Chapter 4

Older Eyes, Cataracts, Lasik and Laser Eye Surgery

If a little kid ever asks you just why the sky is blue, you just look at him or her right in the eye and say, "It's because of quantum effects involving Rayleigh scattering combined with the lack of violet photon receptors in our retinae."

—Phillip C. Plait

Human eyes undergo changes as we age. Good diet and avoiding extreme bright light may have a lessening impact on eye health, but in many cases there is still a deterioration of eyesight. Genetics will play a large role in the aging process and how well sight is preserved as one ages. So there is an element of predestination during aging. But there is plenty of room for changes that the aging astronomer can make that will extend good eyesight and, in turn, the quality of life in the later years. As an aging astronomer, there are strategies that will keep observing time stretching well into later years.

The key to maintaining good eye health is an annual visit to the ophthalmologist. The eye doctor can monitor the status of the eyes, diagnose and assess any changes, and either through prescriptions, eye drops, or as a last resort, perform surgery to correct the various malfunctions of the eyes as we age. Many eye problems can be prevented or corrected if detected in their early stages. An ophthalmologist is a medical doctor, either an M.D. or D.O., with special training to diagnose or treat eye disorders.

Eye health is not to be treated lightly. The Internet is informative, but will not diagnose or provide individualized treatment for any eye problems. The American Academy of Ophthalmology recommends a comprehensive eye examination every

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2–4 years for people between the ages of 40–64 years, with yearly checkups for those over 65 years old. Do yourself a favor. See an ophthalmologist once a year after your 50th birthday. Especially when your hobby is astronomy and your eyes are your primary tools.

Nutrition and Good Eye Health

Before this chapter delves into the disorders of the eye, the question needs to be asked: Are you eating the foods that are best for your eyes? There's more to eye nutrition than Bugs Bunny's diet of just eating carrots. The following foods are recommended by doctors, dietitians, and health authorities for both eye health and overall health, and help protect against sight-threatening diseases:

1. Fish—Cold-water fish such as salmon, tuna, sardines, and mackerel are rich in omega-3 fatty acids which may help protect against dry eyes, macular degeneration, and even cataracts. Omega-3 fatty acid is also a "good" HDL recommended for overall health by keeping cholesterol and the "bad" LDL levels in check.
2. Leafy greens—Spinach, kale, Swiss chard, and collard greens, to name a few, are full of lutein and zeaxanthin, plant pigments that some health experts claim can help stem the development of macular degeneration and cataracts. Broccoli, peas, and avocados are also good sources of the lutein and zeaxanthin antioxidant duo. Again, consumption of leafy greens is recommended for good overall general health.
3. Eggs—The vitamins and nutrients in eggs, including lutein and vitamin A, promote eye health and function. Consult your physician on consuming eggs, as there are concerns over their role in cholesterol development. And there are some, including this author, who are allergic to egg whites, which preclude their consuming them.
4. Whole grains—A diet containing foods with a low glycemic index (GI) can help reduce your risk for age-related macular degeneration. Spelt, buckwheat, quinoa, rye, wild rice, barley, and bulgur are all recommended as part of a diet good for eyes and the rest of the body.
5. Citrus fruits and berries—Oranges, grapefruits, lemons, and berries are high in vitamin C, which may reduce the risk of cataracts and macular degeneration. The benefits of vitamin C have historically been recognized for maintaining a healthy immune system. These fruits are best eaten raw and uncooked, as vitamin C is easily broken down by heat.
6. Nuts and seeds—Pecans, pistachios, walnuts, almonds, brazil nuts, filberts, and others are rich in omega-3 fatty acids and vitamin E that boost eye health. Brazil nuts are also a great source for zinc in the diet. Sunflower seeds are an excellent source for vitamin E and zinc.
7. Deeply colored vegetables and fruits—Finally, the carrot gets its due. Carrots, along with tomatoes, bell peppers, strawberries, pumpkin, corn, and cantaloupe, are all excellent sources of vitamins A and C. The compounds called carotenoids

that give these fruits and vegetables their yellow, orange, and red pigments are also contained in these vegetables, and are thought to help decrease the risk of many eye diseases. Bugs Bunny is finally happy!

8. Legumes—Kidney beans, lima beans, black-eyed peas, and lentils are good sources of bioflavonoids and zinc and can help protect the retina and lower the risk for developing macular degeneration and cataracts. For general good health, beans and legumes are a great source for fiber in the diet.
9. Beef—Apologies to those vegetarians and vegans out there. In moderation, lean beef in the diet can boost eye health. Beef contains zinc, which helps the human body absorb vitamin A and may play a role in reducing risk of advanced age-related macular degeneration.

