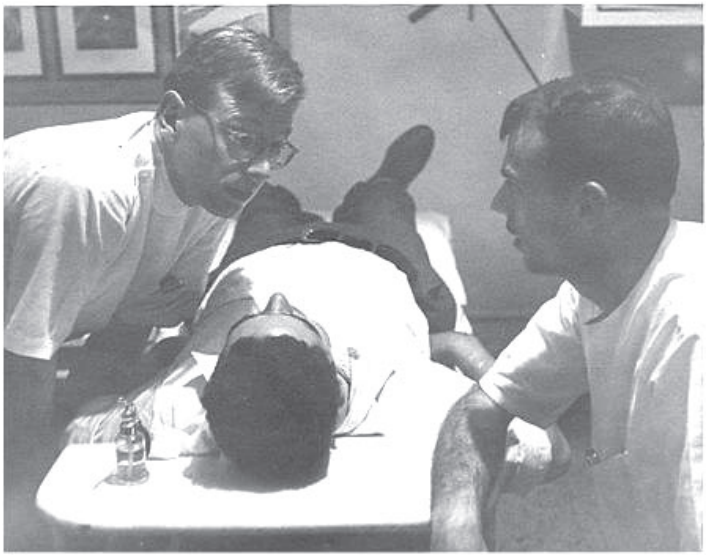
Lasers in eye surgery:
A revolutionary impact on vision treatment
. . . Stanford doctors gave people the "gift of sight"

By Carolyn Bruckmann

Fifteen-year-old Carolyn Bruckmann was a sophomore at Stevenson School in Pebble Beach (Monterey County) when she wrote this CCHS award winning History Day 2010 paper. She tells us: "I had two coaches. One was my AP World History teacher, Byron Stevens. The other was a teacher that I had in middle school who led me through the National History Day process in 7th grade. Her name is Forbes Keaton and she works at All Saints Episcopal Day School. My personal ambition is to become an anthropologist."

Carolyn Bruckmann



Dr. Zweng (left) confers with colleague over patient.

The introduction of lasers to eye surgery in 1963 has transformed the practice of ophthalmology. A group of ophthalmologists spearheaded by Dr. H. Christian Zweng pioneered this innovation. As a result of their efforts, the ruby laser is currently instrumental in healing retinal detachments and tears, which are leading causes of blindness worldwide. It is estimated that around the world "ninety eyes are blinded by [retinal detachment] every hour" (Shah). The subsequent development of the argon laser in 1966 led to the first effective treatment of vision complications due to diabetes. Today in the United States, diabetes is the leading cause of blindness and affects more than nine million adults (www.nlm.nih.gov). Therefore the use of lasers in eye surgery is an innovation that has revolutionized the treatment of both retinal tears and diabetic retinopathy. In addition, the development of the Excimer laser, used in LASIK surgery, has improved vision for millions. Today the use of lasers is an established practice in ophthalmology around the world.

Before the use of lasers in eye surgery, retinal tears led to retinal detachments and usually blindness. The retina is a light-sensitive membrane in the back of the eye that transmits images to the optic nerve. Retinal tears occur when the vitreous humor changes shape. This allows the vitreous fluid, the jelly-like substance inside the eye, to seep behind the retina, causing the retina to pull away from the optic nerve (L'Esperance).

Prior to 1963, there were few techniques used to reattach retinas and none was very effective (Spetz 46). One of these methods entailed doctors "apply[ing] energy on the surface of the eye…or turn[ing] the eye around after loosening muscles to bore a hole in the sclera [the external covering of the back of the eyeball]" (Spetz 46). Recovery "required an inpatient hospital stay and significant recuperation time and was, as Dr. Francis L'Esperance commented, 'really barbaric'" (Spetz 46). Another technique still in use employs the scleral buckle, a device composed of rubber or sponge (Adams). As ophthalmologist Dr. Adams explained, doctors "freeze the retinal tissue and then probe the sclera next to the retinal tear. This freezing process causes the retina to adhere to the sclera by creating a scar. The doctors would finish by wrapping the scleral buckle around the eye" (Adams). This technique often requires a hospital stay and a six- to eight-week postoperative period when patients are required to wear an eye patch at night and refrain from reading (www.surgeryencyclopedia.com).

