Nutrient Deficiencies

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OUTLINE:

I. Introduction
   a. Prevalence of Nutritional Deficiencies
   b. 2020-2025 Dietary Guidelines for Americans (DGA)
II. Essential micronutrients and daily recommendations
III. Mucocutaneous clues to suggest possible nutritional disorders
IV. Water soluble vs Fat soluble vitamins
V. Protein-Energy Malnutrition
VI. Vitamin and Mineral Deficiencies
   a. Vitamins A, K, D, B12, Folate, B1, B2, B3, B6, C
   b. Zinc, Iron, Calcium, Iodine
   c. Biotin
VII. Case Studies
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   b. Pallor
   c. Muscle aches
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   g. Swollen gums
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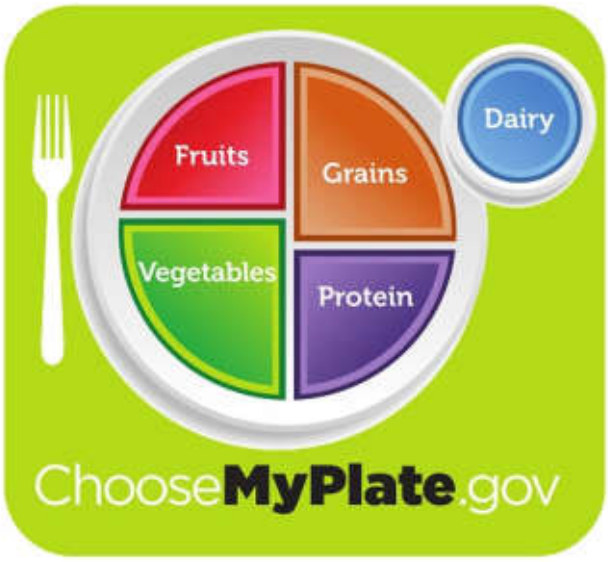
   i. Dry eye
   j. Diarrhea and rash
   k. Sore mouth
   l. Altered mental status
   m. Anemia
   n. Neural tube defect
VIII. Food fortification/Enrichment
IX. Summary tables for Reference
X. Key Points/summary
XI. Review Questions
XII. Additional Resources



OBJECTIVES: After studying this unit you should be able to:

1. List the fat soluble vitamins
2. List the water soluble vitamins
3. List common minerals involved in deficiency syndromes
4. Differentiate between protein and energy deficiency syndromes
5. Identify common presentations of the vitamin and mineral deficiency syndromes and
6. Identify patients at risk for nutrient deficiency
7. Describe diseases caused by deficiencies of vitamins A, D and K
8. List at least four diseases caused by specific water soluble vitamin deficiencies
9. Describe disease manifestations of specific mineral deficiencies
10. Explain the benefits of treatment and prudent use of supplementation
11. Recognize the public health benefits of fortified/enriched foods

I. Introduction

a. What are Essential Nutrients?

i. An essential nutrient is a nutrient required for normal body functioning that cannot be synthesized by the body. Categories include vitamins, dietary minerals, essential fatty acids and essential amino acids.

b. What are Vitamins?

i. Vitamins are organic compounds required for normal metabolism.
ii. Apart from a few exceptions (e.g., vitamin D), the human body cannot synthesize vitamins on its own in sufficient amounts and must, therefore, ensure a steady supply through the diet.
iii. Vitamins are micronutrients that do not provide energy (like macronutrients) but instead have very specific biochemical roles.

c. Prevalence of Nutrient Deficiencies

i. Adequate intake of macronutrients and micronutrients is required for nearly all metabolic, developmental/growth processes and good health throughout life
ii. Dietary Guidelines for Americans (DGA) 2020-2025 identified up to 10 nutrients as under consumed: vitamins A, C, D, E, and K, calcium, dietary fiber, potassium, magnesium and choline, especially vitamin D, calcium, dietary fiber, and potassium
iii. Vitamin D, calcium, potassium and fiber are under consumed to the extent which may lead to adverse health outcomes

Where we have data from 8 years of NHANES (1999–2006), we noticed that the prevalence of nutrient deficiencies hasn't changed over that time period. Future reports may provide information on nutrient levels extending over a longer period of time.

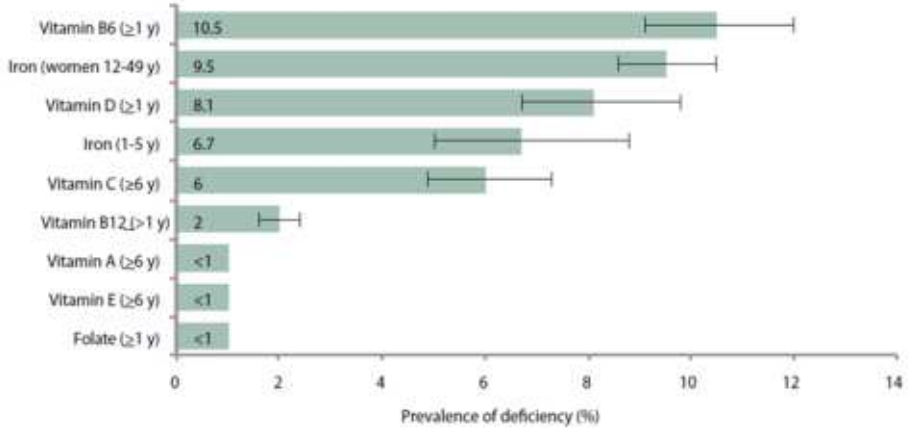


Figure 1. *Prevalence estimates of nutrient deficiencies in U.S. persons, National Health and Nutrition Examination Survey, 2003–2006. Error bars represent 95% confidence intervals. Nutrition indicators were measured in different age (e.g., 1 y and older, 6 y and older) and population groups (e.g., women 12-49 y of age, children 1-5 y of age). Cutoff values used to estimate prevalence are: serum pyridoxal-5'-phosphate < 20 nmol/L, serum body iron < 0 mg/kg, serum 25-hydroxyvitamin D < 30 nmol/L, serum ascorbic acid < 114. μmol/L, serum cobalamin < 200 pg/mL, serum retinol < 20 μg/dL, serum alpha-tocopherol < 500 μg/dL, and red blood cell folate < 95 ng/mL.*

iv. **Centers for Disease Control**
    1. 10% of US population deficient in vitamin D
        a. Up to 31% in non-Hispanic blacks, 12% Mexican Americans, 3% non-Hispanic white
    2. 10% of US population deficient in vitamin B6 and iron
        a. Higher rates of iron deficiency in Mexican-American children aged 1 to 5 years (11%) and in non-Hispanic black (16%) and Mexican-American women (13%) of childbearing age (12 to 49 years) when compared to other race/ethnic groups
    3. Less than 1% US population deficient in folate, Vitamin A and E
    4. Many women ages 20-39 with iodine levels close to insufficiency

d. 2020-2025 Dietary Guidelines for Americans (DGA)

i. DGA recommends consuming nutrient dense foods as part of a healthy eating pattern and as necessary fortified foods and dietary supplements for certain populations

I. Essential micronutrients and some daily recommended values

Vitamins	Minerals/trace Metals	Amino acids/Other
• Biotin • Folic acid • Niacin • Pantothenate • Riboflavin • Thiamine • Vitamin A • Vitamin B6 • Vitamin B12 • Vitamin C • Vitamin D • Vitamin E • Vitamin K	• Calcium • Chloride • Chromium • Cobalt • Copper • Iodide • Iron • Magnesium • Manganese • Molybdenum • Phosphorus • Potassium • selenium • Sodium • Zinc	• Isoleucine • Leucine • Lysine • Methionine • Phenylalanine • Threonine • Tryptophan • Valine • Histidine • Linoleic acid/EPA/DHA omega 3 • Linoleic acid omega 6 • Choline

TABLE 5-12 Guidelines for Daily Administration of Parenteral Micronutrients in Adults and Children

Micronutrient	Adults	Children
Vitamin		
A	1000 µg (= 3300 IU)	700 µg
D	5 µg (= 200 IU)	10 µg
E	10 mg (= 10 IU)	7 mg
K	1 mg	200 µg
C	100 mg	80 mg
Folate	400 µg	140 µg
Niacin	40 mg	17 mg
Riboflavin	3.6 mg	1.4 mg
Thiamine	3 mg	1.2 mg
B_6	4 mg	1 mg
B_{12}	5 µg	1 µg
Pantothenic acid	15 mg	5 mg
Biotin	60 µg	20 µg
Trace Elements		
Copper	0.5-1.5 mg	20 µg/kg/day
Chromium	10-15 µg	0.2 µg/kg/day
Manganese	0.1 mg	1 µg/kg/day
Zinc	2.5-4.0 mg	50 µg/kg/day
Molybdenum	15 µg	0.25 µg/kg/day
Iodine*	—	—
Selenium	100 µg	2 µg/kg/day
Iron	1-2 mg	1 mg/day

*Naturally occurring contamination of parenteral nutrition formulas appears to provide sufficient quantities of iodine.

