Get ready to tackle some of the biggest medical problems facing society! TEAMS 2012 asks students to use their engineering skills to confront some pressing challenges facing the medical and health care industries.

Medicine is increasingly turning to engineers for solutions to some of its challenges. Drug design, medical device design, and clinical research are all areas where engineering skills are necessary to keep pace with the increasing knowledge base provided by primary research. In this era of personalized genome sequencing and personalized medicine, a one-size-fits-all approach no longer holds.

Challenges facing the health care industry today include:

- How can drugs be designed that are effective in treating disease, have minimal side effects, and improve patient quality of life?
- How can prostheses and medical devices be designed to be long lasting and provide full functionality to patients?
- How can clinical trials be designed and managed to obtain maximum information about the effects of the treatment in a fair and ethical way?

Who will address these issues? Engineers!

Explore the difference that engineers can make in medical and health care challenges. The TEAMS competition scenario summaries offer a preliminary overview of the topics covered in the 2012 TSA TEAMS competition. Scenarios may be edited and expanded upon in the actual competition questions; however, the overall content will be similar.

Get started: Begin preparing for the competition by researching the key concepts and any unfamiliar terms presented in the scenarios. A list of related web links is provided at the end of each scenario summary for continued exploration. These links should not be considered all inclusive, and team members and coaches are encouraged to research content beyond the provided list for competition preparation.

Scenario #1

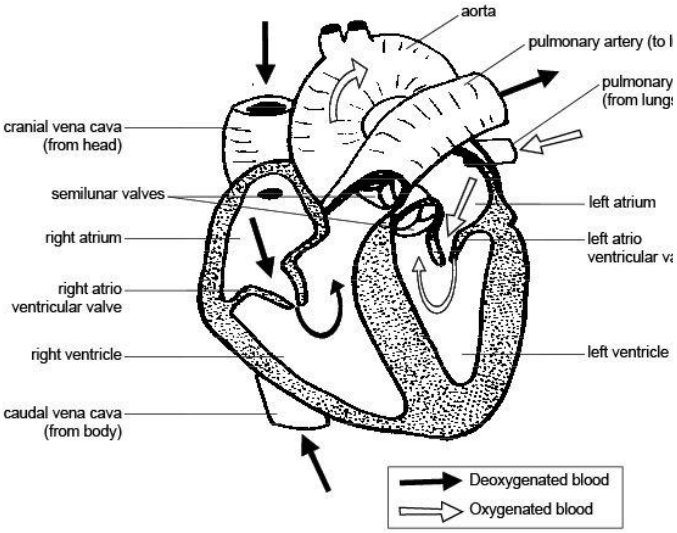
Discover how heart valve replacement surgeries can be more successful when engineers work together to improve artificial heart valves.

More than 250,000 heart valve replacement surgeries take place in the U.S. each year. This surgery replaces diseased heart valves with artificial valves and allows the blood flow to continue smoothly. The surgery usually has a high success rate when a properly designed artificial heart valve is used as a replacement.

How can engineers make a difference? To help ensure a high success rate and avoid complications, your team, working in a lab, will design an artificial heart valve for use during a valve replacement surgery.

Explore more…

- **Heart valve surgery**
  http://TEAMS2012a
- **Heart valve tissue engineering**
  http://TEAMS2012b
- **Biomedical engineering video**
  http://TEAMS2012c



http://upload.wikimedia.org/wikipedia/commons/e/e2/Section_through_heart_to_show_valves_and_blood_flow.jpg; CC BY 3.0; *Ruth Lawson Otago Polytechnic*

Engineering Careers to Explore

- Biomedical engineering
- Mechanical engineering
- Chemical engineering

Scenario #2

Engineers can design and develop improved prostheses for hip replacements, allowing patients to have full functionality of a joint after experiencing degeneration.

Osteoarthritis is one of the major causes of degeneration of the cartilage layer in the hip joint that can make walking difficult and painful. Doctors perform approximately 200,000 total hip replacement surgeries in the U.S. each year in an effort to restore mobility to patients.

How can engineers make a difference? Your team will design and develop a hip joint replacement device that can restore full functionality to a patient.

Explore more…

- **Hip joint surgery**
  http://TEAMS2012d
- **Hip joint replacement**
  http://TEAMS2012e
- **Hip surgery video**
  http://TEAMS2012f

http://commons.wikimedia.org/wiki/File:Hip-replacement.jpg; CC BY-SA 3.0; *KimvdLinde*

Engineering Careers to Explore

- Biomedical engineering
- Mechanical engineering
- Chemical engineering
- Ceramics and materials engineering

Scenario #3

Engineers use the principles of biomechanics to design and develop knee prostheses.

