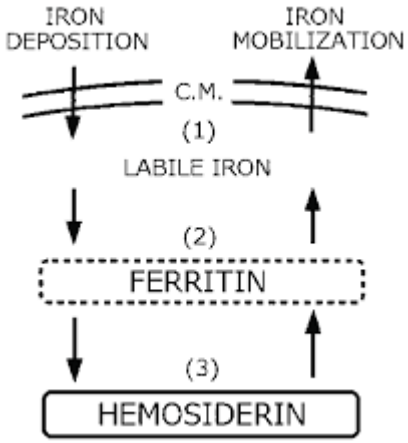
Total body iron:
3–4 g.

Distribution:

- Hemoglobin (major share)
- Myoglobin
- Ferritin (storage)
- Transferrin (transport)

Iron metabolism





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IRON ABSORPTION

Site:
Duodenum.

Two forms:

- Heme iron (better absorbed)
- Non-heme iron ($Fe^{3?}$)

Vitamin C enhances absorption.

Regulatory hormone:
Hepcidin (from liver)

Hepcidin blocks iron release from enterocytes.

IRON DEFICIENCY

Causes:

- Chronic blood loss
- Poor diet
- Pregnancy

Lab findings:

- Low hemoglobin
- Low serum ferritin
- High TIBC
- Low serum iron

Peripheral smear:
Microcytic hypochromic anemia.

HEMOCHROMATOSIS

Iron overload disorder.

Types:

1. Primary (genetic)
2. Secondary (transfusion-related)

Features

- Liver cirrhosis
- Diabetes
- Bronze skin pigmentation
- Cardiomyopathy

Lab:

- High ferritin
- High serum iron
- Low TIBC

HIGH-YIELD INTEGRATION

PTH:
? Calcium
? Phosphate

Magnesium:
Required for PTH release.

Iron deficiency:
Low ferritin first.

Hemochromatosis:
High ferritin + high transferrin saturation.

RAPID MEMORY MAP

- ALP ? Bone formation
- CTX ? Bone resorption
- Phosphate partners calcium
- Magnesium stabilizes nerves
- Iron transported by transferrin
- Ferritin reflects storage
- Hepcidin blocks iron absorption

COPPER

Total body copper ? 100 mg.

Transported in plasma by **ceruloplasmin**.

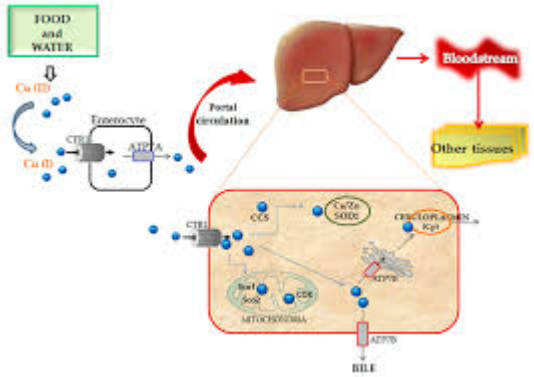
Functions:

- Iron metabolism

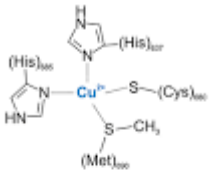
- Collagen cross-linking
- Melanin synthesis
- Antioxidant defense

Important Copper-Dependent Enzymes

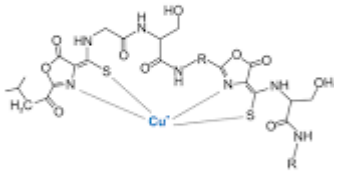
- Ceruloplasmin (ferroxidase)
- Cytochrome c oxidase
- Lysyl oxidase
- Superoxide dismutase



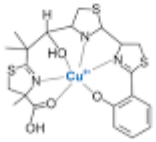
a Ceruloplasmin - Type I copper center



b Methanobactin

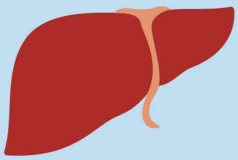


c Yersiniabactin



Symptoms of Wilson Disease

Liver

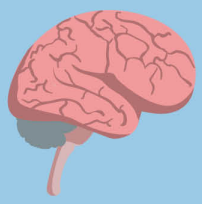


Abdominal pain.