In 1954, ophthalmologists began developing photocoagulation, a technique using light sources to create scarring to treat retinal tears (Spetz 46). Ophthalmologist L'Esperance compared photocoagulation to "wallpaper falling off of the walls in a house and placing paste on the walls to make it adhere" (L'Esperance). Gerd Meyer-Schwickerath pioneered photocoagulation by using a device that utilized the sun as the source of light in order to scar the retina. Nevertheless, Meyer-Schwickerath's procedure proved highly dangerous because the amount and brightness of sunlight could not easily be manipulated, potentially leading to excessively burned retinas.

Following Meyer-Schwickerath's development, doctors continued their efforts to improve the technique used for photocoagulation. Germany became the first country to use a Zeiss photocoagulator, a device that utilized xenon arc lamps instead

of direct sunlight to burn the retina in order to create scar tissue (Spetz 46). In 1959 the Columbia-Presbyterian Medical Center and the Stanford University Medical Center (California) received three Zeiss photocoagulators (Spetz 46). Although an essential step in the development of photocoagulation, the xenon arc lamp's beam was too wide. "It made such a huge spot on the back part of the eye that it would destroy most of the retina" (L'Esperance). As mentioned in an alumni Stanford Research Institute bulletin, "[T]he inaccuracies of the white-light photocoagulator meant it was unsuitable for the most delicate operations" (Schwaar 4). Furthermore the Zeiss photocoagulator caused unnecessary physical pain. Medical researcher Milton Flocks said, "[I]n half a second…the iris contracts and comes down hard, and that hurts" (Spetz 46).

Meanwhile, a new device, the ruby laser, became of interest to ophthalmologists as physicists publicized its potential for medical uses. Doctors began to realize its promise as a therapeutic device in ophthalmology as a substitute for the xenon arc lamps. Physicist Arthur Schawlow of Stanford University, who subsequently received the 1981 Nobel Prize for his research on lasers, demonstrated this potential with the red balloon experiment — he shot a laser beam through a clear outer balloon in order to pop a colored inner balloon. This experiment simulated the idea of a laser passing through the eye's cornea without causing damage and yet burning the patient's retina in order to create scar tissue.

The two American teams that received the Zeiss photocoagulators began to experiment simultaneously. The Stanford research group, headed by Drs. Milton Flocks and H. Christian Zweng, were "a super team out there on the west coast" (L'Esperance). Having taken courses in physics, Dr. Flocks was able to understand the physics and components of a laser; this understanding was essential to helping the group successfully use lasers as the light source in photocoagulation. The team experimented with rhesus monkeys in order to develop the technique, which proved more effective than using rabbits.

In August 1963, Dr. Zweng became the first doctor to use a laser photocoagulator when he operated on patient Donald Scheuch. His wife, Polly Scheuch, remembers the cause of Scheuch's retinal detachment: "He was in the swimming pool with our son and missed catching the tennis ball, which hit him in the eye" (P. Scheuch). Scheuch had been working at the Stanford Research Institute and heard of Zweng's experiments with the laser. Mrs. Scheuch recalls, "Zweng and Flocks were working on using the laser, something that was all very new at the time. This sounded like an easier way to reattach Don's retina, because he knew about the mechanics of the laser. I was all for it because I knew the Zeiss machine was harder on the patient. I guess the only uncertainty I had was because he was the first patient" (P. Scheuch). When questioned about his feelings of being the first patient to experience the surgery, Mr. Scheuch responded, "The only difficulty was obviously my mental pain. You can imagine lying on your back wondering whether you will lose your eye or not" (D. Scheuch). The surgery went smoothly, as Scheuch remembers, "There was never any physical pain involved" (D. Scheuch).

After successfully executing the surgery, word of the success of Zweng and Flocks rapidly spread throughout the medical community. In 1964 they presented their results at the annual American Medical Association conference (Spetz 50). After the meeting, Flocks said, "The doctors didn't even know what a laser was…and after that it went like wildfire" (Spetz 50).

