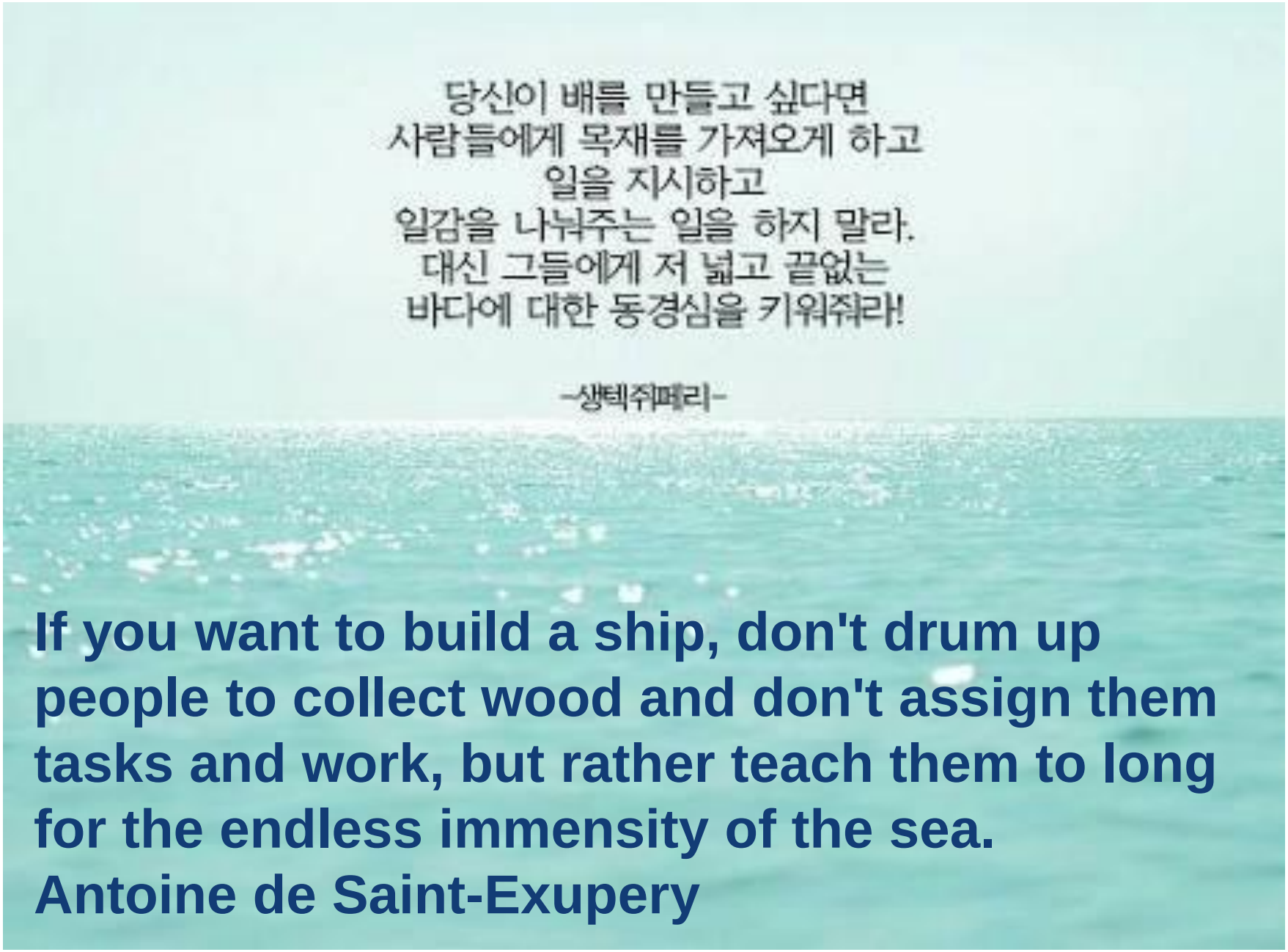
Introduction to Chemical & Biological Engineering



If you want to build a ship, don't drum up people to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea.
Antoine de Saint-Exupery

The College Degrees With The Highest Starting Salaries In 2016

(https://www.forbes.com/pictures/5775434fa7ea436bd18bff25/the-20-college-majors-wit/)

The 25 Bachelor's Degrees With The Highest Salary Potential In 2016-2017

(https://www.forbes.com/pictures/fjle45eedfd/the-25-bachelors-degree/)

What do Chemical Engineers Do?

https://www.aiche.org/community/students/career-resources-k-12-students-parents/what-do-chemical-engineers-do

- Chemical Engineering Touches Everything
  - Petrochemicals, Specialty chemicals, Pulp and paper
  - Biotechnology, Pharmaceuticals, Healthcare, Food processing
  - Electronic and advanced materials, Polymers, Microelectronics,
  - Environmental health and safety industries
  - Manufacturing, Design and construction
  - Business services

What do Chemical Engineers Do?

- Chemical Engineering Touches Everything
  - Don't make the mistake of thinking that chemical engineers only “make things”.
  - Their expertise is also applied in the areas of law, education, publishing, finance, and medicine, as well as in many other fields that require technical training.

What do Chemical Engineers Do?

- Math and Science Are Important
  - Chemical engineers rely on their knowledge of mathematics and science—particularly chemistry and biology— to overcome technical problems safely and economically.
  - And, of course, they draw upon and apply their engineering knowledge to solve any technical challenges they encounter.