Dark urine or a light stool color.

Jaundice.

Brain

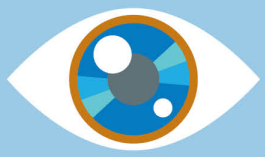


Mood changes.

Anxiety and depression.

Disruptive thoughts and feelings.

Eye



Rings around the edge of your corneas.

Nervous system

Tremors.

Stiff muscles.

Problems with coordination.

Cleveland Clinic

CERULOPLASMIN

Alpha-2 globulin.

Functions:

- Oxidizes $Fe^{2?}$? $Fe^{3?}$
- Facilitates iron binding to transferrin

Decreased in:
Wilson disease.

Copper Disorders

Wilson Disease

Copper accumulation in liver and brain.

Features:

- Liver cirrhosis
- Kayser-Fleischer rings
- Neurological symptoms

Low ceruloplasmin.

Menkes Disease

Defective copper transport.

Features:

- Kinky hair
- Neurological deterioration

IODINE

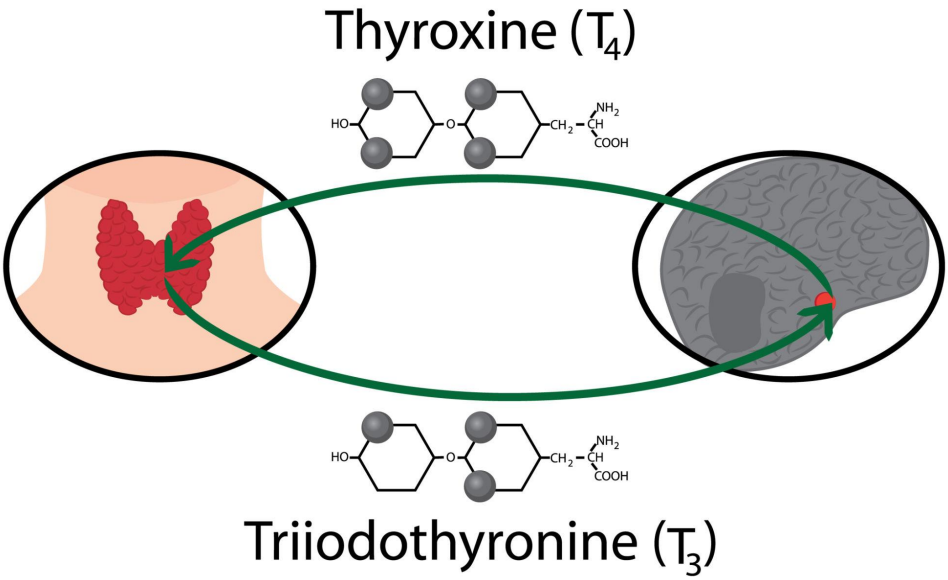
Required for synthesis of:

