

Introduction

Mending Broken Hearts was a public program presented by the Smithsonian's Lemelson Center in October 2004. The program content and format encouraged the audience to explore how advances in artificial hearts and cardiac assist devices are changing our lives. This program has now been adapted for use as an online and classroom activity. Using the Inventing Ourselves website and the resources provided here, you can try this activity in your classroom. You and your students are invited to read or listen to the presentations of our panel of experts, engage in classroom discussion, and take our opinion poll.

The October program began with an introduction about current rates of heart disease and the demand for heart transplants in the United States. The audience then heard presentations by an inventor, a historian, and a bioethicist. While listening, the audience was encouraged to consider questions on ethics as they relate to artificial hearts and related surgeries.

Afterward, audience members broke into small, moderated discussion groups. This was followed by an opinion poll, where each person used a remote-control voting device to answer a series of questions. Results of the poll were compiled and displayed on a large screen in real time. The program concluded with brief remarks from each presenter on their reactions to the poll results.

Although the group that gathered at the National Museum of American History that evening was not a random sample of Americans, and therefore the poll can hardly be considered to reflect the views of the average citizen, the findings were fascinating. The results of some of the questions posed to our audience in October 2004 are at the end of this activity. After completing the activity and opinion poll questions yourself, you may want to see how our audience's answers compare to your own.

Discussion questions to encourage exploration

The issues raised in *Mending Broken Hearts* address some of the most important decisions that you or your students will ever face. Choices related to the health care of ourselves and loved ones are seldom easy. It is important for everyone to consider all of the implications of these decisions long before the stress of illness or accident makes considering options and weighing consequences more difficult. The *Mending Broken Hearts* program was designed to encourage people to consider ethical, moral, and practical issues related to heart transplants and artificial hearts.

Use the following questions and discussion topics to explore these issues with your students. This page was designed to help you prepare your students for the *Mending Broken Hearts* website; however, it can be used as a summary activity or as a stand-alone discussion. Keep in mind that none of these questions have definitive answers and none are meant to encourage your class to reach conclusions or consensus. They are meant to encourage debate, analysis, and consideration.

➤ Introduction

Throughout history and in many cultures, the heart has been the subject of poetry, music, and art as well as medical textbooks. The heart can break when we are dumped by a sweetheart and the heart can stop when we have a heart attack. The heart symbolizes love on Valentine's Day and we put our hand on our heart when we recite the Pledge of Allegiance or listen to the "Star-Spangled Banner," our national anthem. What does your heart mean to you?

➤ Opening questions

- What is a heart?
- What is in your heart?
- How does the heart appear in art? Music? Poetry?
 - How does that relate to the biological function of the heart?

➤ The heart in poetry and music

- The heart is featured in thousands of poems. Share one or two examples with the class. Here are some suggested titles. You are encouraged to find your own or have the students do so.
 - **A poor—torn heart—a tattered heart** by Emily Dickinson
 - **i carry your heart with me** by e. e. cummings
 - **My Heart's in the Highlands** by Robert Burns
 - **Sonnet 46: Mine eye and heart are at a mortal war** by William Shakespeare
 - **Many Red Devils Ran from My Heart** by Stephen Crane
- Popular songs have always featured the heart as a symbol of love or longing. Whether someone loves a person, a cause, or a place, the seat of that affection is located in the heart. Use popular music with your students to explore the symbolism of the heart in song. Here are some suggested titles and performers; encourage your students to find their own.
 - ◆ **Heart of Glass** by Blondie

- ◆ **Achy Breaky Heart** by Billy Ray Cyrus
- ◆ **Heart of a Woman** by R. Kelly
- ◆ **Unchain My Heart** by Joe Cocker
- ◆ **I Left My Heart in San Francisco** performed by many artists including Count Basie, Bobby Darin, Tony Bennett, and Louis Armstrong
- Questions
 - How is the heart represented in these songs and poetry?
 - What is the heart's purpose?
 - What relationship does the biological function of the heart have to these representations?
- The heart is also a symbol of patriotism. When we recite the Pledge of Allegiance or listen to the "Star-Spangled Banner," people in uniform salute and many civilians place their hand over their heart.
 - Why would the heart be seen as the place to symbolize patriotism?
- Final question
 - If the heart could be as easily and as cheaply replaced as a battery in a flashlight, would it still have the symbolism invested in it by poets, songwriters, and patriots?