Osteoarthritis and sports injuries are common causes of knee injuries. In many cases, the damage to cartilage is substantial and necessitates the need for a knee replacement surgery. Surgeons replace more than 300,000 knees in the U.S each year. The design of a replacement device can impact every day functions such as walking, climbing steps, etc.

How can engineers make a difference? Knee replacements are arguably one of the more important advances in orthopedic surgeries of the 20th century. Your team will design and develop a knee joint replacement device that can restore full functionality – including walking, running and jumping – to a patient.

Explore more…

- **Knee surgery**
  http://TEAMS2012g
- **Knee replacement surgery**
  http://TEAMS2012h
- **Knee joint video**
  http://TEAMS2012i

http://commons.wikimedia.org/wiki/File:PTG_P.jpeg; CC BY-SA 3.0; *Fpjacquot*

Engineering Careers to Explore

- Biomedical engineering
- Mechanical engineering
- Chemical engineering
- Ceramics and materials engineering

Scenario #4

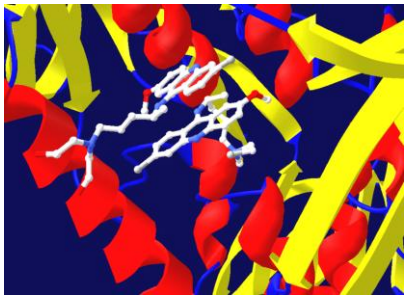
Engineers can help cure disease by designing and developing drugs that target disease.

Drug design is a process of developing new medications based on knowledge of various biological targets. A drug target is a molecule that involves a particular metabolic or signaling pathway that is specific to a disease condition or pathology. A current challenge in the pharmaceutical industry lies in developing drugs that can target a specific disease with minimal side effects. Drug design is at the interface of chemical engineering, genetics, and computational modeling.

How can engineers make a difference? Your team will utilize a multi-pronged approach – using both synthesis and computational techniques – to develop a rational drug design for a specific disease.

Explore more…

- **Engineering better medicines** http://TEAMS2012j
- **Website of a pharmaceutical company** http://TEAMS2012k
- **Drug design video** http://TEAMS2012l



http://upload.wikimedia.org/wikipedia/commons/3/39/Quinacrine_mustard_in_Trypanothione_reductase_active_site.png; *Public Domain*

Engineering Careers to Explore

- Biomedical/biochemical engineering
- Chemical engineering
- Computer engineering

Scenario #5

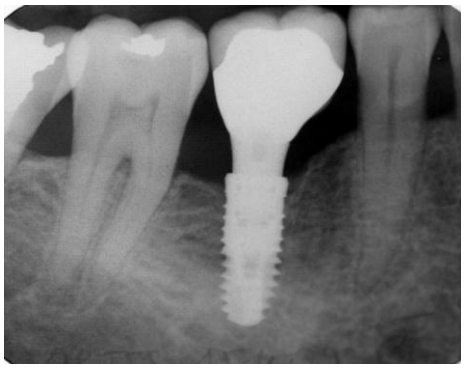
Engineers can help people eat! Engineers design and develop dental implants that restore the ability to chew food.

Broken or damaged teeth often need to be replaced with dental implants in order to provide an individual with mastication efficacy and restoration of the ability to chew food. Among other causes, damage to teeth can be the result of cavities or injuries. The dental implant industry is growing at a rate of 6% each year and by 2015 it is projected to be a $4.2 billion industry. Given the potential growth of the industry, there is an ongoing need for better designed implants (including improved materials and custom fit).

How can engineers make a difference? Using engineering approaches, your team will develop a dental implant, focusing on the size and shape of the implant, as well as materials that can withstand orthodontic forces.

Explore more…

- **Dental implants**
  http://TEAMS2012m
- **Dental implant animation video**
  http://TEAMS2012n



http://upload.wikimedia.org/wikipedia/commons/7/79/Molaire_sur_implant.JPG; CC BY-SA 3.0; *Jbessade*

Engineering Careers to Explore

- Biomedical engineering
- Chemical engineering
- Mechanical engineering
- Materials engineering

Scenario #6

Engineers can design products – for the human body – that use the concepts of fluid dynamics and heat transfer.

The human body is comprised of 60-70% water. Blood, water, the various gases dissolved in blood, fluids present in joints, and urine are all essential to human body functions. The dynamics of these fluids manifest in blood pressure, joint lubrication, and urine output. Understanding the properties of biological fluids is important for grasping the function of these processes.

Additionally, humans are warm-blooded and able to regulate body temperature – under normal circumstances – at approximately 37°C. This ability to maintain body temperature comes at an energy cost – from heat transferred to or absorbed from the environment. In cases of hypothermia, regulation is lost.

