Healthy Eyes

Healthy vision is accomplished through healthy eyes—and good nutrition is vital to healthy eyes. The eye is made of various structures working in concert to focus light rays from objects into images and send them to our brain via electrical impulses. The eye itself is protected in a bony orbit (socket). The socket provides protection against trauma, but it cannot protect the eye from internal injuries.

The front of each eye is covered by an eyelid, which blinks periodically to spread tears over the eye surface and remove unwanted material. The eyelids also have glands that secrete oil onto the cornea, forming a portion of the tear film of the eye.

The cornea is the transparent covering through which light travels. On all sides of the cornea, covering and shaping the rest of the eyeball, lies the sclera, which is made of tough connective tissue. This sclera is the “white” of the eye, while the cornea covers the pupil and the iris (the dark hole and colored portions, respectively). A delicate, thin layer of tissue, the conjunctiva, covers the entire surface of the eyeball and lines the inner surfaces of the lids.

Beyond the cornea lies the iris, which gives the eye its color. The iris is a sphincter made of smooth muscle that contracts and expands in response to light levels. The open area in the middle of the iris is the pupil. When the iris contracts, the pupil gets smaller, allowing less light to enter the eye. Conversely, when the iris sphincter muscle relaxes, the pupil dilates, allowing more light into the eye.

The area between the cornea and the iris is known as the anterior chamber; it is filled with a fluid called aqueous humor. The aqueous humor bathes several structures in the eye. Directly behind the iris is the lens, which is held in place by small, string-like structures called zonules. The lens and the cornea together focus all the images coming into the eye.

Behind the lens, the eye is filled with vitreous humor, a clear substance with the consistency of firm jelly. Vitreous humor fills the bulk of the eyeball and gives it the round shape needed for proper image production. The inner back surface of the eye is lined with light-sensitive nerve tissue called the retina. An easy analogy is to compare the retina of the eye to the film of a camera: they both capture images. The retina consists of photoreceptors (light-detecting cells), nerve fibers, and blood vessels. There are two kinds of photoreceptors: rods and cones. Rods are extremely light sensitive but detect only black and white. Cones detect colors but require more light than rods do. This explains why objects in dim light often appear in shades of grey, black, or white. Together, rods and cones capture the image and send it to the brain via the optic nerve.

The most important part of the retina is the macula. This area has a very high concentration of photoreceptors and is responsible for one’s central vision. The nerve fibers in the macula and the other parts of the retina coalesce to form the optic nerve, which is a sort of cable that connects the eye to the brain.

The eye’s health is highly dependent on healthy neurological and cardiovascular systems. The images obtained by the eye are transferred via electrical impulses to the brain, where they are processed and in turn transformed into the mental images we “see.” Thus, maintaining optimum neurological health and capacity contributes to visual functioning. Similarly, the cardiovascular system supplies the eye with oxygen-rich blood and removes waste products produced in the eye’s structures. The retina and surrounding structures are especially rich in blood vessels and rely on a healthy cardiovascular system. Many nutrients have the potential to maintain or improve the eye and its function by acting on the cardiovascular and brain systems.

HOW THE EYE SEES

When a person looks at an object, light rays bouncing off that object hit the cornea, which bends them toward the center of the retina by a process known as refraction. These bent light rays then go through the pupil and are adjusted by the lens. If the eye is focusing properly, these light rays then fall onto the retina, mostly on the macula, as a clear, though upside-down, image. This image is captured by the photoreceptors and then transferred via the nerve fiber layer of the retina to the optic nerve, which connects to the brain, where the image is interpreted and inverted so that the world appears right-side up.

When the eye does not properly focus the light rays from the image, the result is a refractive error. There are two types of refractive errors:

- **Spherical aberration**. This error occurs when the focused image falls either in front of the retina (near-sightedness, or myopia) or “behind” the retina (far-sightedness, or hyperopia).

- **Astigmatism**. This occurs when the light waves interfere with each other as their distance from the central axis increases so that the image becomes blurry anywhere except in the middle. Astigmatism is usually caused by an irregularly shaped cornea. It can occur alone or in conjunction with myopia or hyperopia.