If the environmental movement of the last half of the 20th century has taught us anything, it is that resources are finite. This can certainly be said of medical resources. There are only so many doctors, hospital beds, drugs, and bandages to go around. When doctors and nurses decide who gets medical care first in an emergency room, this is called "triage." They direct their attention and resources to the person most in need of assistance. A heart attack will be treated long before a sprained ankle.

Society must also decide who is first in line for medical resources and who must wait or even go without. Sometimes these decisions are obvious and can seem cruel, such as when lists are made for transplants of limited organs. Sometimes these decisions are not so obvious, such as when governments have to decide whether to spend money on life-saving, and expensive, miracle surgeries or on health education and wellness programs. Here are some discussion topics to help your students explore these choices.

- Who should be seen first in an emergency room? What criteria should be used?
- If there are six people who need heart transplants and there are only four hearts, what criteria should be considered when deciding who gets the hearts?
 - Factors to consider
 - Age of patient
 - Importance of patient to society
 - ◆ How would you judge this?
 - Ability of patient to pay
 - Wishes of the donor or the donor's family
 - Odds the patient would survive if given a heart
 - Odds the patient would die if not given a heart

- Date the patient went on the donor list (first come, first serve)
- Your foundation has five million dollars to spend on health care related to the heart. How do you think that money should be spent?
 - Preventive measures that might help forestall or eliminate disease.
 - This option would help more people, but the benefits are far in the future and won't save anyone with disease or injury now.
 - If you choose this option, what do you do with the people who are sick right now?
 - Surgery and other methods that might cure heart problems.
 - This option would help save people with disease and injury right now, but you would help fewer people.
 - If you choose this option, how will you help people prevent heart disease so they don't need expensive treatments later in life?
 - Explain the following adages in light of this discussion.
 - A stitch in time saves nine.
 - An ounce of prevention is worth a pound of cure.

Even when risky and invasive medical treatments work, they can sometimes leave the patient with lasting negative side effects. These side effects can range from a slight reduction in mobility to daily, excruciating pain. Sometimes medical procedures force us to cease or curtail important activities. Long-term side effects are among the many factors a patient needs to weigh before deciding on medical procedures.

- ❖ Among the side effects below, which ones would influence you to choose **not** to undergo a major, life-saving medical procedure such as open-heart surgery or a heart transplant?
 - Being unable to accomplish normal tasks without pain.
 - The need to stop doing a special activity, such as a sport or hobby.
 - The need to take daily medications.
- ❖ Are there any aspects of your life right now you would literally not want to live without?
- ❖ Do you think your answer would change if you had a family of your own or someone else who depended on you?
- ❖ Would your answer change if the odds of surviving the operation were higher? Lower?

Almost all medical advances come with risks. New drugs and medical procedures need to be tested and may harm or even kill test subjects. However, without volunteer test subjects we would never know if a new drug or procedure would work and the rest of humanity would be without new cures and treatments. Or, without the results of controlled tests, medicines and drugs would be put on the market and potentially hurt far more people.

- ❖ Would you be willing to volunteer for medical tests for a procedure or medicine that you do not need if it meant better medicine for everyone else?
 - What if you were paid?

- ❖ What if you needed a medical procedure in order to be cured, but your life is not in danger. Would you be willing to test a new procedure that would make you better and is a benefit to humanity, but has unknown side effects and could kill you?
- ❖ Would your answer change if your life was in danger and you would die of a particular illness or injury? Would you be willing to test a new procedure that could prolong your life?
 - Would it matter how long your life potentially could be prolonged?
- ❖ What if you could live your final days pain free but a test procedure could give you an extra year, though with substantial pain and discomfort? Would you test the procedure to advance the development of a new cure or treatment?

