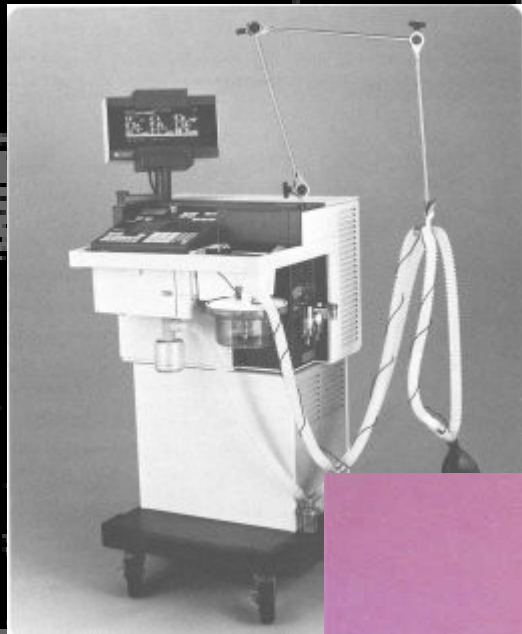
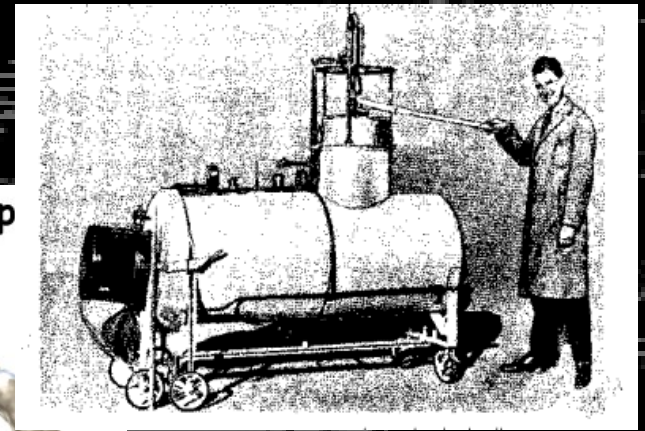
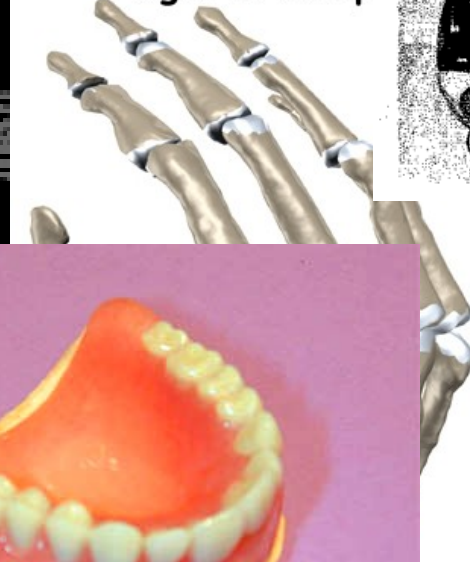