Myopia, hyperopia, and astigmatism can all usually be corrected with eyeglasses, contact lenses, or refractive surgery such as LASIK.

Besides refractive errors, most people develop presbyopia at around the age of 40. This disease occurs when the lens of the eye can no longer focus on near images because of age-related stiffness. For people who never wore glasses, reading glasses are usually necessary starting at around the age of 40. For those who already wear glasses, bifocals or another form of dual correction is often needed. Presbyopia is an irreversible condition.

DISEASES OF THE EYE

Besides refractive and other focusing errors that cause decreased vision, many diseases can temporarily or permanently affect sight.

Probably the most serious problem is skin cancer. Just like the rest of the skin, the eyelids can develop tumors. Since the eyelids, and the rest of the facial skin, have more lifetime sun exposure than other parts of the body, they are at increased risk of developing cancer. Skin cancer can often, but not always, be healed by removing the lesion surgically.

The conjunctiva can become inflamed or infected from numerous diseases. This condition is called conjunctivitis. The most common causes of conjunctivitis include allergies, dry eyes, and viral infection (pinkeye). Bacterial and other types of infections can also cause pinkeye. Allergic reactions, dry eye, and chemical exposure can also lead to inflamed conjunctiva.

Since the cornea helps focus images into our eye, maintaining clarity is essential. Both infection and injury can produce scars that leave the cornea cloudy. Clouded corneas reduce the amount of light that enters the eye, resulting in decreasing stimulation of the photoreceptors and dim vision. Scarring can also affect the shape of the cornea, producing astigmatism. Severe corneal scarring, or keratoconus, is one of the reasons for a corneal transplant operation.

If the tear system is not functioning properly, dry eye may develop. In some instances, it can be debilitating. Dry eye can be caused by numerous rheumatologic and auto-immune diseases, such as Sjögren's syndrome, rheumatoid arthritis, and systemic lupus erythematosus. It has also been linked to many medications. Dry eye can even occur without an obvious cause. Rarely, ocular dryness is severe enough to cause permanent damage to the cornea. Dry eyes can be treated with artificial tear drops or prescription medications such as Restasis® or by unplugging of the tear drainage system.

The first internal structure in the eye is the anterior chamber, where aqueous humor bathes the backside of the cornea, the iris, and the front of the lens. If the aqueous humor is either produced too quickly or drained too slowly, the pressure inside the eye can become elevated. This is one usual component of a disease process called glaucoma, which can be a cause of irreversible vision loss. The elevated pressure in glaucoma presses on the optic nerve fibers, reducing their blood flow, which may lead to cell damage or death. Because of the arrangements of nerve fibers in the optic nerve, glaucoma produces primarily loss of peripheral (side) vision. In advanced cases, glaucoma can also impair central vision. Once vision loss occurs with glaucoma, it cannot return. Treatment includes prescription medications, laser treatments, and surgery. Animal research suggests that Ginkgo biloba supplementation may be helpful in glaucoma prevention and treatment (Hirooka K et al 2004). Recent research has also implicated oxidative stress as a causal factor in glaucoma. Evidence now suggests that increased concentrations of reactive oxygen species play an important role in the development of glaucoma (Izzotti A et al 2006).

Oxidative stress has also been implicated in the development of cataracts (Zoric L et al 2005). A cataract occurs when the lens become cloudy as a result of normal aging. The only cure for cataracts is surgery, although one study has suggested that antioxidant therapy may help reduce the risk of developing them (Zoric L et al 2005). Cataract surgery is the most commonly performed surgery in the United States. With modern advancements, it is extremely safe and restores excellent vision in most patients.

Behind the lens is the vitreous cavity. The vitreous humor can pull away from the back of the eye and form floaters, which are small condensations that appear as black spots or cobwebs in one's vision. The vitreous humor can also form a retinal hole or tear when it pulls away from the back of the eye. Either of these conditions can lead to retinal detachment, in which the retina falls away from the back of the eye. Retinal detachments are medical emergencies. A sensation of a curtain being pulled across the field of vision is a danger sign for retinal detachment. Retinal detachments are usually repaired with surgery, although the surgery is not always successful. Retinal holes or tears can often be treated with laser to help prevent retinal detachment from worsening. Successful treatment of retinal detachment depends on early detection.