Disorders of the Aging Eye

No matter the diet or good health practices exercised, the eye structure experiences these normal changes during the aging process:

1. Reduced pupil size—People in their 60s need three times more ambient light for comfortable reading than those in their 20s. The iris at age 20 can open to a diameter of 7 mm. By age 60, the iris opening is reduced to approximately 5.5 mm. The muscles controlling pupil size and reaction to light lose their strength, causing the pupil to become smaller and less responsive.
2. Dry eyes—The body produces less tears as one ages, necessitating the need for artificial tears and other medications prescribed by the ophthalmologist.
3. Loss of peripheral vision—The size of the eye's field-of-view decreases by 1–3° per decade of life.
4. Decreased color vision—Cells in the retina responsible for normal color vision decline in sensitivity with age. Colors become less bright and contrast between colors is less noticeable. Colors towards the blue end of the spectrum can appear particularly faded.
5. Eye strain—Medically referred to as neurasthenia, it occurs with overuse of the eyes particularly from viewing objects at a fixed distance over a long period of time. It is a common problem in all age groups, especially in this day and age with long hours of computer use, watching television, and reading. As one ages, you are more prone to eye strain as the pupillary reaction to light may be slow or not as effective as in the younger years. In addition, the lens loses its elasticity and tear production may be lesser than normal in the senior years. Although eye strain can be a source of significant discomfort and even cause other symptoms like headaches, it is largely reversible and simple lifestyle changes can prevent it. For amateur astronomers, the one-eyepiece style of observing through a telescope can result in eye strain. The answer is to use binoviewers. See the next chapter.

The following are the medical eye problems that face all people, astronomers, or civilians, that can be diagnosed and treated by ophthalmologists. These are present in order of least troublesome and treatable to major issues that potentially lead to the loss of sight. This information was gathered from the American Academy of Ophthalmology:

Presbyopia—From birth to about age 40, the lens of the eye is flexible and changes shape easily, allowing people to focus their eyes close-in and also far away. The lens in our eye becomes less flexible as we get older. By the late 30s or early 40s, reading glasses or bifocals becomes necessary as the lens becomes less flexible and cannot change shape for close-in focusing. Other treatments include monovision LASIK surgery and kamra corneal inlay. The simple remedy for presbyopia is the use of reading glasses, or bifocals for eyeglass wearers.

Floaters—Close your eyes. See those specks or small clouds moving about your vision. Those are floaters. The gel-like vitreous inside the eye begins to liquify with age and pull away from the retina. Floaters are tiny clumps of gel inside the vitreous that fills the inside of the eye. The specks cast a shadow on the retina, which converts the light and shadows to signals to the brain and registers as floaters. An increase in floaters indicates a change within the vitreous gel. A small minority of patients with new floaters will develop a retinal tear or detachment. Only by examining the retina can an ophthalmologist determine if someone has a tear or detachment. The ophthalmologist is the only person that can treat this disorder.

Cataracts—Cataracts are clouding of the lens in the eye, causing the eyesight to become blurred. Cataracts cause blurred vision, poor night vision, glare or light sensitivity, double vision in one eye, and fading of colors. A person with cataracts will often require brighter light to read. An option for treatment is cataract surgery, to be discussed in greater detail later in this chapter.

Glaucoma—One of the leading causes of blindness, glaucoma is a disease of the optic nerve, which carries signals from your eyes to your brain. Glaucoma exists when the pressure inside the eye damages the optic nerve. This intraocular pressure is caused by the inability of the clear liquid that flows in the eye to drain improperly. This is a serious condition, and can only be treated by an ophthalmologist. Early detection of glaucoma is important. The available treatments can stop the deterioration of the damage, but cannot reverse the damage. People can get glaucoma because of aging, elevated eye pressure, family history of glaucoma, and past eye injuries. Those of African or Spanish descent have a greater incidence of glaucoma.

Macular Degeneration—The macula is the small central area of the retina responsible for fine detail detection. Macular degeneration is a breakdown of the macula and the main cause is aging and thinning of the tissues of the macula, with a resulting gradual loss of vision. Rapid macular degeneration and resulting loss of vision can occur from abnormal blood vessels leaking fluid or blood under the macula. According to a European study published in the October 2008 issue of *Archives of Ophthalmology*, ultraviolet and blue light, especially when combined with low blood plasma levels of vitamin C and other antioxidants, is associated with the development of macular degeneration. This condition is very disturbing to an astronomer, resulting in the ability to see a wide field of stars, but unable to detect any details. Again, the ophthalmologist has treatments to slow and stabilize the condition, but there is no cure.

Diabetic Eye Problems—Older adults often suffer from either Type 1 or Type 2 diabetes, which is the body's inability to use or store sugar properly. Diabetes can cause changes to the human circulatory system. Diabetes affects vision by causing cataracts, glaucoma, and damage to the eye's blood vessels. When internal blood vessels leak or cause scar tissue to form within the eye, blurring and distortion can result. This condition, called diabetic retinopathy, can be prevented by good control of blood sugar and blood pressure. In extreme cases, an ophthalmologist can perform laser surgery to halt further damage and loss of sight. It is mandatory that those amateur astronomers who have diabetes work with their endocrinologist and control their diabetes with diet and with insulin injections for Type 1, or medication with Type 2 diabetes. People with Type 2 diabetes should be examined at the time of diagnosis. People with type 1 should be seen within 5 years of diagnosis. Pregnancy may accelerate diabetic retinopathy.

Cataracts and the Impact on Telescope Use

With the use of the eyes as the chief instrument of enjoying the hobby, the formation of cataracts is a major concern among astronomers. Cataracts form with age. About half the people in the United States have some degree of cataract formation by the age of 80. Cataracts may also form because of trauma and radiation exposure. A small percentage of infants are born every year with cataract. Occasionally, eye surgery accelerates cataract formation. Prolonged exposure to sunlight, diabetes, and smoking increases the risk of the development of cataracts (Fig. 4.1).

So what are cataracts exactly? Clumps of protein or yellow-brown pigment develop and form in the lens, reducing the transmission of light to the retina at the back of the eye. Cataracts can affect one or both eyes, and develop slowly, such that they go unnoticed in the early stages.

