**Nutrition and the Eyes**

**Introduction**

Nutrition and health are lifelong concerns for your patient. Early dietary and lifestyle changes should be made before a problem develops. As a patient ages, many factors can affect overall health and the health of the eyes. Good nutrition and exercise goals set early in life usually define good habits for life. The idea that vitamins and minerals fuel the body and protect vision for the long haul is being taught at much earlier ages. According to Dr. Ivana Kim of Harvard Medical School, “Studies suggest that eating a diet rich in certain nutrients may help the retina to fight free radicals which could damage the retina.” The National Eye Institute has reported that proper levels of vitamins C, E, beta C, zinc and copper have reduced the advancement of age related macular degeneration (ARMD) by 25%; and the risk of moderate vision loss by 19%.\(^1\) It is not certain if ocular changes due to diet can be considered permanent, but even delaying vision loss by seven years or more is of great benefit to most patients.\(^18\)

A healthy diet has many benefits and includes a variety of fresh fruit and vegetables, lean meats, dairy, fish, and nuts. Such a diet is considered a good source of the antioxidant vitamins and minerals that promote good eye health. Plus, there is no evidence that nutrient-dense diets are harmful. In fact, a well-balanced diet is associated with a reduced risk of death due to cancer, cardiovascular disease, and all other causes.\(^13\) Additionally; there is a direct correlation between the colors of the foods being eaten and the nutrients being provided to the eye.

Some other health changes to preserve the eye are: if a patient smokes, quit; use UV protection and have an annual eye exam for early detection of any problems. The body and the eyes are connected and if vision diminishes or is lost, a patient’s entire life is severely affected. Regular exercise and a balanced diet go hand in hand for the general wellbeing and the protection of health.

Some age-related eye diseases may be slowed by the intake of vitamins and minerals consumed in food, or taken as supplements. A patient should consult with his or her doctor before making any dietary changes. As we age, the overall importance of good nutrition increases for a number of reasons. The aging body may have a harder time digesting and
processing the vitamins needed from food alone. Complicating this is the fact that many people cannot absorb or utilize nutrients as efficiently as they age.

Since the eyes are probably the most important organ connected to the senses, certain vitamins and nutrients can help protect the eye from age-related diseases such as age-related macular degeneration (ARMD). Poor nutrition can adversely affect vision in many ways, including restriction of the ability to wear contact lenses. Many causes of blindness are preventable through early examination, early treatment and good nutrition.

The National Eye Institute (NEI) reports that more than 9.3 million Americans have age related macular degeneration (ARMD), one of the leading causes of vision loss for people over 60 years of age. More than 23 million people have cataracts, and about 2.1 million have glaucoma. Diabetic retinopathy affects the vision of more than half of the 25.8 million people over 18 years who have diabetes. Vision loss ranks ahead of memory and hearing loss as measured by the number of people affected.

Patients who control blood pressure, cholesterol, and blood glucose are already taking important steps to protect their health and vision.

There are many dietary components that can directly benefit eye health, but can be difficult to acquire from the typical American diet. Those with blood glucose control issues can have even more trouble getting these eye health nutrients as they need to be extra careful of what they put in their bodies. Supplementation is an effective option for these patients to get the specific ingredients they need to protect their eyes. According to the Ocular Nutrition Society, macular pigment optical density (MPOD) is significant for retinal protection and the dietary components of MPOD are not always easy to obtain with the typical American diet.
Nutrients

Please remember that any of the nutrients mentioned as healthy for the eyes might be contraindicated for a patient due to other conditions. Each patient must exercise caution and work with his or her doctor when determining dietary needs.

According to the Age-Related Eye Diseases Study (AREDS), funded by the National Eye Institute, and other research, foods rich in vitamins C and E, zinc, lutein, zeaxanthin, and omega-3 fatty acids are good for eye health as well as general health. These nutrients are linked to a lower risk for age-related macular degeneration (ARMD), cataract and dry-eye syndrome. Choosing healthier foods is a good thing no matter how early or late in life the choice is made. In the AREDS study, participants took 50 milligrams daily of beta carotene, 500 milligrams daily of vitamin C, 400 international units of vitamin E, and 80 milligrams of zinc.

Eye-healthy food choices include citrus fruits, vegetable oils, nuts, whole grains, orange and yellow vegetables or fruits, dark-green leafy vegetables and cold water fish. People who have diabetes, AMD, or are at risk for these diseases can also benefit by following a low-glycemic (low-GI) index diet. Low GI foods have less impact on blood sugar fluctuations, and are digested more slowly so that the glucose is absorbed more slowly. Sugars and white flours may increase the risk of age-related eye disease. Opting for whole grains which do not have the same risks is a wise nutritional step. For caloric or ingredient restricted diets, eye health supplements are available.

This is promising news for people who are at risk for or who already have AMD. But before stocking up on these supplements, patients should talk with their ophthalmologist. Some people should not take large doses of antioxidants or zinc for medical reasons.

People who smoke should ask their physician before taking the original AREDS supplement, because one of the ingredients, beta carotene, has been associated with a higher risk of lung cancer in smokers or people who have recently quit smoking. An alternate version of the original AREDS supplement formulated to be safe for smokers is available. The AREDS 2 formula does not contain beta carotene.

A study of women also showed overall benefits from taking supplements of folic acid and vitamins B6 and B12.
Vitamins and nutritional supplements are not a cure for eye disease, nor will they give back vision that has already been lost. But good nutrition at all ages is vital for your entire body, and plays an important role in maintaining healthy eyes. Also, much of this research deals with age-related macular degeneration, or AMD, which is a major problem. According to the National Eye Institute it is expected that the number of people who have AMD will double by the year 2020.

AREDS and AREDS 2

Not all evidence proves that taking nutritional supplements can prevent problems in people who currently do not have vision problems from getting AMD in the future. However, Dr. Emily Chew, deputy director of the Division of Epidemiology and Clinical Research at the National Eye Institute, and a lead researcher in the AREDS study, concluded that the recommended ingredients were certainly not harmful.¹

Dr. Penny Asbell, director of the Cornea Service and Refractive Surgery Center at Mount Sinai Medical Center in New York, recommended supplements only for those who already experience specific types of vision loss. For example, Dr. Asbell indicated that supplements may have more benefit to those who suffer from dry AMD, because of the slower progression of vision loss, rather than the more severe wet AMD.

The original formula for the AREDS study was:

- 500 mg of vitamin C
- 400 IUs of vitamin E
- 15 mg of beta carotene
- 80 mg zinc (zinc oxide)
- 2 mg copper (cupric oxide)

The AREDS2 formula consisted of:

- 10 mg of lutein
- 2 mg of zeaxanthin
- 1,000 mg of omega 3 fatty acids (350 mg DHA and 650 mg EPA)
Changes made for the AREDS2 study were that vitamins C and E were replaced by lutein and zeaxanthin; omega-3 fatty acids replaced copper; the amount of zinc was decreased; and beta carotene was eliminated altogether. Beta carotene was eliminated due to the potential increase in the incidence of lung cancer in certain at-risk patients. Zinc was removed due to the possible side effects of abdominal distress, vomiting and diarrhea. High doses of zinc over an extended period of time can cause serious health problems. Copper was removed because it was no longer needed to counterbalance certain nutritional effects of zinc.