Many diseases, both exclusive to the eye and systemic, can cause serious damage to the retina. Macular degeneration is probably

the most feared of all ophthalmic diseases. It occurs when the macula (which is responsible for central vision) becomes diseased, distorting central vision. Macular degeneration is a significant cause of blindness (Seddon JM et al 2004).

Treatments for macular degeneration include laser treatments, surgery, and injection of prescription medications into the eye. One of the greatest nutritional breakthroughs in the treatment of macular degeneration was the release of the Age-Related Eye Disease Study, in which researchers found that vitamins C and E, beta-carotene, and zinc (plus copper) can reduce progression in certain types of macular degeneration (Age-Related Eye Disease Study Research Group 2001). Newer research has also implicated oxidative stress in macular degeneration. It is believed that age-related elevations in oxidative products in the eye may contribute to the development of macular degeneration (Nowak M et al 2005; van Leeuwen R et al 2005). Inflammation has also been identified as a possible aggravating factor in the development of macular degeneration. These findings suggest the possibility of preventing macular degeneration by reducing oxidative stress by using antioxidants and reducing inflammation.

The health of the eye is also affected by systemic diseases, such as diabetes, atherosclerosis, and hypertension, which can cause significant damage to the retina. In diabetic retinopathy, the small blood vessels of the retina become diseased and can leak blood products. Also, they do not carry enough oxygen, so some areas of the retina may become oxygen deficient. The eye may respond by forming more blood vessels (neovascularization), but these blood vessels are very fragile. In many cases, they can bleed directly into the back of the eye. In people with high blood pressure, the retinal blood vessels can change shape and become unhealthy. Atherosclerotic disease can affect the small blood vessels of the eye and cause reduced blood flow.

For More Information

Additional chapters that might be of interest include the following:

- Cataracts
- Glaucoma
- Macular Degeneration
- Retinopathy

HEALTHY EYES: THE BASICS

You can take several steps to protect healthy vision:

- Stop smoking. Smoking can increase one's risk of developing cataracts, macular degeneration, and many other diseases by increasing oxidative stress, narrowing blood vessels, and reducing blood flow to the eye (Thornton J et al 2005; Lindblad BE et al 2005).
- Wear a hat and sunglasses with ultraviolet (UV) protection whenever you are outdoors. The sun's UV rays can increase the risk of developing skin cancer, cataracts, and macular degeneration (Xhauflaire G et al 2005).
- Get regular, comprehensive eye examinations. Many eye diseases have no symptoms until late in the disease. Thus, many eye diseases are not apparent until diagnosed during a comprehensive eye examination. The American Academy of Ophthalmology currently recommends the schedule below for comprehensive medical eye examinations in healthy people with no family or personal history of eye disease and no risk factors for eye disease. Since everyone's situation is different, ask your doctor how often you should get a comprehensive eye examination (American Academy of Ophthalmology 2000).

  Age 20–29: at least once

  Age 30–39: at least twice

  Age 40–64: every 2–4 years

  Age 65 or older: every 1–2 years

- Maintain a healthy diet and adequate nutritional intake. Your eyes rely on the nutrients you consume. This may be especially important in light of recent research implicating oxidative stress in major eye diseases. It is very important that all aging people maintain adequate antioxidant supplies to protect their eyes.

Some of the nutrients that benefit healthy vision work by directly supporting eye function, while others enhance blood flow to the eye by supporting the cardiovascular system. It is important that people with heart disease, such as coronary artery disease, visit their ophthalmologist and carefully follow their dietary program.

Omega-3 fatty acids. One group of dietary supplements that affects both the eye and the cardiovascular system is the omega-3 fatty acids. These essential fatty acids help prevent hardening of the arteries in both the heart and the eye by reducing inflammation. Arteriosclerosis is a pervasive and quiet enemy of the eye. The result of arteriosclerosis is a decrease in nutrients to

the eye and a reduction in the removal of waste products. An added benefit of omega-3 fatty acids is an apparent lower risk of dry eye syndrome, particularly in women (Miljanovic B et al 2005).