# Lectures on Medical Biophysics

Department of Biophysics, Medical Faculty,  
Masaryk University in Brno



Finger arthrop



# Lectures on Medical Biophysics

Department of Biophysics, Medical Faculty,  
Masaryk University in Brno

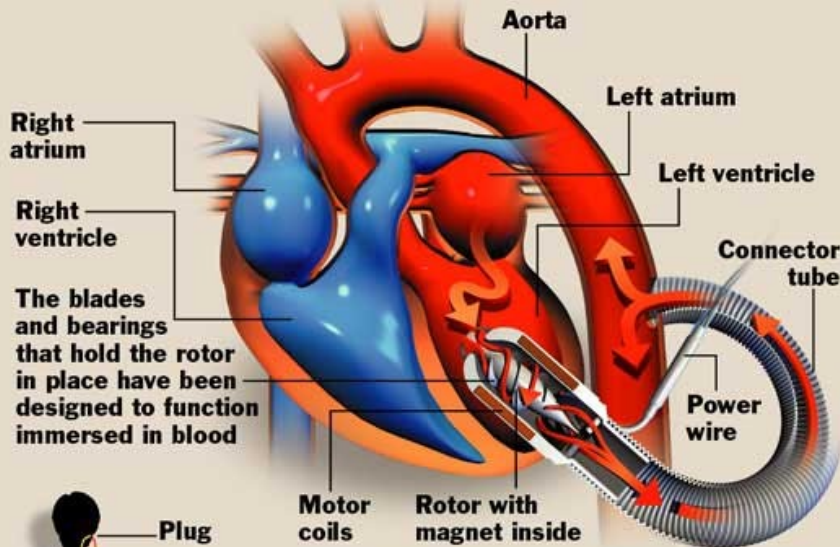


**Devices for substitution and assist of body organs**

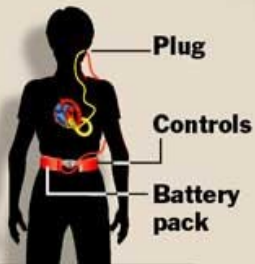
# Support and replacement of heart

**JARVIK 2000** A miniature pump to assist or replace the function of the left ventricle, the heart's main pumping chamber

**THE PUMP** Electric coils cause a rotor with an embedded magnet to spin. Fins on the rotor push oxygen-rich blood (red arrows) from the heart through a tube into the aorta.

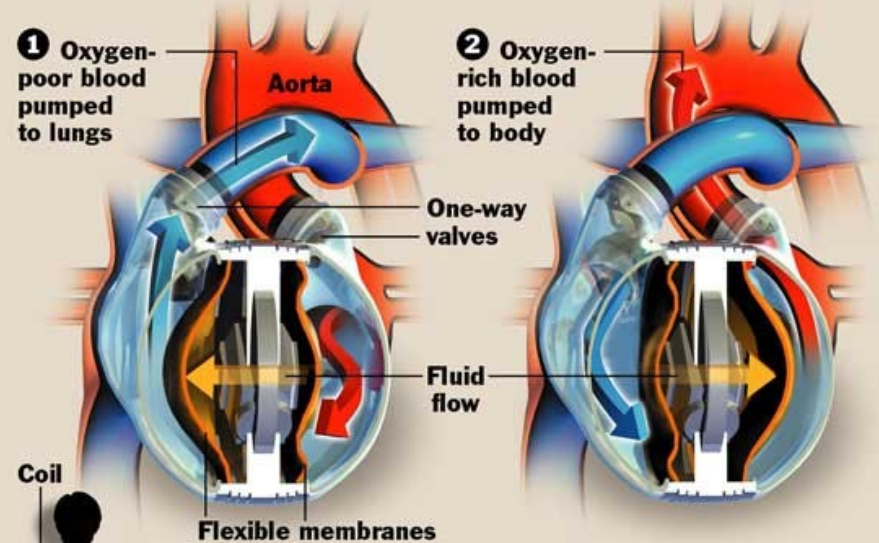


**THE POWER** A rechargeable battery, worn on a belt, will supply electricity to the pump for as long as 12 hours through a plug that penetrates the skin in the back of the skull. This site is particularly resistant to infection.

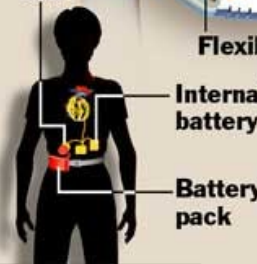


**ABIOMED ARTIFICIAL HEART** A battery-powered replacement heart to allow patients to resume most normal activities

**THE PUMP** A hydraulic pump in the center of the artificial heart pumps a fluid back and forth between two membranes, forcing the blood alternately out of the left and right chambers, creating a pulse.

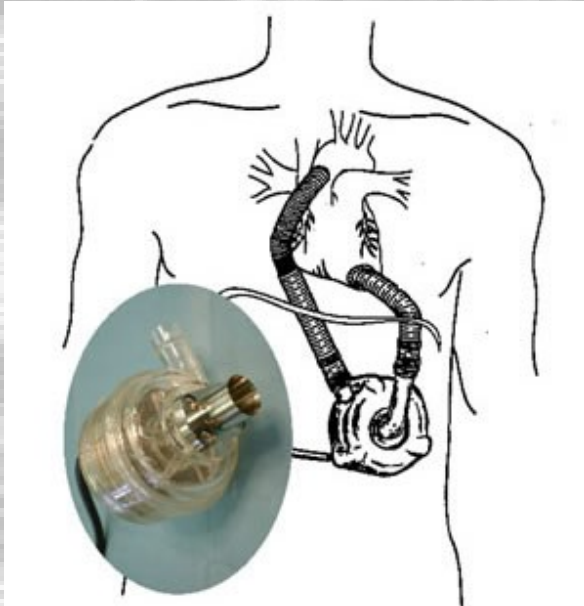


**THE POWER** A battery pack, worn on a belt, transmits power for up to eight hours across the unbroken skin to a coil and battery implanted in the abdomen. Because no wires penetrate the skin, the potential for infection is eliminated.