What does it mean to be human?

- ❖ Ask the above question.
 - Make a list of the factors that define us as humans. Do the students list:
 - Physical attributes?
 - Brain, heart, two feet, two hands, stand upright, etc.
 - Spiritual factors?
 - A soul
 - Intellectual factors?
 - Free choice, rational thought, ability to solve problems, ability to use tools, abstract thought, knowledge of mortality
 - Emotional factors?
 - Ability to love, ability to hate, etc.
 - Pose the following question:
 - If you substitute 50 percent of a person's body with mechanical parts, is she still human?
 - Does it matter which parts are substituted?
 - ◆ Is a mechanical foot different than a mechanical heart?
 - What about 75 percent substitution? 80 percent?
 - ◆ Which parts of your physical body are crucial to your definition of a human?
 - Is it possible to make a person non-human through mechanical or medical means?

Opinion poll questions

Take the poll online on the Inventing Ourselves website, or print out the following questions. After taking the poll, tally the percentages and discuss the results with your class. Your students also may want to see how our audience's answers, listed at the end of this document, compare to their own.

- 1) If you had to decide whether or not to have an artificial heart implanted, which factor would be MOST important to you?
 - a) Prolonging life
 - b) Risk of surgery
 - c) Cost
 - d) Change in quality of life
 - e) Ethical/Religious beliefs
 - f) Other

- 2) How do you think taxpayer dollars are BEST spent to reduce heart disease in the U.S.?
 - a) Prevention treatment and education
 - b) Increased organ-donor registration
 - c) Research support on artificial hearts and assist devices
 - d) All of the above

- 3) Would you agree to have a relatively untested device implanted if you thought it might prolong your life?
 - a) Yes
 - b) No

- 4) If you needed an organ transplant, would you be willing to test a new artificial organ to further scientific research even though you might not survive?
 - a) Yes
 - b) No

- 5) If a life-saving technology is expensive, do you think it should be made available to everyone who needs it regardless of ability to pay?
 - a) Yes
 - b) No

- 6) When considering technological replacements to the human body, which of these values do you think is MOST important for our society?
 - a) Ensuring quality of life
 - b) Guaranteeing equal access to health care
 - c) Promoting scientific discovery
 - d) Setting limits to medical intervention
 - e) Respecting ethical/religious beliefs

- 7) Besides pumping blood, do you think the heart plays a spiritual and emotional role in human life?

- a) Yes
 - b) No
- 8) As more and more implantable devices become commonplace, will the nature of what it means to be human change?
- a) Yes
 - b) No

Glossary

There are many difficult words in the recording and transcript of the *Mending Broken Hearts* program. Use this glossary to help you get through some of the more challenging passages.

ACE Inhibitor

ACE inhibitors, or inhibitors of angiotensin converting enzyme, are a group of drugs used primarily in treating hypertension (high blood pressure) and congestive heart failure, in most cases as the drug of first choice. ACE inhibitors increase cardiac output (blood flow) and lead to increased natriuresis (excretion of sodium in the urine). Brand names of ACE inhibitors (in parentheses) are:

Benazepril
Captopril (Capoten), the first ACE inhibitor
Enalapril (Vasotec/Renitec)
Fosinopril (Monopril), the only member [xxxxxxxxx]
Lisinopril (Lisodur/Lopril/Prinivil/Zestril)
Perindopril (Coversyl)
Quinapril (Accupril)
Ramipril (Altace/Tritace/Ramace)

ACE inhibitors can also be found in nature. Two examples are caseokinins and lactokinins, breakdown products of casein and whey that occur naturally after ingestion of milk products, especially sour milk.

Biomaterial

Biomaterial is a generic term for any type of material used to repair, conserve, or reconstruct organs, appendages, or components of the human body. Examples include prosthetic limbs, breast implants, and artificial tendons.

Cardiologist

Cardiology is the study of the human heart, its functions, and diseases that affect it. A heart specialist is a cardiologist.