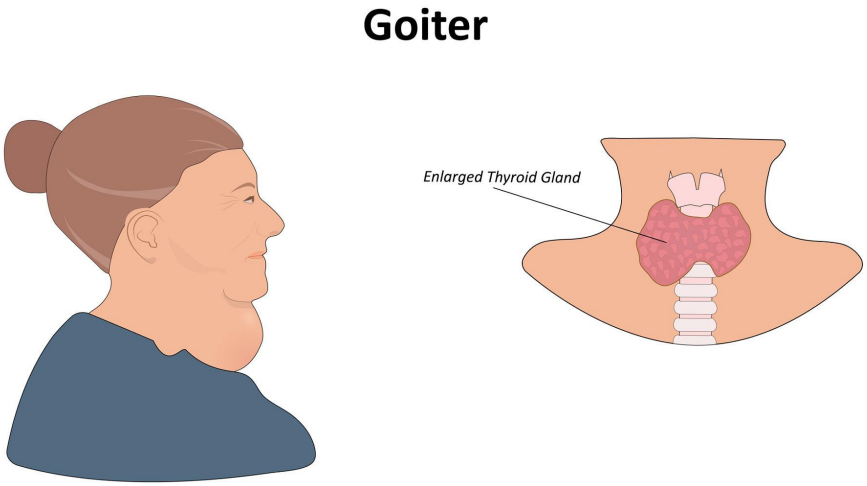
- T3
- T4

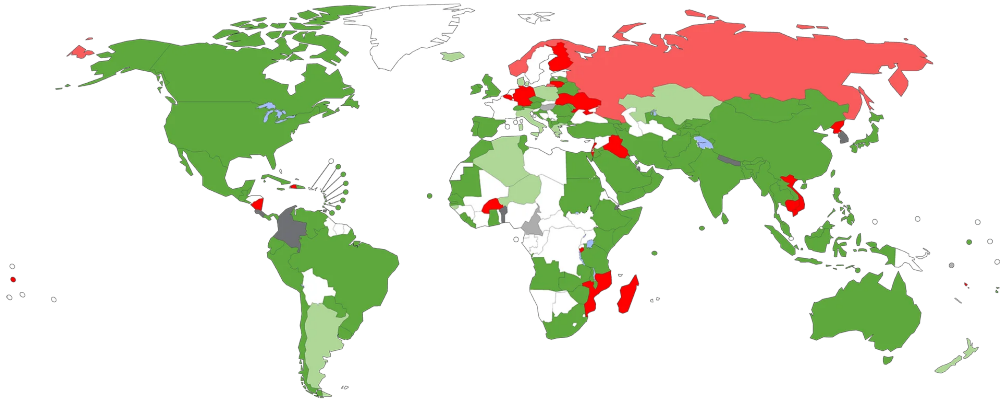
Stored in thyroid gland.

Deficiency leads to:

- Goiter
- Hypothyroidism
- Cretinism (in children)







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ZINC

Functions:

- DNA synthesis
- Cell division

- Wound healing
- Immunity
- Insulin storage

Enzyme component in:

- Carbonic anhydrase
- Alkaline phosphatase

Zinc Deficiency

- Growth retardation
- Hypogonadism
- Delayed wound healing
- Acrodermatitis enteropathica

FLUORIDE

Incorporated into:

Hydroxyapatite ? Fluoroapatite.

Role:

- Prevents dental caries
- Strengthens enamel

Excess:
Dental fluorosis.

SELENIUM

Component of:

Glutathione peroxidase.

Function:

- Antioxidant
- Thyroid hormone metabolism

Deficiency:

Keshan disease (cardiomyopathy).

MANGANESE

Cofactor for:

- Pyruvate carboxylase
- Superoxide dismutase

Deficiency rare.

Excess:
Neurotoxicity.

MOLYBDENUM

Cofactor for:

- Xanthine oxidase

- Sulfite oxidase

Deficiency rare.

COBALT

Component of:

Vitamin B12.

Not independently required apart from B12.

NICKEL

Trace role in:

Enzyme systems (minor role in humans).

Deficiency rare.

CHROMIUM

Enhances insulin action.

Part of:

Glucose tolerance factor.

Deficiency:

Impaired glucose tolerance.

LITHIUM

Not essential nutrient.

Used pharmacologically in:

Bipolar disorder.

Toxicity:

Tremor, nephrotoxicity.