Adult vitamin guidelines adapted from American Society of Parenteral and Enteral Nutrition (ASPEN). Board of Directors and the Clinical Guidelines Task Force. Guidelines for the use of parenteral and enteral nutrition in adult and pediatric patients. JPEN J Parenter Enteral Nutr 2002; 26:144. Children's values adapted from Greene HL, Hambidge KM, Schanler R, Tsang RC. Guidelines for the use of vitamins, trace elements, calcium, magnesium, and phosphorus in infants and children receiving total parenteral nutrition: report of the Subcommittee on Pediatric Parenteral Nutrient Requirements from the Committee on Clinical Practice Issues of the American Society for Clinical Nutrition. Am J Clin Nutr 1988; 48:1324; Am J Clin Nutr 1989; 49:1332; and Am J Clin Nutr 1989; 50:560.

II. Mucocutaneous clues that suggest a possible nutritional disorder

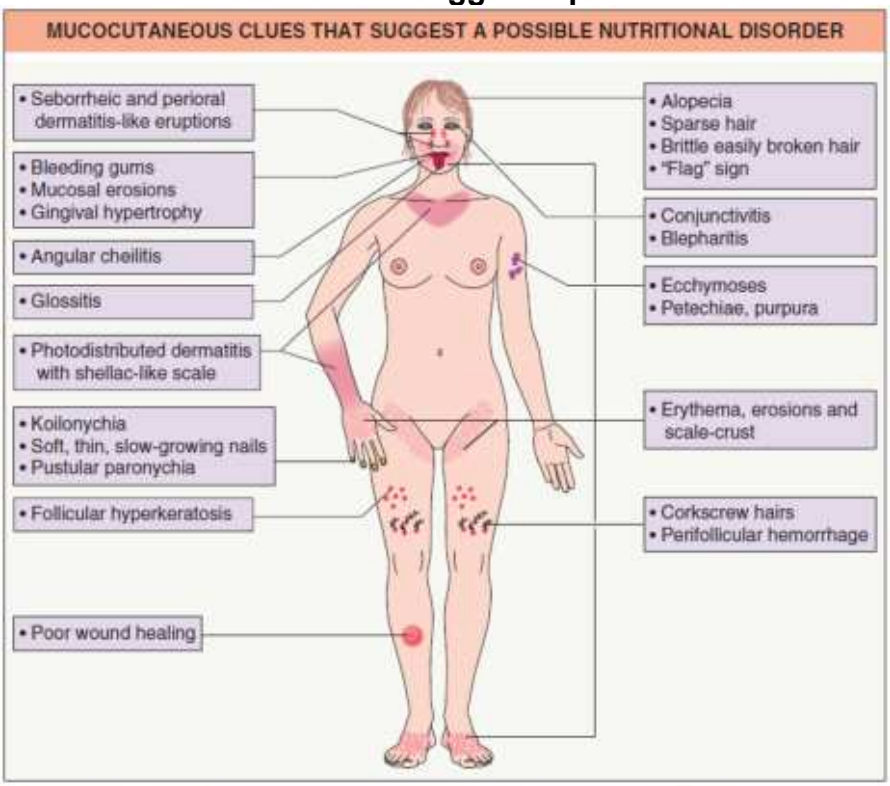


Table 11.3 Nutritional Deficiencies With Characteristic Physical Signs

Vitamin/Mineral	Sign/Symptom
Calcium, phosphorus, vitamin D	Rickets/osteomalacia
Vitamin A	Night blindness, xerophthalmia, Bitot spots, follicular hyperkeratosis
Vitamin C	Scurvy: Bone lesions, bleeding
Vitamin E	Hemolytic anemia, peripheral neuropathy
Vitamin K	Petechiae, ecchymoses
Thiamine (vitamin B_1)	Beriberi: Heart failure, increased intracranial pressure
Niacin	Pellagra: Dermatitis (sun-exposed areas)
Riboflavin (vitamin B_2)	Angular stomatitis, cheilosis
Vitamin B_6	Anemia, dermatitis, neuropathy
Vitamin B_{12}	Anemia, neuropathy
Folate	Anemia
Iron	Anemia, koilonychia
Biotin	Rash, hair loss
Essential fatty acids	Rash, coagulopathy
Zinc	Rash (acrodermatitis), growth failure, delayed sexual development, ageusia
Copper	Bone changes, hypopigmentation, anemia, neutropenia
Selenium	Cardiomyopathy (Keshan disease)

III. Water vs. Fat soluble Vitamins

	Water-Soluble Vitamins: B Vitamins and Vitamin C	Fat-Soluble Vitamins: Vitamins A, D, E, and K
Absorption	Directly into the blood	First into the lymph, then the blood
Transport	Travel freely	Many require transport proteins
Storage	Circulate freely in water-filled parts of the body	Stored in the cells associated with fat
Excretion	Kidneys detect and remove excess in urine	Less readily excreted; tend to remain in fat-storage sites
Toxicity	Possible to reach toxic levels when consumed from supplements	Likely to reach toxic levels when consumed from supplements
Requirements	Needed in frequent doses (perhaps 1 to 3 days)	Needed in periodic doses (perhaps weeks or even months)

NOTE: Exceptions occur, but these differences between the water-soluble and fat-soluble vitamins are valid generalizations.

IV. Protein-Energy Malnutrition

- Clinical syndrome characterized by inadequate intake of protein and/or calories to meet the body's needs
- Can be primary (children) or secondary (illness related)
- Forms
    i. Marasmus
        1. Severe reduction in caloric intake
        2. Greater than 60% reduction in body weight
        3. Most common during first year of life
        4. Growth retardation, weight loss and muscle wasting multivitamin deficiencies, anemia, immune deficiency
    ii. Kwashiorkor
        1. More severe form of malnutrition than marasmus
        2. Mainly children 6 months to 3 years of age
        3. Occurs when protein deprivation is relatively greater than the reduction in total calories
        4. Normal fat and muscle
        5. Generalized edema, fatty liver, hypo- and hyperpigmentation, desquamation, overall loss of color or alternating bands, multivitamin deficiencies, anemia, immune deficiency
    iii. Nutritional dwarfism
        1. Child with failure to thrive may have normal weight for height but short stature and delayed sexual development

TABLE 5-17 Features of Protein-Energy Malnutrition Syndromes in Children

Parameter	Syndrome		
	Kwashiorkor	Marasmus	Nutritional Dwarfism
Weight for age (% expected)	60-80	<60	<60
Weight for height	Normal or decreased	Markedly decreased	Normal
Edema	Present	Absent	Absent
Mood	Irritable when picked up, apathetic when alone	Alert	Alert
Appetite	Poor	Good	Good

Figure 11.6 Kwashiorkor. **A** and **B**, These infants demonstrate kwashiorkor with "flaky paint" dermatosis, pigmentation changes, and pitting edema. *(Courtesy Jonathan Spector, MD, Boston, MA.)*

Kwashiorkor

Figure 11.3 Marasmus. **A**, Note the profound wasting and sparse hair. **B** and **C**, Note the wasting of subcutaneous tissue over the thorax with prominent ribs and loose skinfolds in the groin. **D** and **E**, Note the loss of subcutaneous fat, profound wasting, loose skinfolds, and sparse hair. *(Courtesy Jonathan Spector, MD, Boston, MA.)*

Marasmus

V. Vitamin and Mineral Deficiencies

Vitamin A

- Night blindness
- Follicular hyperkeratosis
- Xeropthalmia (dry eyes)
- Bitot's spot (small plaques of keratin debris)
- Keratomalacia (corneal ulcer and destruction)
- Total blindness

Snapshot 7-1 Vitamin A and Beta-Carotene

DRI Recommended Intakes
Men: 900 μg/day[a]
Women: 700 μg/day[a]

Tolerable Upper Intake Level
Adults: 3,000 μg vitamin A/day

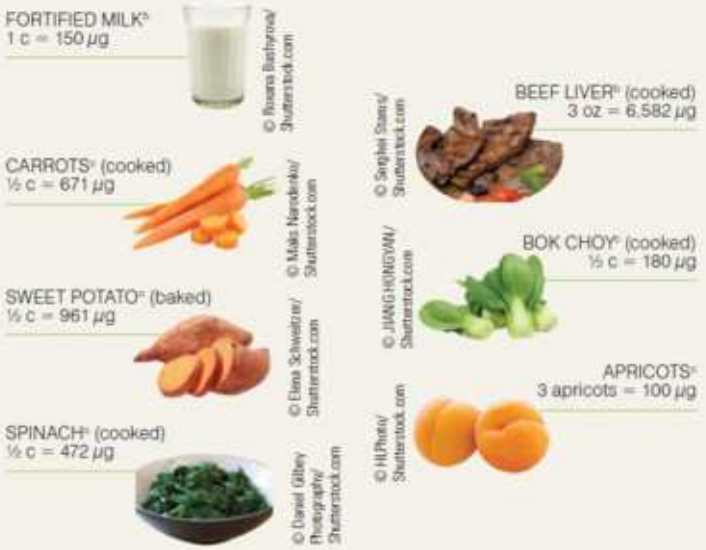
Chief Functions
Vision; maintenance of cornea, epithelial cells, mucous membranes, skin; bone and tooth growth; regulation of gene expression; reproduction; immunity

Deficiency
Night blindness, corneal drying (xerosis), and blindness (xerophthalmia); impaired bone growth and easily decayed teeth; keratin lumps on the skin; impaired immunity

Toxicity
Vitamin A:
Acute (single dose or short-term): nausea, vomiting, headache, vertigo, blurred vision, uncoordinated muscles, increased pressure inside the skull, birth defects
Chronic: birth defects, liver abnormalities, bone abnormalities, brain and nerve disorders
Beta-carotene: Harmless yellowing of skin

*These foods provide 10% or more of the vitamin A Daily Value in a serving. For a 2,000-cal diet, the DV is 900 μg/day.
[a]Vitamin A recommendations are expressed in retinol activity equivalents (RAE).
[b]This food contains preformed vitamin A.
[c]This food contains the vitamin A precursor, beta-carotene.

