

# Micronutrients in Immunity



# Learning Objectives

- Discuss the major functions of micronutrients in body defense systems (i.e., antioxidants and immune function).
- Describe how micronutrients contributing to body defense systems are absorbed, transported, stored, and excreted.
- Identify the deficiency and toxicity symptoms of the nutrients important in body defense systems.
- Identify different the form, functions, absorption, transportation and storage of:
  - Vitamin A
  - Vitamin C
  - Vitamin E
  - Zinc

# Nutrients and Phytochemicals That Function as Antioxidants

- Some vitamins, minerals, plant compounds function as antioxidants
- Protect cells against free radicals
- Nutrients that function as antioxidants:
  - Vitamin E (tocopherol)
  - Vitamin C (ascorbic acid)
  - Vitamin A (retinoids & carotenoids)
  - Phytochemicals
  - Selenium (Se)



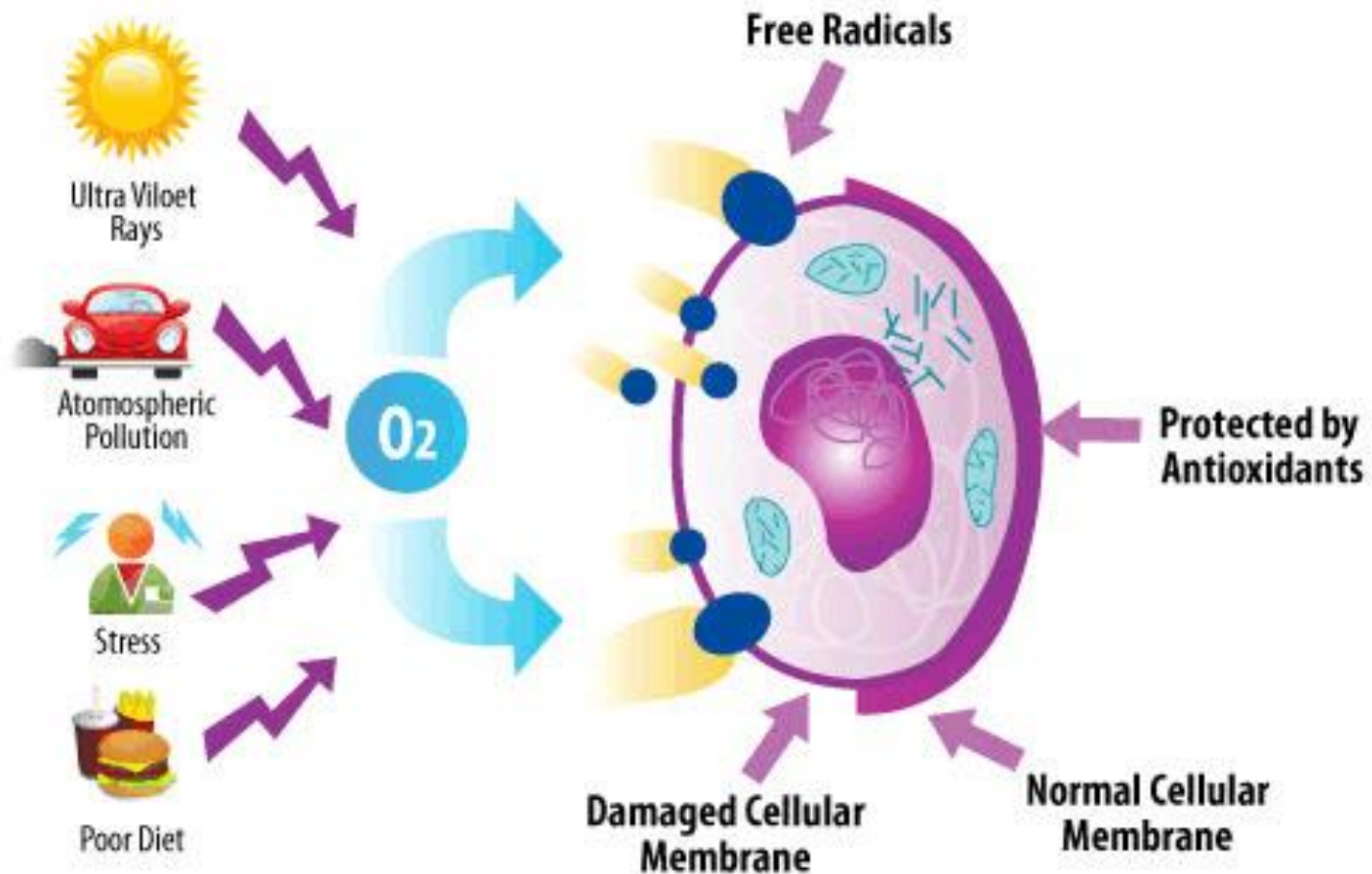
# Defense Against Free Radicals



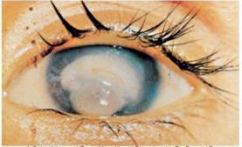

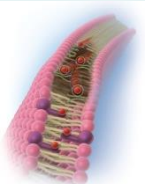
- **Dietary antioxidant:** substance in foods that significantly decreases adverse effects of reactive species such as reactive oxygen and nitrogen species on normal physiological function in humans (from DRI)
  - prevent or repair damage caused by oxidation
  - 326 foods analyzed by USDA
  - oxygen radical absorption capacity (ORAC), measures antioxidant capacity in test tubes, not humans
- **Free radicals:** molecules with an unpaired electron that are unstable



**DNA damage by free radicals sets the stage for disease. Antioxidants help protect and repair cells.**



# Vitamins A, C, & E: Antioxidants

Vitamin	Major Functions	Water or Fat Soluble	Food Sources	Deficiency Symptoms	Toxicity Symptoms
<b>Vitamin A</b> (preformed - <b>retinoids</b> and provitamin A- <b>carotenoids</b> ) 	Vision/eye health; growth, development, reproduction; immune function	FS	Fish/fish oils; dark, leafy greens and dark colored fruit; fortified dairy; eggs	Night blindness; xerophthalmia; macular degeneration; inadequate growth; dry skin	Birth defects; bone pain & fractures; liver toxicity;
