

“SEEING THE WAY: A BRIEF HISTORY OF CATARACT SURGERY”

GRADE LEVELS: 9-12

TIME ALLOTMENT: Two to three 45-minute class periods

OVERVIEW:

In this media-enhanced lesson, students will learn about the history and state-of-the-art of one of the world’s most commonly performed surgical procedures—eye cataract removal and replacement. Using clips from the public television documentary *Through My Eyes: The Charlie Kelman Story*—a biography of one of the ophthalmologists most directly responsible for developing the modern surgery used to treat cataracts—this lesson traces the scientific progression from primitive “couching” treatments in antiquity to the modern use of phacoemulsification and foldable intraocular lenses in the present day. This lesson is recommended for use with students who have recently completed a unit on the anatomy of the eye.

SUBJECT MATTER: History of Science, Biology

LEARNING OBJECTIVES:

Students will be able to:

- Describe how the cornea, lens, and retina of the eye work together in the human eye
- Define a cataract
- Summarize the history of cataract treatment from antiquity to the present day

STANDARDS:

National Science Education Standards

http://www.nap.edu/openbook.php?record_id=4962

Content Standard G

As a result of activities in grades 9-12, all students should develop understanding of

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

World History Standards for Grades 5-12: World History

<http://nchs.ucla.edu/standards/worldera9.html>

Era 9: The 20th Century Since 1945: Promises and Paradoxes

Standard 2E: The student understands major worldwide scientific and technological trends of the second half of the 20th century.

Therefore, the student is able to assess the social and cultural implications of recent medical successes.

MEDIA COMPONENTS:

Video:

Clip 1: “What is a Cataract?” An explanation of what a cataract is (a lens clouded by age degeneration) and how it must be treated (removal).

Clip 2: “Hammer and Chisel Surgery” – A description of the primitive methods of traditional cataract surgery.

Clip 3: “The Eureka Moment” The story of Dr. Kelman’s breakthrough inspiration after years of unsuccessful experimentation trying to develop a new tool to perform eye surgery.

Clip 4: “The Mazzocco Taco” A description of the foldable intraocular lens, which redeemed Dr. Kelman’s controversial phacoemulsification procedure.

Clip 5: “How Charlie Kelman Changed the World.” An evaluation of Kelman’s legacy as a medical innovator.

Websites:

“Anatomy of the Eye”

<http://www.lensshopper.com/eye-anatomy.asp>

An interactive, animated lesson showcasing the various features of the eye’s anatomy.

MATERIALS:

For the class:

Three computers with internet access.

PREP FOR TEACHERS:

Prior to teaching this lesson, you will need to:

Preview all of the video segments and websites used in the lesson.

Download the video segments used in the lesson to your classroom computer, or prepare to watch them using your classroom’s internet connection.

Bookmark the website used in the lesson on each computer in your classroom. Using a social bookmarking tool such as del.icio.us or diigo (or an online bookmarking utility such as portaportal) will allow you to organize all the links in a central location.

INTRODUCTORY ACTIVITY

1. Ask students if they've ever heard of eye cataracts. Has anyone they've known had cataract surgery? According to the World Health Organization, cataracts account for 48% of all the world's blindness—about 18 million people—and operations to treat cataracts are the most common surgical procedures in the developed world. But what exactly IS a cataract?

2. Tell students that they'll find the answer in a brief video clip from the PBS documentary *Through My Eyes: The Charlie Kelman Story*—a biography of one of the ophthalmologists most directly responsible for developing the modern surgery used to treat cataracts. Provide a focus question by asking students to identify whether a cataract is a growth, a disease, or a degenerative condition. PLAY Clip 1: “What is a Cataract?”

3. Review the focus question: “Is a cataract a growth, a disease, or a degeneration?” (*It is a degenerative condition of the lens which comes with age.*) Divide the class into three groups, and have them log on to the “Anatomy of the Eye” website at www.lensshopper.com/eye-anatomy.asp. Allow ten minutes for the groups to explore the interactive, which gives brief descriptions of all the parts of the eye.

4. Explain that you will now be describing several parts of the eye based on information from the interactive. Ask students to raise their hands after each description and offer the correctly corresponding eye part.