**Age-related macular degeneration** (ARMD) creates deposits or blood vessels under the macula which can damage the retina. In some cases, ARMD advances so slowly that people do not notice major vision problems. The AREDS study (continued through the end of 2019) shows that a diet rich in fruits and vegetables and at least two servings of fish per week may prevent changes to the retina. Epidemiologic evidence shows that the amount of macular pigment is inversely associated with the incidence of ARMD.³

**OMEGA’s and other fatty acids**

Omega 3 is an essential fatty acid found in oily fish, as well as some nuts and seeds, such as walnuts and flaxseed. Studies continue to show a relationship between Omega 3 levels and vision. The AREDS 2 formula used for the study is: Vitamin C (500 mg); Vitamin E (400 IU); Lutein (10 mg); Zeaxanthin (2 mg); Zinc oxide (80 mg); and Copper oxide (2 mg). Based on the observations from AREDS and AREDS2: lutein, zeaxanthin, omega-3 fatty acids, EPA, and DHA can reduce the risk of developing advanced AMD. Omega 3 fatty acids are a major regulator of molecular pathways, and areas of cellular and organ function. The eye is an organ that benefits substantially with the inclusion of Omega 3 fatty acids in the diet of a patient.¹⁴

Dr. Barbara Blodi, associate professor at the department of ophthalmology at the University of Wisconsin, and a lead researcher on the AREDS2 trial, indicates that fatty acids in the retina help the cones and rods to function well. According to Dr. Blodi, if AMD could be prevented it would be an important step to help older citizens to stay independent.¹

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Daily dosage</th>
<th>% daily value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C (ascorbic acid)</td>
<td>452 mg</td>
<td>754</td>
</tr>
<tr>
<td>Vitamin E (DL-α-tocopheryl acetate)</td>
<td>400 IU</td>
<td>1334</td>
</tr>
<tr>
<td>Zinc (zinc oxide)</td>
<td>69.6 mg</td>
<td>464</td>
</tr>
<tr>
<td>Copper (cupric oxide)</td>
<td>1.6 mg</td>
<td>80</td>
</tr>
<tr>
<td>Vitamin A (β-carotene)</td>
<td>28,640 IU (17mg)</td>
<td>572</td>
</tr>
</tbody>
</table>

Both omega-3 and omega-6 **essential fatty acids** (EFAs) are the precursors of eicosanoids, locally acting hormones that mediate inflammatory processes. The long-chain omega-3 fatty acids, EPA and docosahexaenoic acid (DHA) are important for eye health. Ingesting proper amounts of the long-chain omega-3 fatty acids EPA and DHA from oily fish or supplements may reduce the risk of several eye diseases — especially dry eyes. DHA is a key fatty acid that is
already present in large amounts in the retina for photo-retinal transduction. Biophysical and biochemical properties of DHA may affect photoreceptor-membrane function by altering permeability, fluidity, thickness, lipid-phase properties, and the activation of membrane-bound proteins.\textsuperscript{10} A diet deficient in DHA could lead to reduced visual capacity.\textsuperscript{21}

There is no recommended dietary allowance (RDA) for EPA/DHA, so the optical industry uses the dietary recommendations set up by the American Heart Association for EPA/DHA, which are largely based on cardiovascular health.

\textbf{Docosahexaenoic acid (DHA)} is naturally concentrated in the retina of the eye and promotes healthy retinal function. DHA is also important for brain and eye development during infancy. DHA deficiency can impair vision, especially in children. Eating larger amounts of fish or omega-3 may help promote macular health and reduce dry-eye syndrome. DHA is important for eye health maintenance.\textsuperscript{10}

The best dietary source of EPA and DHA is oily fish or omega-3 supplements derived from fish or microalgae that are widely available.

<table>
<thead>
<tr>
<th>Fish</th>
<th>EPA + DHA, g/3 oz (85g) serving (edible portion)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trout</strong></td>
<td></td>
</tr>
<tr>
<td>Farmed</td>
<td>0.15</td>
</tr>
<tr>
<td>Wild</td>
<td>0.20</td>
</tr>
<tr>
<td>Crab, Alaskan king</td>
<td>0.35</td>
</tr>
<tr>
<td>Flounder/sole</td>
<td>0.42</td>
</tr>
<tr>
<td>Haddock</td>
<td>0.20</td>
</tr>
<tr>
<td>Halibut</td>
<td>0.40 – 1.00</td>
</tr>
<tr>
<td><strong>Herring</strong></td>
<td></td>
</tr>
<tr>
<td>Atlantic</td>
<td>1.71</td>
</tr>
<tr>
<td>Pacific</td>
<td>1.81</td>
</tr>
<tr>
<td>Mackeral</td>
<td>0.34 – 1.57</td>
</tr>
<tr>
<td><strong>Salmon</strong></td>
<td></td>
</tr>
<tr>
<td>Atlantic, farmed</td>
<td>1.09 – 1.83</td>
</tr>
<tr>
<td>Atlantic, wild</td>
<td>0.90 – 1.56</td>
</tr>
<tr>
<td>Chinook</td>
<td>1.48</td>
</tr>
<tr>
<td>Sockeye</td>
<td>0.68</td>
</tr>
<tr>
<td><strong>Sardines</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.98 – 1.70</td>
</tr>
<tr>
<td><strong>Shrimp, mixed species</strong></td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Tuna</strong></td>
<td></td>
</tr>
<tr>
<td>Fresh</td>
<td>0.24 – 1.28</td>
</tr>
<tr>
<td>White, canned in water, drained</td>
<td>0.73</td>
</tr>
</tbody>
</table>

\textit{Abbreviations: EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid.}

**Gamma-Linolenic Acid**

Gamma-linolenic acid (GLA) is an \textbf{omega-6} fatty acid found in small amounts in the modern diet. Unlike many other omega-6 fatty acids, GLA appears to have anti-inflammatory
The richest sources of GLA are evening primrose oil and starflower oil. One randomized controlled study gave women with dry eyes a daily dose of evening primrose oil plus 300 mg of GLA. This study noted that dry-eye symptoms improved over a 6-month period.1

**General eye problems**

**Hyperopia and myopia** are conditions in which images are not focused on the retina and may occur if the focusing power is too weak or too strong. In *astigmatism*, the cornea has two curves and prevents a perfectly spherical shape. While refractive errors are not essentially helped through nutrition, dry-eye syndrome is an eye condition in which tear film evaporation is high or tear production is low. Vitamin A deficiency can exacerbate dry-eye syndrome. Since the tear is technically a refracting mechanism on the cornea, a deficient tear film can affect perceived vision.

**Dry-Eye Syndrome**

The eyes are producing tears all the time and healthy eyes have a film that remains stable between each blink. In some parts of the world, where malnutrition results in vitamin A deficiency, dry-eye syndrome is a severe problem.

Symptoms of dry eye include stinging and burning sensations of the eyes, a feeling of dryness in the eyes, eye sensitivity to smoke, eye fatigue even after reading for a relatively short period, sensitivity to light, blurred vision, and eyelid adherence upon waking. Other complications are eye redness, painful eyes, and eyesight deterioration.

When the tear evaporation is high or tear production is low, the eyes dry out and become inflamed. The initial treatment may be the use of eye drops or ointments. If the dryness is due to rapid evaporation of the tear as determined by a break-up time (BUT) test, it is the lipid layer of the tear film that is deficient. Produced by the meibomian gland, the lipid layer is heavily dependent on fatty acids provided by good nutrition. One study revealed that taking EPA and DHA supplements daily for three months significantly reduced dry eye symptoms.1

**Other common eye diseases**

The risk of developing an eye disease increases with age. In addition to dry eye, the most common eye diseases include: cataracts, glaucoma, dry-eye disease and macular degeneration.
Cataracts affect vision in over 40% of people between ages 50 and 65 years, over 60% of people age 66 and older, and up to 90% of people over 90 years. Frequent changes in prescriptions for eyeglasses may be needed as the cataracts mature. The lack of opacity of the crystalline lens results from the accumulation of damaged cell protein, and is usually nuclear (central) or cortical (peripheral). The chance of developing cataracts can be greatly reduced by taking certain vitamins before the cataracts start to appear. However, in advanced cases of cataract formation, surgery is the best option by removing a cloudy lens and replacing it with an artificial intra-ocular lens.