Americans Who Had Cataracts in 2010

Age Group	Percentage With Cataracts
50-54	5.2%
55-59	9.1%
60-64	15.4%
65-69	24.7%
70-74	36.5%
75-79	49.5%
80+	68.3%

Fig. 4.1 Percentage of the US population with cataracts (allaboutvision.com)

How does the development of cataracts affect an amateur astronomer? The brightness of the objects being viewed is obviously diminished. But this can be tricky to detect. A lunar observer could go for years and not notice the dimming of the image when viewing through the eyepiece, due to the brightness of the Moon.

Planetary observers may start noticing diminished detail. The swirls and eddies of Jupiter's cloud belts become difficult to spot. The Cassini Division in the rings of Saturn is not quite as definitive. During Mars oppositions, the already low contrast Martian details become even more difficult to observe as the contrast is lessened by the cataracts. When observing any of the planets, astronomers with developing cataracts may notice a faint glow around the planets, somewhat like a halo, where previously there was just blackness.

Deep sky observers and double star observers with developing cataracts will find the stars in clusters and their favorite double stars don't quite sparkle like they used to. The ability to split closely separated doubles becomes a challenge. Some globular clusters that used to easily resolve become mere fuzzballs. Filaments of nebulosity that surround emission or reflection nebulae may become less visible.

The early stages of cataracts for an amateur astronomer can be countered by switching to either a larger aperture telescope or using a refractor telescope. The larger aperture is effective because it gathers more light to send to the eyepiece. The additional light counteracts somewhat the dimmer and lessened detail caused by the early stages of some types of cataracts. However, there is one type of cataract, a posterior subcapsular cataract, where the vision gets dramatically worse with brighter light.

The use of refractors will take a little further explanation.

A refractor is an unobstructed telescope design, with no mirror centered along the light path. The physics of the light image is of an Airy disk. In its unobstructed light path, 80% of the light energy is in the central lobe of the Airy disk, with the remainder 20% energy spread in the first and second lobes of the Airy Disk (Fig. 4.2).

The effect of central obstruction, such as that caused by the secondary mirror in a Newtonian or Cassegrain telescope, is to transfer more light from the center of the Airy disk to the outer lobe rings. The SCT example is of a 33% central obstruction. This would cause the first ring to become almost four times brighter

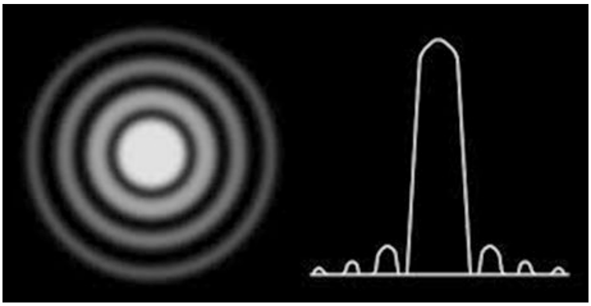

Fig. 4.2 Conceptual depiction of the Airy disk (Hands-on-Optics archive)

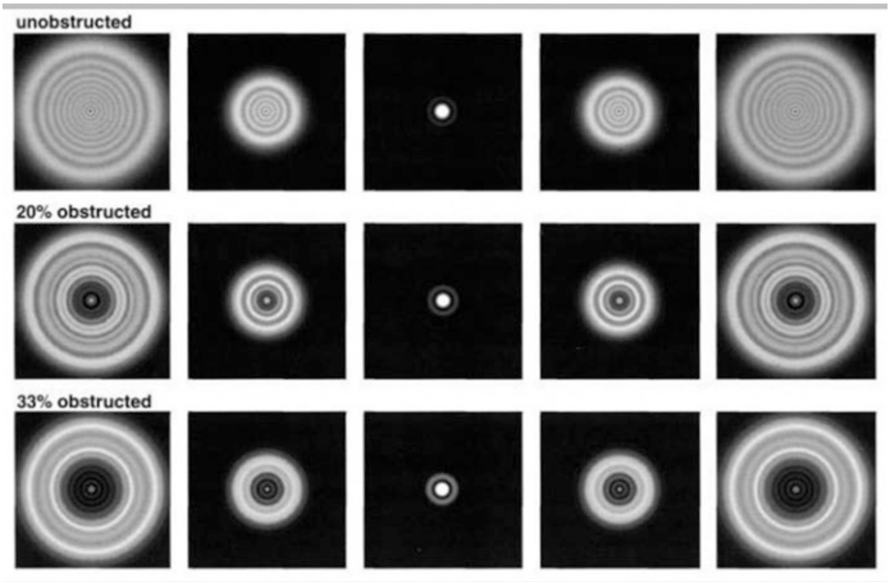

Fig. 4.3 Comparison of a star Airy disk with unobstructed (refractor), 20% obstructed (Newtonian), and 33% obstructed (SCT) optics (Hands-on-Optics archive)

while the central disk would drop in brightness by nearly a factor of 2. The result is blob-like star images that lack the intense tight sparkle that refractor star images have. Planetary details become less distinct with less detail. Overall the image quality is worse when a secondary obstruction is present, with a distinct fall off in contrast.