<b>Vitamin C</b> 	Collagen synthesis; antioxidant; immune function; improves nonheme iron absorption; reactivate vitamin E	WS	Citrus fruits; potatoes; broccoli; spinach; strawberries; tomatoes	Scurvy; poor wound healing; pinpoint hemorrhages; infections	GI disturbances; kidney stones; excess iron absorption
<b>Vitamin E</b> 	Antioxidant; prevents breakdown of vitamin A and unsaturated fatty acids	FS	Vegetable oils; nuts/seeds; fortified cereals	Hemolysis of RBC; anemia; nerve damage	Hemorrhagic toxicity

# Carotenoids

- Plants contain pigments called carotenoids
- Carotenoids are phytochemicals with health promoting chemicals
- Precursors of vitamin A, antioxidant properties



# Carotenoids

- Three carotenoids are **provitamins** - can be turned into vitamin A:
  - Beta-carotene
  - Alpha-carotene
  - Beta-cryptoxanthin
- Other carotenoids that have health benefits:
  - Lycopene
  - Zeaxanthin
  - Lutein



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# Functions of the Carotenoids

- Vision, reduce macular degeneration
  - Leading cause of legal blindness in North America
- Cardiovascular disease prevention
  - May inhibit oxidation of low-density lipoproteins
- Cancer prevention, lung, oral, skin, prostate

# Avoiding Too Much Carotenoids

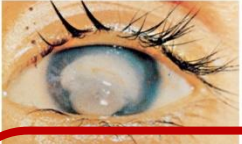

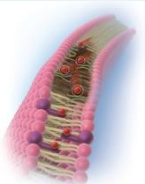
- Excess dietary consumption, no toxic effects
- Hypercarotenemia, too many carrots or beta-carotene supplements/pills
  - Skin may turn yellow-orange

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# Vitamins A, C, & E: Antioxidants

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# Functions of Vitamin C

- Collagen synthesis, most abundant protein in body
- Serotonin and norepinephrine synthesis
- Antioxidant
- Increases iron absorption
- Vital for immune function
- May decrease formation of carcinogen nitrosamines in the stomach
- Doesn't prevent colds but may decrease severity





# Getting Enough Vitamin C



- Adult RDA:
  - 75 mg/day for women
  - 90 mg/day for men
- Smokers need an extra **35 mg** because of increased oxidation by tobacco smoke in lungs
- Average U.S. consumption: 70-100 mg/day