Increased intra-ocular pressure (IOP) is just one sign of glaucoma, yet it is possible to have elevated IOP without the accompanying glaucoma. Glaucoma is actually the damage to the optic nerve caused by increased IOP and is an age-related eye disease that affects about 1 in every 200 people. Glaucoma has no early symptoms and usually goes undetected until it is fairly advanced. Unfortunately, glaucoma affects African Americans at a rate three times more than that of the Caucasian population.

While nutrition to prevent glaucoma has not been specifically cited, it is under study. Early results indicate that decreased risk of glaucoma is seen among patients who consumed more vitamin A, folate, a-carotene and b-carotene, plus the antioxidants lutein and zeaxanthin. When glaucoma does damage cells, the glutamate released usually helps neural transmission, but an excess of glutamate kills the cell. Magnesium minimizes damage from glutamate.

Diabetic retinopathy is a major cause of visual impairment and blindness and develops when high blood sugar levels damages the blood vessels in the retina. Nutritional changes can help to slow this damaging process.\textsuperscript{13}

**Single nutrients**

In addition to combined nutrients that contribute to a healthy eye, such as those in the AREDS studies, the evaluation of single nutrients is warranted. Studies are not consistent due to varying strengths of the nutrients being tested, and it could be that the individual nutrients may need to act synergistically in order to provide ocular protection. Let’s look at these individual nutrients and the best sources to obtain them.
The more commonly known ocular nutrients can be found in foods or taken as supplements.

- Vitamin A: may protect against night blindness and dry eyes
- Omega 3 fatty acids: may prevent macular degeneration and dry eyes (previously discussed)
- Vitamin C: may reduce risks of cataracts and macular degeneration (previously discussed)
- Vitamin D: may reduce risks of macular degeneration
- Zinc: may reduce risks of night blindness
- Vitamin E: may reduce the risk of advanced macular degeneration

<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Description</th>
<th>Recommendations</th>
<th>Mean ± SEM</th>
<th>Weighted percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin C, mg/day</td>
<td>Men: 90, Women: 75</td>
<td>–</td>
<td>9.1 ± 2.1</td>
<td>P1 4.5, P5 12.1, P10 21.2, P25 38.0, P50 73.9, P75 126.1, P90 196.3, P95 247.4, P99 322.7</td>
</tr>
<tr>
<td>Vitamin E, mg/day</td>
<td>Men: 15, Women: 15</td>
<td>–</td>
<td>8.6 ± 0.4</td>
<td>P1 1.6, P5 3.3, P10 3.8, P25 5.4, P50 7.5, P75 10.3, P90 14.5, P95 17.8, P99 30.5</td>
</tr>
<tr>
<td>β-carotene, mg/day</td>
<td>Men: 3–6 mg**</td>
<td>–</td>
<td>2.6 ± 0.1</td>
<td>P1 0.1, P5 0.2, P10 0.3, P25 0.6, P50 1.4, P75 3.1, P90 6.2, P95 9.0, P99 14.8</td>
</tr>
<tr>
<td>Zinc, mg/day</td>
<td>Men: 11, Women: 8</td>
<td>–</td>
<td>13.5 ± 0.2</td>
<td>P1 4.2, P5 5.7, P10 6.7, P25 8.8, P50 12.3, P75 16.5, P90 22.4, P95 25.8, P99 37.5</td>
</tr>
<tr>
<td>Lutein/zeaxanthin, mg/day</td>
<td>Men: 6 mg**, Women: 6 mg**</td>
<td>–</td>
<td>1.2 ± 0.1</td>
<td>P1 0.1, P5 0.2, P10 0.3, P25 0.6, P50 1.0, P75 1.8, P90 2.9, P95 4.9, P99 13.5</td>
</tr>
<tr>
<td>EPA + DHA, mg/day</td>
<td>Men: 250–1000**, Women: 250–1000**</td>
<td>–</td>
<td>120.6 ± 6.1</td>
<td>P1 1.5, P5 5.0, P10 9.0, P25 19.5, P50 47.5, P75 126.5, P90 278.0, P95 471.5, P99 1027.5</td>
</tr>
</tbody>
</table>

Notes: Values in bold indicate values less than RDA or recommendation based on current knowledge of relationships between intakes and risk of disease. **Recommendation based on Panel on Dietary Antioxidants and Related Compounds, Subcommittee on Upper Reference Levels of Nutrients. **Recommendation based on Standing Committee on the Scientific Evaluation of Dietary Reference Intakes. ***Recommendation based on Seldin et al. **Recommendation based on Kris-Etherton et al.

Abbreviations: NHANES, National Health and Nutrition Examination Survey; RDA, recommended dietary allowance; SEM, standard error of mean; EPA, eicosapentaenoic acid; DHA, docosahexaenoic acid; DRIs, dietary reference intakes.

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Vitamin A

Vitamin A deficiency is one of the most common causes of blindness in the world, and was one of the first vitamins to be studied in detail for its effects on the eye. This vitamin is essential for maintaining the retinal light-sensing cells, or photoreceptors. A severe lack of vitamin A can result in night blindness, dry eyes, or even more serious conditions depending on the severity of the deficiency. Vitamin A helps the cornea to form an effective barrier against bacteria and viruses. Vitamin A also promotes good vision in low lighting conditions. Vitamin A is primarily found in animal-derived foods, with the richest dietary sources including liver, egg yolks, and dairy products.
Your body can convert into vitamin A certain antioxidant plant compounds called provitamin A carotenoids, found in high amounts in some fruits and vegetables. Provitamin A carotenoids can provide around 30% of the vitamin A requirements, on average. The most efficient of them is beta-carotene, which is found in high amounts in kale, spinach, and carrots. Beta-carotene in the recommended concentrations can lower the risk of various diseases. However, caution is needed for any patient with an increased risk of developing lung cancer.\(^{21}\)

There are forms of vitamin A called retinols. Retinols have numerous functions in the body, including assisting the bioelectrical process of vision (preventing loss of night vision), eliminating damaged cells from the body, and helping to prevent dry macular degeneration. Vitamin A palmitate assists with day to day vision.\(^{1}\)

**Vitamin C**

Vitamin C, also known as ascorbic acid, is a water soluble vitamin. Vitamin C is a strong antioxidant needed for the production of collagen and connective tissue. These connective fibers provide firm but flexible structures in the body, including the eye. The eyes require high amounts of antioxidants, more than many other organs. The concentration of vitamin C is higher in the aqueous humor of the eye than in any other body fluid.

The level of vitamin C in the aqueous humor is directly proportional to dietary intake. Vitamin C concentration can be increased taking supplements or eating foods rich in vitamin C such as citrus fruit, berries, tomatoes, bell peppers, guavas, kale and broccoli.
Observational studies show that people with cataracts tend to have a low antioxidant status, and that patients who take vitamin C supplements are less likely to get cataracts. In fact, a study performed in the United Kingdom showed that a 10-year use of vitamin C resulted in 33% decreased odds of developing a cortical cataract. The need for antioxidants is not a short term fix, but must be permanently built into a healthy diet.\textsuperscript{8}

The retina is a perfect environment for the production of free radicals and reactive oxygen species (ROS). Free radicals lead to disease by causing tissue injury and inflammation.

Oxidants are the byproducts of oxidation, and oxidation is the process where cells use oxygen to produce energy. In the attempt to gain the missing electrons, the free radicals react with cell structures.

