The immune system consists of various organs, tissues, and cells located throughout the body.

**WHITE BLOOD CELLS (WBCs)**
- The cells of the immune system
- Made inside bone marrow
- WBCs travel through the body inside lymph vessels, which are in close contact with the bloodstream

**THERE ARE SEVERAL TYPES OF WBCs**

- **NEUTROPHILS**
  - Engulf and destroy

- **MONOCYTES (MACROPHAGES)**
  - Engulf and destroy

- **EOSINOPHILS**
  - Fight parasitic infections

- **BASOPHILS**
  - Release histamine

- **LYMPHOCYTES**
  - Attack specific pathogens

- **PLASMA CELLS**
  - Produce antibodies

**THE IMMUNE SYSTEM PROVIDES THREE LEVELS OF DEFENSE AGAINST DISEASE-CAUSING ORGANISMS**

1. **BARRIERS**
   - Prevent entry
   - Skin and mucus membranes
   - Stomach acid and digestive enzymes
   - Beneficial bacteria that live in the colon (the gut microbiota)

2. **INNATE IMMUNITY**
   - General defense
   - WBCs called neutrophils and macrophages engulf and destroy foreign invaders and damaged cells

3. **ACQUIRED IMMUNITY**
   - Specific defense
   - WBCs called T lymphocytes (T cells) target and destroy infected or cancerous cells
   - WBCs called B lymphocytes (B cells) and plasma cells produce antibodies that target and destroy infected or cancerous cells
The immune system is constantly working to protect the body from infection, injury, and disease.

OVERVIEW OF THE IMMUNE SYSTEM

The immune system consists of various organs, tissues, and cells located throughout the body.

WHITE BLOOD CELLS (WBCs)

- The cells of the immune system
- Made inside bone marrow
- WBCs travel through the body inside lymph vessels, which are in close contact with the bloodstream

THERE ARE SEVERAL TYPES OF WBCs

- **NEUTROPHILS** Engulf and destroy
- **MONOCYTES** (MACROPHAGES) Engulf and destroy
- **EOSINOPHILS** Fight parasitic infections
- **BASOPHILS** Release histamine
- **LYMPHOCYTES** Attack specific pathogens
- **PLASMA CELLS** Produce antibodies

THE IMMUNE SYSTEM PROVIDES THREE LEVELS OF DEFENSE AGAINST DISEASE-CAUSING ORGANISMS

1. **BARRIERS** Prevent entry
   - Skin and mucus membranes
   - Stomach acid and digestive enzymes
   - Beneficial bacteria that live in the colon (the gut microbiota)

2. **INNATE IMMUNITY** General defense
   - WBCs called neutrophils and macrophages engulf and destroy foreign invaders and damaged cells

3. **ACQUIRED IMMUNITY** Specific defense
   - WBCs called T lymphocytes (T cells) target and destroy infected or cancerous cells
   - WBCs called B lymphocytes (B cells) and plasma cells produce antibodies that target and destroy infected or cancerous cells
KEY FEATURES OF THE IMMUNE RESPONSE

**OXIDATIVE BURST**

- Certain immune cells produce a concentrated burst of reactive oxygen species (ROS), damaging substances that help kill invading organisms.

**Important nutrients**
- Vitamin C
- Vitamin E
- Iron
- Zinc
- Copper
- Selenium

**Connection**
- Prolonged and continuous exposure to ROS can lead to damage and disease.
- The listed antioxidant nutrients protect immune cells and keep the oxidative burst in check.

**PROLIFERATION**

- Refers to an increase in the number or amount of something
- The immune system is constantly producing cells, chemicals, and proteins to carry out its functions.
- When it encounters a foreign invader, it ramps up production to respond as needed.

**Important nutrients**
- Vitamin A
- Vitamin D
- Folate
- Vitamin B₁₂
- Vitamin B₆
- Iron
- Zinc

**Connection**
- Proliferation requires energy, building blocks, and cofactors to produce the many cells and substances needed to mount an effective immune response.
- The listed micronutrients have essential roles in the production and development of all new cells in the body, including immune cells.

**INFLAMMATION**

- Isolates the injured or infected area
- Helps deliver immune cells, chemical messengers, and antibodies to sites of injury or infection.