What do Chemical Engineers Do?

- Chemical Engineers are
  - Advancing Biomedicine
  - Developing Electronics
  - Enhancing Food Production
  - Generating Energy
  - Improving Materials
  - Saving Environment

Chemical Engineers are Advancing Biomedicine

Chemical Engineers are Advancing Biomedicine

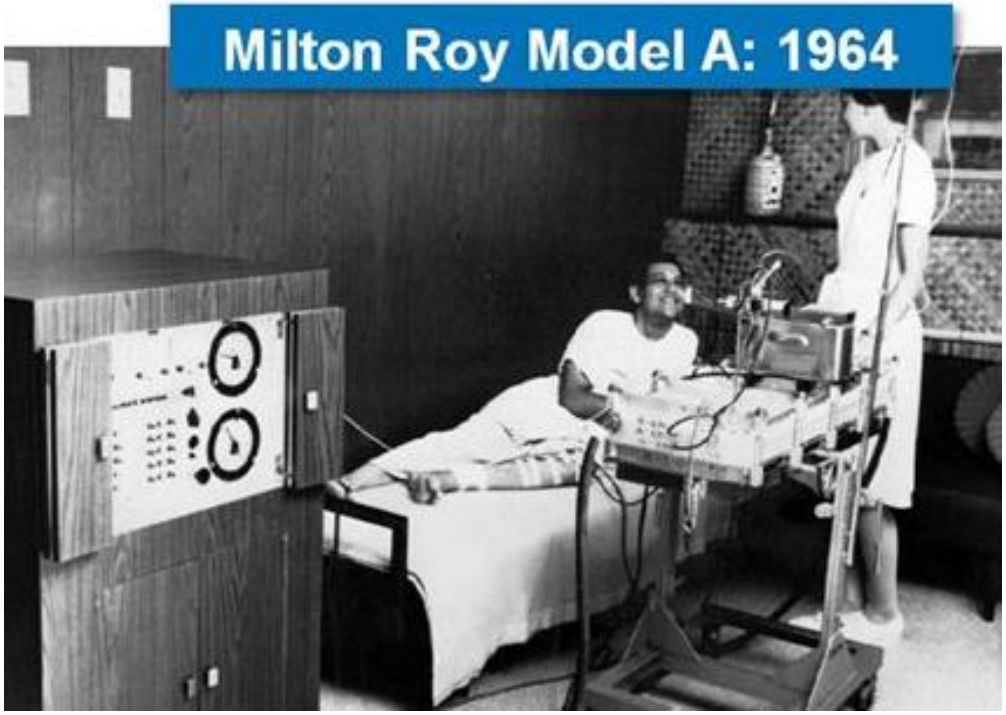
- Chemical engineers have made rich and varied contributions to many biomedical advancements in an effort to
  - Modernize disease diagnosis and treatment options
  - Improve the safety and efficacy of drug-delivery mechanisms
  - Achieve better therapeutic outcomes

Achievements in Advancing Biomedicine

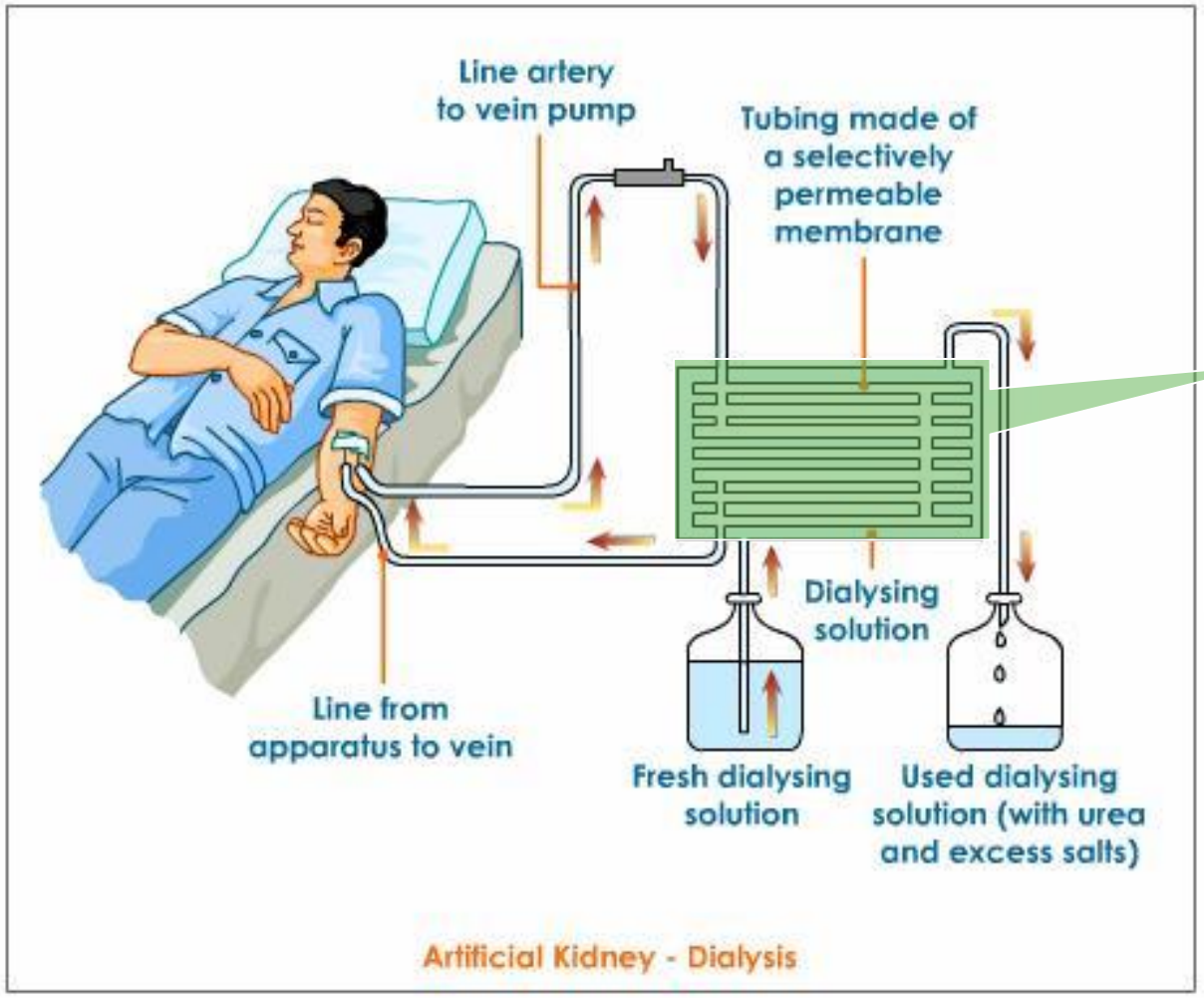
- Kidney Dialysis (artificial kidney)
- Treating Diabetes
- Tissue Engineering
- Drug Delivery