Good Sources*



Vitamin K

- Bleeding diathesis
  - Easy bruisability and mucosal bleeding (epistaxis, GI hemorrhage, menorrhagia, hematuria)
  - Oozing puncture sites/incisions
  - Hemorrhagic disease of the newborn
  - Cutaneous, GI, Intrathoracic or Intracranial hemorrhage of the newborn

Snapshot 7-4 Vitamin K

DRI Recommended Intakes

Men: 120 μg/day
Women: 90 μg/day

Chief Functions

Synthesis of blood-clotting proteins and bone proteins

Deficiency

Hemorrhage; abnormal bone formation

Toxicity

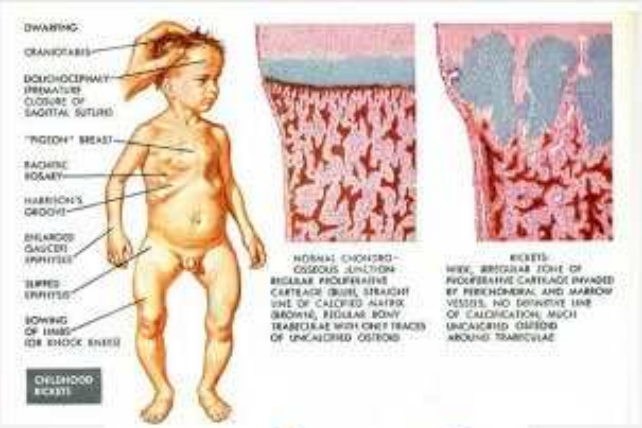
Opposes the effects of anticlotting medication

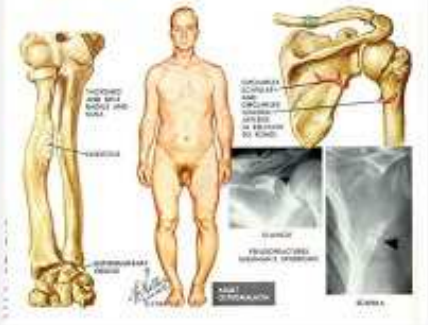
*These foods provide 10% or more of the vitamin K Daily Value in a serving. For a 2,000-cal diet, the DV is 80 μg/day.
Data from USDA.
*Average value.

Good Sources*

Vitamin D

- Active form: 1,25 (OH)2 D
- Rickets (children)
  - Overgrowth of epiphyseal cartilage
  - Deformation of the skeleton due to loss of rigidity
- Osteomalacia (adult)
  - Less severe than rickets
  - Contour of bone not affected
  - Bone is weak and vulnerable to fracture due to osteopenia
- Hypocalcemia





Snapshot 7-2 Vitamin D

DRI Recommended Intakes

Adults: 15 μg (600 IU)/day (19–70 yr)
20 μg (700 IU)/day (> 70 yr)

Tolerable Upper Intake Level

Adults: 100 μg (4,000 IU)/day

Chief Functions

Mineralization of bones and teeth (raises blood calcium and phosphorus by increasing absorption from digestive tract, withdrawing calcium from bones, stimulating retention by kidneys)

Deficiency

Abnormal bone growth resulting in rickets in children, osteomalacia in adults; malformed teeth; muscle spasms

Toxicity

Elevated blood calcium; calcification of soft tissues (blood vessels, kidneys, heart, lungs, tissues of joints), excessive thirst, headache, nausea, weakness

**These foods provide 10% or more of the vitamin D Daily Value in a serving. For a 2,000-cal diet, the DV is 10 μg/day.*
[a]Average value.
[b]Avoid prolonged exposure to sun.

Good Sources*

ENRICHED CEREAL (ready-to-eat) ¾ c = 2.5 μg
© stasklein/Shutterstock.com

SARDINES 3 oz = 4.1 μg
© Picsfive/Shutterstock.com

SALMON OR MACKEREL* 3 oz = 10.0 μg
© HLPhoto/Shutterstock.com

SUNLIGHT Promotes vitamin D synthesis in the skin.[b]
© Lisa A/Shutterstock.com

COD LIVER OIL 1 tsp = 11 μg
© tatti2/Shutterstock.com

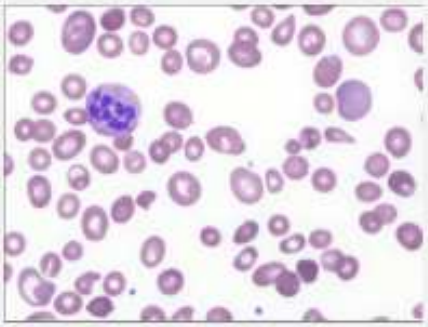
FORTIFIED MILK 1 c = 3 μg
© Rosaria Ballympna/Shutterstock.com

TUNA (light, canned) 3 oz = 5.7 μg
© Bitnoy/Shutterstock.com

Vitamin B12 (cobalamin)

- Megaloblastic anemia
  - RBC macrocytic and oval shape
  - Neutrophil hyper-segmentation
  - Megaloblastic change in all stages of RBC development
- Atrophic glossitis
- Myelin degeneration of the spinal cord (posterior and lateral columns)
  - Loss of position and vibration sensation (early)
  - Paranoid, delirium and confusion (late)

* Anemia and neurologic changes can be cured after administration of B12 but the changes to the gastric mucosa are unaffected



Snapshot 7-10 Vitamin B_{12}

DRI Recommended Intake
Adults: 2.4 μg/day

Chief Functions
Part of coenzymes needed in new cell synthesis; helps to maintain nerve cells

Deficiency
Pernicious anemia;[a] anemia (large-cell type);[b] smooth tongue; tingling or numbness; fatigue, memory loss, disorientation, degeneration of nerves progressing to paralysis

Toxicity
None reported

These foods provide 10% or more of the vitamin B_{12} Daily Value in a serving. For a 2,000-cal diet, the DV is 6 μg/day.
[a]The name pernicious anemia refers to the vitamin B_{12} deficiency caused by a lack of stomach intrinsic factor, but not to anemia from inadequate dietary intake.
[b]Large cell–type anemia is known as either macrocytic or megaloblastic anemia.

Good Sources*

CHICKEN LIVER
3 oz = 18.0 μg

© bit24/ Shutterstock.com

SIRLOIN STEAK
3 oz = 1.5 μg

© Josh Resnick/ Shutterstock.com

COTTAGE CHEESE
1 c = 1.4 μg

© Africa Studio/ Shutterstock.com

PORK ROAST (lean)
3 oz = 0.8 μg

© Dagmara Porankiewicz/ Shutterstock.com

© Picsfive/ Shutterstock.com

SARDINES
3 oz = 7.6 μg

© Ryzhov/ Shutterstock.com

TUNA (in water)
3 oz = 2.5 μg

© Imageman/ Shutterstock.com

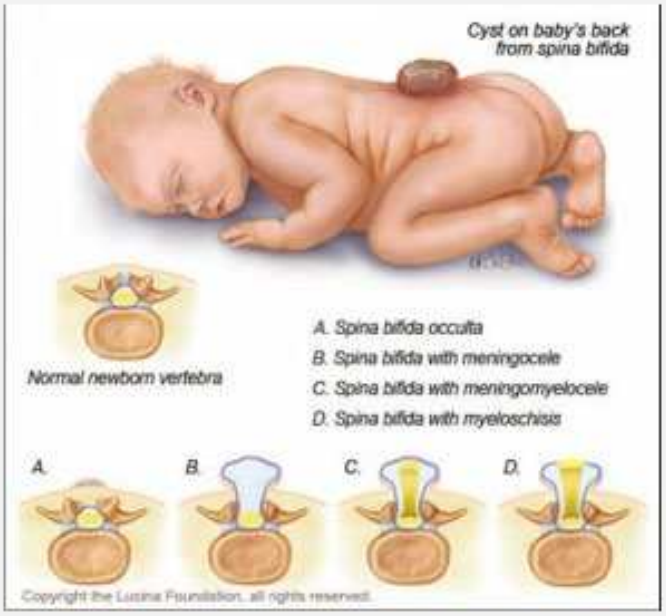
SWISS CHEESE
1½ oz = 1.5 μg

© stockfem/ Shutterstock.com

ENRICHED CEREAL
(ready-to-eat)
¾ c = 6 μg

Folate

- Deficiency clinically same as B12 except neurologic change
  - Megaloblastic anemia
  - Glossitis
  - Diarrhea
- In developing fetus can see neural tube defects