- Provides 40 of the eye's 60 diopters, and can be reshaped through laser surgery. (*Cornea.*)
- Provides 20 of the eye's 60 diopters with a variable shape that enables vision accommodation (i.e. focus changes according to different distances). (*Lens.*)
- Transmits absorbed light as visual signals to the brain. (*Retina.*)
- Controls the vision accommodation reflex by contracting and relaxing the lens. (*ciliary body.*)
- Bonus question: What is a diopter? (*A diopter is a unit of measurement for the optical power of a lens, equal to the reciprocal of the focal length measured in meters; for example, the human eye has 60 diopters, bringing parallel rays of light to focus at 1/60th of a meter.*)

5. Explain to students that the basic functionality of the eye is as follows: the combined refractive power of the cornea and the lens focuses light on the retina, which in turn transmits the light as visual signals to be resolved as images in the brain. A cataract is a cloudiness in the lens which prevents light from reaching the retina.

LEARNING ACTIVITIES

1. Explain that physicians in antiquity didn't properly understand the eye's anatomy and so didn't know what a lens was; they mistakenly believed that cataracts were simply the

eye's liquid "humors" which had coagulated and become cloudy. One thing the ancients *did* know from observation was that cataracts could be dislocated into the eye's vitreous body by accidental trauma to the eye. Because these traumas could actually restore a blinded eye's ability to at least partially see, such accidents were even regarded as blessings from the heavens. Ask students how they think that having a cataract dislocated could actually improve sight. (*Because only 1/3 of the eye's refractive power is in the lens, dislocating a cataract-obstructed lens allows vision through the remaining 2/3 of the eye's refractive power that is located in the cornea.*)

2. Allow each of the class's three groups 30 minutes to research online the history of cataract treatment in one of the following eras: Antiquity (i.e. BCE, or "Before the Common Era"), the Middle Ages (focusing on the Arab world), and the Enlightenment (18th century Europe).

3. Have each group report their findings to the rest of the class. Encourage an understanding of the following key points for each era treatment:

- *Antiquity: By the 6th century BCE, cataracts were being deliberately dislocated in a process called "couching." As described by the ancient Indian physician Sushruta, the process involved the use of a curved needle to push the clouded lens into the rear of the eye and out of the field of vision until the patient could start seeing shapes. The eye would then be soaked with warm clarified butter and bandaged. Physicians from as far as Greece and China traveled to India to learn this surgery, and bronze instruments that could have been used for cataract surgery have been found in excavations in Babylonia, Greece, and Egypt.*
- *Middle Ages: To address the fact that couched cataracts could become infected or migrate back into the field of vision, 10th century Iraqi ophthalmologist Ammar ibn Ali developed a method whereby cataracts could be removed from the eye entirely by suction through a hollow instrument—a method described as "[requiring] a large incision in the eye, a hollow needle, and an assistant with an extraordinary lung capacity." This rare procedure appears to have never been practiced in the West.*
- *The Enlightenment: Modern cataract extraction is generally dated to 1745, when French ophthalmologist Jacques Daviel successfully removed a cataract through a large incision in the cornea in an attempt to correct a botched couching operation. Although this was to become a common procedure, the itinerant surgeons who performed it in the 18th century were notorious for their incompetence. The composers Georg Friedrich Händel and Johann Sebastian Bach were two of the more prominent victims of these traveling "oculists"; both lost their sight as a result of botched cataract removals, and indeed Bach's death several months later was attributed to "the unhappy consequences of [a] very unsuccessful eye operation."*

4. Tell students that they will now be looking at a video clip which describes the basic “hammer and chisel” procedure of cataract removal as it was practiced for almost 200 years from the mid 18th to the mid 20th centuries. Provide a focus question by asking students how modern technology helped compensate for the lost lens, and what the problem with that technology was. PLAY Clip 2: “Hammer and Chisel Surgery.”

5. PAUSE the clip after the ophthalmologist says “There was a real disability with wearing these kinds of thick glasses.” Review the focus question: what modern technology helped compensate for the lost lens, and what the problem with that it? (*Heavy “post-cataract glasses” offered patients some sight, but their strong magnification and distortion was highly disorienting.*) Ask students why they think post-cataract glasses had these problems. (*Because the lenses in post-cataract glasses are necessarily more distant than the eye’s natural lens from the eye’s focal point on the retina, and must therefore be that much more powerful.*)

6. Explain that since the early 19th century, eye surgeons had attempted to insert artificial lenses into the eye to replace the removed cataracts, but that because of the weight of these glass lenses, they sank to the bottom of the eye. Ask students what they think the solution to this problem might have been. (*Suggest that they may find the answer by inspecting the lenses of modern eyeglasses: modern lenses are made of plastic, which is much lighter than glass.*)