Artificial Kidney

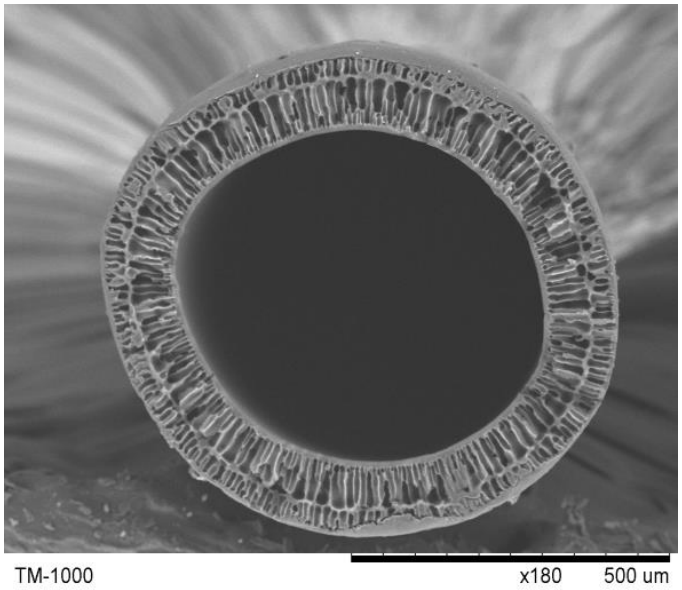
- Milton-Roy Model A
  - designed by chemical engineering professor Les Bab in order to help the daughter of a friend



