

Nutrition to Support Your Immune System

Ridley-Tree Cancer Center

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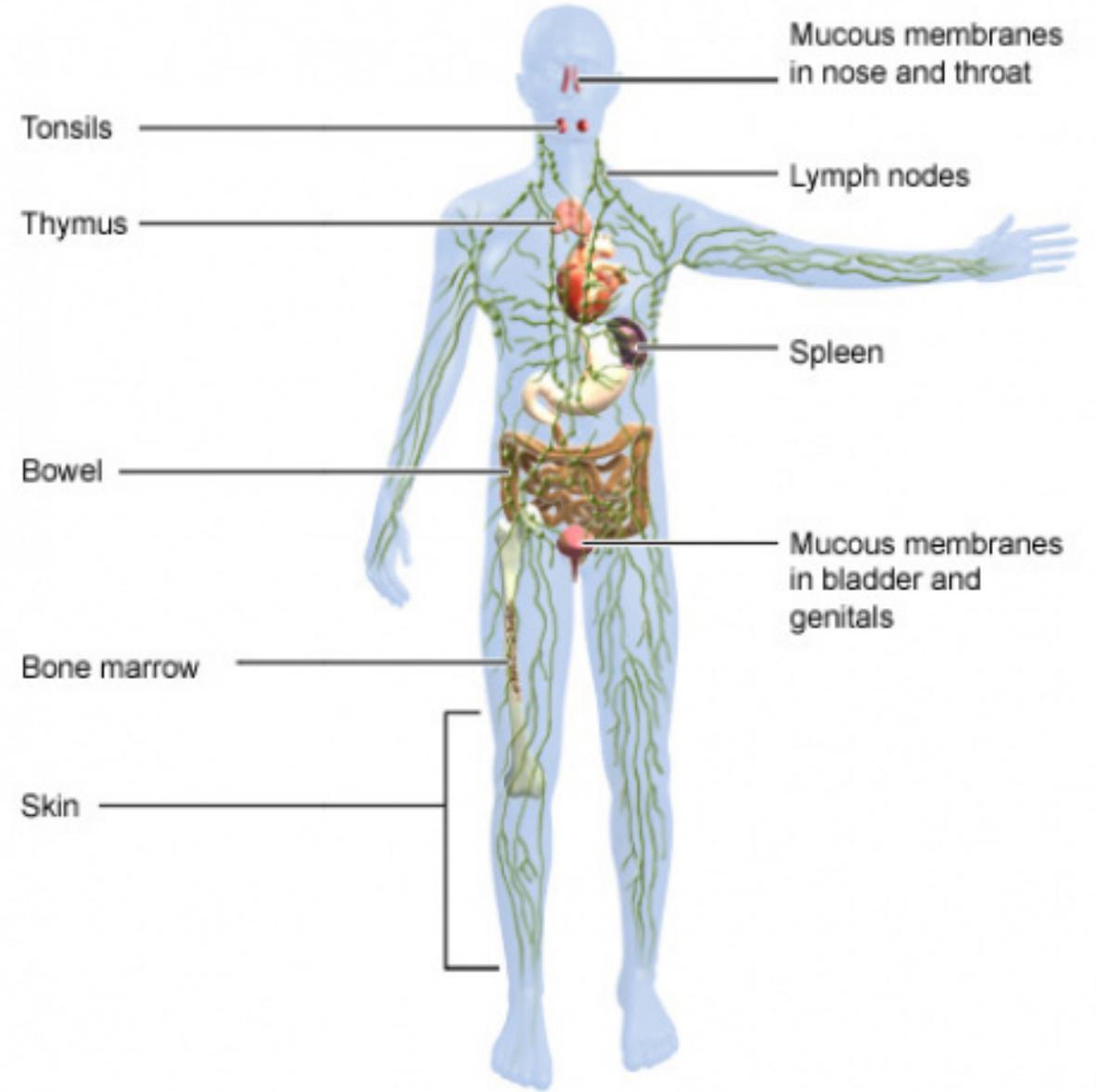
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Overview

- ✓ What is the immune system?
- ✓ Nutrients and foods to support the immune system
- ✓ What are your next steps?
- ✓ Immune boosting menu ideas
- ✓ Recipe demonstration

Immune System:

Designed to fight off germs and foreign substances like bacteria, viruses (think flu, COVID 19), and parasites