TIME Diagram by Joe Lertola

# Implanted heart assist pump (in development)

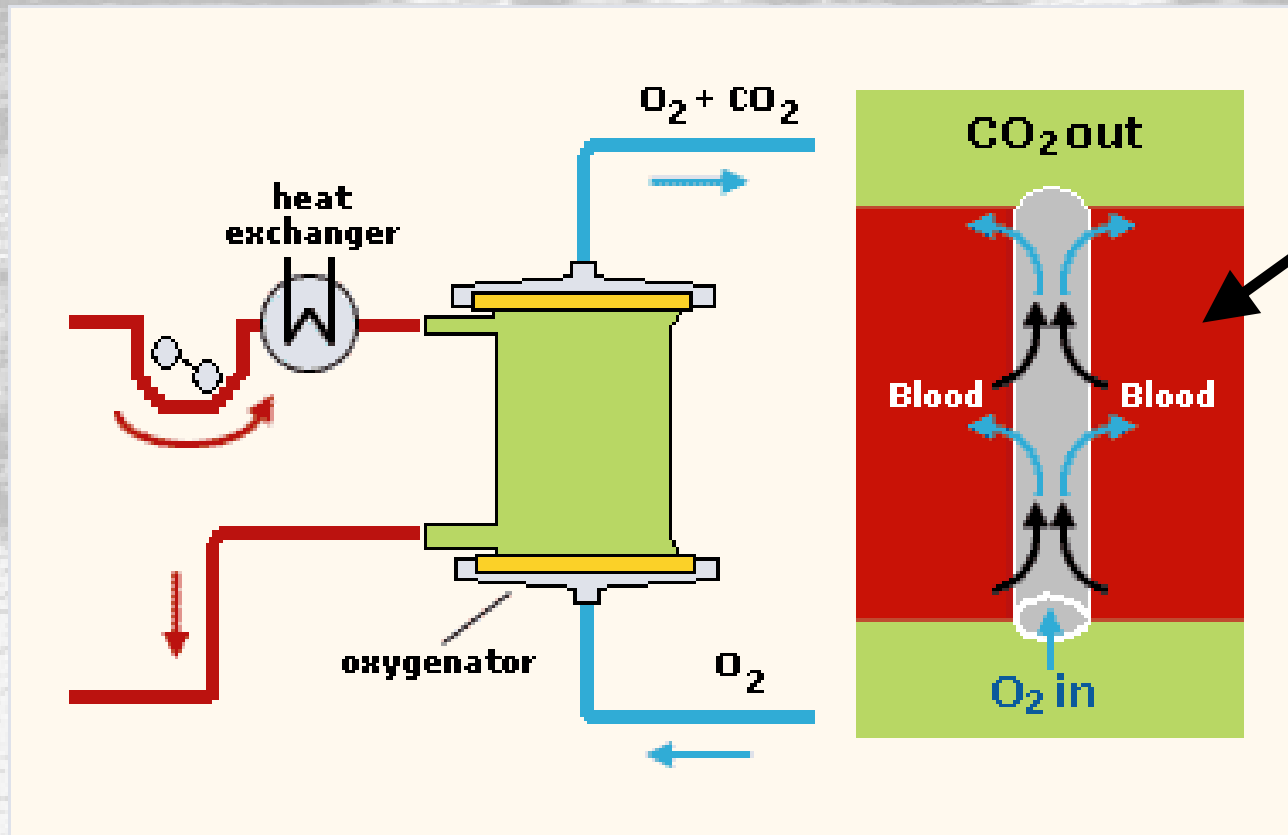


Centrifugal blood pump for short-term (peroperative – during surgery) as well as long-term use to support function of left heart chamber. Requires less energy, simple construction, low haemolytic effect, small volume.

# Cardiopulmonary bypass

- During major heart or lungs surgery is often necessary to substitute function of these organs by an extracorporeal device. The lungs are substituted by **oxygenator**, which delivers oxygen to the body and removes carbon dioxide from it.
- Two types of oxygenators: with direct contact of the gas with blood or based on diffusion of gases through a membrane between blood and gas.
- In the **bubble oxygenators**, the oxygen bubbles ascend in a cylindrical vessel filled by blood. Blood uptakes oxygen and carbon dioxide is removed. Arising foam must be settled, then the blood passes through a filter and the „**bubble trap**“.
- **Membrane oxygenators** are equipped by semipermeable membranes. Problem: certain denaturation of blood proteins and damage to the blood cells on the membranes limit their use to several hours. The membranes are layered or form capillaries. These oxygenators represent good approximation of lungs but it is necessary to disturb the blood layer on membranes by turbulences.