Lipoic acid. Lipoic acid is a very powerful antioxidant that prevents free radical damage, thus reducing oxidative stress and possibly reducing the risk of degenerative eye diseases. It has shown promise as a nutrient to protect rabbits' eyes from ultraviolet damage (Demir U et al 2005).

N-acetyl-carnosine. This supplement has also been shown to support healthy eyes. When administered topically in the form of N-acetyl-L-carnosine, this nutrient can move easily into both the water-soluble and lipid-containing parts of the eye. Once there, it helps prevent DNA strand breaks induced by UV radiation and enhances DNA repair. In the lipid areas of the eye, N-acetyl-L-carnosine partially breaks down and becomes L-carnosine. In a 1999 study of 96 patients aged 60 years or older with cataracts, one to two drops of a carnosine-containing solution was administered three to four times each day for three to six months. At the end of the study, the level of eyesight improved, and the lens became more transparent. For primary senile cataracts, the effective rate was 100 percent; for mature senile cataracts, the effective rate was 80 percent (Wang AM et al 2000).

Vitamin C. Intraocular pressure can be lowered by high doses of vitamin C. The osmotic changes are thought to impact either the outflow or the secretion mechanism to reduce the pressure. Vitamin C may slow the progression of glaucoma (Head KA 2001; Bartlett H et al 2004).

B vitamins. A decrease in B vitamins has been linked to heart disease. Because B vitamins are poorly stored by the human body, they must be ingested on a regular basis. Low levels of B vitamins, including vitamin B12, folic acid, and niacin, have been seen in glaucoma, diabetic retinopathy, and age-related macular degeneration (Head KA 2001).

Bilberry. Studies have shown the herb bilberry to be effective in vascular disorders. Bilberry contains flavonoids and antioxidants that increase microcirculation and support retinal function. This nutrient may especially benefit individuals with macular degeneration, cataracts, diabetic retinopathy, and night blindness (Fursova AZ et al 2005).

Beta-carotene. This vitamin functions as an antioxidant by disabling free radicals. Low intake of beta-carotene is associated with increased free radical damage, which increases the risk of cataracts and macular degeneration (Mayne ST 1996).

Zeaxanthin and lutein. Carotenoids are very numerous; more than 600 are found in red, yellow, green, and orange vegetables and fruits. Carotenoids like zeaxanthin and lutein have highly antioxidative characteristics and help prevent destructive vascular changes in the macula, decreasing the risk of age-related macular degeneration. Studies indicate that high levels of lutein may decrease the incidence of posterior subcapsular cataracts, diminish complaints of glare, and provide better color vision and more critical acuity (Bone RA et al 2001).

Selenium. Selenium is an essential trace mineral with antioxidant properties that works in partnership with vitamin E to protect cellular integrity and cell membranes. It protects the cell membranes from free radical damage, decreasing the risk of macular degeneration, cataracts, and glaucoma. Numerous plants, including grains and garlic, contain selenium, but the concentration is highly dependent on soil content (Brown NA et al 1998).

Coenyzme Q10. This nutrient has been studied in the context of age-related macular degeneration. In a randomized, double-blind, placebo-controlled trial examining the effects of coenzyme Q10 combined with acetyl-L-carnitine and omega-3 fatty acids, researchers found that the nutrient mix improved and stabilized visual functions in patients with early age-related macular degeneration (Feher J et al 2005). In an animal study, coenzyme Q10 and vitamin E, applied topically, were found to help reduce the risk of complications after laser cornea surgery (Brancato R et al 2002).

Vitamin A. Vitamin A, retinol, and retinyl palmitate are multifunctional and essential in virtually all tissues. Vitamin A is required by the photoreceptors of the retina for proper function. Vitamin A, as an antioxidant, has been shown to decrease lipid levels in coronary heart disease and therefore could be protective of the ocular vascular system (Singhal S et al 2001; Brown NA et al 1998).