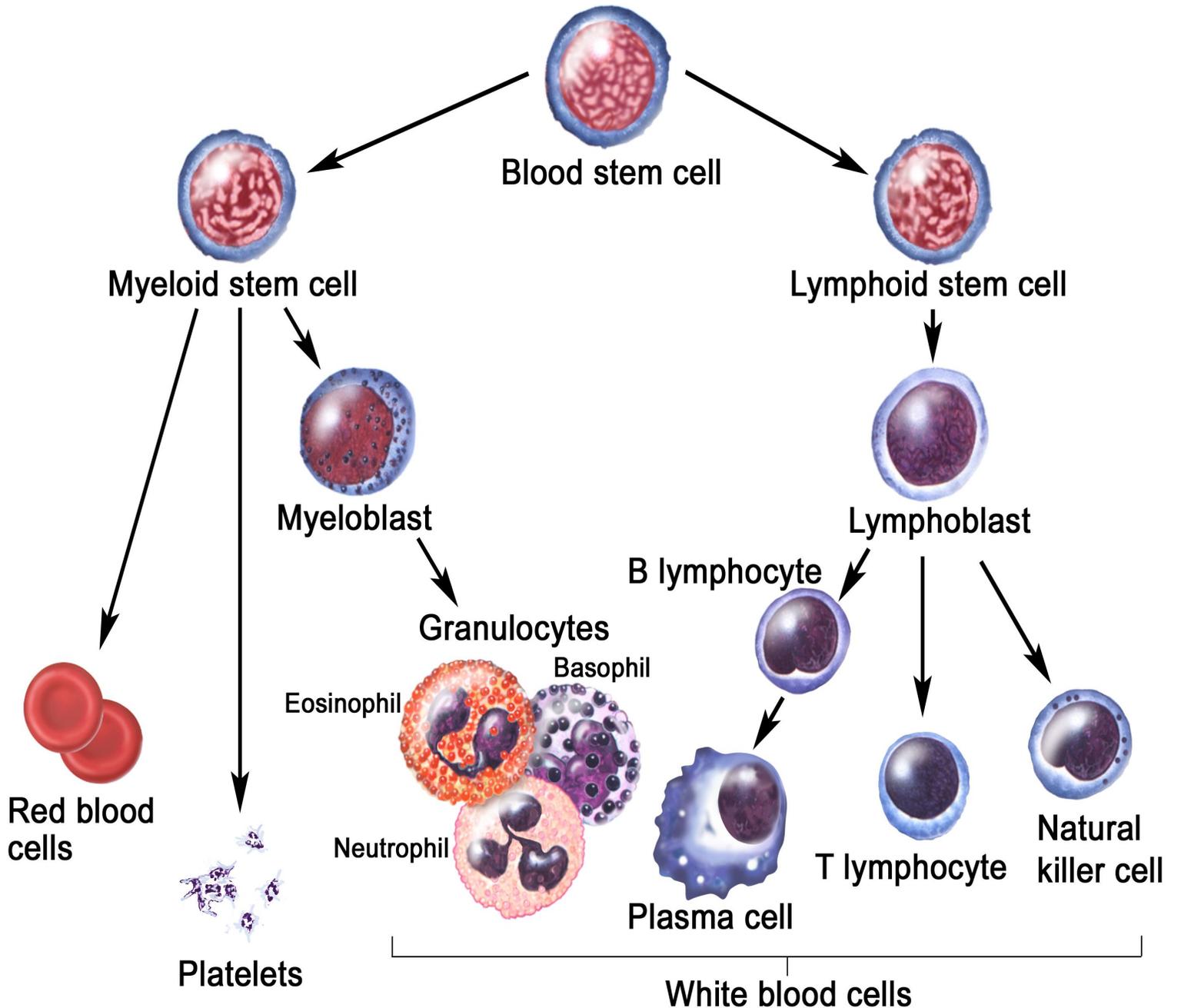


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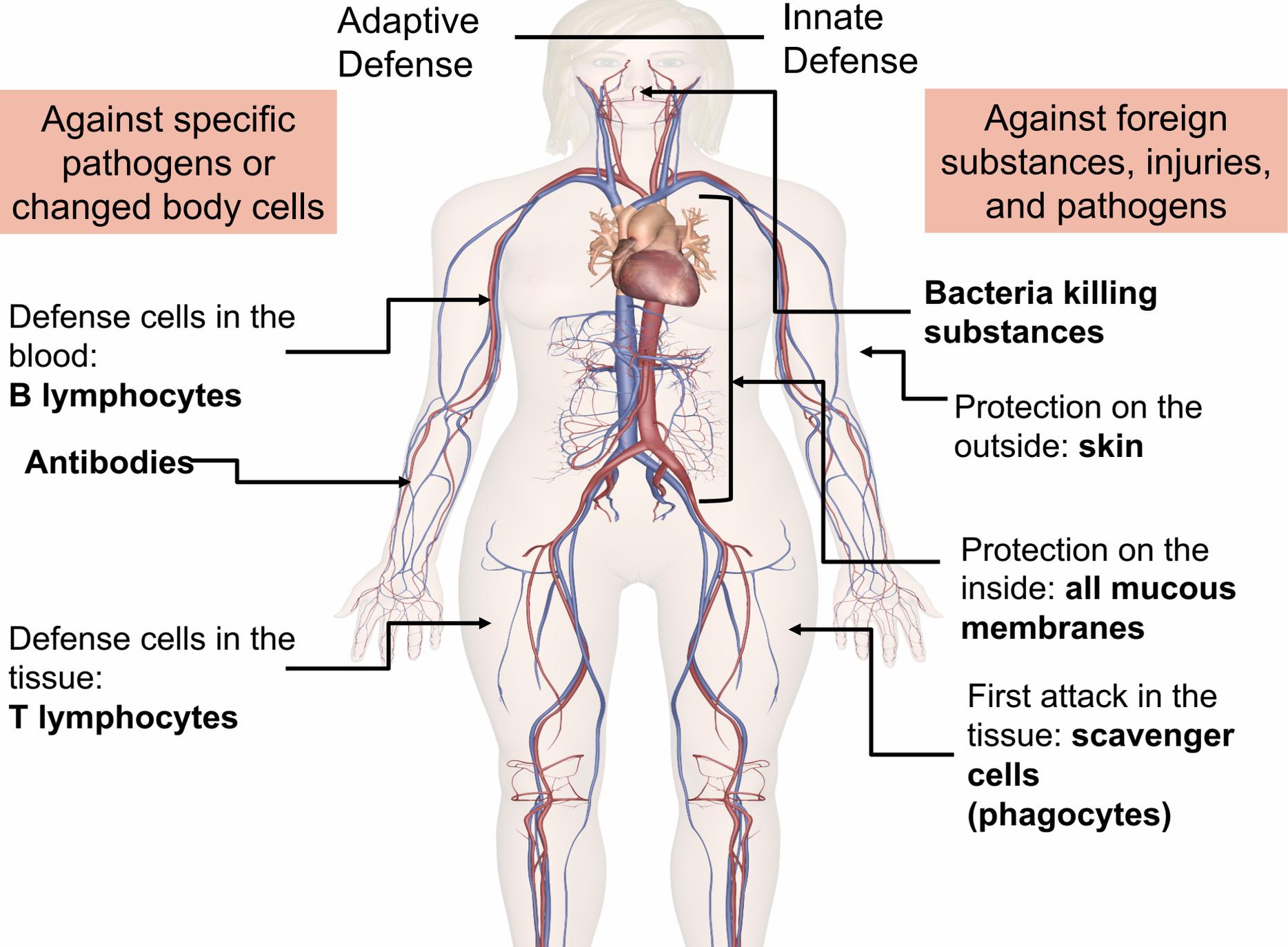
What are the parts of the immune system?