When it became known in the medical community that doctors were using lasers in eye surgery, scientists throughout the country raised doubts about the new method. Their fears were summarized in a *New York Times* article printed in 1966. The article quoted Dr. William T. Ham, Jr., a world expert on the effects of laser radiation on vision and professor at Virginia Commonwealth [University, in Richmond, Virginia]: "Lasers…are becoming widely used in many kinds of physical, biological and medical research. People…should be made aware that laser light can be dangerous to the eye" (Schmeck 1). Ham also emphasized that "the human eye is just about the most sensitive organ to laser radiation" (Schmeck 1).

The Air Force soon became interested in the effects of laser radiation in combat. After the experience of flash blindness from the bombings of Hiroshima and Nagasaki in World War II, scientists were concerned about the effects of laser radiation on the eyes. Taking the protests of scientists into consideration, Zweng tested the ruby laser on himself during 1968 and 1969. For his efforts, Zweng received a certificate from the Air Force expressing their appreciation for:

> [V]oluntarily and with full knowledge of the risks involved, repeatedly expos[ing] his eyes to laser radiation at levels considered hazardous by some experts in order to establish the permissible exposure levels to laser radiation. His outstanding and courageous actions on this important research project demonstrated the safety of…permissible exposure levels to laser radiation. (Air Force testimonial)

Despite all of the success with the ruby laser, Zweng and L'Esperance were not satisfied with it. Addressing this, L'Esperance explained, "The ruby laser was good for things like retinal tears, but it didn't do anything for the leading cause of blindness [diabetic retinopathy]" (L'Esperance). From the 1960s to the present, diabetic retinopathy has been the leading cause of blindness in Americans of ages 25 to 65 (Jacko 513). Diabetes leads to vascular changes throughout the body; in the eye, new, weak blood vessels grow, which often leak, flooding the back of the eyeball with blood. This turns into scar tissue, which prevents light from reaching the optic nerve. Diabetes is particularly prevalent in the U.S. population; 16 million Americans, about 3% of the population, suffer from

diabetes, and 99% of these will develop diabetic retinopathy after 20 years of having the disease (Jacko, 513). Furthermore, with today's rapid increase in the rates of obesity in the United States, the number of diabetics is also increasing.

Until argon laser photocoagulation, there was no treatment to forestall this inevitable blindness caused by diabetes. Zweng and L'Esperance both conducted research using the argon laser. This laser would prove more effective than the ruby laser for treating diabetic retinopathy since blood vessels reflect the red light of the ruby laser. In contrast, the blue-green light of the argon laser is absorbed by the blood vessels. Using the argon lasers, the doctors were able to weld off these blood vessels and prevent the leakage. As Zweng notes in his book, "We introduced the argon laser…between 1966 and 1969…The success of the animal experiments, which demonstrated the effectiveness of the argon laser…made [it] the light source of choice in the prototype laser photocoagulator" (Zweng vii, 27). Using this technique "maintains or improves vision in about 90% of the eyes treated" (Zweng 214). In one experiment that included 16 people, "[I]n the span of 12 or more months, 14 of the 16 treated eyes were healthier, compared to the untreated eyes [none had improved]" (Zweng 211). With the argon laser, doctors were thus able to prevent blindness from diabetic retinopathy.

The success of Zweng's team was publicized in the *New York Times* on November 24, 1972: "[R]esearchers at Stanford University in California have invented a device for treating diseases of the eye with a laser beam. Patent 3,703,176 was granted…to Arthur Vassiliadis, Harold C. Zweng, Norman A. Peppers, and Lloyd E. Alterton" (Jones 1). A further measure of its significance is that 45 subsequent patents have referenced it.