# Cardiopulmonary bypass



Membrane  
oxygenator

Main parts of cardiopulmonary bypass: peristaltic pump, oxygenator, heat exchanger for heating or cooling blood and hence the patient's body.

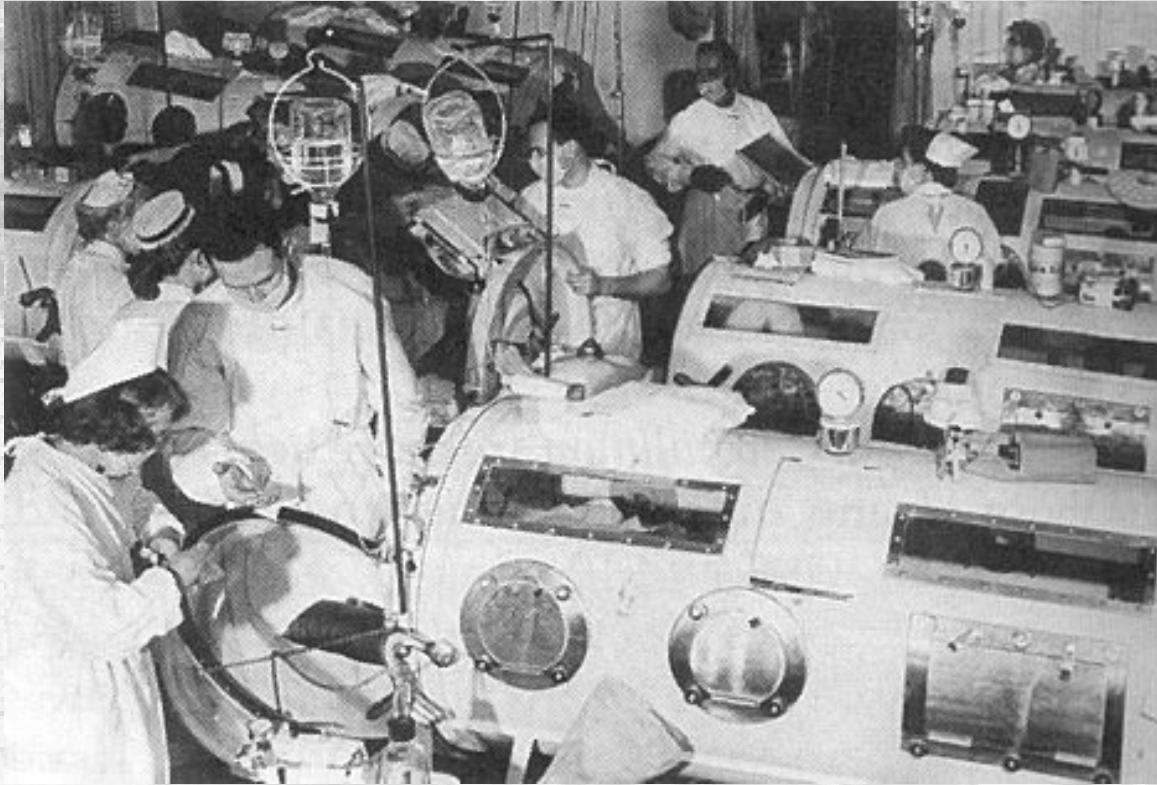
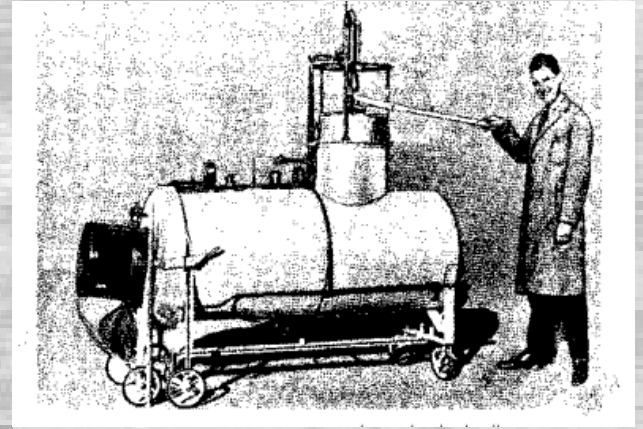
# Cardiopulmonary bypass

Bubble oxygenator with heat exchanger.