Immune System: White Blood Cells

- The cells of the immune system
- Made from stem cells in the bone marrow



Adaptive and Innate Immune Systems



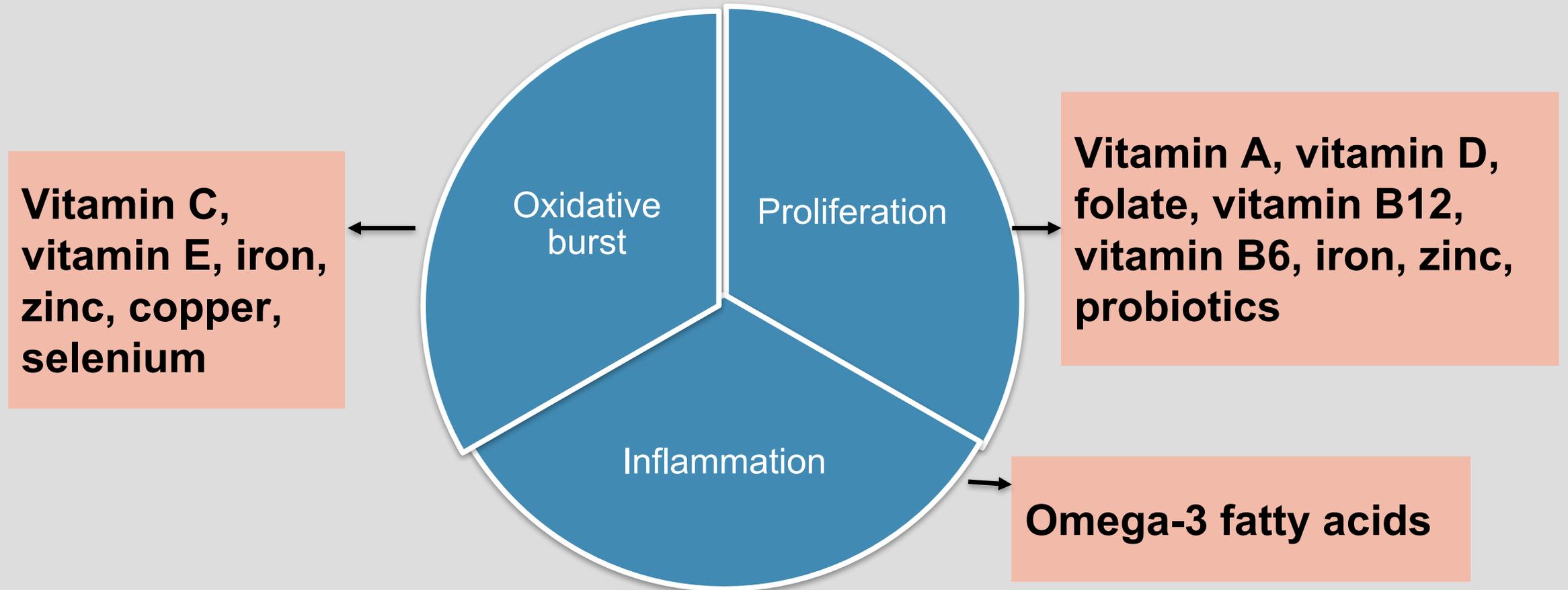
Innate Immune System Functions

- The body's first line of immune response
- Immediate, nonspecific response to foreign substances
- For example, it makes sure that bacteria that have entered the skin through a small wound are detected and destroyed on the spot within a few hours
- Includes protective barriers such as:
 - Skin which keeps out majority of pathogens
 - Mucus that traps pathogens
 - Stomach acid that destroys pathogens
 - Beneficial bacteria that live in the gastrointestinal tract (the gut microbiome)
 - Compounds in sweat and tears help create anti-bacterial compounds
 - Immune system cells that attack all foreign cells entering the body

Innate Immune System: Metabolic Activity

- **Oxidative burst** – Where certain immune cells produce a burst of reactive oxygen species which creates waste in the form of free radicals
- **Proliferation** - When the immune system encounters a foreign invader, it ramps up production of cells, chemicals and proteins
- **Inflammation** – Which isolates the injured or infected area and helps deliver immune cells, chemical messengers, and antibodies to sites of injury or infection

Innate Immune System: Key Nutrient Requirements



Adaptive Immune System Functions

- The second line of defense against foreign invaders
- Involves a complex, targeted response to a specific pathogen
- Provide long-lasting protection; for example, someone who recovers from measles is now protected against measles for their lifetime
- Develops memory of foreign substances so that B and T cells can respond quickly to eliminate repeat invaders

Adaptive Immune System: Metabolic Activity

- **Cell mediated response** - T cells induce apoptosis (cell death) in virus-infected cells, cells contaminated with bacteria, and cancer cells
- **Antibody response** – B cells secrete antibodies that blocks adhesion of bacteria and viruses to mucosa

Adaptive Immune System: Key Nutrient Requirements

**Omega-3 fatty acids,
vitamin A, D, C, E, B6,
B12, folate, zinc, iron,
copper, selenium and
probiotics**

T cells

B cells

Cell mediated
immune
response

Antibody
response

Focus on Food

- Most people don't meet the recommended guidelines for common nutrients in their diet, because of this, our discussion today will focus on getting adequate nutrients through food
- We understand the potential benefits of supplements, but it is a complicated and individual choice best discussed with your registered dietitian/nutritionist or physician