The eye has a high metabolic rate, and thus needs more antioxidant protection. Antioxidants offer some protection from the effects of free radicals, which contain molecules with unpaired neutrons.

Causes of lens oxidants are smoking, excessive hard alcohol consumption, elevated carbohydrate and fat levels, UV and blue light exposure, and a body mass index (BMI) of over 30. (To determine BMI, a NIH calculator is found at: https://www.nhlbi.nih.gov/health/educational/losewt/BMI/bmicalc.htm.

Vitamin C is a small antioxidant molecule that provides a secondary defense for the macula. Vitamin C is concentrated in the retina and aqueous humor.

Many patients do not consume enough vitamin C to meet minimum standards. Vitamin C is available as natural or synthetic l-ascorbic acid, as well as sodium ascorbate. There is little scientific evidence that any form is absorbed more efficiently than another. \textsuperscript{21}
<table>
<thead>
<tr>
<th>Food</th>
<th>Serving</th>
<th>Milligrams (α-tocopherol equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blackberries</td>
<td>½ cup (72 g)</td>
<td>15</td>
</tr>
<tr>
<td>Blueberries</td>
<td>½ cup (74 g)</td>
<td>7</td>
</tr>
<tr>
<td>Broccoli, raw</td>
<td>½ cup (44 g)</td>
<td>39</td>
</tr>
<tr>
<td>Brussels sprouts, cooked</td>
<td>½ cup (78 g)</td>
<td>48</td>
</tr>
<tr>
<td>Cabbage raw, chopped</td>
<td>½ cup (45 g)</td>
<td>16</td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>½ medium (69 g)</td>
<td>25</td>
</tr>
<tr>
<td>Cauliflower, cooked</td>
<td>½ cup (62 g)</td>
<td>28</td>
</tr>
<tr>
<td>Grapefruit, raw, pink</td>
<td>½ medium (128 g)</td>
<td>44</td>
</tr>
<tr>
<td>Grapefruit juice</td>
<td>1 cup (247 g)</td>
<td>94</td>
</tr>
<tr>
<td>Green peppers, raw</td>
<td>½ cup (46 g)</td>
<td>37</td>
</tr>
<tr>
<td>Orange</td>
<td>1 medium (141 g)</td>
<td>63</td>
</tr>
<tr>
<td>Orange juice</td>
<td>1 cup (248 g)</td>
<td>124</td>
</tr>
<tr>
<td>Papaya</td>
<td>1 small (157 g)</td>
<td>96</td>
</tr>
<tr>
<td>Potato, boiled with peel</td>
<td>2 ½” diameter (136 g)</td>
<td>18</td>
</tr>
<tr>
<td>Spinach, raw, chopped</td>
<td>1 cup (38 g)</td>
<td>11</td>
</tr>
<tr>
<td>Strawberries, raw, sliced</td>
<td>½ cup (83 g)</td>
<td>49</td>
</tr>
<tr>
<td>Tomato, raw</td>
<td>1 medium (123 g)</td>
<td>17</td>
</tr>
<tr>
<td>Tomato juice</td>
<td>1 cup (240 g)</td>
<td>22</td>
</tr>
<tr>
<td>Turnip greens, cooked</td>
<td>½ cup (72 g)</td>
<td>20</td>
</tr>
</tbody>
</table>

**Vitamin E**

Vitamin E consists of a family of eight fat-soluble antioxidants: four tocopherols and four tocotrienols. The main function of α-tocopherol in humans appears to be that of an antioxidant. α-Tocopherol attacks free radicals to prevent lipid oxidation. This is important because the retina contains highly concentrated fatty acids. Fatty acids are also involved in the formation of the lipid layer of the tear.

The RDA standard for vitamin E is 15 mg/day of α-tocopherol for both women and men (≥19 years). Only men and women in the 95th percentile of vitamin E intake or greater have intakes of vitamin E provided by diet that meets the RDA standard.

When a molecule of α-tocopherol neutralizes a free radical, it is altered so that it loses its antioxidant capacity. However, other antioxidants, such as vitamin C can regenerate the antioxidant ability of α-tocopherol. A-tocopherol also improves vasodilation. The best dietary sources of vitamin E include almonds, sunflower seeds, and vegetable oils like flaxseed oil.

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving</th>
<th>Milligrams (α-tocopherol equivalents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds, slivered</td>
<td>¼ cup (27 g)</td>
<td>7</td>
</tr>
<tr>
<td>Corn oil</td>
<td>1 tb (14 g)</td>
<td>2</td>
</tr>
<tr>
<td>Peanuts</td>
<td>¼ cup (37 g)</td>
<td>3</td>
</tr>
<tr>
<td>Peanut butter, smooth</td>
<td>2 tb (32 g)</td>
<td>3</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td>¼ cup (35 g)</td>
<td>12</td>
</tr>
<tr>
<td>Safflower oil</td>
<td>1 tb (14 g)</td>
<td>5</td>
</tr>
<tr>
<td>Soybean oil</td>
<td>1 tb (14 g)</td>
<td>1</td>
</tr>
<tr>
<td>Wheat-germ oil</td>
<td>1 tb (14 g)</td>
<td>20</td>
</tr>
</tbody>
</table>
**β-Carotene**

β-Carotene belongs to a class of compounds called carotenoids and is an orange pigment commonly found in fruits and vegetables and. β-carotene is the primary dietary source of provitamin A. The AREDS-1 trial showed evidence that β-carotene may play a role in age-related eye disease. According to AREDS, supplementation with β-carotene along with vitamins C and E, zinc, and copper reduced the risk of developing advanced AMD.

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving</th>
<th>Milligrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricots, raw</td>
<td>1 medium (35 g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Broccoli, cooked</td>
<td>½ cup (78 g)</td>
<td>0.8</td>
</tr>
<tr>
<td>Cantaloupe, raw</td>
<td>½ cup (78 g)</td>
<td>1.2</td>
</tr>
<tr>
<td>Carrots, raw</td>
<td>1 medium (61 g)</td>
<td>5.3</td>
</tr>
<tr>
<td>Carrots, cooked</td>
<td>½ cup (78 g)</td>
<td>6.3</td>
</tr>
<tr>
<td>Kale, cooked</td>
<td>½ cup (65 g)</td>
<td>3.7</td>
</tr>
<tr>
<td>Lettuce, romaine</td>
<td>½ cup (38 g)</td>
<td>0.5</td>
</tr>
<tr>
<td>Pepper, red, sweet</td>
<td>1 medium (119 g)</td>
<td>2.9</td>
</tr>
<tr>
<td>Pumpkin, cooked</td>
<td>½ cup (123 g)</td>
<td>8.5</td>
</tr>
<tr>
<td>Spinach, cooked</td>
<td>½ cup (95 g)</td>
<td>5.0</td>
</tr>
<tr>
<td>Spinach, raw</td>
<td>1 cup (38 g)</td>
<td>2.1</td>
</tr>
<tr>
<td>Sweet potato, cooked</td>
<td>½ cup (164 g)</td>
<td>15.5</td>
</tr>
<tr>
<td>Winter squash, cooked</td>
<td>½ cup (85 g)</td>
<td>3.9</td>
</tr>
</tbody>
</table>

A high intake of dietary β-carotene is considered to have no adverse effects on the health of the average patient, but it can have an adverse effect of patients who are at risk for lung cancer. The reasons for the increase in lung cancer risk are thought to be due to the pro-oxidant effects of high doses of β-carotene in an oxidative stressed environment, such as a smoker's lung.