7. Explain that the breakthrough with plastic lenses came during WWII, when a British surgeon named Harold Ridley noticed that shattered particles of lightweight plexiglas airplane canopies lodged in airmen’s eyes did not become infected. Deducing that plexiglas—technically called polymethyl methacrylate—was biologically inert, Ridley devised a polymethyl methacrylate “intraocular” lens which he successfully implanted in a post-cataract eye in 1949. Ask students what they think “intraocular” means. (*“Inside the eye.”*)

8. While in itself revolutionary, Ridley’s procedure still required a large incision (approximately 5-7mm) in the eye to accommodate the width of his intraocular lens. Tell students that they will now continue watching the video clip, which will introduce Dr. Charles “Charlie” Kelman. Provide a focus question by asking students what Kelman’s objection to such large incisions was. PLAY the clip through to the end.

9. Review the focus question: What was Kelman’s objection to the large incisions of traditional cataract surgery? (*Large incisions are highly vulnerable to infection which could result in blindness or worse.*) Explain that after years of unsuccessful experimentation with various tools which could break up or “macerate” a lens through a small incision, Kelman had a revelation in an unlikely context. Provide a focus question by asking students how Kelman first tested his breakthrough tool. PLAY Clip 3: “The Eureka Moment.”

10. Review the focus question: How did Kelman first test his breakthrough tool? (*He used an ultrasonic dental probe to inscribe lines on a removed cataract.*) In 1967, based

on this discovery, Kelman introduced “phacoemulsification”—a new procedure which used a modified ultrasonic probe to macerate and emulsify cataract lenses, the fragments of which could then be removed by suction through a much smaller incision (3mm) than had been previously required.

11. Ask students if they think the phacoemulsification procedure made the implanting of intraocular lens any easier? (*Accept all answers.*) Explain that phacoemulsification was initially a highly controversial procedure; besides being an exceedingly delicate and dangerous operation, many ophthalmologists argued that it was also pointless, since the smaller incision made possible by phacoemulsification had to be enlarged anyhow to accommodate the insertion of the intraocular lens. Tell students the next video clip they will be looking at describes the most recent major innovation in cataract surgery. Provide a focus question by asking them what the “Mazzocco Taco” is. PLAY Clip 4: “The Mazzocco Taco.”

12. Review the focus question: What is the Mazzocco Taco? (*A foldable intraocular lens which required a much smaller insertion incision.*) Explain that it had been Dr. Kelman’s phacoemulsification that had inspired Dr. Thomas Mazzocco to create his folding intraocular lens in the first place; now that second innovation was helping to redeem the first. Tell students that the final clip they will be watching discusses the resulting impact of Kelman’s breakthrough. Provide a focus question by asking students how phacoemulsification has impacted non-ophthalmological operations. PLAY Clip 5: “How Charlie Kelman Changed the World.”

13. Review the focus question: How has phacoemulsification impacted non-ophthalmological operations? (*Phacoemulsification pioneered micro-incision surgery, which has now been adapted for use in operations on the brain, spinal cord, and gallbladder.*)

CULMINATING ACTIVITY

1. For thousands of years, cataracts had been treated by physicians working with primitive tools, no real understanding of the eye’s anatomy, an abysmal success rate, and little to no advancement in the state of the art from one generation to the next. In the 20th century, however, accelerating advances in medical knowledge, technique, and technology have resulted in cataract replacement surgery that quickly and reliably restores sight to tens of millions each year—something conceivable only to a few visionaries and innovators just a few decades ago.

2. Ask your students if they can think of any other medical advances in the last century which have improved and/or extended our lives, and write their answers on the board. (*Suggestions may include such innovations as organ transplants, the discovery of penicillin, proper dental care, LASIK eye surgery, etc.*)

3. Have the class vote on which four medical innovations or inventions they see as most significant. Divide the class back into their three groups and assign one of the top three innovations or inventions to each group. Each group should work together to research online and develop a presentation describing the process of their innovation or invention's discovery or development, focusing as much as possible on the narrative of the process—including any initial mistaken assumptions, experimental blind alleys, accidental breakthroughs, scientific skepticism, and final acceptance.

4. Have the groups give their presentations before the rest of the class.