What is It?

- A medical equipment that provides Cardiopulmonary bypass, (temporary mechanical circulatory support) to the stationary heart and lungs.

- Heart and Lungs are made “functionless temporarily”, in order to perform surgeries:
  - CABG (Coronary artery bypass grafting)
  - Valve repair
  - Aneurysm
  - Septal Defects
History

- Lewis and Taufic first used the **Hypothermia Approach** clinically on September 2, 1952. Under moderate total body hypothermia, Lewis and Taufic used a short period of circulatory arrest to repair a congenital defect in a 5 year-old girl.

- An alternative approach named **Cross-Circulation** was used by Dr. C. Walt when on March 26, 1954, when he repaired a VSD in a 12 month-old infant.
On May 6, 1953, Dr. Gibbon used his heart–lung machine to successfully repair an atrial septal defect in an 18 year-old girl, marking the first successful clinical use of a Heart–Lung Machine.
Heart and lung machine
Modified – Mayo Clinic (1955)
Present Day Machine

Heart and lung machine
Present Day Machine

- Water-resistant computer with battery back-up
- Flexible LED lamp consumes just 6 watts.
- Fixed-height shelf
- Control panel for entire machine mounts on any of four masts.
- Four support/mounting masts. Tow are telescoping
- Roller pumps for moving blood in pulses.
- Transformer and electrical connections. Only low-power (24-V) connections accessible to staff.
- Storage drawer
- Chassis holds electronic modules
- Emergency battery provides uninterruptible power supply for entire machine.
- Twin pump module handle low-flow rates
- Side guard used to move unit. Caster simplify moving the device.

Heart and lung machine
Principles and Necessity

Heart is Stopped

Blood diverted through tubes and is pumped to maintain flow

Blood circulated systemically bypassing the heart and lungs

Temperature regulation of blood and gaseous exchange is done
Heart and lung machine
Coronary Artery Bypass

blockage
CARDIOPLEGIA

- The intentional and temporary cessation of cardiac activity.
- Common procedure for accomplishing asystole is infusing cold crystalloid cardioplegia into the coronary circulation. Iced (4 degrees Celsius) solution of dextrose, potassium chloride, and Magnesium rich solution is introduced via specialized Cannula.
Parts

- Five pump assemblies
- Venous Cannula
- Arterial Cannula - dual-stream aortic perfusion catheter / meshed cannula
- Venous Reservoir
- Oxygenators
- Heat Exchangers
- Cardiotomy Reservoir and Field Suction
- Filters and Bubble Traps
- Tubing and Connectors
Heart and lung machine
FIVE PUMP ASSEMBLIES

- A centrifugal or roller head pump can be used in the arterial position for extracorporeal circulation of the blood.
- Left ventricular blood return is accomplished by roller pump, drawing blood away from the heart.
- Surgical suction created by the roller pump removes accumulated fluid from the general surgical field.
- The cardioplegia delivery pump.
- Emergency Backup of the arterial pump in case of mechanical failure.
Five Pump Assemblies

- Centrifugal pumps consist of plastic cones, which when rotated rapidly, propel blood by centrifugal force.
- Forward blood flow, varies with the speed of rotation and the after load of the arterial line.
- Centrifugal blood pumps generate up to 900 mm Hg of forward pressure, but only 400 to 500 mm Hg of negative pressure. Hence, less gaseous micro emboli.
- Centrifugal pumps produce pulse less blood flow
- Roller pumps consist tubing, which is compressed by two rollers 180° apart. Forward flow is generated by roller compression and flow rate depends upon the diameter of the tubing, rate of rotation.
PUMPS TYPES

A
Roller Pump
Heart and lung machine

B
Impeller Pump

C
Centrifugal Pump
VENOUS RESERVOIRS

- Reservoirs may be rigid (hard) plastic canisters ("open" types) or soft, collapsible plastic bags ("closed" types).
- The venous reservoir serves as volume reservoir
- Facilitates gravity drainage,
- Venous bubble trap present,
- Provides a convenient place to add drugs, fluids, or blood, and adds storage capacity for the perfusion system.
Oxygenators

Heart and lung machine
Membranous Oxygenators

- Imitate the natural lung by interspersing a thin membrane of either micro porous polypropylene or silicone rubber between the gas and blood phases.
- With micro porous membranes, plasma-filled pores prevent gas entering blood but facilitate transfer of both oxygen and CO2.
- The most popular design uses sheaves of hollow fibers connected to inlet and outlet manifolds within a hard-shell jacket.
Bubble Oxygenators

- Large bubbles improve removal of $\text{co}_2$ greater in oxygenation
- Smaller bubbles are very efficient at oxygenation but poor in $\text{co}_2$ removal
- Venous blood drains directly into a chamber into which oxygen is infused through a diffusion plate (sparger).
- The sparger produces thousands of small (approximately 36 µm) oxygen bubbles within blood.
- Gas exchange occurs across a thin film at the blood-gas interface around each bubble
- Produce more particulate and gaseous microemboli are more reactive to blood elements.
Heat Exchangers

- Control body temperature by heating or cooling blood passing through the perfusion circuit

- Temperature differences within the body and perfusion circuit are limited to 5°C to 10°C to prevent bubble emboli
Filters and Bubble Traps

- In the circuit, micro emboli are monitored by arterial line ultrasound or monitoring screen filtration pressure.
- **Depth filters** consist of porous foam, have a large, wetted surface and remove micro emboli by impaction and absorption.
- **Screen filters** are usually made of woven polyester or nylon thread.
Tubing

- Medical grade Polyvinyl Chloride (PVC) tubing
- It is flexible, compatible with blood, inert, nontoxic, smooth, nonwettable, tough, transparent, resistant to kinking and collapse,
- Can be heat sterilized
- The **Duraflo II heparin coating** ionically attaches heparin to a quaternary ammonium carrier (alkylbenzyl dimethyl - ammonium chloride), which binds to plastic surfaces.
Perfusion Monitors and Sensors

- A low-level sensor with alarms on the venous reservoir and a bubble detector on the arterial line are desirable safety devices.
- Flow-through devices are available to continuously measure blood gases, hemoglobin/hematocrit, and some electrolytes.
- Temperatures of the water entering heat exchangers.
STERILIZATION

- Ethylene dioxide is commonly used
- 4 hours of sterilization at 55°C or 18 hours at 22°C.
- Disadvantages of ethylene dioxide, are the toxicity and explosive nature
- Disposable tubing, reservoirs and oxygenator
- Steam sterilization as PVC can withstand heat
ADVANTAGE

- Allow doctor to operate in a blood-free area, should contribute to less surgical error
- In the future, the heart-lung pump will hopefully become portable, allowing for paramedics to aid heart attack patients on the scene
- In future development to allow for less brain damage after the surgery
DISADVANTAGES

- Post perfusion Syndrome - a transient neurocognitive impairment associated with cardiopulmonary bypass.
- Some research shows the incidence is initially decreased by off-pump coronary artery bypass.
- “Pumphead” syndrome - some effect can include defects to attention concentration, short term memory loss and fine motor function.