Curator

A curator is the person in charge of a museum's collections. The curator acquires artifacts for certain collections, preserves or restores them, ensures that they are properly stored, and puts them on display for the public.

Cyborg

A cyborg is a person whose natural physiological functioning is aided by or dependent on a mechanical or electronic device such as artificial legs or a pacemaker. Generally, the term "cyborg," a combination of "cybernetic" (automatic control) and "organism," describes any living organism that depends on, or enhances its abilities by using, technology.

Dystopian

Dystopian is a description of a highly undesirable society or condition, the opposite of utopian.

Electrophysiology

Electrophysiology is the branch of physiology (study of the functions of the human body) dealing with the electric phenomena associated with the body and its functions, commonly the nervous system.

Homolysis

Homolysis means a cell being destroyed by elements of the same type of cell. In chemistry, homolysis is the separation of a neutral molecule, generating two free radicals—atoms with no molecule to call home.

In Vitro Fertilization

In vitro fertilization (IVF) is a technique in which egg cells are fertilized outside a woman's body. IVF is a major treatment for infertility where other methods of achieving conception have failed.

Polyurethane

Polyurethane is a versatile synthetic material that can be as soft as foam or almost as hard as wood. It is used in:

- Furniture
- Houses (insulation and walls)
- Medical devices
- Sealants and fireproofing
- Surfboards and hulls of recreational boats
- Varnish and paints
- Wheels (mostly skateboard, rollerblade, and model car wheels)

Polyvinyl Chloride

Commonly abbreviated PVC, polyvinyl chloride is a widely used [plastic](#). In hard form, it can be vinyl siding, window profiles, phonograph records (thus the term “vinyl” records), and pipe, plumbing, and conduit fixtures. It is often used in medical devices.

Silastic

Silastic (“silicone” + “plastic”) is a brand name for a silicone-based material (polydimethylsiloxane) with the properties of rubber but a better capability of withstanding extremely high and low temperatures and other causes of deterioration. Used in products such as jet-plane engines, gaskets, and electrical insulation, in the medical field it is especially valuable for making devices like shunts to control hydrocephalus, heart valves, and breast implants.

Additional resources

Here is a small selection of books and websites for further exploration by you and your class. Most publications should be available at your local bookstore or library or can be ordered online from bookstore websites.

Websites

Explore bioethics with a teen at the University of Pennsylvania's High School Bioethics Project at <http://www.bioethics.upenn.edu/highschool/>. (Some parts require free registration.)

Get the latest information on how to keep your heart healthy from the American Heart Association at <http://www.americanheart.org/>.

The online version of the PBS series *Nova* has a lot of useful resources to accompany its episodes: "Cut to the Heart" at <http://www.pbs.org/wgbh/nova/heart/> and "Electric Heart" at <http://www.pbs.org/wgbh/nova/eheart/>.

The famous walkthrough heart at the Franklin Institute can be enjoyed from afar through its virtual exhibition *The Heart: An Online Exploration* at <http://sln.fi.edu/biosci/biosci.html>.

Information about recent advances in artificial heart surgery can be found at The Implantable Artificial Heart Project in Louisville, Kentucky: <http://www.heartpioneers.com/index.html>.

Enjoy an interesting array of virtual exhibitions on the history of medicine at the National Museum of Health and Medicine: <http://nmhm.washingtondc.museum/>.

Books for teens and young adults; suitable for students in grades 7 and up.

Bankston, John, *Robert Jarvik and the First Artificial Heart*, Mitchell Lane Publishers, 2002.

Berger, Melvin, and Anne Green, *The Artificial Heart*, Scholastic Library Publishing, 1987.

Egendorf, Laura K., ed., *Medical Ethics: Current Controversies*, Thomson Gale, 2005.

Finn, Jeffrey, Eliot Marshall, and Dale Garrell, eds., *Medical Ethics*, Chelsea House Publications, 1990.

Giddens Sandra, and Owen Giddens, *Future Techniques in Surgery*, Rosen Publishing Group, 2002.