**Important nutrients**
- EPA
- DHA

**Connection**
- Inappropriate activation or the inability to turn off inflammation can lead to tissue damage and chronic disease.
- EPA and DHA have anti-inflammatory activity that can help keep inflammation in check.
<table>
<thead>
<tr>
<th>NUTRIENT</th>
<th>RDA (ADULTS)</th>
<th>GOOD SOURCES</th>
</tr>
</thead>
</table>
| EPA + DHA                    | No RDA (Advised to consume two servings of oily fish/week) | herring 3 oz, 1.8 g  
salmon 3 oz, 1.5 g  
sardines 3 oz, 1.2 g  |
| Vitamin A*                   | Men: 900 µg/day RAE  
Women: 700 µg/day RAE | egg 1 large, 80 µg RAE  
carrot** ½ cup raw, 534 µg RAE  
sweet potato** ½ cup baked, 961 µg RAE  |
| Vitamin C*                   | Men: 90 mg/day  
Women: 75 mg/day | sweet red pepper 1 medium, 152 mg  
kiwifruit 1 medium, 91 mg  
strawberries 1 cup whole, 85 mg  |
| Vitamin D*                   | 19-70 years: 600 IU/day  
71 years and older: 800 IU/day | pink salmon 3 oz, 370 IU  
sardines 3 oz, 164 IU  
fortified milk 1 serving, 120 IU  
sunshine  |
| Vitamin E*                   | All adults: 15 mg/day | almonds 1 oz, 7 mg  
sunflower oil 1 T, 6 mg  
avocado 1 whole, 2.7 mg  |
| Folate                       | All adults: 400 µg/day DFE | lentils ½ cup cooked, 179 µg DFE  
spinach ½ cup cooked, 131 µg DFE  
enriched bread*** 1 slice, 84 µg DFE  |
| Vitamin B<sub>12</sub>       | All adults: 2.4 µg/day | clams 3 oz, 84.1 µg  
mackerel 3 oz, 16.1 µg  |
| Vitamin B<sub>6</sub>        | 19-50 years: 1.3 mg/day  
Men 51 years and older: 1.7 mg/day  
Women 51 years and older: 1.5 mg/day | salmon 3 oz, 0.5 mg  
turkey 3 oz, 0.7 mg  
potato with skin 1 medium, 0.7 mg  |
| Zinc                         | Men: 11 mg/day  
Women: 8 mg/day | oysters 6 medium, 27-50 mg  
bread 3 oz, 4-6 mg  |
| Iron*                        | Men and women 51 years and older: 8 mg/day  
Women 19-50 years: 18 mg/day | beef 3 oz, 1.6 mg  
tuna 3 oz, 1.3 mg  
lentils ½ cup cooked, 3.3 mg  |
| Copper                       | All adults: 900 µg/day | oysters 6 medium, 2,397 µg  
cashew nuts 1 oz, 622 µg  
lentils 1 cup cooked, 497 µg  |
| Selenium                     | All adults: 55 µg/day | tuna 3 oz, 92 µg  
pork 3 oz, 32.5 µg  
whole-wheat bread 1 slice, 8.2 µg  |

RDA = Recommended Dietary Allowance  
RAE = retinol activity equivalents  
DFE = dietary folate equivalents  
IU = International Units  
g = grams  
mg = milligrams  
µg = micrograms  
oz = ounce(s)  
T = Tablespoon  

*Underconsumed by eating the typical American diet. Iron underconsumed by adolescent females and pregnant women only  
**A source of provitamin A carotenoids  
***A source of folic acid, the synthetic form of folate
FOR SOME NUTRIENTS, GETTING MORE THAN THE RDA MIGHT BE OF FURTHER BENEFIT

VITAMIN C

Routine supplementation with vitamin C (0.25 to 2 g/day) reduces the occurrence of the common cold in individuals undergoing heavy physical stress (marathon runners, skiers, and soldiers in subarctic conditions).

Routine supplementation with vitamin C slightly reduces the duration of the common cold.

The LPI recommends a daily intake of at least 400 mg of vitamin C for generally healthy adults.

VITAMIN D

Low vitamin D status is linked to a higher risk of upper respiratory tract infections and some autoimmune disorders. Supplementation with vitamin D reduces the risk of acute respiratory tract infection.

The LPI recommends 2,000 IU (50 µg) of supplemental vitamin D daily for generally healthy adults.

SOURCES

Micronutrient Information Center

- lpi.oregonstate.edu/mic/health-disease/immunity-in-brief
- lpi.oregonstate.edu/mic/health-disease/immunity

© 2018 Linus Pauling Institute