Snapshot 7-9 Folate

DRI Recommended Intake
Adults: 400 μg DFE/day[a]

Tolerable Upper Intake Level
Adults: 1,000 μg DFE/day

Chief Functions
Part of a coenzyme needed for new cell synthesis

Deficiency
Anemia, smooth, red tongue; depression, mental confusion, weakness, fatigue, irritability, headache; a low intake increases the risk of neural tube birth defects

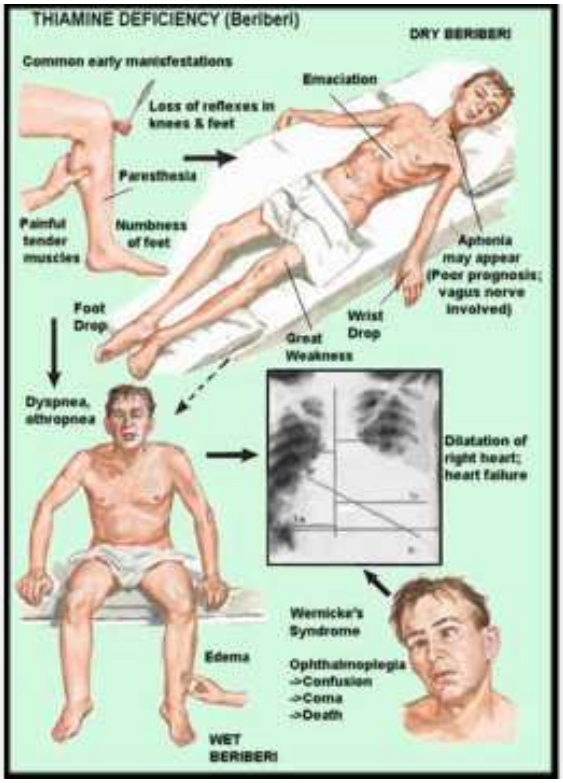
Toxicity
Masks vitamin B_{12}–deficiency symptoms

[a]These foods provide 10% or more of the folate Daily Value in a serving. For a 2,000-cal diet, the DV is 400 μg/day.
[b]Folate recommendations are expressed in dietary folate equivalents (DFE). Note that for natural folate sources, 1 μg = 1 DFE; for enrichment sources, 1 μg = 1.7 DFE.
[c]Some highly enriched cereals may provide 400 μg or more in a serving.

Good Sources*

Vitamin B1 (thiamin)

- Most common in chronic alcoholism
- Polished rice diet, chronic renal dialysis, persistent nausea and vomiting post bariatric surgery
- Dry beriberi (polyneuropathy)
- Wet beriberi (heart failure, peripheral edema)
- Wernicke-Korsakoff syndrome
  - Hemorrhage and degeneration of the mammillary bodies



Snapshot 7-6 Thiamin

DRI Recommended Intakes

Men: 1.2 mg/day
Women: 1.1 mg/day

Chief Functions

Part of coenzyme active in energy metabolism

Deficiency[a]

Beriberi with possible edema or muscle wasting; enlarged heart, heart failure, muscular weakness, pain, apathy, poor short-term memory, confusion, irritability, difficulty walking, paralysis, anorexia, weight loss

Toxicity

None reported

**These foods provide 10% or more of the thiamin Daily Value in a serving. For a 2,000-cal diet, the DV is 1.5 mg/day.*
[a]Severe thiamin deficiency is often related to heavy alcohol consumption.

Good Sources*

Vitamin B2 (riboflavin)

- Cheilosis (cheilitis, angular stomatitis) – 1st and most characteristic sign
- Glossitis – tongue atrophy, red-blue discoloration
- Eye change – interstitial keratitis, corneal vascularization, corneal ulcer
- Scaling (seborrheic) dermatitis – nasolabial folds and cheeks, scrotal, vulva

Snapshot 7-7 Riboflavin

DRI Recommended Intakes

Men: 1.2 mg/day
Women: 1.1 mg/day

Chief Functions

Part of coenzyme active in energy metabolism

Deficiency

Cracks and redness at corners of mouth; painful, smooth, purplish red tongue; sore throat; inflamed eyes and eyelids, sensitivity to light; skin rashes

Toxicity

None reported

**These foods provide 10% or more of the riboflavin Daily Value in a serving. For a 2,000-cal diet, the DV is 1.7 mg/day.*

Good Sources*

Vitamin B6 (pyridoxine)

- Most common in chronic alcoholism and pregnancy
- Functions in protein metabolism and heme synthesis
- Clinically resembles B12 and niacin deficiencies
  - Seborrheic dermatitis
  - Cheilosis
  - Glossitis
  - Peripheral neuropathy
  - Irritability, depression, confusion
  - Convulsion
  - Sideroblastic anemia

Snapshot 7-11 Vitamin B_6

DRI Recommended Intake
Adults (19–50 yr): 1.3 mg/day

Tolerable Upper Intake Level
Adults: 100 mg/day

Chief Functions
Part of a coenzyme needed in amino acid and fatty acid metabolism; helps to convert tryptophan to niacin and to serotonin; helps to make hemoglobin for red blood cells

Deficiency
Anemia, depression, confusion, abnormal brain wave pattern, convulsions; greasy, scaly dermatitis

Toxicity
Depression, fatigue, impaired memory, irritability, headaches, nerve damage causing numbness and muscle weakness progressing to an inability to walk and convulsions; skin lesions

**These foods provide 10% or more of the vitamin B_6 Daily Value in a serving. For a 2,000-cal diet, the DV is 2 mg/day.*

Good Sources*

Vitamin B3 (Niacin)

- Corn based diet
- Pellagra (3 D's)
  - Dermatitis – sharply demarcated scaling and desquamation of exposure area, bilateral symmetry
  - Diarrhea – caused by atrophy of gastrointestinal epithelium
  - Dementia – from neuron degeneration in the brain and spinal cord. Can also manifest as anxiety or insomnia
- Early signs: glossitis, stomatitis, vaginitis, vertigo, burning dysesthesias

IMAGE COURTESY OF THE PUBLIC HEALTH IMAGE LIBRARY OF THE CENTERS FOR DISEASE CONTROL AND PREVENTION.

Snapshot 7-8 Niacin

DRI Recommended Intakes

Men: 16 mg/day[a]
Women: 14 mg/day

Tolerable Upper Intake Level

Adults: 35 mg/day

Chief Functions

Part of coenzymes needed in energy metabolism

Deficiency

Pellagra, characterized by flaky skin rash (dermatitis) where exposed to sunlight; mental depression, apathy, fatigue, loss of memory, headache; diarrhea, abdominal pain, vomiting; swollen, smooth, bright red or black tongue

Toxicity

Painful flush, hives, and rash ("niacin flush"); excessive sweating; blurred vision; liver damage, impaired glucose tolerance

**These foods provide 10% or more of the niacin Daily Value in a serving. For a 2,000-cal diet, the DV is 20 mg/day. The DV values are for preformed niacin, not niacin equivalents.*
[a]Niacin DRI Recommended Intakes are expressed in niacin equivalents (NE); the Tolerable Upper Intake Level refers to preformed niacin.

Good Sources*

Vitamin C (ascorbic acid)

- Fatigue
- Depression
- Connective tissue defects (gingivitis, petechiae, perifollicular hemorrhage and coiled hairs, hyperkeratotic papular rash, internal bleeding, impaired wound healing)
- Scurvy – severe deficiency, characterized by hemorrhagic manifestations, abnormal osteoid and dentin formation

Scorbutic gums. Unlike other lesions of the mouth, scurvy presents a symmetrical appearance without infection.

Pinpoint hemorrhages. Small red spots appear in the skin, indicating spontaneous bleeding internally.

Snapshot 7-5 Vitamin C

DRI Recommended Intakes

Men:	90 mg/day
Women:	75 mg/day
Smokers:	add 35 mg/day

Tolerable Upper Intake Level

Adults: 2,000 mg/day

Chief Functions

Collagen synthesis (strengthens blood vessel walls, forms scar tissue, provides matrix for bone growth), antioxidant, restores vitamin E to active form, supports immune system, boosts iron absorption

Deficiency

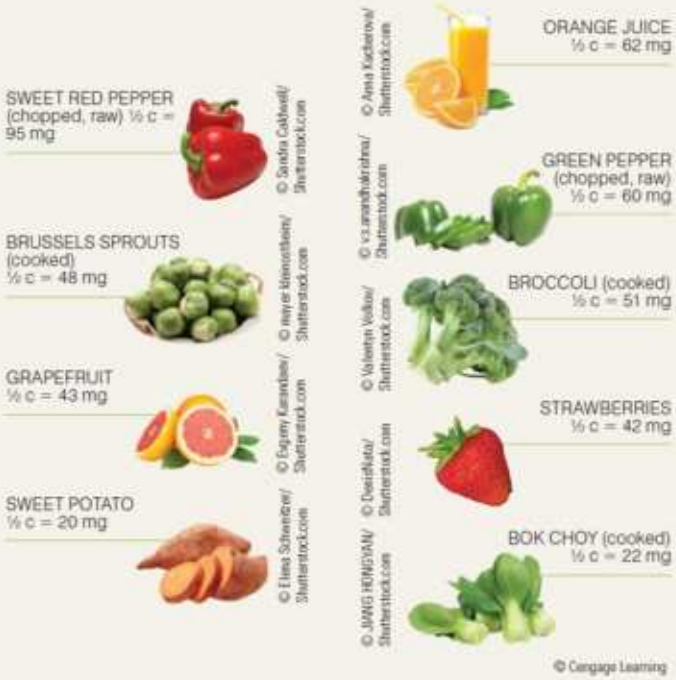
Scurvy, with pinpoint hemorrhages, fatigue, bleeding gums, bruises; bone fragility, joint pain; poor wound healing, frequent infections