Thus, a refractor is capable of a much tighter, more intense star image, with nebulae and planets viewed with greater intensity and contrast. The increased contrast available through the use of a refractor can be an effective counter to the effects of the early onset of cataracts and other eye deficiencies of age. This image contrast improvement is even greater using an apochromatic refractor versus an achromatic refractor (Fig. 4.3).

The downside using a refractor is the increased cost of refractor per inch of aperture. Achromats and apochromats are reasonably affordable in apertures up to 100–120 mm. Alt-az and German equatorial mounts for this size of refractor are also quite attainable. However, 130 mm apertures and up, the cost of both telescope and mount increase exponentially. For example, a 200 mm Newtonian on a Dobsonian mount will cost under $400. For example, a 200 mm SCT can be had in the $1000 range. An apochromatic refractor telescope of 200 m aperture with an appropriate mounting can be equivalent in cost to a Mercedes-Benz or BMW car! And is virtually immobile. A 102 mm refractor is the recommended size for a refractor, and is a manageable size for the aging astronomer.

Cataract Surgery

Eventually, the inevitable occurs. Cataract surgery is required. Modern cataract surgery is a common form of eye surgery performed in the United States, and is one of the safest and most effective surgical procedures performed today. More than three million cataract surgeries are performed in the United States every year, with a 98% or better success rate with excellent visual outcomes. That's a great batting average!

While rare, complications after cataract surgery can occur. Most problems can be treated successfully, but there is a risk of some degree of vision loss. Remember, this still is surgery, and surgery has risks. This is best discussed with your eye surgeon. The complications include:

1. Inflammation or infection of the eye
2. Bleeding in the eye
3. Swelling of the cornea
4. Detachment of the retina
5. Increased pressure inside the eye
6. Dislocation of the implanted lens
7. Accumulation of fluid in the retina
8. Drooping eyelid

So, what exactly is the cataract surgery procedure. The short, crude explanation is the surgeon makes two small incisions in the eye and removes the cataract with an ultrasound probe. An artificial lens is inserted into the eye using the same incision. Zip-zap zowie, new fresh vision in place of the old fuzzy cloudy vision (Fig. 4.4).

Cataract surgery is a procedure used to remove the natural lens in the eye when it becomes clouded. The natural lens is replaced with a plastic, artificial lens that is permanent, requires no care, and can significantly improve vision. Newer artificial lenses can have the natural focusing ability of a young lens, allowing for distance and some near vision, as well. This is a major benefit for those lifelong eyeglass wearers, with the post-procedure result of wearing either a weaker prescription set of eyeglasses or none at all!

Cataract removal is one of the most frequently and commonly performed surgical procedures in the world. The surgery is typically an outpatient procedure that takes less than an hour. Most patients are awake during the procedure and need only local anesthesia. If you need to have cataracts in both eyes removed, you will typically have two separate surgeries. This way, the first eye can heal before the second eye surgery.

There are two types of cataract surgery:

1. Small incision cataract surgery (as previously and crudely described) involves making a small incision in the side of the cornea (the clear outer covering of the eye) and inserting a tiny probe into the eye. The probe emits ultrasound waves that soften and break up the lens into little pieces so it can be suctioned out. This process is called phacoemulsification.

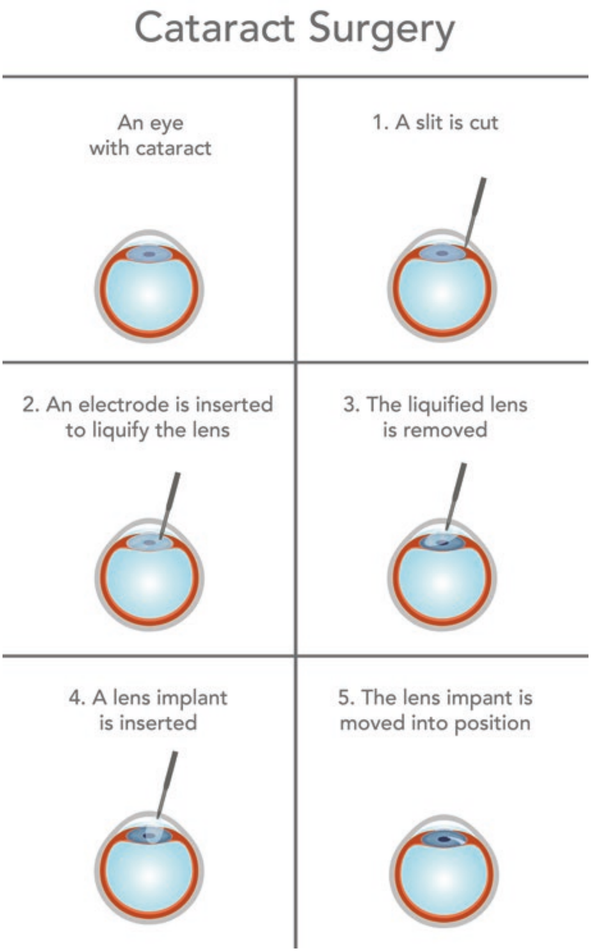

Fig. 4.4 Graphical depiction of cataract surgery (Adam Chen)

During this procedure, the surgeon removes the cataract but leaves most of the thin outer membrane of the lens, called the lens capsule, in place. The incision made for this procedure is so small that the surgeon generally does not need to use sutures to close the opening.