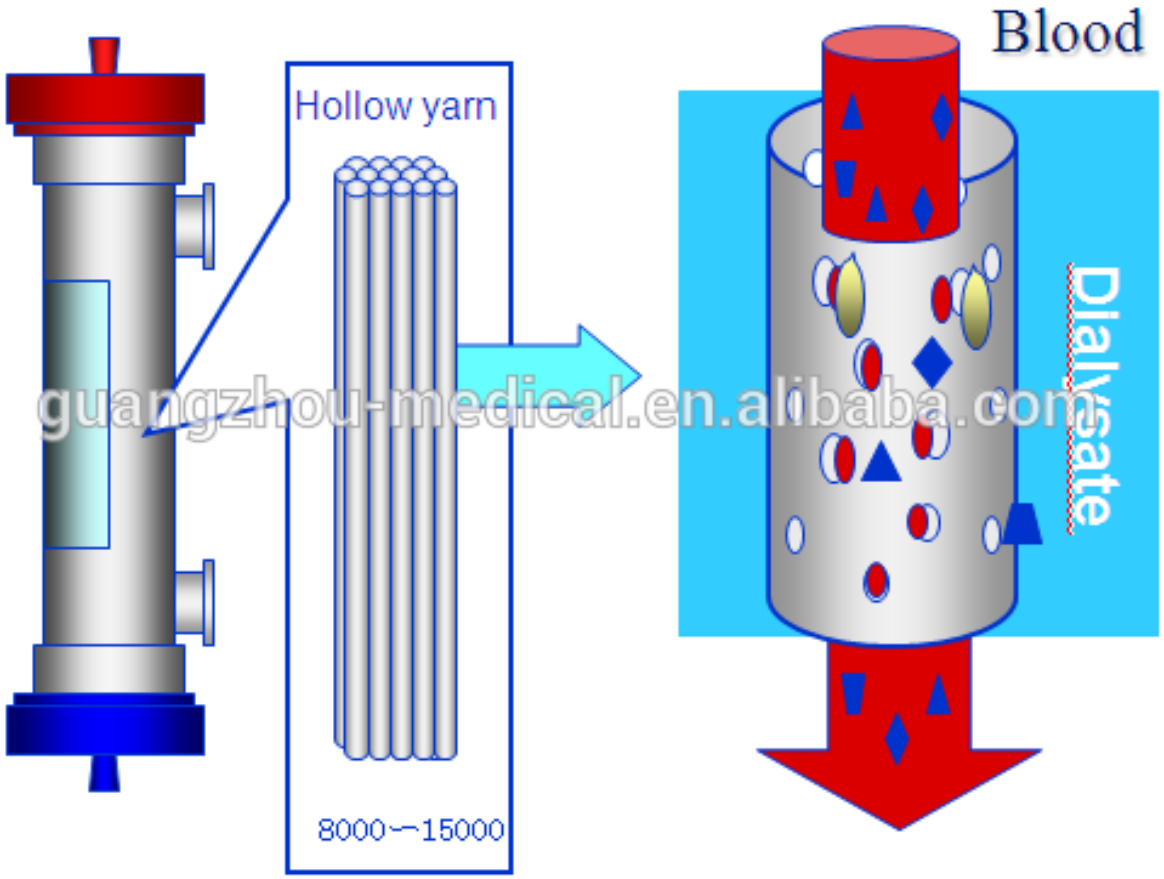
Artificial Kidney



Artificial Kidney



Artificial Kidney



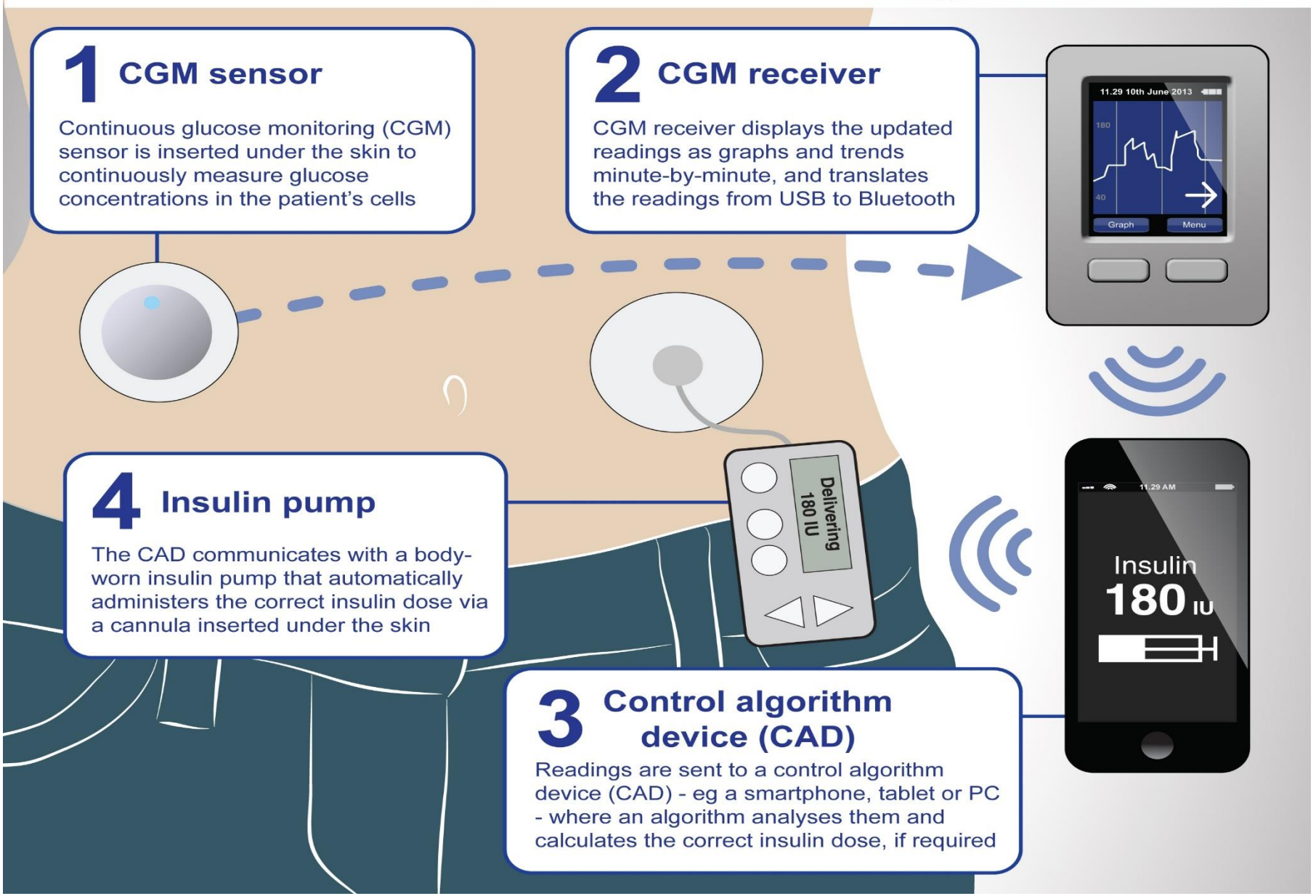
Artificial Kidney

- Chemical engineers have continued to create smaller, more effective, and more affordable dialysis machines.
- An excellent example of the life-enhancing synergies that result when chemical engineers join forces with physicians and biomedical researchers
- One of the “Ten Wonders of Biomedical Eng.”
- Essentially mass-transfer device (Mass Transfer)