Toxicity

Nausea, abdominal cramps, diarrhea; rashes; interference with medical tests and drug therapies; in susceptible people, aggravation of gout or kidney stones

**These foods provide 10% or more of the vitamin C Daily Value in a serving. For a 2,000-cal diet, the DV is 60 mg/day.*

Good Sources*



Zinc

- Acrodermatitis enteropathica (often around the eye, nose, mouth, anus, and distal parts)
- Anorexia with diarrhea
- Growth retardation in children
- Impaired wound healing
- Hypogonadism
- Altered immune function
- Impaired night vision
- Depressed mental function
- Increased incidence of congenital malformations in infants of zinc-deficient mothers

Snapshot 8-6 Zinc

DRI Recommended Intakes
Men: 11 mg/day
Women: 8 mg/day

Tolerable Upper Intake Level
Adults: 40 mg/day

Chief Functions
Activates many enzymes; associated with hormones; synthesis of genetic material and proteins, transport of vitamin A, taste perception, wound healing, reproduction

Deficiency[a]
Growth retardation, delayed sexual maturation, impaired immune function, hair loss, eye and skin lesions, loss of appetite

Toxicity
Loss of appetite, impaired immunity, reduced copper and iron absorption, low HDL cholesterol (a risk factor for heart disease)

**These foods provide 10% or more of the zinc Daily Value in a serving. For a 2,000-cal diet, the DV is 15 mg/day.*
[a]A rare inherited form of zinc malabsorption causes additional and more severe symptoms.
[b]Some oysters contain more or less than this amount, but all types are zinc-rich foods.
[c]Enriched cereals vary widely in zinc content.

Good Sources*

Calcium

- Calcium deficiency symptoms can vary widely—ranging from nonexistent or mild to severe and life-threatening
- Osteomalacia
- Tetany
- Arrhythmias

Snapshot 8-1 Calcium

DRI Recommended Intakes

Adults: 1,000 mg/day (19–50 yr men and women; 51–70 yr men)
1,200 mg/day (51–70 yr women; >70 yr men and women)

Tolerable Upper Intake Level

Adults: 2,500 mg/day (19–50 yr)
2,000 mg/day (>50 yr)

Chief Functions

Mineralization of bones and teeth; muscle contraction and relaxation, nerve functioning, blood clotting

Deficiency

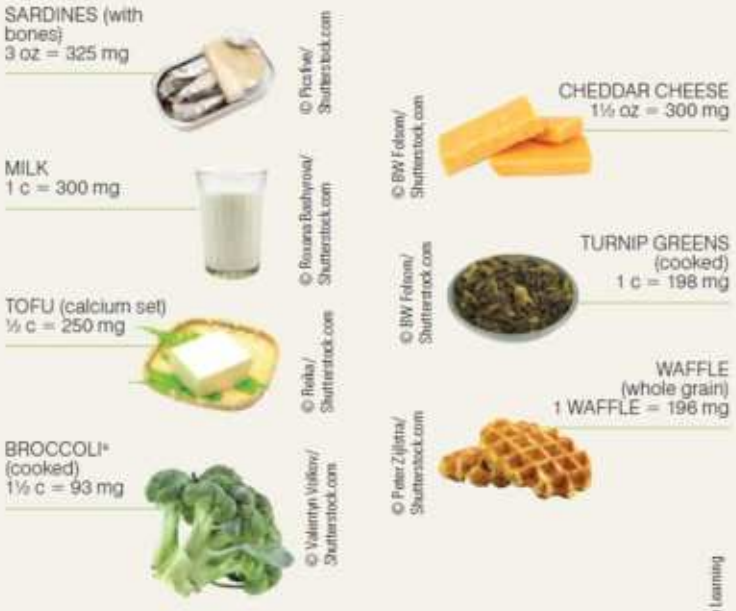
Stunted growth and weak bones in children; bone loss (osteoporosis) in adults

Toxicity

Elevated blood calcium; constipation; interference with absorption of other minerals; increased risk of kidney stone formation

**These foods provide 10% or more of the calcium Daily Value in a serving. For a 2,000-cal diet, the DV is 1,000 mg/day.*
**Broccoli, kale, and some other cooked green leafy vegetables are also important sources of bioavailable calcium. Almonds also supply calcium. Spinach and chard contain calcium in an unabsorbable form. Some calcium-rich mineral waters may also be good sources.*

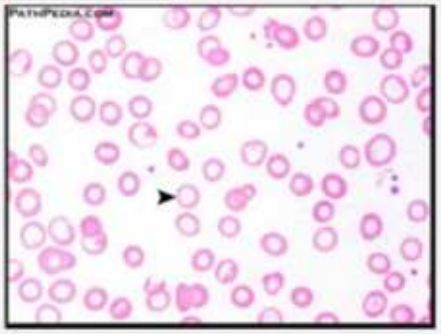
Good Sources*



Iron

- Koilonychia (spoon nail)
- Alopecia
- Fatigue
- Atrophic changes of the tongue and gastric mucosa
- Hypochromic microcytic anemia

- Plummer-Vinson syndrome
  - Microcytic hypochromic anemia
  - Atrophic glossitis
  - Esophageal webs (dysphagia)



Snapshot 8-5 Iron

DRI Recommended Intakes
Men: 8 mg/day
Women (19–50 yr): 18 mg/day
Women (51+): 8 mg/day

Tolerable Upper Intake Level
Adults: 45 mg/day

Chief Functions
Carries oxygen as part of hemoglobin in blood or myoglobin in muscles; required for cellular energy metabolism

Deficiency
Anemia: weakness, fatigue, headaches; impaired mental and physical work performance; impaired immunity; pale skin, nailbeds, and mucous membranes; concave nails; chills; pica

Toxicity
GI distress; with chronic iron overload, infections, fatigue, joint pain, skin pigmentation, organ damage

**These foods provide 10% or more of the iron Daily Value in a serving. For a 2,000-cal diet, the DV is 18 mg/day.*
Note: Dried figs contain 0.6 mg per ¼ c; raisins contain 0.8 mg per ¼ c.
[a]Some clams may contain less, but most types are iron-rich foods.
[b]Legumes contain phytates that reduce iron absorption.
[c]Enriched cereals vary widely in iron content.

Good Sources*

Iodine

- Maternal deficiency leads to fetal deficiency
  - Spontaneous abortions, still birth, hypothyroidism, cretinism and dwarfism
  - Cognitive delay
- Adults
  - Goiter

Biotin

- Rare
- Altered mental status
- Myalgia
- Hyperesthesia
- Anorexia
- Seborrheic dermatitis
- Alopecia

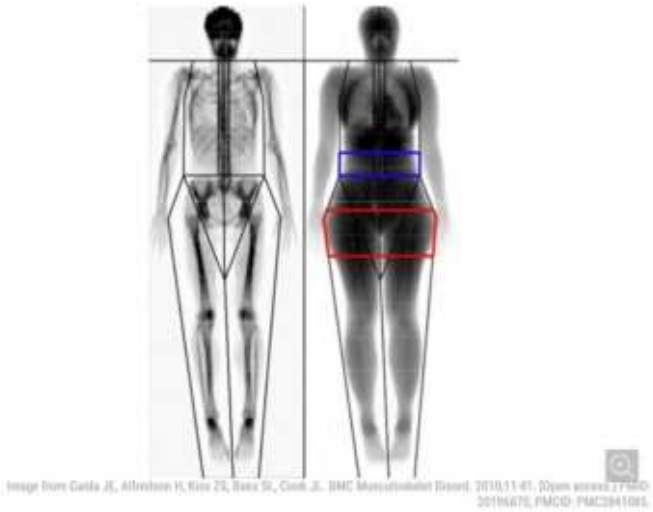
Figure 11.13 Biotin deficiency. **A** and **B**, This child on chronic hyperalimentation developed dermatitis in the perianal, perioral, and eyelid areas along with some thinning of hair. **C** and **D**, The rash has cleared dramatically after 4 days of biotin.