Nutrient Recommendations

- Dietary Reference Intakes (DRI) - is the general term for a set of reference values used to plan and assess nutrient intakes of healthy people. These values vary by age and sex and include:
 - **Estimated Average Requirement (EAR)** - The average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group
 - E.g. EAR for calcium is set using a criteria for maximizing bone health and is set at a point that will meet the needs of half of the population
 - **Recommended Dietary Allowance (RDA)**: Average daily level of intake sufficient to meet the nutrient requirements of nearly all (97%-98%) healthy people
 - **Adequate Intake (AI)**: Established when evidence is insufficient to develop an RDA and is set at a level assumed to ensure nutritional adequacy

Prevalence of Micronutrient Inadequacies Among US Residents Ages ≥ 4 Years

- National Health and Nutrition Examination Survey (NHANES) 2007-2010 (n = 16,444)

Nutrient	% < Estimated Average Requirement (EAR)
Vitamin D	95
Vitamin E	88
Vitamin A	43
Vitamin C	39
Zinc	11
Folate	9.5
Vitamin B6	9.5
Iron	7.4
Copper	4.2
Vitamin B12	2.5
Selenium	0.3

12 Nutrients to Support the Immune System

I. Copper

RDA: 900 mcg/day

<u>Food</u>	<u>Copper (mcg)</u>
❑ Sesame seeds, 1/4 cup	1470
❑ Cashew nuts, 1/2 cup	880
❑ Soybeans (edamame), 1 cup	700
❑ Shiitake mushrooms, 1/2 cup	650
❑ Garbanzo beans, 1 cup	508
❑ Chocolate, 1 ounce 70% dark	501
❑ Asparagus, 1 cup	300



2. Iron

RDA: men and women 51 years and older: 8 mg/day,
women 19–50 years: 18 mg/day

<u>Food</u>	<u>Iron (mg)</u>
<input type="checkbox"/> White beans, ½ cup canned	4
<input type="checkbox"/> Tofu, ½ cup firm	3
<input type="checkbox"/> Lentils, ½ cup	3
<input type="checkbox"/> Spinach, ½ cup boiled	3
<input type="checkbox"/> Cumin seeds, 2 tsp	3
<input type="checkbox"/> Tomatoes, ½ cup canned	2
<input type="checkbox"/> Turmeric, 2 tsp	2
<input type="checkbox"/> Asparagus, 1 cup	1.5



3. Zinc

RDA: adults 19+ years: men: 11 mg/day, women: 8 mg/day

Food

Zinc (mg)

- Oysters, 6 medium
- Chicken, dark meat 3 oz
- Beef, 4 oz
- Pumpkin seeds, 1/4 cup
- Yogurt, 1 cup
- Asparagus, 1 cup
- Shiitake mushrooms, 1/2 cup

27–50

2.4

4–6

2.5

1.5

1

1



4. Vitamin D

RDA: adults 19-70 years: 600 IU/day, 71 years and older: 800 IU/day

Food

Vitamin D (IU)

- | | |
|----------------------------------------------------------------------|---------|
| <input type="checkbox"/> Cod liver oil, 1 tablespoon | 1360 |
| <input type="checkbox"/> Sockeye salmon, 3 oz | 570 |
| <input type="checkbox"/> Mushrooms, raw, 1 cup exposed to UV light | 366 |
| <input type="checkbox"/> Sardines, 3 oz | 175 |
| <input type="checkbox"/> Fortified milk and milk alternatives, 1 cup | 100-144 |
| <input type="checkbox"/> Tuna fish, 3 oz light canned | 40 |
| <input type="checkbox"/> Sunshine | |



5. Vitamin C

RDA: men 90 mg/day, women 75 mg/day

<u>Food</u>	<u>Vitamin C (mg)</u>
❑ Papaya, 1 whole	170
❑ Bell pepper, 1 cup	115
❑ Broccoli, 1 cup	100
❑ Brussel sprouts, 1 cup	97
❑ Strawberries, 1 cup	85
❑ Pineapple, 1 cup	80
❑ Orange, 1 medium	70
❑ Kiwi, 1 2-inch	64
❑ Cauliflower, 1 cup	55



5. Vitamin C

<u>Food</u>	<u>Vitamin C (mg)</u>
❑ Kale, 1 cup	53
❑ Cabbage, 1 cup	50
❑ Parsley, 1/2 cup	40
❑ Melon, 1/2 cup	30
❑ Tomatoes, 1 cup	24
❑ Asparagus, 1 cup	14
❑ Blueberries, 1 cup	14
❑ Fennel, 1 cup	10
❑ Pomegranate seeds, 1/2 cup	9

6. Vitamin B6

RDA: 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

Food

Vitamin B6 (mg)

<input type="checkbox"/> Chickpeas, 1 cup canned	1.1
<input type="checkbox"/> Turkey, 3 oz	0.7
<input type="checkbox"/> Salmon, 4 oz	0.6
<input type="checkbox"/> Sweet potato, 1 cup	0.5
<input type="checkbox"/> Spinach, 1 cup	0.4
<input type="checkbox"/> Garlic, 6 cloves	0.2
<input type="checkbox"/> Bell peppers, 1 cup	0.2



7. Vitamin A

RDA: women: 700 mcg/day, men: 900 mcg/day

Food

Vitamin A (mcg)

<input type="checkbox"/> Sweet potato, with skin, 1 cup	1921
<input type="checkbox"/> Carrots, 1 cup raw	1020
<input type="checkbox"/> Spinach, 1 cup boiled	940
<input type="checkbox"/> Cantaloupe, 1 cup	270
<input type="checkbox"/> Bell pepper, 1 cup	144
<input type="checkbox"/> Mango, 1 whole	115