Following the development of the argon laser, hundreds of doctors came to learn about laser photocoagulation. L'Esperance, who taught some of these seminars on how to treat diabetic retinopathy with lasers, commented, "We had Chris Zweng and Hunter Little on the West Coast. I had a laboratory [at Columbia-Presbyterian Medical Center, New York City], and then we had doctors at Johns Hopkins. We had a course every three months lasting around three days. The basic faculty, Chris Zweng, Hunter Little, Arnold Patz [and I], gave 12 of the clinics and usually 60 to 80 people would come from all over the world" (L'Esperance). Zweng wrote, that as of 1977, "We have treated approximately 2,500 eyes in…9,500 treatment sessions…Now about 1,000 instruments based on our prototype are being used throughout the world by several thousand ophthalmologists…[a]pproximately 900 ophthalmologists have taken the 20 courses" (Zweng vii). Despite these frequent treatment sessions, L'Esperance admitted, "Every time we treated somebody it would be a new thing" (L'Esperance).

Although this group of doctors all worked collaboratively, Zweng was central in the promotion of the argon laser. L'Esperance recognized this: "Chris had so much charisma and he was such a great speaker. He just made it happen; Chris was by far the best of the four of us" (L'Esperance). In 1969, Zweng wrote *Argon Laser Photocoagulation*, with the assistance of Hunter Little, while continuing to teach the courses and treat patients. In its preface, Zweng recognized the urgency of spreading photocoagulation and was willing to do whatever required to do this: "We feel…a great responsibility to disseminate to those ophthalmologists who perform argon laser photocoagulation to avoid our mistakes…and to deepen the often shallow knowledge possessed by the general physician and internist of retinal diseases" (Zweng vii). Zweng recognized that further advancements were necessary, "Indications…must be sharpened further, techniques still improved, and complications more completely avoided" (Zweng vii). Dr. Zweng passed away in 1977 and, in memory of his accomplishments, the Zweng Memorial Retinal Research Foundation was established.

Photocoagulation remained the sole application of lasers to eye surgery until the development of LASIK eye surgery, which uses the Excimer laser to reshape the cornea. Unlike its predecessors, the Excimer laser does not burn tissue; instead, it evaporates the external layer. In 1978, American scientist Rangaswamy Srinivasin of the IBM T.J. Watson Research Center became the first to apply the laser to this purpose (http://www.lasik-eye-surgery.info/history.html). With the use of the Excimer laser, the surgery became increasingly accurate because of the precision of the laser, making changes "the width of a hair" (Goldberg 1). LASIK surgery cures eye conditions such as astigmatism and near-sightedness; presently, one million patients have the surgery each year (Goldberg 1). In a magazine article published around the time that LASIK was gathering momentum, author Marian Segal noted:

> In two studies, approximately 75 percent of the patients who were interviewed about their reasons for seeking radial keratotomy stated that they wished to see well without physical dependence on...spectacles or contact lenses. Patients also sought [LASIK] to improve their performance in profession or sport, to improve cosmetic appearance, [or] for simple convenience. (Segal 1)

In essence, LASIK eye surgery truly cures vision deficiencies, while glasses merely correct them.

Lasers began a new era in eye surgery. With their application to eye surgery, it is no longer necessary for doctors to cut open eyes in order to reattach retinas. This development drastically improved outcomes, reducing recovery time, pain, and risk of infection. Subsequently the development of the argon laser led to a cure for the vision losses associated with diabetes. Finally, LASIK surgery has eliminated the need for glasses for millions. Thus the application of lasers to eye

surgery has had a profound impact on the world; it originally prevented blindness and now also improves vision. In essence, the application of lasers to eye surgery has provided people throughout the world with the gift of sight.

BACKGROUND INFORMATION ON PEOPLE MENTIONED IN THIS PAPER

1. Harold Christian Zweng was an ophthalmologist at the Palo Alto Medical Foundation and member of the Stanford Medical School faculty. Dr. Zweng was also affiliated with the Stanford Research Institute.

2. The L'Esperance reference (first page, end of second paragraph) refers to Francis L'Esperance. Dr. L'Esperance is affiliated with the Columbia-Presbyterian Medical Center, Manhattan, New York City. He graduated from Harvard Medical School and worked as an ophthalmologist in New York City.

3. Kimberly Adams is a retired ophthalmologist who practiced in Guilford, Connecticut. She graduated from Harvard, studied at Oxford University and received a medical degree from Cornell University.

4. Gerd Meyer-Schwickerath was an ophthalmologist from Germany. He was the head of the University Eye Clinic in Essen in 1959 and went on to invent the Zeiss photocoagulator.