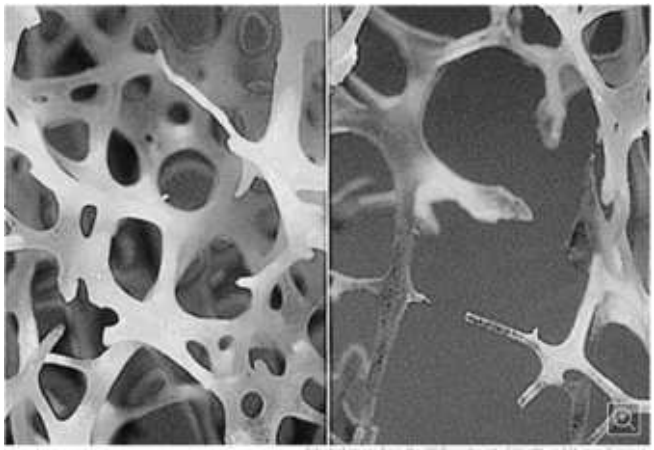
A. Marco is a 2 year old boy who presents to clinic with lethargy and a "puffy abdomen". His mother reports this all started after he stopped breast feeding; his main diet is a rice-based beverage. What diagnosis is suspected?

B. Mrs. P is a 65 year old woman, widowed for 6 months who has been referred to you for assistance in managing her nutritional intake. She has lost 10 lbs over the past 6 months. A physical exam revealed the following changes. What deficiency disease/disorder should be suspected?

C. Martha is a 62 year old woman who presents with generalized muscle aches and some difficulty ambulating. She has not been taking any medications or supplements. Her serum 25-hydroxyvitamin D (25(OH)D) is 15 ng/ml and her estimated glomerular filtration rate is 35 ml/min/1.73 m^2. DEXA (dual energy x-ray absorptiometry) scan used to measure bone mineral density reveals a T-score of -2.5 at the femoral neck.

1. Which of the following statements about this patient's condition is correct?
    a. Her vitamin D level can be associated with low parathyroid hormone levels
    b. Her vitamin D level is adequate for bone health
    c. She has osteoporosis and should be treated with vitamin D then Denosumab
    d. She has osteopenia (based on T-score) and should be treated with alendronate





D. A 45 year old woman recently emigrated from Australia to the united states. She presents with complaints of constipation of several weeks duration, is experiencing increased sensitivity to cold weather, and has had weight gain of 10 lbs in the past 3 months despite a decreased appetite. She also describes feeling of fullness in her neck. See image.

1. Deficiency(ies) of which of the following may be responsible for this patient's condition?
    a. Iodine
    b. Copper
    c. Selenium
    d. Iodine and selenium
    e. All of the Above

E. A 55 year old man presents with the skin changes shown. He is taking isoniazid for tuberculosis of the gastrointestinal tract and has been experiencing GI disturbance for the past few weeks. He also reports irritability and sadness.

1. Which of the following statements about the patient's condition is the most accurate?
    a. The skin changes shown are never itchy.
    b. This condition can resolve spontaneously without treatment.
    c. Supplementation with vitamin B6 (pyridoxine) prevents this condition.
    d. This condition is less likely to occur in people who obtain their food energy mainly from maize (corn).

Image from OpenStax CNX, Rice University | Herbert L. Fred, MD, Hendrik A. van Dijk.

F. A 70 year old woman presents with a rash as shown. She has a complex medical history (breast cancer, recurrent venous thrombosis, papillary thyroid cancer, anemia, leukopenia, splenomegaly and bronchiectasis). She denies experiencing pain, itching or trauma. She has had no contact with plants, new soaps or lotions. Has been receiving warfarin for several months, with a therapeutic international normalized ratio (INR) and a platelet count of 177,000/uL. Dietary history reveals that the patient was limiting her intake of fruits and vegetables.

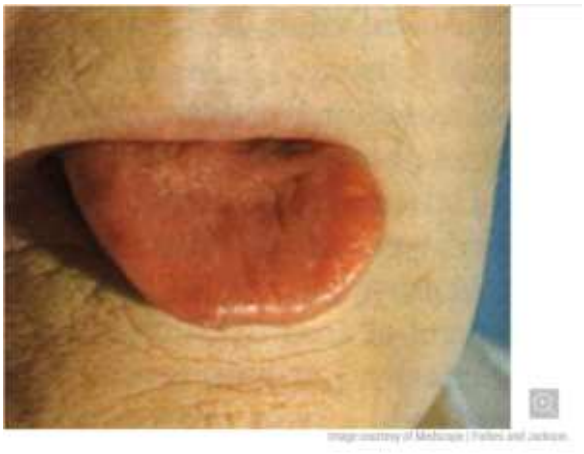
1. Which of the following is the most likely diagnosis?
    a. Senile purpura
    b. Idiopathic thrombocytopenic purpura
    c. Vitamin C deficiency
    d. Excessive warfarin anticoagulation

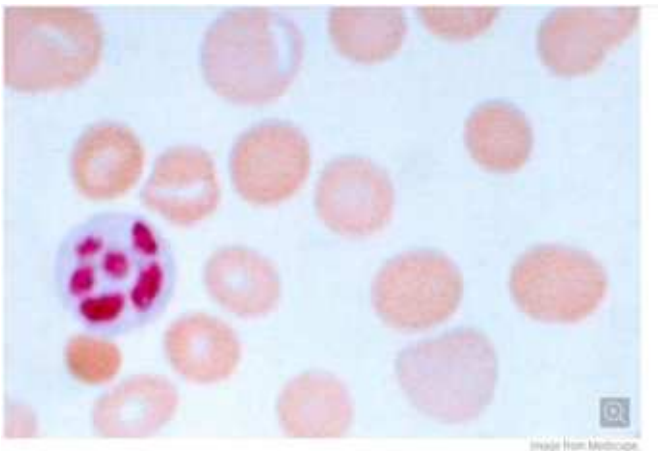
G. A 5 year old boy presents to the pediatricians office with swollen, tender and bleeding gums. His mother reports that he has been irritable and bruises easily. Dietary history reveals he is a "picky eater" and mostly limits himself to bread and plain pasta.

1. Which of the following is the most likely diagnosis?
    a. Dental caries
    b. Lymphoma
    c. Vitamin C deficiency
    d. Vitamin K deficiency

H. A 70 year old woman presents with a lemon yellow pallor and atrophic glossitis (smooth, shiny appearing tongue with loss of filiform papillae). She also has ataxia and weakness. Surgical history is remarkable for a complete gastrectomy 2 years ago. CBC reveals hemoglobin level of 10 g/dL. And a peripheral blood smear is shown.

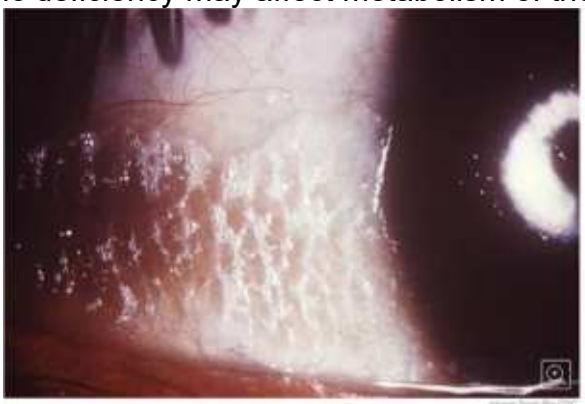
1. Based on the blood smear and physical findings which of the following statements is correct regarding this patient's condition?
    a. Her condition is caused by a deficiency in a fat soluble vitamin
    b. Folate deficiency is the most common cause
    c. Neurologic signs of her condition include vision problems, delirium and dementia
    d. Macrocytosis of red blood cells is not seen until after megaloblastic changes of white blood cells
    e. The vitamin deficiency in this patient should be treated by oral supplements only.





I. **A 35 year old man who recently emigrated from Kenya presents with a chief complaint of eye irritation for several weeks. An ophthalmologic exam reveals moderate dry eye with excessive mucus formation on the corneal surface and punctate corneal fluorescin staining. Medical history is significant for gallstones and an attack of acute pancreatitis.**

1. Which of the following statements about this patient's nutrient deficiency is most accurate?
    a. The kidney is the main site of storage for the deficient nutrient
    b. The nutrient is derived only from animal sources
    c. The recommended daily allowance of this nutrient for an adult male older than 19 is 900 mg
    d. Zinc deficiency may affect metabolism of the nutrient



J. **A 2 year old girl presents with persistent diarrhea and periorificial skin changes consisting of sharply demarcated, brightly erythematous plaques. Her mother also stated that the child's hair is falling out. The child was successfully weaned from breast milk at age 5 months. Her sibling had the same condition at age 3 years. Second photo shows changes after a few weeks treatment.**