8. Folate

RDA: adults 400 mcg/day

<u>Food</u>	<u>Folate (mcg)</u>
<input type="checkbox"/> Asparagus, 1 cup	270
<input type="checkbox"/> Spinach, 1 cup cooked	260
<input type="checkbox"/> Lentils, 1/2 cup cooked	179
<input type="checkbox"/> Beets, 1 cup cooked	136
<input type="checkbox"/> Garbanzo beans, 1/2 cup	135
<input type="checkbox"/> Romaine lettuce, 2 cups	130
<input type="checkbox"/> Avocado, 1/2 cup	60



9. Vitamin B12

RDA: adults 2.4 mcg/day

<u>Food</u>	<u>Vitamin B12 (mcg)</u>
<input type="checkbox"/> Sardines, 3 oz	8
<input type="checkbox"/> Salmon, 4 oz	5.6
<input type="checkbox"/> Tuna, 4 oz	2.6
<input type="checkbox"/> Scallops, 4 oz	2.4
<input type="checkbox"/> Nutritional yeast, 2 tbsp	2.4
<input type="checkbox"/> Yogurt, 1 cup	1
<input type="checkbox"/> Egg, 1	0.5



10. Selenium

RDA: adults 55 mcg/day

<u>Food</u>	<u>Selenium (mcg)</u>
<input type="checkbox"/> Tuna, 3 oz	92
<input type="checkbox"/> Salmon, 4 oz	43
<input type="checkbox"/> Tofu, 4 oz	20
<input type="checkbox"/> Mushrooms, 1/2 cup	18
<input type="checkbox"/> Egg, 1 each	15
<input type="checkbox"/> Asparagus, 1 cup	10



II. Vitamin E

RDA: adults 15 mg/day

<u>Food</u>	<u>Vitamin E (mg)</u>
<input type="checkbox"/> Sunflower seeds, 1/4 cup	12
<input type="checkbox"/> Almonds, 1 oz	7
<input type="checkbox"/> Sunflower oil, 1 tbsp	6
<input type="checkbox"/> Spinach, 1 cup	3.7
<input type="checkbox"/> Avocado, 1 whole	2.7
<input type="checkbox"/> Chili peppers, 2 tsp	2



12. Omega-3 Fatty Acids

- Three main types - alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA)
- No RDA, Adequate Intake for ALA for women: 1.1 gm/day, men: 1.6 gm/day

12. Omega-3 Fatty Acids

<u>Food</u>	<u>Omega-3's (gm)</u>
<input type="checkbox"/> Flaxseed oil, 1 tbsp	7 gm
<input type="checkbox"/> Chia seeds, 1 ounce	5 gm
<input type="checkbox"/> Flaxseeds, 2 tablespoons	3
<input type="checkbox"/> Walnuts, 1/2 cup	2.7
<input type="checkbox"/> Sardines, 3 oz	1.4
<input type="checkbox"/> Salmon, 4 oz	1.3
<input type="checkbox"/> Beef, grass fed 4 oz	1.1
<input type="checkbox"/> Soybeans (edamame), 1 cup	1
<input type="checkbox"/> Brussels sprouts, 1 cup	0.2



Probiotics

- Are a combination of live beneficial bacteria and/or yeasts that naturally live in your body (majority are in the gut) and have been shown to benefit both innate and adaptive immune responses
 - Your gut constitutes approximately 60% of your entire immune system
- Influence immune functions by interacting with gut-associated immune cells
- Require regular consumption because they have not been shown to permanently alter your gut microbiome

Probiotics

- More important than quantity is diversity of strains and sources of probiotics for a healthy gut microbiome
- 2 common strains of probiotics are *Lactobacillus* and *Bifidobacterium*

Probiotics

- Add in a variety of sources:

Probiotic foods:

- Kefir
- Yogurt with live active cultures
- Fermented vegetables
- Sauerkraut
- Tempeh
- Kombucha tea
- Kimchi
- Miso



Phytonutrients/Phytochemicals

- Are plant (phyto) chemicals: compounds in plants (fruits, vegetables, whole grains, nuts, seeds, and legumes) that contribute to their color, taste, and smell
- Give carrots their vibrant orange hue, Brussels sprouts their bitter taste, and hot peppers their searing bite

Phytonutrients/Phytochemicals

- A few examples of the way they function:
 - ✓ Enhance immunity and intercellular communications
 - ✓ Prevent DNA damage and help with DNA repair from exposure to toxins
 - ✓ Reduce the kind of oxidative damage to cells that can spark cancer
 - ✓ Supports apoptosis (programmed cell death) of damaged cells
 - ✓ Inhibit the reproduction of cancer cells and slow the growth of tumors

Phytonutrients/Phytochemicals



Color	Phytonutrient	Fruit/veg
White	Allyl sulfide	Leeks, garlic, onions
Red	Lycopene	Tomatoes
Red-purple	Anthocyanins and polyphenols	Grapes, berries, cranberries
Orange	α - and β -carotene	Carrots, mangos, pumpkins
Orange-Yellow	β -cryptoxanthin and flavonoids	Cantaloupe, peaches, tangerines
Yellow-Green	Lutein and zeaxanthin	Spinach, avocados
Green	Glucosinolates	Broccoli, kale

Herbs And Spices To Support The Immune System

- Turmeric/Curcumin + Black pepper
- Ginger
- Cinnamon
- Basil
- Rosemary
- Cayenne pepper
- Cloves
- Oregano
- Garlic



Garlic To Support The Immune System

- Garlic contains allicin which is an antimicrobial compound
- Allicin helps to prevent free radical damage to linings of blood vessels, limiting inflammation
- Allicin forms when garlic is crushed or diced and left in the open air at room temperature for at least ten minutes before being eaten
- Some studies have shown that both fresh garlic as well as aged garlic extract may reduce viral upper respiratory infection severity as well as function in the prevention of infection with viruses that can cause colds

Inflammatory Foods in your Diet to Decrease



Excess calories



Refined and processed
carbohydrates –
Added sugars, white flour



Trans fats



Red meat, processed meats

Inflammatory Foods to Avoid



Online Resources

- Environmental Working Group: www.EWG.org
- Institute for Functional Medicine: www.IFM.org
- Physicians Committee for Responsible Medicine: www.pcrm.org
- Micronutrient Information Center
<https://lpi.oregonstate.edu/mic/health-disease/immunity>
- Dietary Guidelines for Americans 2015–2020, Eighth edition,
www.health.gov/dietaryguidelines/2015/guidelines/

Immune Boosting Breakfast



Immune Boosting Lunch



Immune Boosting Dinner



Immune Boosting Snacks



What Is Your Next Step?