5. Milton Flocks was a researcher on the clinical faculty at Stanford University.

6. Donald Scheuch was the first patient of ruby laser photocoagulation. He once was the chief of the Stanford Research Institute's research activities. He currently resides in Portola Valley.

7. Hunter Little was an ophthalmologist in Menlo Park, California. He practiced with H. Christian Zweng.

8. Arnold Patz was an ophthalmologist as well as a director of the Wilmer Eye Institute at Johns Hopkins University.

BIBLIOGRAPHY

Adams, Kimberly, M.D., ophthalmologist in Guilford, CT. Personal Interview. 16 Feb. 2010. Dr. Adams was practicing when LASIK eye surgery came out. Therefore she remembers learning how the surgery works and was able to describe to the author an overall summary of the surgery. Dr. Adams provided knowledge on how doctors used to reattach retinas previous to laser photocoagulation. Most importantly she was able to verify information provided by secondary sources and point the author to different sources that might be useful.

Flocks, Milton. "Commentary on Zeiss Photocoagulator" as cited in Spetz, Joanne. "Physicians and Physicists: The Interdisciplinary Introduction of the Laser to Medicine." *Sources of Medical Technology; Universities and Industry* 5 (1995): 41-66. *The National Academies Press*. Web. 24 Jan. 2010. <http://www.nap.edu/openbook.php?record_id=4819&page=41>. Milton Flocks, who was interviewed by Joanne Spetz, described the drawbacks of the Zeiss photocoagulator. This device was used to burn the tissue of the retina prior to the laser. Therefore this source emphasized why the laser was a necessary innovation to the success of photocoagulation.

Jones, Stacy V. "Device Treats Eyes With a Laser Beam." *The New York Times Online*. 24 Nov. 1972. 24 Jan. 2010. http://select.nytimes.com/gst/abstract.html?res=F10E17FB3B5C117088DDAC0A94D9415B828BF1D3&scp=1&sq=Device%20treats%20eyes%20with%20a%20laser%20beam&st=cse. This article from the *New York Times* proved to be valuable because it was the official publication of the accomplishment of Drs. Zweng, Flock, Little, and Vassiliadis. Although published several years after the team successfully completed a laser photocoagulation surgery, this article demonstrates how successful their technique had become; word of its effectiveness had traveled across the country to New York.

L'Esperance, Francis, M.D. "Commentary on Surgery" as cited in Spetz, Joanne. "Physicians and Physicists: The Interdisciplinary Introduction of the Laser to Medicine." *Sources of Medical Technology; Universities and Industry* 5 (1995): 41-66. *The National Academies Press*. Web. 24 Jan. 2010. <http://www.nap.edu/openbook.php?record_id=4819&page=41>. This interview was found in a book written by Joanne Spetz. A quote by Dr. L'Esperance articulated that previous to laser photocoagulation, the technique used to reattach retinas was both painful and not as efficient or safe.

L'Esperance, Francis, M.D. Telephone interview. 1 Feb. 2010. L'Esperance, a doctor who worked with Drs. Zweng, Little, and Flocks, provided substantial information on the development of photocoagulation. He described the effects that this innovation had by discussing the clinics that were offered in order to spread the idea of the eye surgery. He also specified certain dates when instrumental events occurred in the development and post-development of the laser eye surgery.

Scheuch, Donald. Telephone interview. 7 Feb. 2010. Mr. Scheuch was the first patient to undergo laser photocoagulation. Having his input on what it was like and what his thoughts had been, proved fruitful in both the understanding of the operation and the understanding of what impact the surgery had. Mr. Scheuch told about what he had to do during the surgery, what his eye felt like afterwards and what effect the surgery had.

Scheuch, Polly. Telephone interview. 7 Feb. 2010. Polly Scheuch, wife of the first man to undergo laser photocoagulation, disclosed information about her husband's surgery. Everything she said about his experience further proved the increased benefits of the new surgery. She also gave advice for other sources of further research.