Treating diabetes

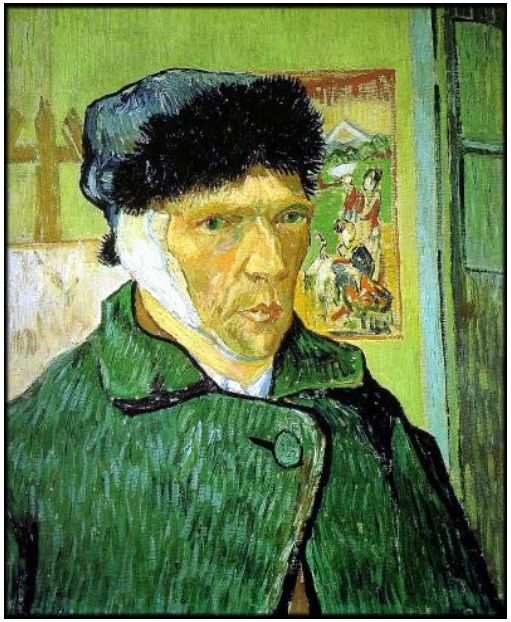
- Combined efforts of chemical engineers, physicians, and biomedical researchers
- Glucose level monitoring (Biosensor)
  - Microanalytical techniques (small blood samples)
  - Continuous monitors implanted beneath the skin
  - Use of implanted microchips to control insulin addition
- Insulin Injection (Process Control)
  - Continuous-infusion insulin pump

Artificial pancreas *at a glance*



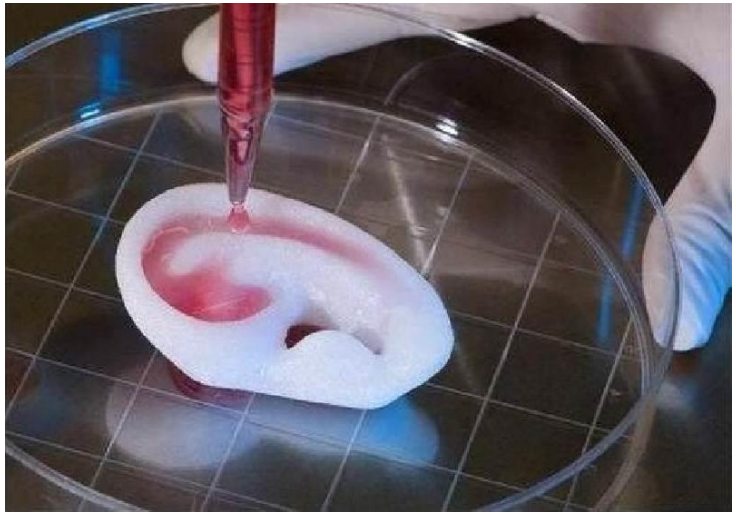
Tissue Engineering

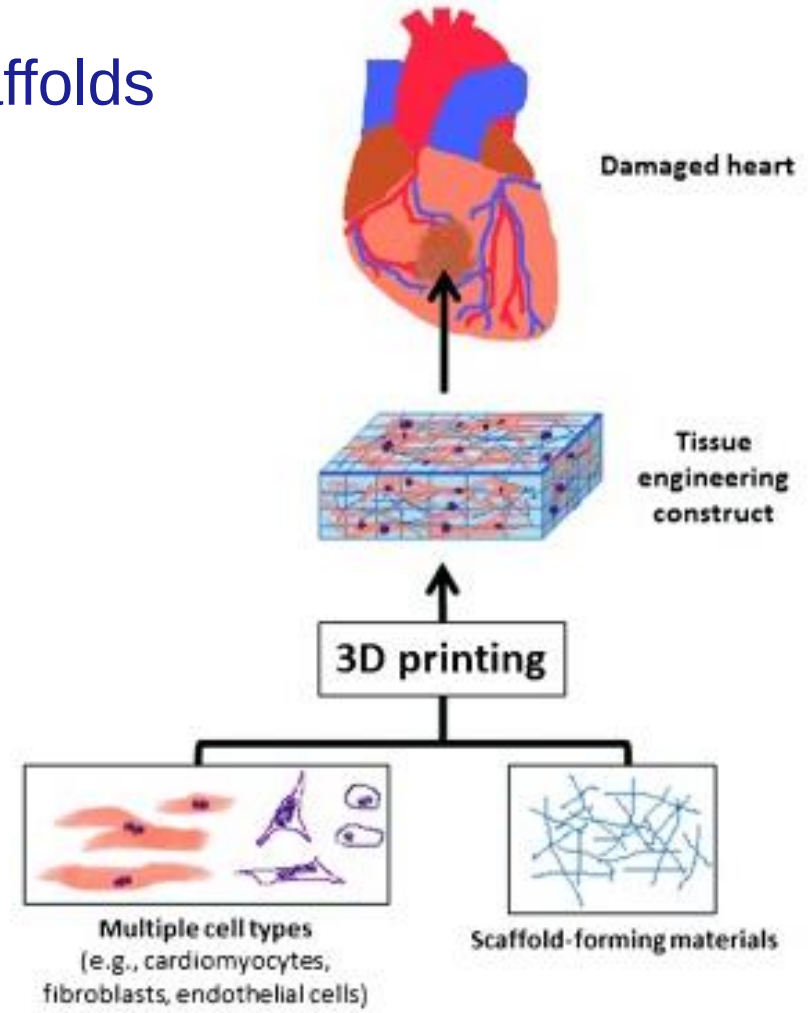
- To repair or replace damaged or diseased organs and tissues
- Use of living cells as building materials