HIGH-YIELD SUMMARY

Copper ? Iron metabolism
Ceruloplasmin ? Ferrooxidase
Iodine ? Thyroid hormones
Zinc ? Growth & immunity
Fluoride ? Teeth
Selenium ? Antioxidant
Chromium ? Insulin action
Cobalt ? Vitamin B12

TRACE ELEMENTS – COMPLETE FAQ SET

COPPER

Q1. What is the normal role of copper in the body?
Iron metabolism, collagen cross-linking, antioxidant defense.

Q2. What plasma protein transports copper?
Ceruloplasmin.

Q3. What is the function of ceruloplasmin?
Oxidizes $Fe^{2?}$ to $Fe^{3?}$ for binding to transferrin.

Q4. Which disease is associated with low ceruloplasmin?
Wilson disease.

Q5. What are the main features of Wilson disease?
Liver cirrhosis, neurological symptoms, Kayser-Fleischer rings.

Q6. What is Menkes disease?
Defective copper transport leading to neurological deterioration and kinky hair.

IODINE

Q7. What is the main function of iodine?
Synthesis of thyroid hormones (T3, T4).

Q8. Where is iodine stored?
Thyroid gland.

Q9. What is goiter?
Enlargement of thyroid due to iodine deficiency.

Q10. What is cretinism?
Severe congenital hypothyroidism due to iodine deficiency.

ZINC

Q11. What are the major functions of zinc?
DNA synthesis, cell division, immunity, wound healing.

Q12. Name one zinc-containing enzyme.
Carbonic anhydrase.

Q13. What is acrodermatitis enteropathica?
Inherited zinc absorption defect.

Q14. Features of zinc deficiency?
Growth retardation, delayed wound healing, hypogonadism.

FLUORIDE

Q15. What is the role of fluoride in teeth?
Forms fluoroapatite and prevents dental caries.

Q16. What is dental fluorosis?
Excess fluoride causing mottled enamel.

SELENIUM

Q17. Selenium is a component of which enzyme?
Glutathione peroxidase.

Q18. What is the role of selenium?
Antioxidant and thyroid hormone metabolism.

Q19. What disease is associated with selenium deficiency?
Keshan disease (cardiomyopathy).

MANGANESE

Q20. Name one manganese-dependent enzyme.
Pyruvate carboxylase.

Q21. What happens in manganese excess?
Neurotoxicity.

MOLYBDENUM

Q22. Name one molybdenum-dependent enzyme.
Xanthine oxidase.

Q23. Is molybdenum deficiency common?
No, it is rare.

COBALT

Q24. What is the biological role of cobalt?
Component of Vitamin B12.

Q25. Does cobalt have an independent function apart from B12?
No.

NICKEL

Q26. Is nickel essential in humans?
Its role is minimal and not clearly defined.

CHROMIUM

Q27. What is the main function of chromium?
Enhances insulin action.

Q28. What happens in chromium deficiency?
Impaired glucose tolerance.

LITHIUM

Q29. Is lithium an essential nutrient?
No.

Q30. What is lithium used for clinically?
Treatment of bipolar disorder.

Q31. Name one toxicity feature of lithium.
Tremor.

INTEGRATED EXAMINER QUESTIONS

Q32. Which trace element deficiency causes neurological and hepatic manifestations?
Copper deficiency or Wilson disease (copper excess).

Q33. Which trace element is important for thyroid hormone synthesis?
Iodine.

Q34. Which trace element is important in antioxidant defense along with glutathione?
Selenium.

Q35. Which trace element improves insulin sensitivity?
Chromium.

Q36. Which trace element deficiency causes growth retardation?
Zinc deficiency.

Q37. Which mineral protects against dental caries?
Fluoride.

Q38. Which trace element abnormality is seen in Wilson disease?
Copper accumulation with low ceruloplasmin.

Q39. Which trace element forms part of Vitamin B12?
Cobalt.

Q40. Which trace element excess can cause neurotoxicity?
Manganese.