Zinc. This mineral is required to maintain the integrity of the immune system and of carbohydrate and protein metabolism. The retina has the highest concentration of zinc of any organ system (Grahn BH et al 2001). Previous studies suggested that zinc may play a role in reducing the risk of age-related macular degeneration. However, more recent studies have presented a complex picture. At lower doses, zinc does have a protective effect against macular degeneration by supporting epithelial cells in the retina. However, at higher doses, zinc has the opposite effect (Wood JP et al 2003). Fortunately, this dangerous effect of zinc is attenuated by antioxidants, such as vitamin E, taken at the same time as the zinc. Thus, for anyone consuming zinc to help prevent age-related macular degeneration, antioxidants are recommended (Wood JP et al 2003).

LIFE EXTENSION FOUNDATION RECOMMENDATIONS

As is the case with other organ systems, maintaining healthy vision and reducing the risk of an eye disease rely on paying regular visits to a physician and taking preventive steps, including nutritional supplementation, to support optimal function. If you have symptoms of an eye disease or have a confirmed disease of the eye, please see the chapter on that condition in this section for more specific recommendations. The following supplements have been shown to support general eye health:

- **Omega-3 fatty acids**—1400 milligrams (mg) EPA and 1000 mg DHA daily
- **Lipoic acid**—150 to 300 mg daily
- **Vitamin C**—1 to 3 grams (g) daily
- **Vitamin B complex**—at least 50 mg of each vitamin in the B family daily
- **Beta-carotene**—5000 international units (IU) daily
- **Vitamin A**—4000 to 5000 IU daily with food
- **Vitamin E**—400 IU daily (with at least 200 mg gamma tocopherol)
- **Bilberry**—100 mg daily
- **Zeaxanthin**—3.75 mg daily
- **Lutein**—at least 10 mg free lutein daily
- **Selenium**—200 to 400 micrograms (mcg) daily
- **Zinc**—15 to 30 mg daily
- **Coenyzme Q10**—50 to 100 mg daily, with D-limonene to enhance absorption
- In addition, eye drops containing **N-acetyl-L-carnosine** may be applied 3 to 4 times daily

GENERAL EYE HEALTH SAFETY CAVEATS

An aggressive program of dietary supplementation should not be launched without the supervision of a qualified physician. Several of the nutrients suggested in this protocol may have adverse effects. These include:

Beta-Carotene

- Do not take beta-carotene if you smoke. Daily intake of 20 milligrams or more has been associated with a higher incidence of lung cancer in smokers.
- Taking 30 milligrams or more daily for prolonged periods can cause carotenoderma, a yellowish skin discoloration (carotenoderma can be distinguished from jaundice because the whites of the eyes are not discolored in carotenoderma).

Coenzyme Q10

- See your doctor and monitor your blood glucose level frequently if you take CoQ10 and have diabetes. Several clinical reports suggest that taking CoQ10 may improve glycemic control and the function of beta cells in people who have type 2 diabetes.
- Statin drugs (such as lovastatin, simvastatin, and pravastatin) are known to decrease CoQ10 levels.

EPA/DHA

- Consult your doctor before taking EPA/DHA if you take warfarin (Coumadin). Taking EPA/DHA with warfarin may increase the risk of bleeding.
- Discontinue using EPA/DHA 2 weeks before any surgical procedure.

Lipoic Acid

- Consult your doctor before taking lipoic acid if you have diabetes and glucose intolerance. Monitor your blood glucose level frequently. Lipoic acid may lower blood glucose levels.

Niacin (nicotinic acid)

- Do not take high doses of nicotinic acid (1.5 to 5 grams daily or more) if you have liver dysfunction, an unexplained elevation in your serum aminotransferase (transaminase) level, active peptic ulcer disease, arterial bleeding, or if you consume large amounts of alcohol.
- Consult your doctor before taking high doses of nicotinic acid if you have a history of jaundice, peptic ulcer disease, gastritis, disease of the liver or bile ducts, gout, kidney dysfunction, or cardiovascular disease (especially acute myocardial infarction or unstable angina).