Example 2-Month Action Plan

Month 1

- Start eating more colorful non-starchy vegetables, especially dark green and purple/blue/red fruits, such as...
 - Double your portion of salad or vegetables at dinner
 - Blend spinach into smoothies
 - Snack on fresh or cut up bell peppers and hummus
 - Top yogurt with strawberries

Example 2-Month Action Plan

Month 2

- Start substituting pro-inflammatory foods with anti-inflammatory foods, such as...
 - Instead of sweetened/flavored yogurt purchase unflavored and mix in your own fruit and nuts
 - Prepare a meatless meal one or more times per week using beans or lentils as the protein source
 - Add more herbs and spices to meals
 - Request vegetable toppings rather than meat toppings on foods such as pizza

Next we will be doing a recipe demonstration...

Adapted from the cookbook “Saladish: A Crunchier, Grainier, Herbier, Heartier, Tastier Way with Vegetables” by Ilene Rosen

It's All Green: the Vegetables

Ingredients:

- Choose whichever vegetables look beautiful. Aim for 1-2 pounds of vegetables for 3-4 people
- 4 ounces green beans and/or sugar snap peas, trimmed
- 4 ounces asparagus, trimmed
- 3 ounces zucchini, ends trimmed and cut diagonal into 1/2-inch pieces
- 1 large celery stalk, cut into thirds crosswise and lengthwise into sticks
- 1 medium green bell pepper, cut into 1/2-inch pieces
- 3 ounces fennel bulbs, trimmed root ends and cut off stalks, cut bulbs lengthwise in half and into wedges
- 3 ounces Belgian endives, ends trimmed and leaves separated

Adapted from the cookbook “Saladish: A Crunchier, Grainier, Herbier, Heartier, Tastier Way with Vegetables” by Ilene Rosen

It's All Green: the Vegetables

1. Bring large pot of salted water to a rolling boil and ready a large bowl of ice water
2. Add the green beans and/or snap peas to the boiling water and blanch just until they turn bright green. Remove them with a large slotted spoon and transfer to the ice water. Return the water in the pot to a boil and repeat with the asparagus, blanching until just tender, about 2 minutes depending on thickness, before transferring to the ice water. Set aside.

Adapted from the cookbook “Saladish: A Crunchier, Grainier, Herbier, Heartier, Tastier Way with Vegetables” by Ilene Rosen

Pumpkin Seed Hummus

Ingredients:

- 2 cups pumpkin seeds, toasted
- 2 large garlic cloves
- 2 tablespoons Dijon mustard
- ½ cup rice vinegar
- ⅔ cup of olive oil
- ¼ cup hot water, or more if necessary
- 1 teaspoon salt
- ½ teaspoon pepper

Directions

1. Put the pumpkin seeds and garlic in the bowl of a food processor or in a blender and pulse until uniformly ground, scraping down the sides as necessary. The mixture will be rough and sandy looking.
2. Add the mustard and vinegar and pulse to combine. With the motor running, slowly drizzle in the oil, stopping to scrape down the sides of the bowl. Drizzle in the hot water, processing until it is the consistency of thick hummus. Season to taste with salt and pepper. Transfer to a small serving bowl. Cover and refrigerate until ready to serve.

Adapted from the cookbook “Saladish: A Crunchier, Grainier, Herbier, Heartier, Tastier Way with Vegetables” by Ilene Rosen

Avocado Mint Dip

Ingredients:

- 1 large ripe avocado
- 5 teaspoons fresh lemon juice
- 3 tablespoons chopped fresh mint leaves
- A pinch of cayenne pepper
- ½ tsp salt
- 5 tablespoons water

Directions:

1. Pit the avocado and scoop the flesh into the bowl of a food processor or into a blender.
2. Add the lemon juice, mint, and cayenne, salt and pulse to puree, pouring in the water as you go.
3. Transfer to a small serving bowl. Cover and refrigerate until ready to serve.

Adapted from the cookbook “Saladish: A Crunchier, Grainier, Herbier, Heartier, Tastier Way with Vegetables” by Ilene Rosen

Cilantro Cumin Dip

Ingredients:

- ½ cup olive oil
- 5 teaspoons of cumin seeds
- 2 ½ cups chopped fresh cilantro leaves
- 3 tablespoons rice vinegar
- 1 tablespoon seasoned rice vinegar
- 2 teaspoons Dijon mustard
- ½ tsp salt and ¼ tsp pepper

Directions:

1. Pour the oil into a small saucepan and add the cumin seeds. Bring to a simmer over medium heat and simmer gently for 10 minutes. Let cool
2. Put the cilantro, vinegars, and mustard in the bowl of a food processor or in a blender and pulse to combine. With the motor running, drizzle in the cumin oil and seeds until the mixture is emulsified. Transfer to a small serving bowl. Cover and refrigerate until ready to serve.