Scaffold & 3D Printing

- Biocompatible polymer scaffolds
- Biodegradable polymer
  - e.g. nerve-guide conduits
- (Polymer Materials)





D.J. Richards et al, Israel Journal of Chemistry, 53, 805, 2013

Tissue Engineering

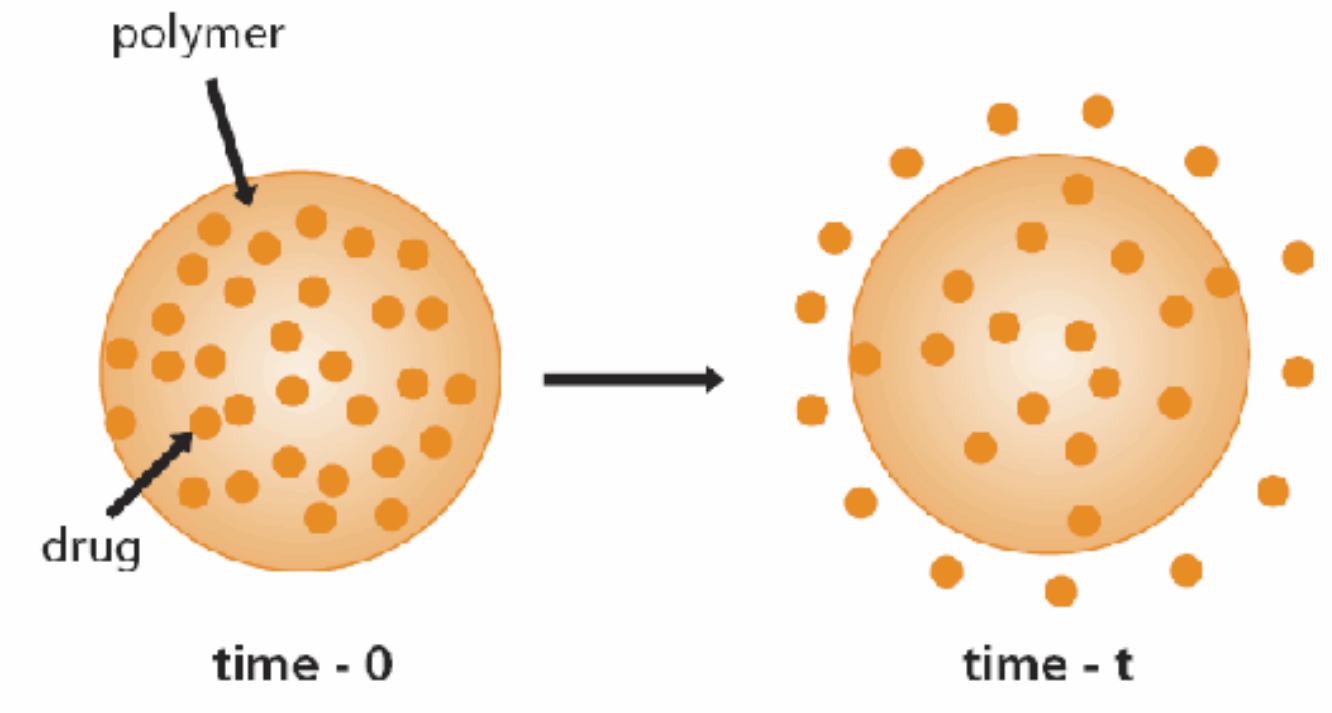
- Transplantation cells for specific biochemical functions
  - improving pancreas, liver, or bladder functions
- Replacement tissues
  - artificial skin, bones, cartilage, blood vessels, tendons, and ligaments
- Stem cells
  - able to regenerate functional human tissues.

Drug Delivery

- Conventional method
  - by mouth or injection
- Early advancements using chemical principles

  (Mass Transfer & Polymer Materials)
  - Nasal sprays that deliver finely atomized amounts of a drug via inhalation
  - Transdermal patches that deliver controlled doses through the skin, and
  - Controlled-release capsules and wafers that deliver drugs over an extended period.