RAPID MEMORY MAP

Copper ? Iron metabolism
Ceruloplasmin ? Ferrooxidase
Iodine ? Thyroid hormone
Zinc ? Growth & immunity
Fluoride ? Teeth
Selenium ? Antioxidant
Chromium ? Insulin action
Cobalt ? B12

TRACE ELEMENTS – MCQs

---

1. Copper is transported in plasma mainly by:

A. Transferrin
B. Albumin
C. Ceruloplasmin
D. Ferritin

---

2. Ceruloplasmin functions as:

A. Iron storage protein
B. Ferrooxidase
C. Hemoglobin
D. Hormone

---

3. Low ceruloplasmin is seen in:

A. Hemochromatosis
B. Wilson disease
C. Thalassemia
D. Pernicious anemia

---

4. Kayser-Fleischer rings are seen in:

A. Iron deficiency
B. Wilson disease
C. Zinc deficiency
D. Fluorosis

---

5. Menkes disease is due to:

A. Iron excess
B. Defective copper transport
C. Zinc deficiency
D. Selenium toxicity

---

6. Iodine is required for synthesis of:

A. Insulin
B. Thyroid hormones
C. Cortisol
D. Growth hormone

---

7. Goiter most commonly results from deficiency of:

A. Copper
B. Zinc
C. Iodine
D. Chromium

---

8. Congenital iodine deficiency causes:

A. Rickets
B. Cretinism
C. Pellagra
D. Scurvy

---

9. Zinc is a component of:

A. Hemoglobin
B. Carbonic anhydrase
C. Collagen
D. Albumin

---

10. Zinc deficiency leads to:

A. Hyperthyroidism
B. Growth retardation
C. Iron overload
D. Polycythemia

---

11. Acrodermatitis enteropathica is due to deficiency of:

A. Copper
B. Zinc
C. Selenium
D. Manganese

---

12. Fluoride strengthens teeth by forming:

A. Hydroxyapatite
B. Fluoroapatite
C. Ferritin
D. Hemoglobin

---

13. Excess fluoride causes:

A. Goiter
B. Dental fluorosis
C. Hemolysis
D. Cirrhosis

---

14. Selenium is a component of:

A. Catalase
B. Glutathione peroxidase
C. Superoxide dismutase
D. Transferrin

---

15. Selenium deficiency causes:

A. Keshan disease
B. Wilson disease
C. Beriberi
D. Rickets

---

16. Manganese is required for:

A. Pyruvate carboxylase
B. Hemoglobin
C. Thyroxine
D. Collagen

---

17. Molybdenum is a cofactor for:

A. Xanthine oxidase
B. Hexokinase
C. Lactate dehydrogenase
D. Pepsin

---

18. Cobalt is an essential component of:

A. Hemoglobin
B. Vitamin B12
C. Insulin
D. Collagen

---

19. Chromium primarily enhances:

A. Thyroid function
B. Insulin action
C. Collagen synthesis
D. Iron absorption

---

20. Chromium deficiency leads to:

A. Hypothyroidism
B. Impaired glucose tolerance
C. Anemia
D. Bleeding

---

21. Lithium is used clinically for:

A. Epilepsy
B. Bipolar disorder
C. Diabetes
D. Hypertension

---

22. Lithium toxicity commonly causes:

A. Hypoglycemia
B. Tremor
C. Goiter
D. Jaundice

---

23. Copper is required for:

A. DNA replication
B. Iron oxidation
C. Clotting
D. Thyroid hormone synthesis

---

24. Ceruloplasmin helps in:

A. Iron storage
B. Iron transport
C. Iron oxidation
D. Iron excretion

---

25. Wilson disease results in:

A. Copper deficiency
B. Copper accumulation
C. Iron overload
D. Zinc deficiency

---

26. Zinc plays an important role in:

A. Wound healing
B. Clotting
C. Myelin formation
D. Thyroid hormone synthesis

---

27. Selenium also plays a role in:

A. Thyroid hormone metabolism
B. Hemoglobin synthesis