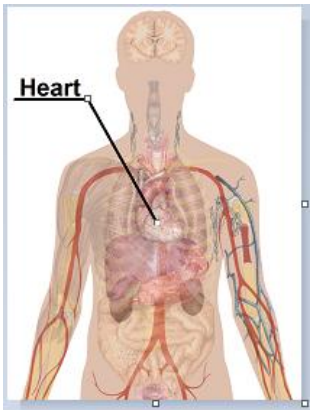
How can engineers make a difference? Your team will improve tools that can help doctors accurately measure temperature and blood pressure.

Explore more…

- **Importance of water in the body** http://TEAMS2012o
- **Blood flow and blood pressure** http://TEAMS2012p

Engineering Careers to Explore

- Biomedical engineering
- Mechanical engineering
- Chemical engineering
- Electrical engineering



http://upload.wikimedia.org/wikipedia/commons/3/3c/Human_body_diagrams_-_adding_line_to_human_body_image_with_organs.png; *Public Domain*

Scenario #7

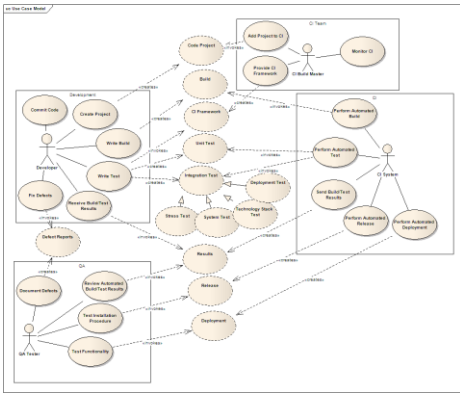
Engineers can design data management systems for clinical trials that safeguard patients and improve data recording and representation.

To prepare for FDA analysis, clinical trials are significant for testing the effects of new therapeutic treatments and medications on a small population. Clinical trial results contain information about a population's response to a given treatment. Data management is an important part of conducting the trial. The FDA has instituted safeguards to ensure that data is not misrepresented and the patient population is not harmed.

How can engineers make a difference? Engineers can play a big role in designing data management systems for clinical trials. In this scenario, your team will focus on the intricacies of clinical trial data management that keep the trial population safe and ensure that data is kept accurately and securely.

Explore more…

- **How do clinical trials work?** http://TEAMS2012q
- **Overview of clinical data management systems** http://TEAMS2012r
- **Clinical trial management video** http://TEAMS2012s



http://commons.wikimedia.org/wiki/File:CCTS_CI_Use_Case.png; *Public Domain*

Engineering Careers to Explore

- Computer engineering
- Chemical engineering
- Bioengineering

Scenario #8

Engineers can help make life-saving treatments available to the public by improving clinical trials.

A clinical trial is a well-designed, closely monitored study of a treatment or medicine in a small population of human beings. It is conducted in order to understand the effects of a treatment. There are many layers to a clinical trial, but, at its core, it requires skills in designing good experiments. Challenges include calculating sample size, determining what outputs to measure, deciding how to keep track of data, and interpreting the data statistically. The results from a clinical trial help determine the future of potentially life-saving treatments and their availability to the public.

How can engineers make a difference? Your team will improve the quality of a clinical trial by determining the study design and statistical analyses of the trial.

Explore more…

- **Understanding clinical trials** http://TEAMS2012t
- **Food and Drug Administration** http://TEAMS2012u
- **Clinical trial animations video** http://TEAMS2012v

http://commons.wikimedia.org/wiki/File:FDA_microbiologist_working_in_a_biosafety_laboratory_tests_for_high_risk_pathogens_in_food.jpg; *Public Domain*

Engineering Careers to Explore

- Computer engineering
- Chemical engineering
- Biochemical engineering

Part 2: Comprehensive Scenario

A world effort: Challenges face the biomedical community on a global level. Better drugs are needed to treat diseases, improved prostheses are required for an increasing number of older and injured patients, and efficient and accurate analysis and management are key elements of ensuring a healthy future for people around the world.

Engineering can have an important role in discovering innovative solutions to these challenges. Topics in Part-2 will focus on broadening your perspective about how to tackle these challenges and think about solutions to problems, such as:

- What different materials can be used to develop prostheses?
- How can the lifespan of a prosthesis be improved?
- How does drug design vary from one disease to another?
- What are the ethical aspects of designing a clinical trial?
- How does gender affect the design of hip and knee implants?
- How will the design of each of the four heart valves differ from one another?
- How can fluid flow in the body relate to the design of heart valves?
- How does the genetic background of a population influence drug design?

Explore more…

- **Biomedical Engineering Society**
  http://TEAMS2012w
- **FDA**
  http://TEAMS2012x
- **National Library of Medicine**
  http://TEAMS2012y