# Vitamin C Deficiency - Scurvy

- Causes scurvy due to reduced collagen synthesis, causing bruising, bleeding gums
- 1700s half of sailing crew on long voyages died
- British physician discovered citrus fruits prevented and restored health of sailors
- Future food rations included limes, resulting in nickname “limeys”





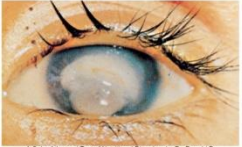

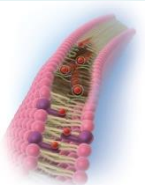
# Pinpoint Hemorrhages

## Early Scurvy Sign

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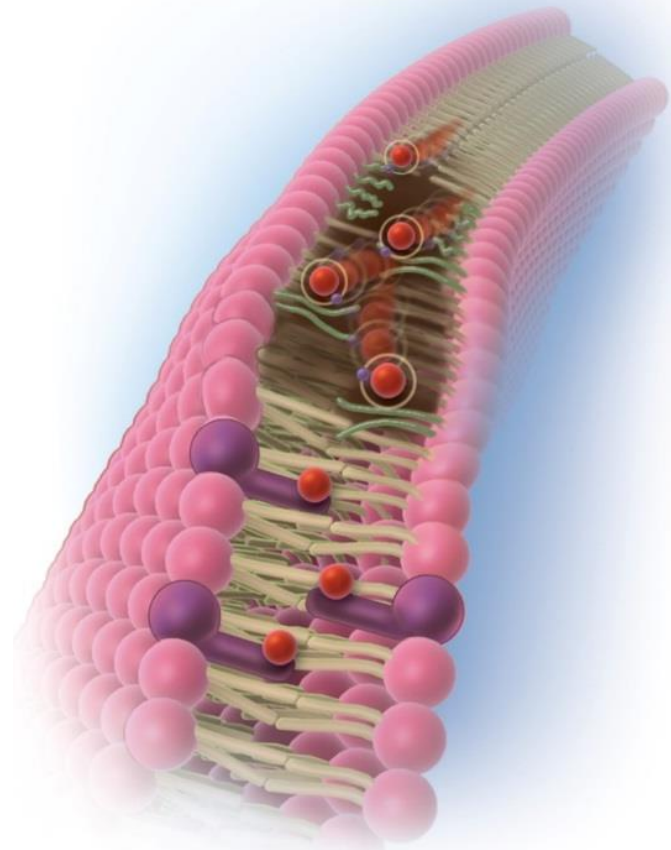
# Vitamins A, C, & E: Antioxidants