C. Insulin secretion
D. Bone formation

---

28. Which trace element is essential for antioxidant defense?

A. Zinc
B. Selenium
C. Fluoride
D. Nickel

---

29. Which trace element abnormality causes neurotoxicity when in excess?

A. Zinc
B. Copper
C. Manganese
D. Fluoride

---

30. Which trace element deficiency causes impaired immunity?

A. Zinc
B. Chromium
C. Nickel
D. Lithium

---

31. Nickel in humans:

A. Has major metabolic role
B. Is part of hemoglobin
C. Has minimal defined role
D. Causes anemia

---

32. Iodine deficiency leads to increased:

A. T3
B. T4
C. TSH
D. Insulin

---

33. Copper deficiency may cause:

A. Microcytic anemia
B. Polycythemia
C. Hypercalcemia
D. Hypothyroidism

---

34. Which trace element is involved in collagen cross-linking?

A. Zinc
B. Copper
C. Selenium
D. Chromium

---

35. Fluoride deficiency predisposes to:

A. Dental caries
B. Rickets
C. Pellagra
D. Hemochromatosis

---

36. Keshan disease primarily affects:

A. Brain
B. Heart
C. Liver
D. Kidney

---

37. Chromium is part of:

A. Glucose tolerance factor
B. Hemoglobin
C. Collagen
D. Ceruloplasmin

---

38. Kayser-Fleischer rings are due to deposition of:

A. Iron
B. Copper
C. Zinc
D. Fluoride

---

39. Zinc is important for:

A. Thyroid hormone synthesis
B. DNA polymerase activity
C. Hemoglobin oxygen binding
D. Collagen hydroxylation

---

40. Copper-dependent enzyme involved in iron metabolism:

A. Ceruloplasmin
B. Ferritin
C. Transferrin
D. Catalase

---

41. Which trace element is essential for superoxide dismutase?

A. Zinc and copper
B. Iodine
C. Fluoride
D. Nickel

---

42. Manganese toxicity resembles:

A. Parkinsonism
B. Anemia
C. Rickets
D. Hypothyroidism

---

43. Iodine is organified in thyroid by:

A. Peroxidase
B. Transferrin
C. Catalase
D. Hexokinase

---

44. Zinc deficiency affects which system prominently?

A. Skeletal
B. Reproductive
C. Respiratory
D. Renal

---

45. Excess copper may cause:

A. Hypoglycemia
B. Liver damage
C. Hypothyroidism
D. Fluorosis

---

46. Selenium deficiency impairs:

A. Collagen synthesis
B. Antioxidant defense
C. Clotting
D. Iron transport

---

47. Which trace element deficiency may cause hypogonadism?

A. Zinc
B. Selenium
C. Fluoride
D. Nickel

---

48. Ceruloplasmin is synthesized in:

A. Thyroid
B. Liver
C. Kidney
D. Bone marrow

---

49. The most important trace element for thyroid hormone production:

A. Selenium
B. Iodine
C. Zinc
D. Copper

---

50. Cobalt deficiency manifests as deficiency of:

A. Iron
B. Vitamin B12
C. Zinc
D. Copper

ANSWER KEY

1. C

2. B

3. B
4. B
5. B
6. B
7. C
8. B
9. B
10. B
11. B
12. B
13. B
14. B
15. A
16. A
17. A
18. B
19. B
20. B
21. B

22. B

23. B

24. C

25. B

26. A

27. A

28. B

29. C

30. A

31. C

32. C

33. A

34. B

35. A

36. B

37. A

38. B

39. B

40. A

41. A

42. A

43. A

44. B

45. B

46. B

47. A

48. B

49. B

50. B

TRACE ELEMENTS – VIVA VOCE

COPPER & CERULOPLASMIN

Q1. What is the main function of copper in the body?
Iron metabolism, collagen cross-linking, antioxidant defense, melanin synthesis.

Q2. Which plasma protein transports copper?
Ceruloplasmin.