References

- Slide 5 – innate and adaptive
- Cologne, Germany: Institute for Quality and Efficiency in Health Care (IQWiG); 2006-. The innate and adaptive immune systems. [Updated 2020 Jul 30]. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK279396/>
- Adaptive immune system:
 - https://en.wikipedia.org/wiki/Cell-mediated_immunity Janeway, Charles; Travers, Paul; Walport, Mark; Shlomchik, Mark (2001). *Immunobiology* (5th ed.). New York: Garland Science. ISBN 978-0-8153-3642-6.
 - Eissmann, Philipp. "[Natural Killer Cells](#)". *British Society for Immunology*. *British Society for Immunology*.
 - Saldana, José. "[Macrophages](#)". *British Society for Immunology*. *British Society for Immunology*.
- Prevalence of Micronutrient Inadequacies
 - Moshe A, Goldman J, Cleveland L. 2005. What We Eat in America, NHANES 2001-2002: Usual nutrient intakes from food compared to dietary reference intakes. U.S. Department of Agriculture, Agricultural Research Service. Available at: <http://www.ars.usda.gov/Services/docs.htm?docid=13793>.
- Nutrient content:
 - <https://ods.od.nih.gov/>
 - www.whf.com

References

- Iron
 - Doherty CP. Host-pathogen interactions: the role of iron. J Nutr. 2007;137(5):1341-1344. [\(PubMed\)](#)
 - Beard JL. Iron biology in immune function, muscle metabolism and neuronal functioning. J Nutr. 2001;131(2S-2):568S-579S; discussion 580S. [\(PubMed\)](#)
 - Cassat JE, Skaar EP. Iron in infection and immunity. Cell Host Microbe. 2013;13(5):509-519. [\(PubMed\)](#)
 - Maggini, S.; Beveridge, S.; Sorbara, J.P.; Senatore, G. Feeding the immune system: The role of micronutrients in restoring resistance to infections. CAB Rev. 2008, 3, 1–21. [CrossRef]
 - <http://www.whfoods.com/genpage.php?tname=nutrient&dbid=70>
 - <https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/>

References

- Zinc
 - Prentice, S. They are what you eat: Can nutritional factors during gestation and early infancy modulate the neonatal immune response? *Front. Immunol.* 2017, 8, 1641. [CrossRef]
 - Savino, W.; Dardenne, M. Nutritional imbalances and infections affect the thymus: Consequences on T-cell-mediated immune responses. *Proc. Nutr. Soc.* 2010, 69, 636–643. [CrossRef]
 - Prasad AS. Zinc in human health: effect of zinc on immune cells. *Mol Med.* 2008;14(5-6):353-357. ([PubMed](#))
 - Ma J, Betts NM. Zinc and copper intakes and their major food sources for older adults in the 1994-96 continuing survey of food intakes by individuals (CSFII). *J Nutr.* 2000;130(11):2838-2843. ([PubMed](#))
 - Briefel RR, Bialostosky K, Kennedy-Stephenson J, McDowell MA, Ervin RB, Wright JD. Zinc intake of the U.S. population: findings from the third National Health and Nutrition Examination Survey, 1988-1994. *J Nutr.* 2000;130(5S Suppl):1367S-1373S. ([PubMed](#))

References

- Vitamin D

- <https://lpi.oregonstate.edu/mic/health-disease/immunity>
- <https://ods.od.nih.gov/factsheets/VitaminD-HealthProfessional/>
- Brennan A, Katz DR, Nunn JD, et al. Dendritic cells from human tissues express receptors for the immunoregulatory vitamin D3 metabolite, dihydroxycholecalciferol. *Immunology*. 1987;61(4):457-461. [\(PubMed\)](#)
- Provvedini DM, Tsoukas CD, Deftos LJ, Manolagas SC. 1,25-dihydroxyvitamin D3 receptors in human leukocytes. *Science*. 1983;221(4616):1181-1183. [\(PubMed\)](#)
- Veldman CM, Cantorna MT, DeLuca HF. Expression of 1,25-dihydroxyvitamin D(3) receptor in the immune system. *Arch Biochem Biophys*. 2000;374(2):334-338. [\(PubMed\)](#)
- Bhalla AK, Amento EP, Clemens TL, Holick MF, Krane SM. Specific high-affinity receptors for 1,25-dihydroxyvitamin D3 in human peripheral blood mononuclear cells: presence in monocytes and induction in T lymphocytes following activation. *J Clin Endocrinol Metab*. 1983;57(6):1308-1310. [\(PubMed\)](#)
- Clark, A.; Mach, N. Role of Vitamin D in the Hygiene Hypothesis: The Interplay between Vitamin D, Vitamin D Receptors, Gut Microbiota, and Immune Response. *Front. Immunol*. 2016, 7, 627. [\[CrossRef\]](#) [\[PubMed\]](#)
- Calder, P.; Prescott, S.; Caplan, M. Scientific Review: The Role of Nutrients in Immune Function of Infants and Young Children Emerging Evidence for Long-Chain Polyunsaturated Fatty Acids; Mead Johnson & Company: Glenview, IL, USA, 2007.

References

- Vitamin D continued
 - Brennan A, Katz DR, Nunn JD, et al. Dendritic cells from human tissues express receptors for the immunoregulatory vitamin D3 metabolite, dihydroxycholecalciferol. *Immunology*. 1987;61(4):457-461. (PubMed)
 - Provvedini DM, Tsoukas CD, Deftos LJ, Manolagas SC. 1,25-dihydroxyvitamin D3 receptors in human leukocytes. *Science*. 1983;221(4616):1181-1183. (PubMed)
 - Veldman CM, Cantorna MT, DeLuca HF. Expression of 1,25-dihydroxyvitamin D(3) receptor in the immune system. *Arch Biochem Biophys*. 2000;374(2):334-338. (PubMed)
 - Bhalla AK, Amento EP, Clemens TL, Holick MF, Krane SM. Specific high-affinity receptors for 1,25-dihydroxyvitamin D3 in human peripheral blood mononuclear cells: presence in monocytes and induction in T lymphocytes following activation. *J Clin Endocrinol Metab*. 1983;57(6):1308-1310. (PubMed)