Schmeck, Harold. "Laser Beam's Peril to Eye Stressed." *New York Times on the Web*. 31 Dec. 1996. 14 Feb. 2010. http://select.nytimes.com/mem/archive/pdf?res=F30B1FF8385F137A93C3AA1789D95F428685F9. This newspaper article was published around the time that protests were occurring to prevent the application of lasers to eye surgery. Many doctors and physicists feared the unknown effects that lasers would have if used on the human eye. This article illustrated that fear and provided quotes from a doctor who was against this use of lasers at that time.

Schwaar, Robert, ed. "History Corner – The Laser Photocoagulation Project." *SRI Alumni Association Newsletter* (Apr. 2002): 4. *SRI International Alumni Association*. Web. 24 Feb. 2010. <http://alumni.sri.com/newsletters/Apr-02.pdf>. This newsletter, published by the Stanford Research Institute (SRI), details the history of Dr. Zweng's first patient. It briefly explains the history of the collaboration of the SRI with doctors to develop the use of lasers in eye surgery.

"Slit Lamp Photocoagulator." U.S. Patent number 3703176. This patent was issued for the slit lamp photocoagulator for treating eye disorders. <http://www.google.com/paxtents/about?id=O_Q5AAAAEBAJ&dq=3703176.> The author used this site to see how many patents referenced the slit lamp photocoagulator to determine its significance.

United States Air Force commendation presented to H. Christian Zweng, M.D., c. 1970. This plaque was given to Zweng in gratitude for his work with the laser in determining thresholds for laser radiation in the eye. The U.S. Air Force recognized dedication to science and courage in using the device on his own eyes and presented Zweng with this certificate. This primary source proved useful because it represents the whole country in expressing appreciation for this new eye surgery.

Zweng, H. Christian, M.D., and Hunter L. Little, M.D. *Argon Laser Photocoagulation*. Saint Louis: The C.V. Mosby Company, 1977. Written by two of the pioneers in the field of laser eye surgery, this book went into great detail in the explanation of photocoagulation and how it works. This primary source defined diabetic retinopathy and its causes. It provided specific statistics on the effects of photocoagulation on diabetic retinopathy, therefore conveying the innovation's impact on society.

SECONDARY SOURCES

Bekker, Mary. "Scleral Buckling." *Encyclopedia of Surgery*. Encyclopedia of Surgery. Web. 25 Feb. 2010. <http://www.surgeryencyclopedia.com>. This site detailed the scleral buckle and its use in eye surgery. It was one of the reasons why doctors worked to use lasers in photocoagulation; they realized the urgency of keeping this method as a last resort.

Goff, Karen Goldberg. "Visionary Treatment." *Insight on the News*, 26 July 1999: 40. *Questia*. Web. 22 Jan. 2010. This magazine article discussed LASIK eye surgery. It explained that LASIK eye surgery is a process in which the "surgeon uses a knife to cut a flap of corneal tissue, lases targeted cells beneath it, and then replaces the flap" (Goldberg 1). This source also presents the pros and cons of LASIK. It acknowledges the benefits of not having to wear glasses.; however, it also describes the disadvantages and dangers of the surgery.

Jacko, Julie A., Holly S. Vitense, and Ingrid U. Scott. "26 Perceptual Impairments and Computing Technologies." *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications*. Ed. Julie A. Jacko and Andrew Sears. Mahwah, NJ: Lawrence Erlbaum Associates, 2003. 504-519. *Questia*. Web. 22 Jan. 2010. This source provided extensive information on diabetic retinopathy. It gave helpful statistics regarding how many Americans have diabetic retinopathy and how many of these men and women will become blind. It explained the cause of diabetic retinopathy and how it can be treated, thanks to laser photocoagulation. This book also highlighted other diseases that can be treated with laser eye surgery.

Lavine, Jay B. *The Eye Care Sourcebook*. Chicago: Contemporary Books, 2001. *Questia*. Web. 28 Jan. 2010. Written for the general public, this book provided information on eye diseases common to humans. It explained why these diseases develop, as well as how to treat each one. This proved especially fruitful when gathering information about how laser eye surgery has impacted diabetic retinopathy. Furthermore, this secondary source defined LASIK eye surgery and described the process of the surgery and the outcomes that have occurred.