**Zinc**

Zinc is important in maintaining the health of the retina, since it is an essential constituent of many enzymes needed for optimal metabolism of the eye. Zinc ions play an important role in scavenging superoxide radicals. Zinc is important for antioxidant and immune function of the eye; as well as playing a role in the structure of cell membranes. Zinc is vital to many biological functions and helps the immune system fight off invading bacteria and viruses. The body uses zinc to produce many proteins, including deoxyribonucleic acid (DNA), the building blocks for all tissue. Zinc participates in cell signaling which influences nerve-impulse transmission; the eye is heavily dependent on the nerve-impulse transmission of signals to the brain.

The macula contains protective antioxidant enzymes that need zinc to properly function. These zinc-needy enzymes include glutathione peroxidase, catalase, and superoxide dismutase; these enzymes work together with zinc.

The recommended daily allowance (RDA) for zinc is 11 mg/day for men and 8 mg/day for women (≥19 years). However, men and women in the 25th percentile of zinc intake have intakes of dietary zinc that do not meet the RDA. Further, zinc absorption is lower in individuals on vegetarian diets. In these cases, supplements are needed. However, too much zinc can
cause copper deficiency anemia, if you take a supplement that contains zinc, it also should include copper.

Good dietary sources of zinc include oysters, crab, wheat germ, peanuts and dark chocolate, and fortified cereals.

<table>
<thead>
<tr>
<th>Food</th>
<th>Serving</th>
<th>Milligrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds, dry roasted</td>
<td>1 ounce (28 g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Beans, baked</td>
<td>½ cup (127 g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Beef, cooked</td>
<td>3 ounces (85 g)</td>
<td>1.0</td>
</tr>
<tr>
<td>Cashews</td>
<td>1 ounce (28 g)</td>
<td>1.6</td>
</tr>
<tr>
<td>Cereal, cooked, multigrain</td>
<td>1 cup (100 g)</td>
<td>0.6</td>
</tr>
<tr>
<td>Cheese, cheddar</td>
<td>1 ounce (28 g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Chicken (dark meat, cooked)</td>
<td>3 ounces (85 g)</td>
<td>1.8</td>
</tr>
<tr>
<td>Chickpeas (garbanzo beans)</td>
<td>½ cup (82 g)</td>
<td>1.3</td>
</tr>
<tr>
<td>Corn flakes</td>
<td>1 cup (28 g)</td>
<td>0.3</td>
</tr>
<tr>
<td>Crab, dungeness, cooked</td>
<td>3 ounces (85 g)</td>
<td>4.7</td>
</tr>
<tr>
<td>Milk</td>
<td>1 cup (244 g)</td>
<td>1.2</td>
</tr>
<tr>
<td>Oysters, cooked</td>
<td>3 medium (75 g)</td>
<td>24.9</td>
</tr>
<tr>
<td>Peanuts</td>
<td>1 ounce (28 g)</td>
<td>0.9</td>
</tr>
<tr>
<td>Pork, cooked</td>
<td>3 ounces (85 g)</td>
<td>2.2</td>
</tr>
<tr>
<td>Turkey (dark meat, cooked)</td>
<td>3 ounces (85 g)</td>
<td>3.8</td>
</tr>
<tr>
<td>Yogurt, fruit</td>
<td>1 cup (227 g)</td>
<td>1.8</td>
</tr>
</tbody>
</table>

Copper

Copper is essential to all living organisms as a trace dietary mineral. It is a key component of the respiratory enzyme complex, and is also found in humans in the liver, muscle and bone.

Copper has a variety of health benefits, including improving eye health and helping to inhibit the progression of advanced age-related macular degeneration. Copper acts as an antioxidant, and assists in the development of flexible connective tissue for proper eye structure. Copper can be found in seafood, nuts, seeds, wheat bran cereals and whole grains.
Anti-inflammatories and anti-oxidants

The eye has a very high metabolic rate and has a higher need for antioxidant protection. Most research has focused on vitamins A, C and E. These are thought to maintain healthy cells and tissues in the eye and are found in many fruits and vegetables, such as oranges, tomatoes and in green leafy vegetables. They can also be found in nuts, seeds, dairy products and other foods.

Flavonoids (also called bioflavonoids) are found in fruits, vegetables and certain beverages that have both antioxidant and anti-inflammatory properties. They are believed to play a role in the prevention of cataracts. Quercetin is one of the most widely consumed flavonoids; it is found in apples, berries, nuts, tea and onions. Red wine, or whole fruit red grape juice, also is a good source of many flavonoids.

An imbalance of antioxidants can be partly to blame on the excessive consumption of fat, dairy, salt, refined cereals, sugar, and vegetable oils which are more typical for the average American.

It is unfortunate that increasing the intake of antioxidants will not restore vision that is already lost, but the good news is that such intake may slow the progress of disease.

An imbalance of antioxidants can accelerate the oxidative damage that occurs due to the normal aging process of the eye. Antioxidants are found as supplements on store shelves, or naturally occurring in the body and in foods. Research suggests that eating green leafy vegetables reduces the chance of vision loss. Generally, the body processes nutrients easier when ingested in the form of food rather than a supplement. However, since the average American diet does not include the types or quantities of natural foods that would offer eye protection, antioxidant supplements may be prudent.

Zeaxanthin and Lutein

Lutein (“LOO-teen”) and zeaxanthin (“zeeah-ZAN-thin”) are yellow pigments that occur in many plants and vegetables. The yellow color of the macular region of the retina is due to the presence of macular pigment, composed of the two dietary compounds lutein and zeaxanthin, and a third, called meso-zeaxanthin. This third compound is probably formed from either lutein
or zeaxanthin in the retina. Lutein and zeaxanthin usually occur together in foods and function as a natural sunblock. In a study of 39,876 women studied for their intake of carotenoids, vitamin C and E, plus zeaxanthin and lutein, results showed that the women using the supplements in the blind control study showed a significantly decreased risk of developing cataracts.\(^\text{8}\)

Scarce in the typical American diet, think of zeaxanthin as an essential and internal sun protection. Lutein and zeaxanthin together help protect against blue light in a natural method. The human body cannot make lutein or zeaxanthin; they have to be eaten daily. They also do not have vitamin A inter-activity.\(^\text{21}\)

Studies suggest that consuming at least 10mg of lutein per day has beneficial effects on macular pigment levels. Lutein is a carotenoid that is now thought to have more preventive properties than vitamin A at a dosage of 5 mg daily. The central part of the retina (macula) has the highest concentration of lutein and zeaxanthin in the body, and these pigments appear to have a protective effect against macular degeneration. Also, studies show that a diet high in lutein and zeaxanthin may reduce the risk for cataracts. Excellent food sources of lutein and zeaxanthin include kale, spinach, collard greens, corn and egg yolks.

Lutein and zeaxanthin are found in many of the same foods, especially high quantities of both nutrients are found in green leafy vegetables. Unlike β-carotene, these two carotenoids do not have vitamin A activity. Of the 20–30 carotenoids found in human blood and tissues, only lutein and zeaxanthin are found in the lens and retina. In addition to their role as antioxidants, lutein and zeaxanthin are believed to limit retinal oxidative damage by absorbing incoming blue light. Although the crystalline lens actually has natural substances that absorb blue light, over time the blue light itself will decrease this natural defense system.