2. Extracapsular surgery requires a somewhat larger incision in the cornea to allow the lens core to be removed in one piece. This approach may be used if the cataract has advanced to the point where phacoemulsification can't break up the clouded lens. If yearly periodic eye examinations have been a practice, it is unlikely the cataracts will have reached this stage resulting in this slightly more complicated procedure. Through this incision, your surgeon opens the lens capsule, removes the central portion of the lens, and leaves the capsule in place.

Once the eye surgeon removes the natural lens, he or she generally replaces it with a clear plastic lens called an intraocular lens (IOL). The IOL is placed in the lens capsule that was left in the eye. The artificial lens can focus light onto the back of the eye and improve vision.

Prior to the procedure, make sure to talk with the ophthalmologist about your astronomy requirements, particularly the need to have a wrinkle-free insertion of the IOL.

When implanting an IOL is not possible because of other eye problems, contact lenses and, in some cases, eyeglasses may be able to correct vision.

Intraocular lenses come in three basic forms: monofocal, astigmatic (toric), and multifocal lenses.

Monofocal lenses are the most commonly implanted lenses. They have the same power in all areas of the lens. They can have a fixed focus or allow for changes in focus.

Fixed focus monofocal IOLs can provide excellent distance vision. However, since these lenses have a fixed focus set for distance vision, you may need to use reading glasses for good near vision. These are the recommended lenses for amateur astronomers. These monofocal lenses allow for the greatest sharpness and contrast required for observing through a telescope.

Accommodating monofocal IOLs is a relatively new lens option that can be used for patients who want both good distance and near vision without the use of eyeglasses or contact lenses. These lenses also have a single focusing power. However, they can shift from focusing on distance objects to focusing on near ones by physically moving inside the eye in response to the focusing action of the eye muscles. This type of lens has a downside. Many patients have noted glare and halos around lights, decreased sharpness of vision, and lack of contrast, especially at night or in dim lighting conditions. Not recommended for amateur astronomers.

Astigmatic (toric) IOLs are monofocal IOLs that have astigmatism correction in them. They can be used for patients who suffer from high astigmatism and want to reduce it.

Multifocal lenses are like bifocal eyeglasses. Several areas of the lens have different powers, which allow individuals to see clearly at far, intermediate and near distances. However, these multifocal lenses are not suitable for everyone. For some individuals, they may cause more problems with night vision and glare than monofocal IOL lenses. Caution is advised for amateur astronomers because of the glare issues and lessened low-light contrast.

Post-Cataract Surgery Recovery and Issues

Since cataract surgery is normally performed as an outpatient procedure, going home on the day of the surgery is allowed so long as someone else is driving. Help is needed at home for a few days because the doctor may limit activities such as bending and lifting.

It is normal to feel itching and some mild discomfort after cataract surgery. There may be temporary fluid discharge from the treated eye and don't be surprised by light sensitivity. Avoid rubbing or pressing on the surgically repaired eye. Try not to bend from the waist to pick up objects on the floor. Do not lift any heavy objects. Movement is limited to walking, climbing stairs, and doing light household chores.

The doctor may prescribe medications to prevent infection and control eye pressure. After a few days, the eye should be comfortable. Normal activities can be resumed within about 8 weeks.

During this healing time, the ophthalmologist will want to monitor eye health and vision. In many cases, refractive testing will occur to check if eyeglasses are still needed for distance and reading activities. Most patients benefit from some form of eyeglasses or contact lenses for optimum vision. Most people need to wear glasses after cataract surgery, at least for some activities. Typical follow-up visits occur 1 day, 1 week, 3–4 weeks, 6–8 weeks, and 6 months after surgery.

Following cataract surgery, regular eye exams are needed to monitor eye health and vision. For amateur astronomers, have your eyes checked at least once a year.

There is a postoperative condition called "secondary cataract" or "aftercataract." This occurs when the lens capsule, the membrane that wasn't removed during surgery and supports the lens implant, becomes cloudy and impairs vision. Another term for this condition is posterior capsular opacification (PCO) (Fig. 4.5).

A secondary cataract can develop months or years after cataract surgery. Cataract symptoms return and vision becomes blurry again. Cell growth on the back of the capsule gradually clouds eye vision.

There is no way to know who may develop clouding of the lens capsule after cataract surgery. Up to 50% of cataract surgery patients experience this problem (Fig. 4.6).

Treatment for a secondary cataract is fairly simple. It involves a technique called YAG laser capsulotomy, in which a laser beam makes a small opening in the

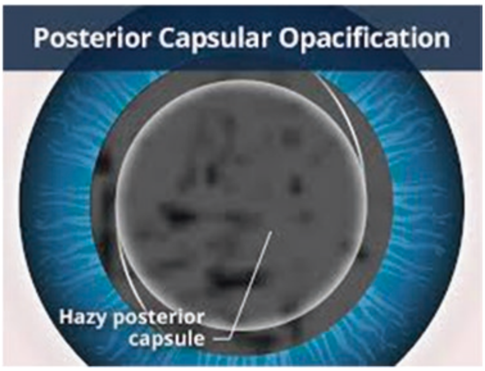

Fig. 4.5 Posterior capsular opacification (PCO) (Allaboutvision.com)