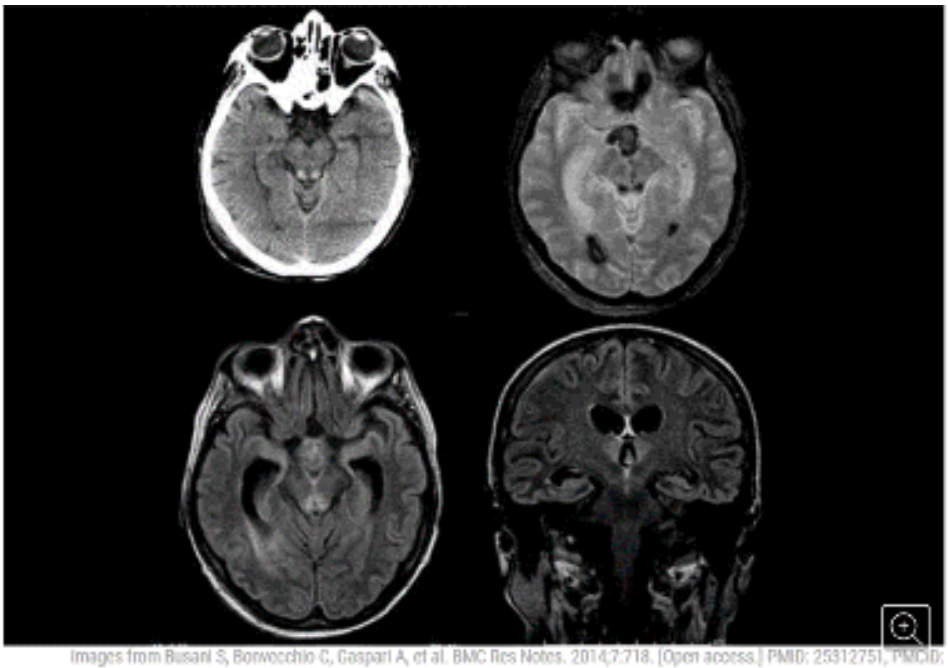
1. Which of the following statements about this patient's condition is the most accurate?
    a. This condition is transmitted in an autosomal dominant manner
    b. The nails are always normal in this condition
    c. Breast milk analysis can help in the diagnosis
    d. Checking the serum alkaline phosphatase level cannot help in making the diagnosis

K. A 52 year old man with a history of diabetes mellitus type 2 is seen at a dental clinic and is noted to have erythema, maceration and fissuring at the corners of the mouth. The lesions are slightly painful.

1. Deficiencies of which of the following vitamins is a known cause of this patient's condition?
    a. Vitamin B1
    b. Vitamin B2
    c. Vitamin B12
    d. Vitamin D
    e. Vitamin C

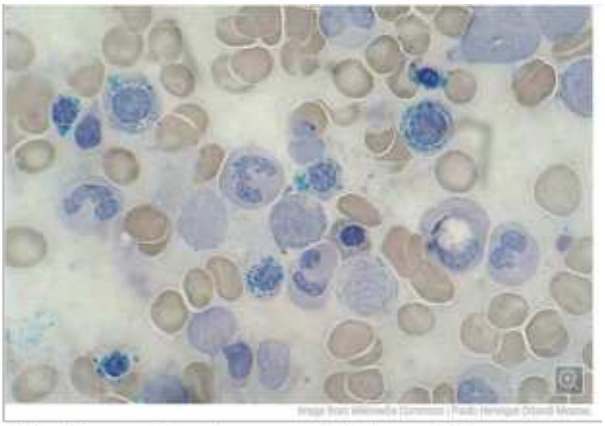
L. A middle aged woman presents to the emergency room with persistent, recurrent vomiting, and ataxia, she is irritable and has oculomotor dysfunction and trouble remembering things. She has a surgical history of duodenopancreatectomy with gastric enteric anastomosis. Her neurologic status is deteriorating and brain imaging is as shown.

1. Which of the following statements about the patient's condition is correct?
    a. Her condition is caused by a deficiency in a fat soluble vitamin that is absorbed in the jejunum
    b. The leading cause of this condition in the developed world is alcoholism
    c. The ocular symptoms are irreversible
    d. The CT and MRI images confirm metastatic pancreatic tumor in the brain



Images from Busani S, Bonvecchio C, Gaspari A, et al. BMC Res Notes. 2014;7:718. [Open access.] PMID: 25312751, PMCID: PMC4209869.

M. Some nutritional deficiencies often present with anemia that on peripheral smear examination demonstrates the same hematologic characteristics found on smears associated with myelodysplastic syndromes (MDS), with ring sideroblasts present.



Peripheral blood smear with iron stain

1. Nutritional deficiencies of which of the following can present with the type of anemia shown in the image?
    a. Iron
    b. Copper
    c. Lead
    d. Vitamin B3 and iron
    e. Vitamin B6 and copper
    f.

N. A newborn baby has a myelomeningocele or a neural tube defect. Deficiency of which nutrient during pregnancy can result in this condition?

a. Vitamin B12
b. Thiamin
c. Zinc
d. Folate
e. Selenium

	Fat-soluble vitamins	Water-soluble vitamins
Vitamins	Vitamin A (retinol) Vitamin D (calciferol) Vitamin E (tocopherol) Vitamin K (phytomenadione)	Vitamin B_1 (thiamine) Vitamin B_2 (riboflavin) Vitamin B_3 (niacin) Vitamin B_5 (pantothenic acid) Vitamin B_6 (pyridoxine) Vitamin B_7 (biotin) Vitamin B_9 (folate) Vitamin B_{12} (cobalamin) Vitamin C (ascorbic acid)
Sources	• Mainly diet • Intestinal flora: small amounts of vitamin K are synthesized by intestinal bacteria • Vitamin D is predominantly synthesized in the body	• Mainly diet • Intestinal flora: small amounts of vitamin B_7, B_9, and B_{12} are synthesized by intestinal bacteria
Absorption	• Absorption depends on intestinal and pancreatic function • Require lipids for absorption	• Absorption in the intestine via specific luminal transporters
Storage	• Can be stored for long periods of time in the liver and adipose tissue	• Not stored in the body, except vitamins B_9 and B_{12}, which are stored in the liver ○ Hepatic stores of B9 last for approx. 3-4 months, whereas hepatic stores of B12 last for approx. 3-4 years.
Primary Functions	○ Hormones (vitamin D) ○ Antioxidants (e.g., vitamin E) ○ Cell signaling (e.g., vitamin A) ○ Gene transcription (e.g., vitamins A and E)	○ Coenzymes and precursors to organic cofactors in various chemical reactions (e.g., B vitamins) ○ Antioxidants (vitamin C)
Deficiency Causes	○ Malnutrition ○ Malabsorption syndromes with steatorrhea (cystic fibrosis and celiac disease) ○ Bile acid deficiency (e.g., cholestasis, bile acid malabsorption) ○ Medications or supplements (e.g., orlistat, mineral oil) ○ Genetic disorders (e.g., hereditary forms of rickets)	○ Restricted diet (e.g., vegan diet) ○ Malabsorption disorder (e.g., gastritis, following gastric resection) ○ Congenital disorders (e.g., Hartnup disease) • Deficiency of B-complex often causes glossitis, dermatitis, and diarrhea
Excess	• Excess accumulation is possible (due to over supplementation) → toxicity	• Accumulation and subsequent toxicity are exceedingly rare • No toxicity has been described for vitamins B_1, B_2, B_5, B_7, B_9, and B_{12}.

Accumulation and toxicity occur almost exclusively with fat-soluble vitamins.

Name	Active Forms	Food Sources	Functions	Deficiency	Toxicity
Vitamin A (Retinol)	• Retinal • Retinoic acid	• Liver, kidney, butter, egg yolks, leafy veggies	• **Vision** (retinal pigments) • Antioxidant • Gene transcription • Differentiation of epithelial cells into specialized tissue (i.e., pancreatic cells and goblet cells) • Prevents squamous metaplasia and formation of Bitot spots	• **Night blindness** • Xerosis cutis • **Bitot spots** • Keratomalacia • Immunosuppression	Acute toxicity: • nausea, vomiting, blurred vision, dizziness Chronic toxicity • Alopecia • Arthralgias • Hepatic toxicity • Pseudotumor cerebri • Teratogenicity
Vitamin D (Calciferol)	• 1,25-dihydroxyvitamin D (calcitriol) • Storage form: 25-hydroxyvitamin D (calcidiol)	• Cholecalciferol (provitamin D3): fish, milk, plants, exposure to sunlight • Ergocalciferol (provitamin D2): plants, fungi, yeast, fortified foods (e.g., milk, cereals, formula)	• Calcium and phosphate homeostasis • ↑ Absorption of Ca^{2+} and PO_4^{3-} in the intestine • ↑ Bone resorption at high levels • ↑ Bone mineralization at low levels	• **Rickets** (in children) • **Osteomalacia** (in adults) • Hypocalcemic tetany	• Hypercalcemia • Hypercalciuria
Vitamin E (tocopherol)	• Tocopherol • Tocotrienol	• Meat, eggs, oils, leafy vegetables	• Antioxidant	• Muscle weakness • Demyelination of posterior columns and spinocerebellar tract • **Hemolytic anemia**	• Infants: ↑ risk of necrotizing enterocolitis (NEC) • ↑ Anticoagulant effect of warfarin
Vitamin K (phytomenadione)	• Vitamin K hydroquinone	• Green vegetables, broccoli, spinach • Synthesized by intestinal flora	• Cofactor in γ-carboxylation of various proteins, e.g., clotting factor II, VII, IX, and X as well as protein C and S	• **Coagulopathy – blood clotting impariment**	• Hemolytic anemia • Hyperbilirubinemia • Jaundice • Infants: kernicterus