While there are no RDA standards for lutein and zeaxanthin, intakes of approximately 6 mg/day have been associated with a decreased risk of AMD. Patients with a carotenoid dense diet have a significant decrease in the odds of developing cataracts; unless diabetes is present.
Zeaxanthin alone

Zeaxanthin is a bioflavonoid (or flavonoid), which is a type of pigment found in almost all herbs, fruits, and vegetables. Zeaxanthin belongs to a group of bioflavonoids known as carotenoids. Zeaxanthin provides the body with anti-inflammatory and antioxidant protection. Egg yolks, sweet corn, and red grapes may be high in both lutein and zeaxanthin. In fact, egg yolks are considered one of the best sources due to their high fat content. Carotenoids are better absorbed when eaten with fat.7

Zeaxanthin occurs in the brain while meso-zeaxanthin does not. Although termed a zeaxanthin, meso is actually formed from lutein in the retina and is not found in human brain tissue. It is not common to the average American diet.15 Zeaxanthin is concentrated in spinach, collards, orange juice, lettuce, oranges, tangerines, peas, peaches, carrots, broccoli and celery.

Lutein alone

A yellow pigment found in the eye, called Lutein, continues to be studied in the AREDS2 trial. Lutein, is found in fruits and vegetables with yellow plant pigments, such as yellow and orange peppers, sweet corn and saffron. Green leafy vegetables such as kale, spinach and broccoli also have high levels of lutein, as do persimmons, and egg yolks. Lutein is a primary carotenoid in the lens of the eye and concentrated in the macula. It plays a protective role in the macula by filtering short-wave blue light and also in performing antioxidant functions. Low levels of lutein intake have been associated with a high prevalence of neovascular AMD. As previously noted, decreased macular pigment density is associated with an increased risk for AMD. It is believed that lutein helps keep the eyes safe from oxidative stress and the high-energy photons of blue light. Research studies have shown that there is a direct relationship between lutein intake and pigmentation in the eye. There is clinical evidence of a relationship between low plasma concentrations of lutein, and an increased risk of developing age related macular degeneration (AMD).7

Evaluation studies show that linkages exist with lutein intakes, ocular and neural health, and cognitive performance in children. The concentrations of luteins found in the macula correlate with the levels found in brain tissue.16 Early cognitive development in children and the effect of lutein on cognition have just recently been studied. Macular pigment density relates to better
memory and improved academic performance in children ages 8 to 11. This suggests that the same nutrients supply both the eyes and the brain with lutein.  

Since both lutein and zeaxanthin are not produced by the body, a steady source of nutrients rich in these materials must be ingested on a daily basis for both the eyes and the brain. Children who are picky eaters may suffer academically. A supplement of lutein/zeaxanthin may help fill in the nutritional gap.  

Lutein can be found in broccoli, spinach, kale, corn, orange peppers, kiwi fruit, grapes, orange juice, zucchini, squash, persimmons and egg yolks.

<table>
<thead>
<tr>
<th>Lutein/zeaxanthin content of foods</th>
<th>Milligrams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli, cooked</td>
<td>1.7</td>
</tr>
<tr>
<td>Brussels sprouts, cooked</td>
<td>1.0</td>
</tr>
<tr>
<td>Corn, sweet, cooked</td>
<td>1.4</td>
</tr>
<tr>
<td>Kale, cooked</td>
<td>10.3</td>
</tr>
<tr>
<td>Lettuce, raw, romaine</td>
<td>1.1</td>
</tr>
<tr>
<td>Peas, green, cooked</td>
<td>1.1</td>
</tr>
<tr>
<td>Spinach, cooked</td>
<td>6.7</td>
</tr>
<tr>
<td>Spinach, raw</td>
<td>4.5</td>
</tr>
</tbody>
</table>

**Nutrients, foods and supplements being studied**

**Selenium**

Selenium is another antioxidant that has not yet been fully studied in relation to vision. Studies are being done on this nutrient. Dr. Chew is conducting a study where participants are taking a 50 mcg supplement of selenium daily, but results are not yet conclusive.

**Turmeric**
Turmeric is an antioxidant nutrient being studied for possible abilities to prevent cataracts. Nothing conclusive has yet been proven. Currently being studied with participants taking two 500 mg capsules twice a day, the report is not in.

Riboflavin and B12

Vitamin B2 (riboflavin) has also been used for years in helping to strengthen the cornea through a process called collagen cross-linking to slow down the eye disorder keratoconus. This type of cross-linking is used in combination with a UV-a light. In this application, riboflavin is a photosensitizer and at the same time prevents damage to deep ocular structures. While B12 can be ingested as a vitamin, the ocular cross linking process using B2 is not related to taking B12 internally.

Food as a natural resource of nutrients

Nature has everything needed for energy boosts and vision protection. To get the most from what you eat, choose a variety of colorful produce that's rich in antioxidants. Increasing the nutritional intake can be accomplished by selecting foods with selenium, vitamin E, vitamin C, alpha lipoic acid, zinc, and omega-3 fats. A colorful salad or some vegetables as a side dish is a great start. However, if your patient is on a restrictive diet for any of a variety of reasons, then supplements are advised to provide these nutrients.

Eat large quantities of dark green leafy vegetables rich in carotenoids, the pigments that include precursors of Vitamin A. Spinach and collard greens are possibly the most beneficial vegetables in this respect. Lutein and zeaxanthin are also found in these vegetables. However, green leafy vegetables might be contraindicated for persons taking blood thinners or who suffer from the rare condition, hemochromatosis (the body absorbs too much iron).
Kale is a leafy green and is a rich source of lutein, zeaxanthin, vitamin C and beta-carotene. Other good sources of ocular nutrients include collard greens, turnip greens and spinach, broccoli, peas, kiwi, red grapes, yellow squash, oranges, corn, mangoes and honeydew melon. But in order for your body to absorb lutein and zeaxanthin, be sure to eat them with a bit of healthy fat such as a drizzle of olive oil or a few slices of avocado.

Sweet potatoes are orange tubers and provide a good source of beta carotene. Your body converts beta carotene to vitamin A, which helps prevent dry eyes and night blindness. Beta carotene and vitamin A also help reduce the risk eye infections. Other sources of beta carotene are deep orange food like carrots and butternut squash; as well dark green foods including spinach and collard greens. Liver, milk and eggs are other great sources of vitamin A.

Strawberries are a good for your eyes, containing plenty of vitamin C, which is an antioxidant that can help lower your risk of cataracts. Also, be sure to load up your plate with other vitamin C-rich foods including bell peppers, broccoli, citrus (such as orange and grapefruit) and cantaloupe.

Salmon is one of the best fish to provide omega-3 fatty acids. Another benefit of eating salmon is it is a source of vitamin D, which also guards against macular degeneration. Sardines, mackerel, milk, liver, and fortified orange juice can also provide vitamin D. Vitamin D3 specializes in reducing the risk of age-related eye problems and regulates cell growth, not just in the eye, but the entire body.

Walnuts provide vitamin E omegas. Flax or chia seeds contain omegas. Chia seeds contain more omega 3s than flax seeds or salmon, more calcium than a glass of milk, and more antioxidants than blueberries. They are also a great way to get more fiber into your diet.

Bell Peppers hold a nutritional bonanza that could help reduce the risk of prostate cancer and age-related macular degeneration. Just one cup provides 100 percent of the recommended daily value of vitamins A and C. Bell peppers are also fat-free, low-calorie, and are high fiber. In
addition to giving your body the dose of vitamins it needs; bell peppers fill you up fast and help to curb your hunger.

Carrots are perfect for on-the-go snacking. "Eating carrots won't make you see better than you already do, but there is a lot of truth in the idea that they can help protect vision," says Dr. Carr. "Carrots contain a lot of vitamin A, and there have been several studies recently showing that this vitamin – along with vitamins C and E – helps to reduce the impact of both cataracts and age-related macular degeneration (AMD)." Toss them in your salad, dip them in hummus, or just munch on them plain for a flavorful burst of nutrition.