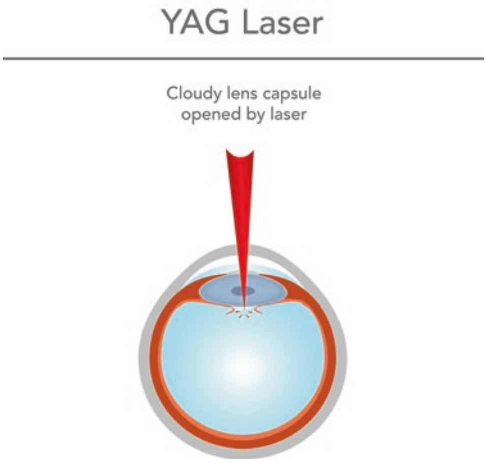

Fig. 4.6 A schematic of YAG laser capsulotomy (Adam Chen)

clouded capsule to allow light through. It is a painless outpatient procedure that usually takes less than 5 min. Most patients are asked to stay in the doctor's office for about an hour to make sure the eye pressure doesn't increase. Most patients immediately experience improved vision, while some experience gradual improvement over several days.

LASIK Surgery

One of the great advancements in eye care in the last 50 years has been the development of techniques for correcting myopia (nearsightedness) and hyperopia (farsightedness).

The most common type of laser vision correction, LASIK is an acronym for Laser-Assisted in situ Keratomileusis, a surgical procedure used to repair nearsightedness, farsightedness, and astigmatism by reshaping the cornea. It is unique in that it also corrects lesser-known problems like "halos," "starbursts," and "ghost images," drastically improving night vision.

LASIK surgery is a controversial procedure among the amateur astronomy community. There is anecdotal evidence that both supports the procedure and those against the procedure. As with any surgery, consultation with the ophthalmologist is required. The discussion should include the fact that astronomy is an important activity. Anecdotal evidence exists that many amateur astronomers who have had LASIK surgery suffer aftereffects that impair their enjoyment of their favorite hobby, with blurriness or halos as a common complaint. Again, remember this is a form of surgery, and surgeries have inherent risks.

For the over-50 years old amateur astronomer, LASIK surgery is not recommended since the likelihood of cataracts development is high. Cataract surgery with an IOL will correct the individual's vision and in many cases is covered by insurance. LASIK surgery is not covered by insurance and is an out-of-pocket expense.

Most corrective measures, including glasses, contacts, and conventional laser surgery, only address issues called lower-order aberrations, providing a satisfactory solution for many people. However, higher-order aberrations, which LASIK targets, still detract from overall quality of vision.

LASIK is a minimally invasive operation during which the patient remains awake, and anesthetic drops are administered to completely numb the eyes. The correction itself takes less than 10 min per eye, with the entire process lasting a few hours. Side effects are generally few.

How is LASIK surgery performed?

1. First, ophthalmologist uses either a mechanical surgical tool called a microkeratome or a femtosecond laser to create a thin, circular "flap" in the cornea.
2. The surgeon folds back the hinged flap to access the underlying cornea and removes some corneal tissue using an excimer laser.
3. This highly specialized laser uses a cool ultraviolet light beam to remove ("ablate") microscopic amounts of tissue from the cornea to reshape it so it more accurately focuses light on the retina for improved vision.
4. For nearsighted people, the goal is to flatten the cornea; with farsighted people, a steeper cornea is desired.

Excimer lasers can also correct astigmatism by smoothing an irregular cornea into a more normal shape. It is a misconception that LASIK cannot treat astigmatism.

After the laser reshapes the cornea, the flap is then laid back in place, covering the area where the corneal tissue was removed. Then the cornea is allowed to heal naturally.

The healing and recovery process is fairly simple, requiring only topical anesthetic drops, and no bandages or stitches are required (Fig. 4.7).

Common LASIK complications and side effects are listed below:

1. Temporary discomfort and vision disturbances—Discomfort during the first few days following LASIK surgery, such as mild irritation and light sensitivity, is normal and to be expected. During the first few weeks or months you also may experience: halos; glare and starbursts in low-light environments, especially at night; dry eye symptoms; hazy vision; and reduced sharpness of vision. In the vast majority of cases, these problems are temporary and disappear completely within 3–6 months.
2. Flap complications—The LASIK procedure involves the creation of a thin hinged flap on the front surface of the cornea. This is lifted during surgery for laser reshaping of the eye. The flap is then replaced to form a natural bandage. If the LASIK flap is not made correctly, it may fail to adhere properly to the eye's surface or microscopic wrinkles called striae could develop in the flap. These