- Consult your doctor before taking high doses of nicotinic acid if you have diabetes. High doses of nicotinic acid can negatively affect glucose tolerance. Monitor your serum glucose level frequently if you take nicotinic acid and have diabetes.
- Have your doctor monitor your serum aminotransferase level if you take high-doses of nicotinic acid.
- Nicotinic acid may cause flushing, principally of the face, neck, and chest. This flushing is thought to be prostaglandin-prostacyclin mediated. Histamine may also play a role in the flushing.
- Nicotinic acid can cause dizziness, palpitations, rapid heartbeat, shortness of breath, sweating, chills, insomnia, nausea, vomiting, abdominal pain, and muscle pain.
- High doses of nicotinic acid can cause blurred vision, macular edema, toxic amblyopia, and cystic maculopathy.

PABA (Para-aminobenzoic Acid)

- Do not take PABA if you are taking sulfonamides or have a kidney disease.
- PABA can cause anorexia, nausea, vomiting, fever, and rash.

Selenium

- High doses of selenium (1000 micrograms or more daily) for prolonged periods may cause adverse reactions.
- High doses of selenium taken for prolonged periods may cause chronic selenium poisoning. Symptoms include loss of hair and nails or brittle hair and nails.
- Selenium can cause rash, breath that smells like garlic, fatigue, irritability, and nausea and vomiting.

Vitamin A

- Do not take vitamin A if you have hypervitaminosis A.
- Do not take vitamin A if you take retinoids or retinoid analogues (such as acitretin, all-trans-retinoic acid, bexarotene, etretinate, and isotretinoin). Vitamin A can add to the toxicity of these drugs.
- Do not take large amounts of vitamin A. Taking large amounts of vitamin A may cause acute or chronic toxicity. Early signs and symptoms of chronic toxicity include dry, rough skin; cracked lips; sparse, coarse hair; and loss of hair from the eyebrows. Later signs and symptoms of toxicity include irritability, headache, pseudotumor cerebri (benign intracranial hypertension), elevated serum liver enzymes, reversible noncirrhotic portal high blood pressure, fibrosis and cirrhosis of the liver, and death from liver failure.

Vitamin B1 (Thiamin)

- Consult your doctor before taking vitamin B1 for a thiamin deficiency, lactic acidosis secondary to thiamin deficiency, Wernicke-Korsakoff syndrome, Wernicke's encephalopathy, or Korsakoff's psychosis.

Vitamin B2 (riboflavin)

- High doses of vitamin B2 (riboflavin) may interfere with the Abbott TDx drugs-of-abuse assay.
- Riboflavin absorption is increased in hypothyroidism and decreased in hyperthyroidism.
- If you are taking nucleoside reverse-transcriptase inhibitors, even a mild riboflavin deficiency can increase your risk of lactic acidosis.

Vitamin B6

- Individuals who are being treated with levodopa without taking carbidopa at the same time should avoid doses of 5 milligrams or greater daily of vitamin B6.

Vitamin B12 (cyanocobalamin)

- Do not take cyanocobalamin if you have Leber's optic atrophy.

Vitamin C

- Do not take vitamin C if you have a history of kidney stones or of kidney insufficiency (defined as having a serum creatine level greater than 2 milligrams per deciliter and/or a creatinine clearance less than 30 milliliters per minute.
- Consult your doctor before taking large amounts of vitamin C if you have hemochromatosis, thalassemia, sideroblastic

anemia, sickle cell anemia, or erythrocyte glucose-6-phosphate dehydrogenase (G6PD) deficiency. You can experience iron overload if you have one of these conditions and use large amounts of vitamin C.

Vitamin E

- Consult your doctor before taking vitamin E if you take warfarin (Coumadin).
- Consult your doctor before taking high doses of vitamin E if you have a vitamin K deficiency or a history of liver failure.
- Consult your doctor before taking vitamin E if you have a history of any bleeding disorder such as peptic ulcers, hemorrhagic stroke, or hemophilia.
- Discontinue using vitamin E 1 month before any surgical procedure.

Zinc

- High doses of zinc (above 30 milligrams daily) can cause adverse reactions.
- Zinc can cause a metallic taste, headache, drowsiness, and gastrointestinal symptoms such as nausea and diarrhea.
- High doses of zinc can lead to copper deficiency and hypochromic microcytic anemia secondary to zinc-induced copper deficiency.
- High doses of zinc may suppress the immune system.

For more information see the Safety Appendix