Blueberries are packed with antioxidants so they pack a punch for overall eye health and physical wellness. According to a study by Tufts University, blueberries may help to reduce your risk of cataracts, glaucoma, heart disease, cancer, and other conditions. Blueberries are also good for the brain. Studies have shown that blueberries may not only help improve learning and memory capacity, but also can fight the effects of Alzheimer's disease. They are high in the soluble fiber pectin, which can help lower cholesterol.

Turkey is an all-purpose protein source that is delicious in chili, burgers, tacos, sandwiches, and more. It's also loaded with zinc and B-vitamin niacin, which can help prevent cataracts.

Wild salmon is rich in omega-3s to help protect tiny blood vessels in the eyes.

Vitamin D is found in fish oils, fatty fish, fortified milk or fortified cereals and is necessary for the regulation of the calcium and phosphorus found in the body. Vitamin D also plays an important role in maintaining proper bone structure. Vitamin D has been shown to reduce levels of amyloid beta accumulation, a hallmark of aging. It also has a significant effect on retinal macrophage numbers and shapes. AMD is associated with both amyloid beta accumulation and inflammation. Vitamin D supplementation appears to benefit both of these conditions.

Choosing foods for specific nutrients

**Fatty acids** are found in cold water fish, such as salmon, mackerel, and rainbow trout; sunflower oil, and corn oil.

**Lutein, zeaxanthin, carotenoids and anti-oxidants** are found in orange or yellow produce and leafy greens like spinach, kale, collard greens, chard, and mustard greens. It is the pigments that give fruits and veggies their spectrum of colors that are full of antioxidants. Most leafy greens also contain vitamins A, C, and E.

**Vitamin C** is commonly found in raspberries, blueberries, blackberries, strawberries, grapefruit and oranges. Since vitamin C cannot be produced by the body, dietary measures or supplements are needed to obtain vitamin C. The American Optometric Association reports that numerous studies link vitamin C intake to decreased risk of cataracts. Added to your breakfast cereal, blended in a smoothie, or added to a salad for a sweet burst of flavor as well as good health.
Vitamin E is found in nuts, from peanuts to pistachios. In fact, it takes only one handful of almonds to provide half of your daily vitamin E requirement, protecting cells in the eye. According to the American Optometric Association, it also may reduce the risk of cataracts and age-related macular degeneration.

Zeaxanthin, vitamin A, beta carotene and vitamin C are all contained in **orange bell peppers**. In fact, a study in the British Journal of Ophthalmology reports that orange peppers contained the highest amount of zeaxanthin of all the fruits and veggies the researchers tested. They are great as a crunchy raw dipping treat or sauteed into any dish.

Omegas are found in fish, particularly oily fish like tuna, salmon, mackerel, and trout. These healthy fats promote retinal health and may help prevent dry eyes. The essential trace mineral, zinc, can also be found in a variety of seafood. Seafood also contains astaxanthin, another antioxidant that gives some seafood its reddish pigment. This super nutrient has also been shown to protect against diseases such as age-related macular degeneration.

Green Tea has antioxidants that may help lower risk of developing cataracts and macular degeneration. Green tea contains healthful substances called catechins, which are responsible for its anti-inflammatory and antioxidant properties. Other foods that are that are high in catechins include red wine, chocolate, berries and apples. Black tea also boasts catechins, but in lower amounts than its green cousin. Also, the relaxation obtained by sipping a high quality tea has been known for centuries. Relaxation works to limit free-radical damage.

**Other less-traditional foods, supplements and herbs**

Less traditional nutrients, minerals and herbs are being studied in relationship to possible benefits to eye health:

**Bilberry** is thought to improve low light vision and prevent macular degeneration. As early as the 1940s, World War II pilots with the Royal Air Force claimed that bilberries significantly increased their night vision when conducting night missions. While that claim was never
concretely proven, the antioxidant properties of bilberry are known and may have a positive effect on vision.\textsuperscript{9}

Bilberries are smaller and of a darker blue color than blueberries. They are also softer and juicier than blueberries, making them difficult to transport. Because of these factors, bilberries are only available fresh in markets and are more expensive than blueberries. Bilberries contain natural antioxidants called anthocyanosides that can strengthen blood cells, significantly reducing hemorrhaging in the eye that can lead to both macular degeneration and diabetic retinopathy.\textsuperscript{15} Bilberries are also a good source of chromium, which helps control blood sugar. In addition, bilberries contain both vitamin A and vitamin C, which are vital to eye health.\textsuperscript{9}

**Magnesium** is a mineral that is present in relatively large amounts in the body. Researchers estimate that the average person’s body contains about 25 grams of magnesium, and about half of that is in the bones. Magnesium is important in more than 300 chemical reactions that keep the body working properly. Magnesium helps to regulate taurine, and in turn, taurine can substitute for magnesium when magnesium is deficient. Both taurine and magnesium stabilize cell membranes, such as those in the eye. Magnesium specifically minimizes the damage that is done by excess glutamate. It can be found in green leafy vegetables, Brazil nuts, almonds, soybeans, halibut and quinoa. Lowering the glutamate intake from monosodium glutamate (MSG) found in many fast and snack foods is also healthy for the eye and the entire body.

**Taurine** is an amino acid, a chemical that is a required building block of protein. It plays an important role in membrane stabilization and antioxidation. Taurine is essential for the proper development and function of the retina. Taurine is found in seafood and meat.

**Benfotiamine** is an antioxidant and relative of vitamin B1 (thiamine) that increases the enzyme that redirects glucose and harmful glucose metabolites, and helps protect against generalized and ocular micro vascular damage. Benfotiamine also improves nerve conduction and sensations in those who have neuropathy due to poor blood glucose control.
Pycnogenol® is an extract found in French Maritime Pine bark. Pycnogenol hinders inflammation and improves blood vessel brittleness. It also interferes with the breakdown of the blood-retinal barrier, reducing the likeliness of bleeding into the retina.

Curcumin is a component of turmeric with broad benefits for the body, brain, and eye. Curcumin reduces inflammatory cytokines implicated in obesity and insulin resistance. This nutrient also protects against membrane changes linked to blood glucose-related eye health concerns and improves retinal blood flow.

Gingko biloba is an antioxidant and may increase ocular blood flow. However, it may also interact negatively with medications.

Coleus forskohlii works with the ciliary epithelium to produce a type of cellular signal that might reduce intraocular pressure (IOP).

Salvia miltiorrhiza, or Chinese sage, is used in Chinese medicine to treat glaucoma. The value to eye health is under study, but it can have side effects and interact with prescribed medicines.

Flaxseed oil provides essential omega-3 fatty acids; but should not be used by a patient on anticoagulants.
Coffee does provide antioxidants, but drinking over 3 cups a day might be contraindicated in patients who have glaucoma.

Food resource or supplement?

Indeed, antioxidants found as supplements on store shelves are also found naturally in the body and in many types of foods. Previous research suggests that eating green leafy vegetables reduced the chance of vision loss and is the most economical resource of the antioxidants.

Antioxidants are much more numerous in foods than in individual supplements, according to Julie Mares, professor of nutrition the department of ophthalmology and visual sciences at the University of Wisconsin School of Medicine, who has studied the link between nutrition and eye health for more than a decade.

While it is nearly impossible for someone who suffers from vision loss to receive the amount of nutrients he or she needs just from a healthy diet, taking an overload of the amount of nutrient doesn't guarantee that you can avoid disease or see better. The body can only use so much of the vitamins and pigments, and there is no evidence that taking more than necessary is beneficial. Also, the cost of such nutrients and micronutrients may contraindicate the overuse of any product. Most nutrients that are in excess of the body's need are usually excreted.