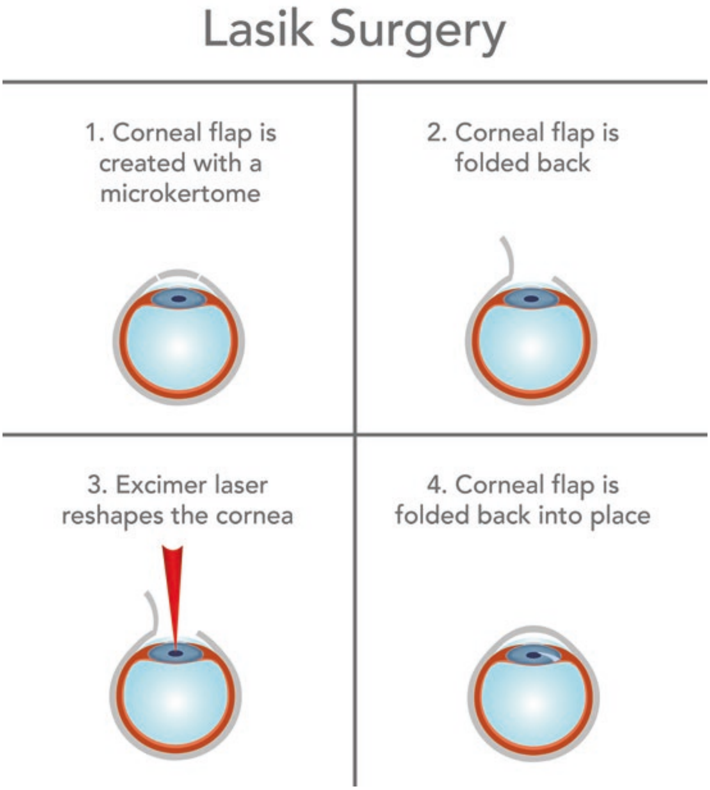

Fig. 4.7 LASIK eye surgery (Adam Chen)

flap complications can cause optical aberrations and distorted vision. Studies indicate that flap complications occur in 0.3–5.7% of LASIK procedures, according to the April 2006 issue of *American Journal of Ophthalmology*. In a study of 3009 consecutive LASIK surgeries performed August 2002–July 2009 using a femtosecond laser for flap creation, flap complications occurred in fewer than one-half of 1% (0.37%) of these procedures, and all complications were successfully managed within the same surgical session. Again, remember that you can reduce your risk of LASIK complications by choosing a reputable, experienced eye surgeon.

3. Irregular astigmatism—This is caused by an unequally curved corneal surface. Irregular astigmatism also can occur from laser correction that is not centered properly on the eye or from irregular healing. Resulting symptoms may include double vision or "ghost images." In these cases, the eye may need re-treatment or enhancement surgery.
4. Epithelial ingrowth—This is when cells from the outer layer of the cornea (epithelium) grow under the flap after LASIK surgery. In most cases, epithelial

ingrowth is self-limiting and causes no problems. But in some cases (reported to be 1–2% of LASIK procedures), symptoms of discomfort and/or blurred vision can occur, and additional surgery is needed to lift the flap and remove the epithelial cells.

5. Diffuse lamellar keratitis (DLK)—With the nickname "The Sands of the Sahara," this is inflammation under the LASIK flap that may have several causes. Some inflammation of the cornea after LASIK surgery is normal. But if it is uncontrolled, as in DLK, it can interfere with healing and cause vision loss. If DLK occurs, it usually responds to therapies such as antibiotics and topical steroids. Also, the flap might need to be lifted and cleaned for removal of inflammatory cells and to prevent tissue damage.
6. Keratectasia or keratoconus—This is a very uncommon bulging of the eye's surface that can occur if too much tissue is removed from the cornea during LASIK or if the cornea prior to LASIK is weak as evidenced from measurements of the cornea. Rarely does keratoconus develop after LASIK with no known risk factors. Enhancement laser surgery is usually not suitable, and gas permeable contact lenses or corneal lenses may be prescribed to hold the cornea in place, or a treatment called corneal collagen cross-linking may be performed to strengthen the cornea.
7. Dry eyes after LASIK—Some people who have LASIK surgery experience a decrease in tear production that can cause eye discomfort and blurred vision. Almost half of all LASIK patients experience some degree of temporary dry eye syndrome, according to the April 2006 issue of *American Journal of Ophthalmology*. Dry eye syndrome after LASIK surgery usually is temporary and can be effectively treated with lubricating eye drops or other measures. Dry eye problems usually disappear when healing of the eye is complete, which can take up to 6 months. People who already have severe dry eye usually are eliminated as LASIK candidates.
8. Significant undercorrection, overcorrection, or regression—Not everyone will achieve 20/20 vision after LASIK eye surgery, and contact lenses or corrective eyeglasses for some or all activities may still be required in rare cases. If the laser removes too much or too little corneal tissue, or the eye's healing response is not typical, the visual outcome will be less than optimal. One possible cause of a less-than-perfect outcome is that the eyes did not respond to laser eye surgery in a predictable manner. Another possible cause is that the eyesight may have been optimal shortly after LASIK but regressed over time due to "over-healing." In most cases, a significant undercorrection or regression can be successfully treated with additional laser vision correction after your surgeon confirms your residual refractive error is stable. Regression of the LASIK effect is common.
9. Eye infection—Infections rarely occur after LASIK. Because the corneal flap acts as a natural bandage, eye infections occur less frequently after LASIK than after flap-free corneal refractive procedures like PRK. Still, it is very important to use medicated eye drops as directed after the LASIK procedure to avoid infection and control inflammation as the eyes heal.

Astronomers should approach LASIK with caution. At night, when the exit pupil is relatively large, the diameter of the exit pupil is equal or exceeds the diameter of the circle of the scarred tissue, causing diffraction/halo artifacts around any bright lights (car lights, street lights). However, once sufficient light is available and the exit pupil shrinks, the artifacts are gone.

LASIK Surgery Incompatibility with Cataract Surgery

LASIK surgery and cataract surgery are two different procedures to improve vision by correcting two different problems: two different roads to the same goal. Lasik seeks to correct focusing disorders like nearsightedness, farsightedness, and astigmatism by reshaping the cornea of the eye. The presence of a small amount of cataract would not diminish the results of LASIK, but if and when the cataracts grow, cataract surgery is still required. This would mean two surgeries on each eye rather than one. Additionally, LASIK is not usually covered by insurance as it is cosmetic, and is considered elective surgery.