Judson, Karen, *Medical Ethics: Life and Death Issues*, Enslow Publishers, 2001.

McClellan, Marilyn, *Organ and Tissue Transplants: Medical Miracles and Challenges*, Enslow Publishers, 2003.

Metos, Thomas H., *Artificial Humans: Transplants and Bionics*, Julian Messner Publications, 1985.

Roleff, Tamara L., ed., *Biomedical Ethics: Opposing Viewpoints*, Thomson Gale, 1998.

Torr, James D., ed., *Organ Transplants*, Thomson Gale, 2002.

Winters, Adam, *Organ Transplant: The Debate over Who, How, and Why*, Rosen Publishing Group, 2000.

These books are more academic and appropriate for advanced teens and adults.

Fox, Renée C., *The Courage to Fail: A Social View of Organ Transplants and Dialysis*, 2d ed., rev., University of Chicago Press, 1978.

Fox, Renée C., and Judith P. Swazey, *Spare Parts: Organ Replacement in American Society*, Oxford University Press, 1992.

Fye, W. Bruce, *American Cardiology: The History of a Specialty and Its College*, Johns Hopkins University Press, 1996.

Johnson Stephen L., *The History of Cardiac Surgery, 1896–1955*, Johns Hopkins University Press, 1970.

Klaidman, Stephen, *Saving the Heart: The Battle to Conquer Coronary Disease*, Oxford University Press, 2000.

Levy, Daniel, and Susan Brink, *A Change of Heart: How the People of Framingham, Massachusetts, Helped Unravel the Mysteries of Cardiovascular Disease*, Knopf Publishing Group, 2005.

Plough, Alonzo L., *Borrowed Time: Artificial Organs and the Politics of Extending Lives*, Temple University Press, 1986.

Weisse, Allen B., *Heart to Heart: The Twentieth Century Battle against Cardiac Disease: An Oral History*, Rutgers University Press, 2002.

Education standards

The *Mending Broken Hearts* program can help you and your students meet a number of different national standards in several content fields. Most state education standards are similar to the national standards; many are based directly on them. Using the national standards listed below in conjunction with your local standards, *Mending Broken Hearts* should be a useful classroom resource.

Project 2061, created by the American Association for the Advancement for Science, is a long-term initiative to advance literacy in science, mathematics, and technology. Its educational benchmarks have been adopted by many local school systems. The complete standards can be found at <http://www.project2061.org/>.

Mending Broken Hearts can help your students meet the following Science and Technology Benchmarks:

- ❖ By 8th grade, students should know:
 - New technologies increase some risks and decrease others. Some of the same technologies that have improved the length and quality of life for many people have also brought new risks.
 - ❖ By 12th grade, students should know:
 - In deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits.
 - Human inventiveness has brought new risks as well as improvements to human existence.
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The *National Science Education Standards* were created by the country's national science organizations in 1996. They are still used as a guideline for many state and local science standards. The complete standards can be found at <http://www.nap.edu/readingroom/books/nse/html/>.

Mending Broken Hearts can help your students meet the following Science Standards:

- ❖ Content Standards 9–12:
 - Science and Technology
 - Understanding basic concepts and principles of science and technology should precede active debate about the economics, policies, politics, and ethics of various science- and technology-related challenges. However, understanding science alone will not resolve local, national, or global challenges.
 - Progress in science and technology can be affected by social issues and challenges. Funding priorities for specific health problems serve as examples of ways that social issues influence science and technology.
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The development of the *National Standards for History* was administered by the National Center for History in the Schools at the University of California, Los Angeles, under the

guidance of the National Council for History Standards in 1996. They are a model for history educators and curriculum specialists throughout the nation. The complete standards can be found at the website of the National Council for History in the Schools at <http://nchs.ucla.edu/standards/>.