"We know that our body processes nutrients easier when it is given in the form of food rather than as a supplement," said Mares. Therefore, it seems prudent to advise your patients to simply eat a healthy diet with the variety and quantity of foods needed to provide essential nutrients. However, a patient on a restricted diet may benefit from an eye healthy supplement.

Summary

Today's patients generally know the value of good nutrition but might not equate nutrition with good eyesight. A discussion of information related to patient lifestyle, including diet, is important.

The entire body needs good nutrition and the eyes are extremely important to perform all daily tasks. With this in mind, and while studies continue, it is good practice for eye care
professionals to promote the type of good nutrition that may assist eye health. While the eye care professional isn’t a nutritionist, information about ocular nutrition related to the eye is easy to impart to a grateful patient.
Nutrition and the Eyes

References

1. Published June 23, 2015; Nutrition and Eye Health at a Glance; Manouchehr Saljoughian, PharmD, PhD; US Pharm. 2015;40(6):HS-11-HS-16.


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16. KEMINO11838-03 and Pentvision White Paper, Elizabeth J. Johnson, PhD

17. “Diabetes and Eye Problems: Read About Symptoms and Treatment.” MedicineNet


Test Questions

1. What does ARMD stand for?
   - a) All Remedy Mineral Disorder
   - b) Age Related Mineral Deficiency
   - c) Age Related Macular Degeneration
   - d) Any Reasonable Macular Device

2. Which of the following is true about poor nutrition?
   - a) Food digestion becomes easier on the body
   - b) It is typically prescribed by doctors to cataract patients
   - c) It reduces the likelihood of refractive errors
   - d) It can cause restriction of the ability to wear contact lenses

3. What is true about the color of fresh foods ingested?
   - a) It causes indigestion
   - b) There is a direct correlation between color and nutrients provided
   - c) There is no correlation
   - d) Some foods are too colorful

4. According to the NEI, how many people over 60 years of age have ARMD?
a) More than 2.1 million
b) One in ten
c) More than 9.3 million
d) 23 million

5. Which study removed copper from the formula?
   a) AREDS2
   b) AREDS
   c) Age producing tests
   d) Age related tests

6. Which of these is a resource of Omega 3 oil?
   a) Lard
   b) Oily fish
   c) Bone meal
   d) Celery

7. What standard is used by the optical industry for EPA and DHA?
   a) ANSI
   b) OSHA
   c) American Heart Association Cardiovascular standards
   d) American Diabetes Food Pyramid standards

8. What is true about Gamma-Linolenic Acid?
   a) A rich source is primrose oil
   b) It is found in large amounts in the modern diet
   c) It is not a fatty acid
   d) It is proven to treat cataracts

9. Which of these statements is correct?
   a) The initial treatment for dry-eye syndrome is usually lens replacement
   b) A deficient tear film can affect vision
   c) Vitamin E cannot be found in supplement form
   d) Eyes produce tears once every hour

10. Dry eye symptoms may include:
    a) A stinging sensation
    b) The ability to read late into the night
    c) Clear eyesight at all times
    d) Ocular comfort

11. What age range of persons has the highest incidence of cataracts?
    a) 50 to 60 years old
b) Over 90 years old  
c) Over 65 years old  
d) There is no correlation between age and cataracts

12. Increased intra-ocular pressure is a sign of:
   a) Myopia  
   b) Cataracts  
   c) Hyperopia  
   d) Glaucoma

13. What nutrient minimizes damage from glutamate?
   a) Iron  
   b) Copper  
   c) Magnesium  
   d) Calcium

14. Why is it thought that studies are not consistent?
   a) There are too many foods to evaluate  
   b) The nutrients tested come in varying strengths  
   c) Food deteriorates quickly if not refrigerated  
   d) The food must always be cooked

15. Zinc can reduce ________________:
   a) The need for sodium  
   b) Night blindness  
   c) The appetite  
   d) Tears

16. Vitamin A can be converted into:
   a) Vitamin C  
   b) Calcium  
   c) Provitamin A  
   d) Alternate Vitamin A

17. Who should use caution before taking beta carotene?
   a) Children  
   b) People over 60 years old  
   c) Teenagers to eat fast food  
   d) Any patient with an increased risk of lung cancer

18. What does retinol assist?
   a) Day to day vision  
   b) The bioelectrical process of vision  
   c) Nothing related to the eye
19. Ascorbic acid is also known as ________________:
   a) Retinol
   b) Citrus fruit
   c) Vitamin C
   d) Flavonoid

20. Where was a study conducted regarding the 10 year use of Vitamin C?
   a) The United Kingdom
   b) Yale University
   c) Washington, D.C.
   d) Finland

21. Complete this sentence. People with cataracts tend ________________
   a) to have a low antioxidant status
   b) to be younger than 60
   c) to fast once a week
   d) to have excellent vision

22. What does ROS stand for?
   a) Retinal oxygen state
   b) Routine orange status
   c) Reactive oxygen species
   d) Retinal odd status

23. Vitamin C is concentrated in ________________
   a) The eyelid
   b) The aqueous humor
   c) Eyelashes
   d) Punctal drainage

24. To what family do tocopherols belong?
   a) Vitamin C
   b) Vitamin A
   c) Vitamin B2
   d) Vitamin E

25. What is the RDA standard for vitamin E intake?
   a) 150 mg per day
   b) 15 mg per day
   c) There is no set standard
   d) 29 mg per day
26. What happens after a molecule of a-tocopherol neutralizes a free-radical?

   a) It dies
   b) It is cleared through the tear film
   c) It is altered
   d) It turns orange

27. Which of these is cited as a good source of vitamin E?

   a) Peppermint oil
   b) Flaxseed oil
   c) Strawberries
   d) Melon

28. Zinc helps to produce proteins, including ________________________.

   a) DNA
   b) Lactose
   c) Fructose
   d) Twotose

29. Too much zinc can cause:

   a) Acne
   b) Copper deficiency anemia
   c) Copper excess accumulation
   d) Vein fragility

30. What is true about the metabolic rate of the eye?

   a) It is very high
   b) It is very low
   c) It is sluggish
   d) It has never been measured

31. In addition to quercitin and red wine, what was cited as a good source of flavonoids?

   a) Cinnamon
   b) Gelatin
   c) Grape juice
   d) Butterbeans

32. What has the highest concentration of lutein and zeaxanthin in the body?

   a) The bones
   b) The central part of the retina
   c) The cornea
   d) The skin

33. Carotenoids are absorbed better when ___________________________?
a) Ingested as a supplement
b) Eaten at night
c) Eaten in the morning
d) Eaten with fat

34. In addition to ocular health, lutein has a linkage to ________________________.

a) Cognitive performance in children
b) Muscular memory
c) Ligament strength
d) Dementia

35. Lutein and zeaxanthin must be ingested on a daily basis because:

a) They have no calories
b) They contain large amounts of glucose
c) They are not produced by the body
d) They make the glycemic index level rise

36. What is true about a study being conducted by Dr. Chew?

a) Participants are taking 500 mcg of the nutrient being studied
b) It is studying copper
c) The nutrient is being taken each Saturday of the week
d) The results are not yet conclusive

37. What is used for collagen cross-linking?

a) Vitamin C
b) Riboflavin
c) Vitamin B12
d) Vitamin E

38. What fruit was eaten by World War II pilots in the belief that it increased night vision?

a) Limes
b) Apples
c) Cherries
d) Bilberries

39. What is taurine?

a) A form of Vitamin C
b) An amino acid
c) A derivative of beef
d) Part of the Vitamin E family

40. What is another name for Chinese sage?
a) Gingko biloba
b) Green tea
c) Curcumin
d) Salvia miltiorrhiza