One of the unfortunate realities of cataract surgery in an eye that has had previous LASIK surgery is that the process of selecting an artificial lens isn't quite as precise as for those who have not had LASIK. Ophthalmologists have a number of different compensatory methods, but have varying degrees of success with all of them. If the data is available, one tactic used by ophthalmologists is to average the results of four different tests, two of which take into account pre-LASIK measurements, and two based on current measurements post-LASIK.

Cataract surgery replaces the focusing lens of the eye that has become clouded due to aging or other causes. The shape of the cornea is not significantly changed as in the LASIK procedure. Cataract surgery is covered by most insurance providers once the cataract has reached the definition of mature, which can vary.

To add to the level of confusion, some people who desire LASIK are not good candidates for LASIK and can be helped by removing their lens and inserting an intraocular lenses, namely, cataract surgery without the cataracts. This is not customarily covered by insurance providers as it is considered cosmetic in nature.

The Role of Sunglasses and UV Radiation

Unlike the recommendation of the ZZ Top song "Cheap Sunglasses," spend some good money on good quality sunglasses. And wear sunglasses in all seasons, not just the summer. The Sun is emitting a full spectrum of radiation all the time, including the winter.

Ultraviolet (UV) and to a lesser extent blue light are on the high-energy end of the visible spectrum, and as such are contributors to failing eyesight. Ever wonder why, in old movies about the Old West or the desert, blind people are depicted with cataract-laden eyes?

UV rays have higher energy than visible light rays, which makes them capable of producing changes in the skin that create a suntan. UV radiation, in moderation, has the beneficial effect of helping the body manufacture adequate amounts of vitamin D.

Too much exposure to UV causes a painful sunburn. Too much UV radiation and skin cancer becomes an issue. These rays also can cause sunburned eyes—a condition called photokeratitis or snow blindness.

Sunglasses that block 100% of UV are essential to protect the eye from damage that could lead to cataracts and snow blindness.

There is a growing concern over the amount of high-energy blue light (HEV) that enters the eye. The fact that blue light penetrates all the way to the retina (the inner lining of the back of the eye) is important, because laboratory studies have shown that too much exposure to blue light can damage light-sensitive cells in the retina. This causes changes that resemble those of macular degeneration, which can lead to permanent vision loss. Research is being conducted over the concern that the added blue light exposure from computer screens, smartphones, and other digital devices might increase a person's risk of macular degeneration later in life.

Blue light is also good. It's well documented that some blue light exposure is essential for good health. Research has shown that high-energy visible light boosts alertness, helps memory and cognitive function, and elevates mood.

In fact, something called light therapy is used to treat seasonal affective disorder (SAD), a type of depression that's related to changes in seasons, with symptoms usually beginning in the fall and continuing through winter. The light sources for this therapy emit bright white light that contains a significant amount of HEV blue light rays.

Also, blue light is very important in regulating circadian rhythm, the body's natural wakefulness and sleep cycle. Exposure to blue light during daytime hours helps maintain a healthful circadian rhythm. Too much blue light late at night (reading a novel on a tablet computer or e-reader at bedtime, for example) can disrupt this cycle, potentially causing sleepless nights and daytime fatigue.

Anyone who spends a lot of time outdoors is at risk for eye problems from UV and HEV radiation. Risks of eye damage from UV and HEV exposure change from day to day and depend on a number of factors, including:

1. Geographic location—UV levels are greater in tropical areas near the earth's equator. The greater the distance from the equator, the smaller the risk.
2. Altitude—UV levels are greater at higher altitudes.
3. Time of day—UV and HEV levels are greater when the sun is high in the sky, typically from 10 a.m. to 2 p.m.
4. Setting—UV and HEV levels are greater in wide open spaces, especially when highly reflective surfaces are present, like snow and sand. In fact, UV exposure can nearly double when UV rays are reflected from the snow. UV exposure is less likely in urban settings, where tall buildings shade the streets.
5. Medications—Certain medications, such as tetracycline, sulfa drugs, birth control pills, diuretics, and tranquilizers, can increase your body's sensitivity to UV and HEV radiation.

Surprisingly, cloud cover doesn't affect UV levels significantly. The risk of UV exposure can be quite high even on hazy or overcast days. This is because UV is invisible radiation, not visible light, and can penetrate clouds.

There are various eyeglass formulations and sunglasses that filter UV radiation and provide degrees of filtration of blue light frequencies. Again, consult your ophthalmologist and optometrist on the best choices.

And don't wear sunglasses at night … it's not cool. It's silly!

Except when an eyeglass wearer has photochromic lenses in their glasses. Photochromic lenses are eyeglass lenses that are clear indoors or at night, and darken automatically when exposed to sunlight. Amateur astronomers who wear eyeglasses should consider these for everyday wear. There is a convenience factor and safety element to always having UV protection for eyeglass wearers. Some people like these, other don't. The big complaint is that they're either too dark indoors or not dark enough outdoors.

The molecules responsible for causing photochromic lenses to darken are activated by the sun's UV radiation. Because UV rays penetrate clouds, photochromic lenses will darken on overcast days as well as sunny days.

Photochromic lenses typically will not darken inside a vehicle because the windshield glass blocks most UV rays. Recent advancements in technology allow some photochromic lenses to activate with both UV and visible light, providing some darkening behind the windshield.