Mending Broken Hearts can help your students meet the following History Content Standards:

- ❖ Era 9 Postwar United States:
 - ❖ Standard 1C: The student understands how postwar science augmented the nation's economic strength, transformed daily life, and influenced the world economy.
 - Grades 5–12: Identify various pioneers in modern scientific research and explain how their work has changed contemporary society.
 - Grades 9–12: Explain the advances in medical science and assess how they improved the standard of living and changed demographic patterns.

Mending Broken Hearts can help your students meet the following Standards in Historical Issues-Analysis and Decision-Making:

- ❖ Standard 5:

The student engages in historical issues-analysis and decision-making.
Therefore, the student is able to:

 - Analyze the interests, values, and points of view of those involved in the dilemma or problem situation.
 - Identify causes of the problem or dilemma.
 - Propose alternative ways of resolving the problem or dilemma and evaluate each in terms of ethical consideration (is it fair? just?), the interest of the different people involved, and the likely consequences of each proposal.
 - Formulate a position or course of action on an issue by identifying the nature of the problem, analyzing the underlying factors contributing to the problem, and choosing a plausible solution from a choice of carefully evaluated options.
 - Evaluate the consequences of the actions taken.

Opinion poll results, Smithsonian Institution, October 2004

If you had to decide whether or not to have an artificial heart implanted, which factor would be MOST important to you?	Votes For Answer	Pct. of Total Votes
1. Prolonging life	2	4%
2. Risk of surgery	1	2%
3. Cost	0	0%
4. Change in quality of life	37	77%
5. Ethical/Religious beliefs	4	8%
6. Other	4	8%

If you had to decide whether or not to have an artificial heart implanted, which factor would be LEAST important to you?	Votes For Answer	Pct. of Total Votes
1. Prolonging life	4	8%
2. Risk of surgery	5	10%
3. Cost	10	21%
4. Change in quality in life	1	2%
5. Ethical/Religious beliefs	24	52%
6. Other	2	4%

How do you think taxpayer dollars are BEST spent to reduce heart disease in the U.S.?	Votes For Answer	Pct. of Total Votes
1. Prevention treatment and education	30	63%
2. Increased organ-donor registration	2	4%
3. Research support on artificial hearts and assist devices	0	0%
4. All of the above	15	31%

What should be the purpose of artificial hearts?	Votes For Answer	Pct. of Total Votes
1. A temporary device until a heart transplant is available	7	14%
2. A permanent device to replace the natural heart	1	2%
3. Both uses are acceptable	38	79%
4. Neither use is acceptable	2	4%

Would you agree to have a relatively untested device implanted if you thought it might prolong your life?	Votes For Answer	Pct. of Total Votes
1. Yes	13	28%
2. No	32	71%
You are waiting for an organ transplant. Would you be willing to participate in a clinical trial for a new artificial organ to further scientific research even though you might not survive?	Votes For Answer	Pct. of Total Votes
1. Yes	24	52%
2. No	22	47%
If a life-saving technology is expensive, do you think it should be made available to everyone who needs it regardless of ability to pay?	Votes For Answer	Pct. of Total Votes
1. Yes	37	82%
2. No	8	17%
In the context of technological enhancements to the human body, which of these values do you think is MOST important for our society?	Votes For Answer	Pct. of Total Votes
1. Ensuring quality of life	19	41%
2. Guaranteeing equal access to health care	17	36%
3. Promoting scientific discovery	5	10%
4. Setting limits to medical intervention	3	6%
5. Respecting ethical/religious beliefs	2	4%
Assuming all medical risks were equal, how comfortable would you be having your heart replaced with an artificial device versus replacing other organs such as a kidney or a liver?	Votes For Answer	Pct. of Total Votes
1. More comfortable	2	4%
2. Less comfortable	21	44%

3. About the same 24 51%

Besides pumping blood, do you think the heart plays a spiritual and emotional role in human life?	Votes For Answer	Pct. of Total Votes
1. Yes	16	35%
2. No	29	64%

As more and more implantable devices become commonplace, will the nature of what it means to be human change?	Votes For Answer	Pct. of Total Votes
1. Yes	17	36%
2. No	30	63%