Q3. What is the function of ceruloplasmin?
Oxidizes Fe^{2}? to Fe^{3}? to allow binding with transferrin.

Q4. What happens to ceruloplasmin levels in Wilson disease?
They decrease.

Q5. What is the basic defect in Wilson disease?
Impaired copper excretion leading to copper accumulation.

Q6. What are Kayser-Fleischer rings?
Copper deposition in cornea.

Q7. What is Menkes disease?
Defective copper transport causing deficiency symptoms.

Q8. Which copper-dependent enzyme is involved in collagen cross-linking?
Lysyl oxidase.

IODINE

Q9. What is the biological role of iodine?
Synthesis of thyroid hormones T3 and T4.

Q10. Where is iodine stored?
Thyroid gland.

Q11. What hormone increases in iodine deficiency?
TSH.

Q12. What is goiter?
Enlargement of thyroid gland due to chronic TSH stimulation.

Q13. What is cretinism?
Severe congenital hypothyroidism due to iodine deficiency.

Q14. Which enzyme helps organification of iodine?
Thyroid peroxidase.

ZINC

Q15. Name one important zinc-containing enzyme.
Carbonic anhydrase.

Q16. What are the main functions of zinc?
DNA synthesis, growth, immunity, wound healing.

Q17. What are features of zinc deficiency?
Growth retardation, hypogonadism, delayed wound healing.

Q18. What is acrodermatitis enteropathica?
Inherited defect in zinc absorption.

Q19. Zinc deficiency affects which system prominently?
Reproductive and immune systems.

FLUORIDE

Q20. What is the role of fluoride in teeth?
Forms fluoroapatite, increases resistance to caries.

Q21. What is dental fluorosis?
Excess fluoride causing mottled enamel.

SELENIUM

Q22. Selenium is a component of which enzyme?
Glutathione peroxidase.

Q23. What is the role of glutathione peroxidase?
Reduces hydrogen peroxide and prevents oxidative damage.

Q24. What disease is associated with selenium deficiency?
Keshan disease.

Q25. Selenium also participates in which endocrine function?
Thyroid hormone metabolism (deiodinase enzymes).

MANGANESE

Q26. Name one manganese-dependent enzyme.
Pyruvate carboxylase.

Q27. What happens in manganese excess?
Neurotoxicity resembling Parkinsonism.

MOLYBDENUM

Q28. Name one molybdenum-dependent enzyme.
Xanthine oxidase.

Q29. Is molybdenum deficiency common?
No, it is rare.

COBALT

Q30. What is the biological role of cobalt?
Component of Vitamin B12.

Q31. Does cobalt have an independent metabolic function?
No, its role is via B12.

NICKEL

Q32. Is nickel essential in humans?
Its role is minimal and not clearly defined.

CHROMIUM

Q33. What is the main role of chromium?
Enhances insulin action.

Q34. Chromium is part of which factor?
Glucose tolerance factor.

Q35. What happens in chromium deficiency?
Impaired glucose tolerance.

LITHIUM

Q36. Is lithium an essential trace element?
No.

Q37. What is lithium used for clinically?
Treatment of bipolar disorder.

Q38. Name one sign of lithium toxicity.
Tremor.

Q39. Why is lithium monitoring important?
Narrow therapeutic index and nephrotoxicity risk.

INTEGRATED QUESTIONS (EXAMINER STYLE)

Q40. Which trace element links mineral metabolism with iron metabolism?
Copper (via ceruloplasmin).

Q41. Which trace element deficiency leads to hypothyroidism?
Iodine deficiency.

Q42. Which trace element is most important for wound healing?
Zinc.

Q43. Which trace element acts as antioxidant via enzyme system?
Selenium.

Q44. Which trace element is directly involved in insulin sensitivity?
Chromium.

Q45. Which trace element disorder causes liver cirrhosis and neurological signs?
Wilson disease (copper overload).