References

- Omega-3's
 - Galli C, Calder PC. Effects of fat and fatty acid intake on inflammatory and immune responses: a critical review. *Ann Nutr Metab.* 2009;55(1-3):123-139. ([PubMed](#))
 - Calder PC. The relationship between the fatty acid composition of immune cells and their function. *Prostaglandins Leukot Essent Fatty Acids.* 2008;79(3-5):101-108. ([PubMed](#))
 - Calder PC. n-3 polyunsaturated fatty acids, inflammation, and inflammatory diseases. *Am J Clin Nutr.* 2006 Jun;83(6 Suppl):1505S-1519S. doi: 10.1093/ajcn/83.6.1505S. PMID: 16841861.
 - Li H, Ruan XZ, Powis SH, Fernando R, Mon WY, Wheeler DC, Moorhead JF, Varghese Z. EPA and DHA reduce LPS-induced inflammation responses in HK-2 cells: evidence for a PPA R-gamma-dependent mechanism. *Kidney Int.* 2005 Mar;67(3):867-74. doi: 10.1111/j.1523-1755.2005.00151.x. PMID: 15698426.

References

- Vitamin B6
 - Wishart, K. Increased micronutrient requirements during physiologically demanding situations: Review of the current evidence. *Vitamin. Miner.* 2017, 6, 1–16. [CrossRef]
 - Vitamin A
 - Maggini, S.; Beveridge, S.; Sorbara, J.P.; Senatore, G. Feeding the immune system: The role of micronutrients in restoring resistance to infections. *CAB Rev.* 2008, 3, 1–21. [CrossRef]
- Folate
 - Calder, P.; Prescott, S.; Caplan, M. Scientific Review: The Role of Nutrients in Immune Function of Infants and Young Children Emerging Evidence for Long-Chain Polyunsaturated Fatty Acids; Mead Johnson & Company: Glenview, IL, USA, 2007

References

- Vitamin B-12
 - Saeed F., Nadeem M., Ahmed R., Nadeem M., Arshad M., Ullah A. Studying the impact of nutritional immunology underlying the modulation of immune responses by nutritional compounds—A review. *Food Agric. Immunol.* 2016;27:205–229. doi: 10.1080/09540105.2015.1079600
 - Tamura J, Kubota K, Murakami H, et al. Immunomodulation by vitamin B12: augmentation of CD8+ T lymphocytes and natural killer (NK) cell activity in vitamin B12-deficient patients by methyl-B12 treatment. *Clin Exp Immunol.* 1999;116(1):28-32. ([PubMed](#))

References

- Selenium
 - Maggini, S.; Beveridge, S.; Sorbara, J.P.; Senatore, G. Feeding the immune system: The role of micronutrients in restoring resistance to infections. *CAB Rev.* 2008, 3, 1–21. [[CrossRef](#)]
 - Saeed F., Nadeem M., Ahmed R., Nadeem M., Arshad M., Ullah A. Studying the impact of nutritional immunology underlying the modulation of immune responses by nutritional compounds—A review. *Food Agric. Immunol.* 2016;27:205–229. doi: 10.1080/09540105.2015.1079600. [[CrossRef](#)] [[Google Scholar](#)]
- Vitamin E
 - Saeed F., Nadeem M., Ahmed R., Nadeem M., Arshad M., Ullah A. Studying the impact of nutritional immunology underlying the modulation of immune responses by nutritional compounds—A review. *Food Agric. Immunol.* 2016;27:205–229. doi: 10.1080/09540105.2015.1079600.

References

- Probiotics
 - Jiao Y, Wu L, Huntington ND, Zhang X. Crosstalk between gut microbiota and innate immunity and its implication in autoimmune diseases. *Front Immunol*. 2020;11:282. doi:[10.3389/fimmu.2020.00282](https://doi.org/10.3389/fimmu.2020.00282)
 - Yue B, Luo X, Yu Z, Mani S, Wang Z, Dou W. Inflammatory bowel disease: a potential result from the collusion between gut microbiota and mucosal immune system. *Microorganisms*. 2019;7(10):440. doi:[10.3390/microorganisms7100440](https://doi.org/10.3390/microorganisms7100440)
 - de Vrese M, Schrezenmeir J. Probiotics, prebiotics, and synbiotics. *Adv Biochem Eng Biotechnol*. 2008;111:1-66. ([PubMed](#))
 - Ruemmele FM, Bier D, Marteau P, et al. Clinical evidence for immunomodulatory effects of probiotic bacteria. *J Pediatr Gastroenterol Nutr*. 2009;48(2):126-141. ([PubMed](#))
 - Vieira AT, Teixeira MM, Martins FS. The role of probiotics and prebiotics in inducing gut immunity. *Front Immunol*. 2013;4:445. ([PubMed](#))
 - Oelschlaeger TA. Mechanisms of probiotic actions - A review. *Int J Med Microbiol*. 300(1):57-62. ([PubMed](#))
 - Kok CR, Hutkins R. Yogurt and other fermented foods as sources of health-promoting bacteria. *Nutr Rev*. 2018;76(Suppl 1):4-15. doi:[1093/nutrit/nuy056](https://doi.org/10.93/nutrit/nuy056)
 - Azad MAK, Sarker M, Wan D. Immunomodulatory effects of probiotics on cytokine profiles. *Biomed Res Int*. 2018;2018:8063647. doi:[1155/2018/8063647](https://doi.org/1155/2018/8063647)

References

- Garlic
 - Nantz MP, Rowe CA, Muller CE, Creasy RA, Stanilka JM, Percival SS. Supplementation with aged garlic extract improves both NK and CD4+ T cell function and reduces the severity of cold and flu symptoms: a randomized, double-blind, placebo-controlled nutrition intervention. *Clin Nutr*. 2012;31(3):337-344. doi:[10.1016/j.clnu.2011.11.019](https://doi.org/10.1016/j.clnu.2011.11.019)
 - Percival SS. Aged garlic extract modifies human immunity. *J Nutr*. 2016;146(2):433S-436S.
- Phytonutrients
 - www.harvardhealth.edu