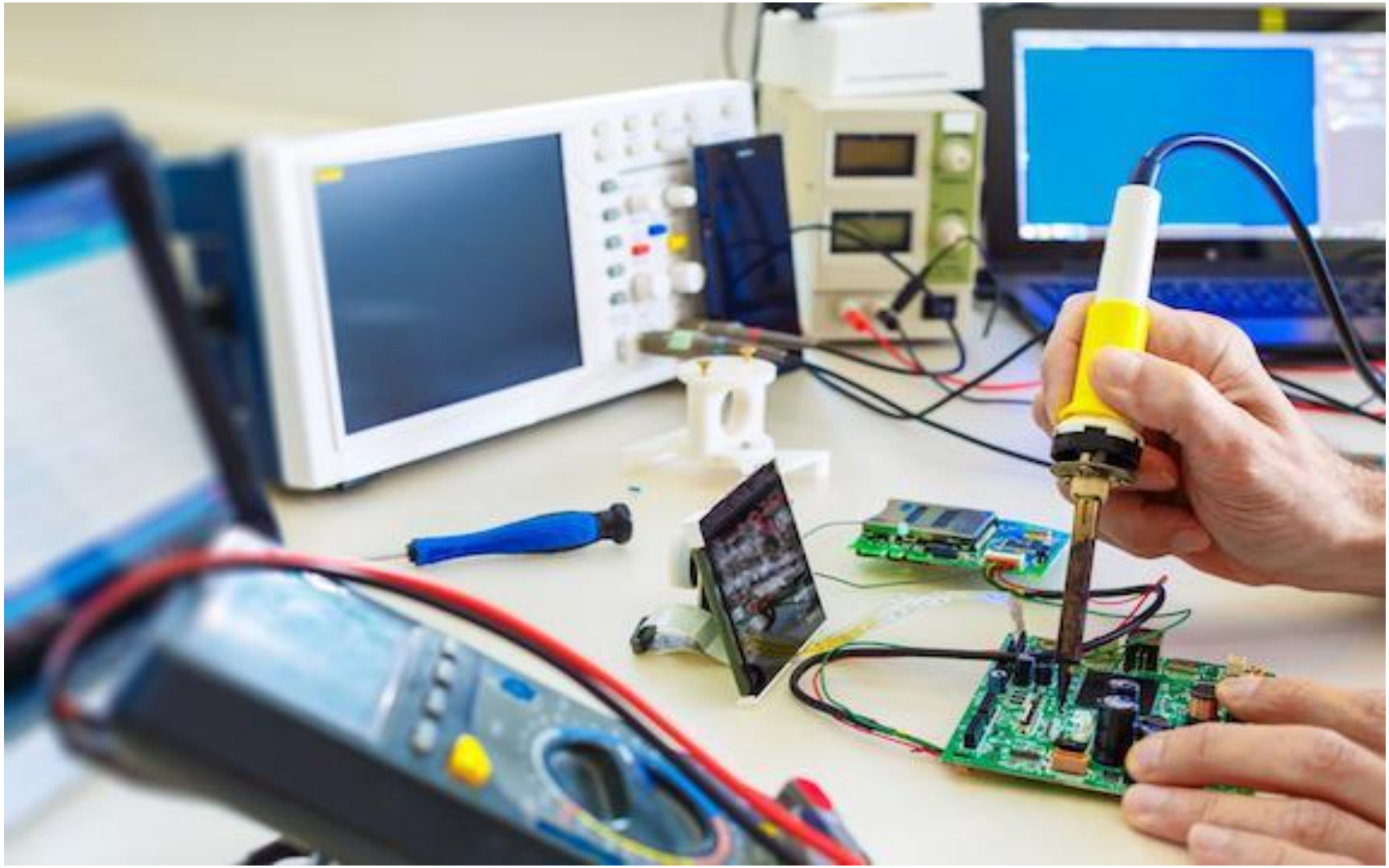
Drug Delivery



Drug Delivery

- With the help of chemical engineers
  - directly to the desired location within the body
  - release drug on demand.
- Advantages
  - Reduce or delay premature degradation of a drug in the body
  - Maximize the ability of a drug without affecting healthy tissue and organs
  - Minimize the total amount of the drug
  - Reduce potential side effects

Chemical Engineers are Developing Electronics



Chemical Engineers are Developing Electronics

- Chemical engineers contributed to the invention of semiconductor chips.
  - from children's toys to phones, automobiles, medical sensors, and communications satellites

- Chemical engineers are routinely involved with
  - Development of advanced semiconductor materials
  - Manufacturing processes required to produce them

(Inorganic Materials & Process)

Semiconductor

- Silicon → Semiconductor chip
  - requires the multidisciplinary expertise of chemical engineers
  - From sand to silicon

    https://www.youtube.com/watch?v=Q5paWn7bFg4

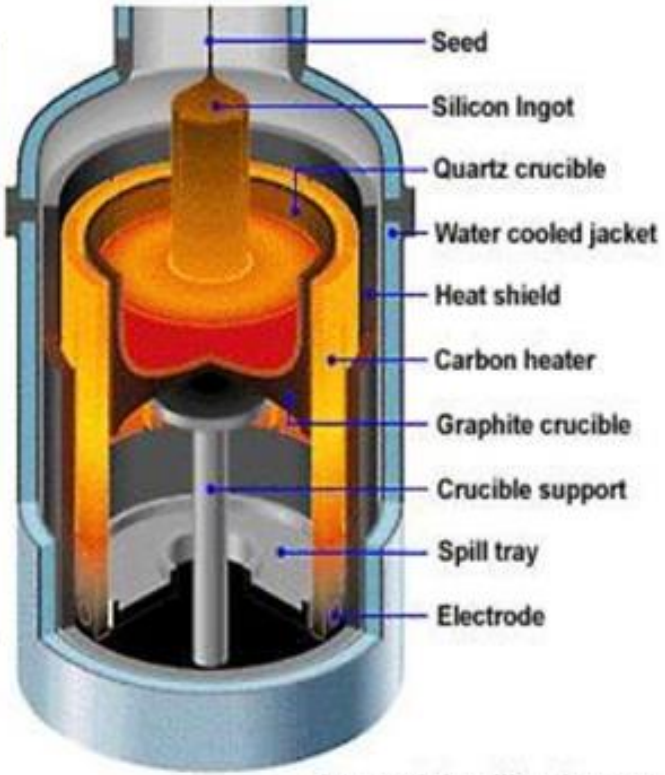
- Silicon ingot
  - The successful growth of silicon ingots requires an understanding of fluid mechanics, heat and mass transfer, and crystallization.