"Leading Cause of Blindness." *Medicine Plus*. National Institute of Health, 2008. Web. 13 Feb. 2010. http://www.nlm.nih.gov. This website described eye conditions such as glaucoma, macular degeneration and diabetic retinopathy. It stressed the dangers of diabetic retinopathy and provided a number of statistics on eye conditions.

Meadows, Michelle. "Saving Your Sight; Early Detection Is Critical." *FDA Consumer*, Mar-Apr. 2002: 22+. *Questia*. Web. 19 Jan. 2010. This magazine article was used in the author's preliminary research. It offered details on specific eye diseases such as glaucoma, macular degeneration and diabetic retinopathy. This article is a reference primarily because it contained information on diabetic retinopathy, though it also proved useful in learning about the general structure of the eye and how these diseases are treated.

Patlak, Margie. "Lights for Sight; Lasers Beginning to Solve Vision Problems." *FDA Consumer*, July-Aug. 1990: 14+. *Questia*. Web. 19 Jan. 2010. This magazine article was referred to early in the author's research in order to obtain background information on the laser's application to eye surgery. It briefly sums up what the laser is used for in ophthalmology and what the laser's role has been in curing several eye diseases.

"Retinal Tears and Detachment." 2005. Prevent Blindness America. 20 Feb. 2010. <http://www.preventblindness.org/eye_problems/retinal.html.> This specific section of the website describes and discusses retinal tears. It not only defines the causes of retinal tears, but also suggests various treatment methods. For this reason, it gave the author a sense of what methods were used to treat retinal tears prior to laser photocoagulation.

Segal, Marian. "Eye Surgery Helps Some See Better." *FDA Consumer*, July-Aug. 1995: 15+. *Questia*. Web. 16 Feb. 2010. Written by Marian Segal at a time when LASIK eye surgery was gathering momentum and acclaim, this magazine article discussed LASIK eye surgery. It went into detail about how LASIK works. More importantly, it provided quotes from interviews explaining why LASIK is a desirable surgery for people to have as well as what the dangers of the surgery are.

Shah, Shaheen. "Blindness and visual impairment due to retinal diseases." *Community Eye Health Journal*. London School of Hygiene and Tropical Medicine, 2007. Web. 12 Feb. 2010. <http://www.cehjournal.org/0953-6833/22/jceh_22_69_008.html>. This site summarized the retinal diseases that exist and gave statistics on the number of people that had these conditions. It also gave statistics regarding the prevalence of diabetes in the United States.

Spetz, Joanne. "Physicians and Physicists: The Interdisciplinary Introduction of the Laser to Medicine." *Sources of Medical Technology; Universities and Industry* 5 (1995): 41-66. *The National Academies Press*. Web. 24 Jan. 2010. <http://www.nap.edu/openbook.php?record_id= 4819&page=41>. This book proved invaluable due to the information it provided on the history of the development of the laser and how it was applied to photocoagulation. It provided the author with an understanding of why the laser was applied to eye surgery as well as what happened after the technique was publicized.

"The history of Lasik Surgery." *New Vision; Lasik*. 2003. Web. 25 Jan. 2010. <http://www.lasik-eye-surgery.info>. This website gave a brief summary of the history of LASIK eye surgery. It described the major doctors who were involved in its development and the effects that the surgery has had. It proved useful because it gave the author a sense of how and why LASIK came about.

"Looking Backward, Looking Forward: Visions of the Golden State"

The Bancroft Library presents an online exhibit

http://bancroft.berkeley.edu/Exhibits/online.html#9
Click on the banner to enter the online exhibit.

This online exhibit looks at four key events and celebrations in California during the last 150 years of statehood and examines a few aspects of California's unique development, noting accomplishments as well as a few missteps.

The exhibit begins with the Constitutional Convention and California's campaign for statehood in 1850; then looks at two grand world's fairs: The Panama-Pacific International Exposition of 1915 and The Golden Gate International Exposition of 1939; and ends with the celebration of California First Days, 1962-63, when California overtook New York as the most populous state in the Union.

California has been perceived by many as the embodiment of "progress," a place that not only looks towards the future but also shapes it.