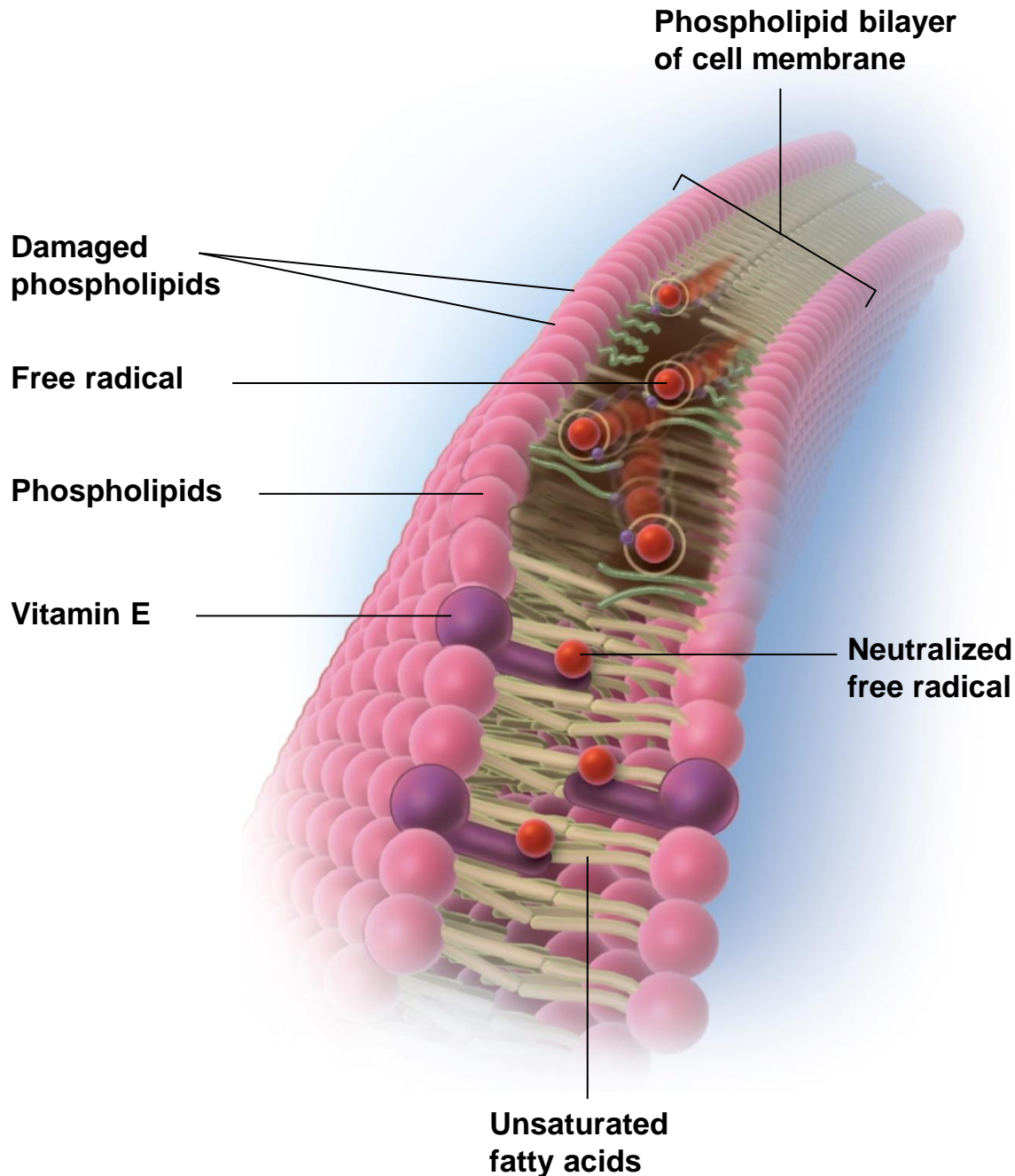
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# Vitamin E as an Antioxidant

- Fat-soluble vitamin found in adipose tissue and cell membrane
- Lipids in these membranes are polyunsaturated fatty acid (PUFA)
  - PUFAs susceptible to oxidative attack
- Vitamin E donates electrons or hydrogens to free radicals to make cell more stable
- Vitamin E important in areas exposed to  $\uparrow$  levels of oxygen
  - RBCs and lungs





- Vitamin E can insert itself into cell membranes
- It helps stop free-radical chain reactions

# Avoiding Too Much Vitamin E

- Megadosing does not provide significant health benefits or prevent against oxidative damage
- Not stored in the liver – stored in fat tissue
- UL is 1,000 mg/day
- Excess can interfere with vitamin K and anticoagulant medications causing hemorrhage (Coumadin & aspirin)

# Functions of Zinc

## Functions:

- Immunity
- DNA synthesis and function
- Protein metabolism, wound healing, and growth
- Development of sexual organs and bones
- Storage, release, and function of insulin
- Cell membrane structure and function
- **Indirect antioxidant function**
  - Component of superoxide dismutase (SOD), an enzyme that aids in the prevention of oxidative damage to cells



# Zinc: Deficiency

- Growth retardation and sexual organ immaturity
- Acne-like rash, taste alterations
- Hair loss
- Poor wound healing



Photo courtesy of Harold H. Sandstead, M.D.

Low intakes of zinc limit growth in people worldwide. On the right, an Egyptian farm boy, 16 years old and 49 inches tall, experienced limited growth and sexual development associated with zinc deficiency.

# Getting Enough Zinc

**Sources:** animal-protein foods, fortified cereals & grains, wheat germ, some cheese, asparagus

**Toxicity** can occur from zinc supplements and overconsumption of zinc-fortified foods

- Interferes with copper metabolism
- Intakes over 100 milligrams result in diarrhea, cramps, nausea, vomiting, loss of appetite, depressed immune system function

# Phytochemicals

- Health-promoting compounds found in plant food
- Functions:
  - Antioxidants
  - Inhibit cancer and cell death
  - Alter absorption, production, and metabolism of cholesterol
  - Mimic or inhibit hormones and enzymes
  - Decrease formation of blood clots
  - Decrease inflammation, affecting immune-related disorders