Semiconductor

- Silicon ingot (서랄스키 방법)

Wafer growth – Czochralski Method (Cz)

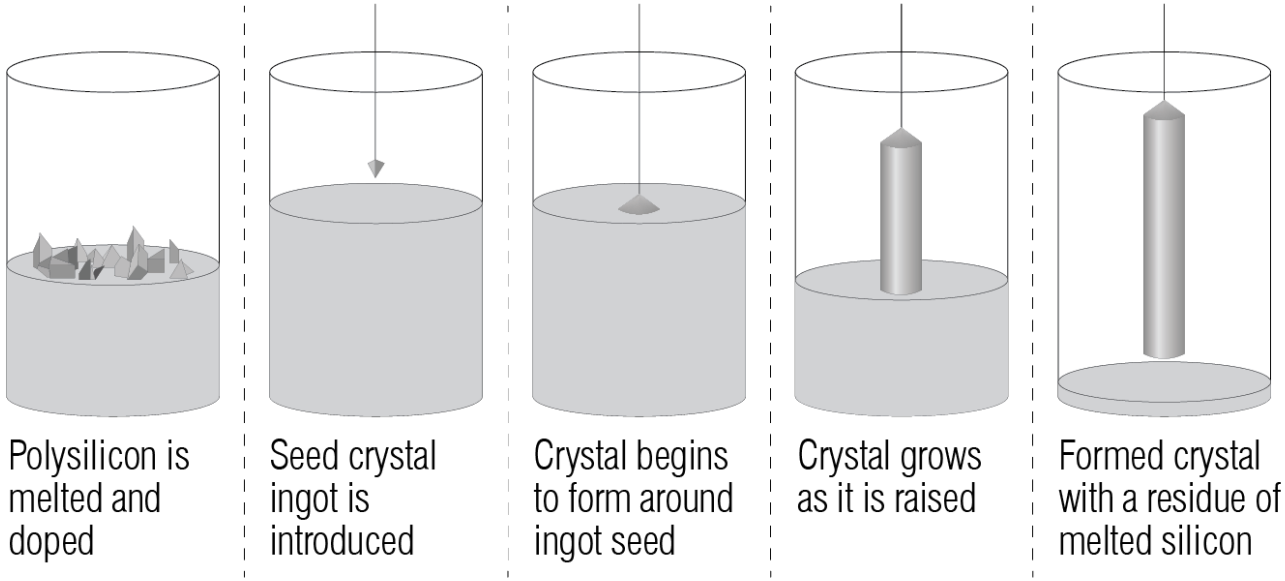
-From the high purity poly-Si, single crystal silicon is required,
-The Cz process is the most common for large wafer diameter production.
- Pull rate, melt temperature and rotation rate are all important control parameters.



Cz crystal pulling furnace

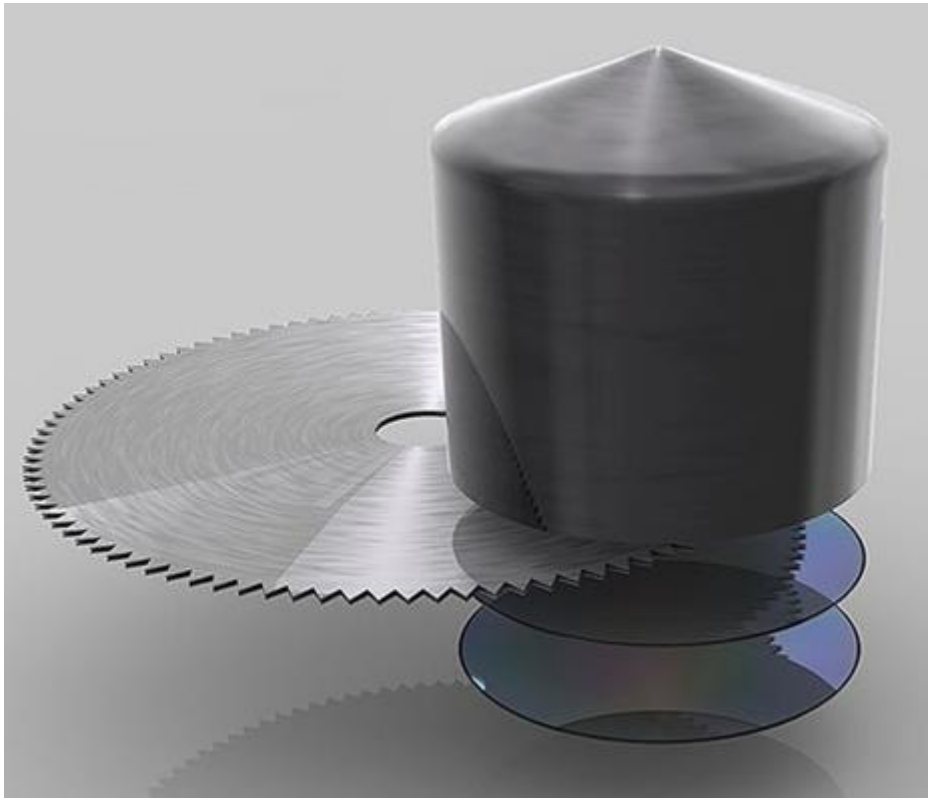
Semiconductor

- Silicon ingot



Semiconductor

- Silicon ingot → Wafers



Semiconductor

- Silicon ingot → Wafer → Integrated circuit
- The highly polished wafers next undergo a successive series of process steps.
- Each step involves the deposit of a complex layer of either a conductor, a semiconductor, or an insulating material.
- These materials deposited in many layers produce the transistors, resistors, and capacitors that ultimately make up an integrated circuit.