Fat soluble vitamins: ADEK

Name	Active forms	Sources	Functions	Deficiency	Toxicity
Vitamin B_1 (thiamine)	• Thiamine pyrophosphate (TPP)	• Whole grain cereals (e.g., whole wheat, brown rice), yeast, pork, legumes	• Coenzyme for various reactions involving dehydrogenase enzymes in carbohydrate and amino acid metabolism	• **Wernicke-Korsakoff syndrome** • **Beriberi**	• No toxicity has been described
Vitamin B_2 (riboflavin)	• FMN/$FMNH_2$ • FAD/$FADH_2$	• Meat, fish, eggs, milk, green vegetables, yeast	• Coenzyme in redox reactions	• Conjunctivitis with corneal vascularization • Cheilosis	• No toxicity has been described
Vitamin B_3 (niacin)	• NAD^+/NADH • $NADP^+$/NADPH	• Meat (liver), cereals, seeds, legumes	• Coenzyme in redox reactions	• Glossitis • **Pellagra**	• Flushing • Possibly: nausea, vomiting, pruritus, hives • Hyperglycemia • Hyperuricemia
Vitamin B_5 (pantothenic acid)	• Pantothenic acid	• Liver, kidney, egg yolks, broccoli, milk	• Vital component of coenzyme A: cofactor for acyl transfer reactions and fatty acid synthesis	• Dermatitis • Enteritis • Alopecia • Adrenal insufficiency	• No toxicity has been described
Vitamin B_6 (pyridoxine)	• Pyridoxal phosphate	• Meat, nuts, whole grains, vegetables	• Cofactor for decarboxylation reactions, transamination, and glycogen phosphorylase • Cystathionine synthesis • Heme synthesis • Synthesis of niacin from tryptophan • Synthesis of histamine and certain neurotransmitters (serotonin, dopamine, norepinephrine, epinephrine, and GABA)	• Convulsions • Irritability • **Sideroblastic anemia** • Peripheral neuropathy	• Dizziness • Nausea • Peripheral neuropathy • Dermatosis, photosensitivity
Vitamin B_7 (biotin)	• Biotin	• Eggs, meat, fish, seeds, nuts	• Cofactor for carboxylases, transcarboxylases, and decarboxylases	• Dermatitis • Conjunctivitis • **Alopecia** • Enteritis • Neurologic symptoms • Muscle pain	• No toxicity has been described

Vitamin B_9 (folate)	• Tetrahydrofolate (THF)	• Green leafy vegetables, dried legumes	• Coenzyme for 1-carbon transfer methylation reactions • Synthesis of nitrogen-containing bases for DNA and RNA	• **Most common vitamin deficiency in developed countries** • Macrocytic, megaloblastic anemia • Hypersegmented polymorphonuclear cells • Glossitis • In pregnancy: **fetal neural tube defects**	• No toxicity has been described
Vitamin B_{12} (cobalamin)	• Cobamamide • Methylcobalamin	• Meat and dairy products	• Cofactor for methylmalonyl-CoA (cobamamide) and methionine synthase (methylcobalamin) • DNA synthesis	• Macrocytic, **megaloblastic anemia** • **Neurologic symptoms** (e.g., paresthesias) • Hypersegmented polymorphonuclear cells	• No toxicity has been described
Vitamin C (ascorbic acid)	• Ascorbic acid	• Citrus fruits, strawberries, tomatoes, potatoes, cabbage, spinach	• Hydrophilic antioxidant • Conversion of dopamine to norepinephrine: coenzyme in dopamine β-hydroxylase • Collagen synthesis: coenzyme in hydroxylation reaction of proline and lysine • Facilitates iron absorption (keeps iron in Fe^{2+}reduced state)	• **Scurvy** • Weakened immune response	• Fatigue • Nausea, vomiting, diarrhea • Calcium oxalate nephrolithiasis • Increased risk of iron toxicity in predisposed individuals (e.g., hereditary hemochromatosis)

KEY POINTS/SUMMARY

- **Fat soluble vitamins:** ADEK
- **Water soluble vitamins:** B vitamins and vitamin C
- **Protein/Energy deficiency syndrome:**
    - **Marasmus (caloric restriction)**: NO edema, good appetite, loss of subcutaneous fat
    - **Kwashiorkor (protein > calorie restriction)**: EDEMA, poor appetite, dermatitis
- **Mucocutaneous signs of deficiency:** can include alopecia, brittle hair, seborrheic and perioral dermatitis, inflamed bleeding gums, angular cheilitis, glossitis, changes to the hair follicles and nails, poor wound healing and a variety of rashes/dermal changes (be familiar with these changes as they relate to specific deficiencies)
- ******Be Familiar with the common signs and symptoms on deficiencies tables******
  *******Know the names used for the vitamins*******

- **Vitamin A Deficiency:** Affects the eyes, bitot spots, Xerophthalmia (dryness), follicular hyperkeratosis, night blindness
- **Vitamin D Deficiency:** Bones and muscles affected. Can overlap with calcium disorders. Rickets (children)/osteomalacia (adults), osteoporosis. Dark skin and low sun exposure puts increased risk
- **Vitamin K Deficiency:** bleeding disorders. Petechiae, ecchymoses. Hemorrhagic disease of the newborn
- **Vitamin B12 Deficiency:** blood cells and nerves = megaloblastic anemia, neuropathy, glossitis
- **Vitamin B1 Deficiency:** aka thiamine. **BeriBeri** (wet and dry), Wernicke-Korsakoff.
- **Vitamin B2 Deficiency:** aka riboflavin. Angular stomatitis, cheilosis
- **Vitamin B3 Deficiency:** aka niacin. People who obtain their food energy from maize (corn) are commonly affected. **Pellagra** - **the 4 Ds** – photosensitive Dermatitis, Diarrhea, Dementia, Death
- **Vitamin B6 Deficiency:** aka pyridoxine. anemia dermatitis, neuropathy, Sideroblastic anemia
- **Vitamin C Deficiency:** wound healing and soft tissue affected. Scurvy, corkscrew hairs with perifollicular hemorrhage, bleeding gums
- **Folate:** anemia, neural tube defects
- **Iron:** anemia, pallor and koilonychias
- **Calcium:** varying symptoms including arrhythmias and tetany, joint and muscle pains
- **Iodine:** thyroid function. Cretinism/cognitive delay, goiter
- **Biotin:** rash, hair loss
- **Zinc:** rash (acrodermatitis), alopecia, diarrhea, immune function impaired. Zinc levels in breast milk usually adequate for 4-6 months. Adult deficiency is usually dietary related
- **Supplementation:** The FDA recommends consuming nutrient dense foods as part of a healthy eating pattern. Use of fortified foods and dietary supplements are recommended for certain populations
- Benefits of fortified/enriched food
    - **Fortification:** refers to foods that have nutrients added to them which are not naturally occurring in that food.
        - one of the most successful public health interventions in US history: Goiter, cretinism, beriberi, pellagra and rickets are just a sample of the nutrient deficiencies that have mostly disappeared due to fortification
    - **Enrichment:** typically refers to adding nutrients lost during food handling, processing and storage back into a food.

Additional resources

- https://www.merckmanuals.com/professional/nutritional-disorders
- **Impact of Frequency of Multi-Vitamin/Multi-Mineral Supplement Intake on Nutritional Adequacy and Nutrient Deficiencies in U.S. Adults.** *Nutrients* **2017**, *9*(8), 849; https://doi.org/10.3390/nu9080849
- https://www.cdc.gov/nutritionreport/pdf/Nutrition_Book_complete508_final.pdf

REVIEW QUESTIONS:

1. List the fat soluble vitamins

2. List the water soluble vitamins

3. Adults with a vitamin D deficiency have poor bone mineralization leading to
    a. Pellagra
    b. Rickets
    c. Scurvy
    d. Osteomalacia

4. Vitamin C deficiency symptoms include which of the following?
    a. Red spots
    b. Bitot spots
    c. Loose teeth
    d. Anemia
    e. Only a and b
    f. Only c and d
    g. a, b, and c
    h. a, c and d

5. Deficiency of which mineral is a leading cause of mental retardation worldwide?
    a. Iron
    b. Iodine
    c. Zinc
    d. Chromium

6. Too little of which of the following in the diet is associated with osteoporosis?
    a. Vitamin B12
    b. Vitamin D
    c. Sodium
    d. Niacin

7. An 8 month old child with growth retardation, weight loss and muscle wasting presents with lethargy. No edema is noted on physical exam. Which of the following is the most likely diagnosis?
    a. Nutritional Dwarfism
    b. Kwashiorkor
    c. Marasmus
    d. Vitamin D deficiency

8. Match the syndrome/symptom with the correct deficiency

1. Thiamin	a. Neural tube defect
2. Vitamin A	b. Scurvy
3. Pyridoxine	c. Pellagra
4. Zinc	d. Megaloblastic anemia
5. Vitamin D	e. Microcytic anemia
6. Ascorbic acid	f. Night blindness
7. Niacin	g. Wernicke-korsakoff
8. Folate	h. Sideroblastic anemia
9. Cobalamin	i. Osteomalacia
10. Iron	j. Acrodermatitis enteropathica

Answers: 1. A, D, E, K **2.** B and C **3.** D **4.** H **5.** B **6.** B **7.** C **8.** 1-g, 2-f, 3-h, 4-j, 5-l, 6-b, 7-c, 8-a, 9-d, 10-e.