The common problem of all cardiopulmonary bypasses is the need of certain increase of circulating blood volume – it can be done by dilution.



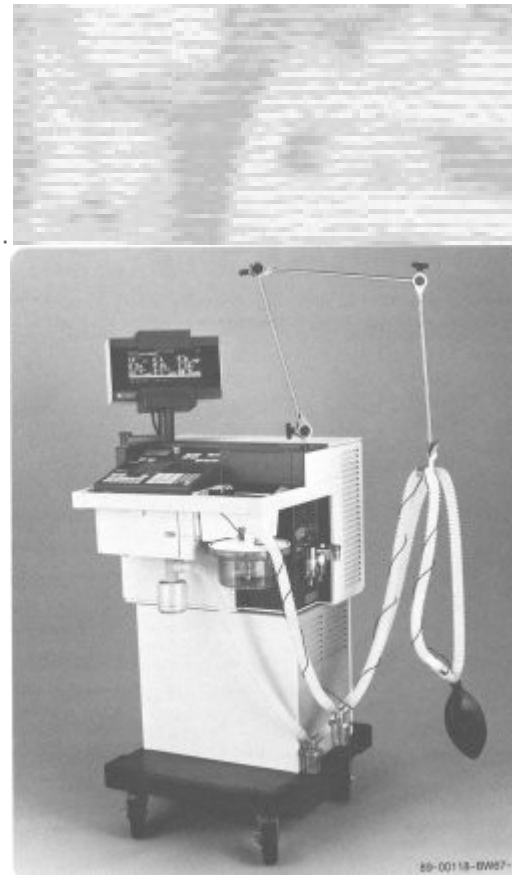
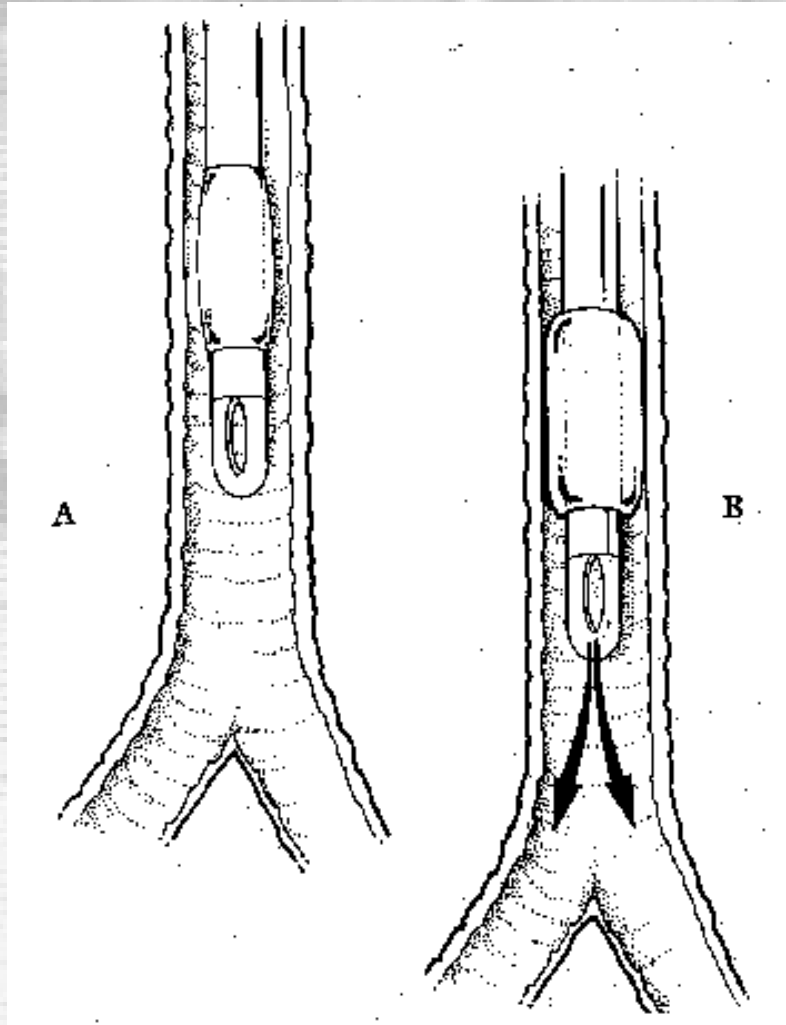
# „Iron lungs“ (in the past)





# Mechanical ventilation of lungs

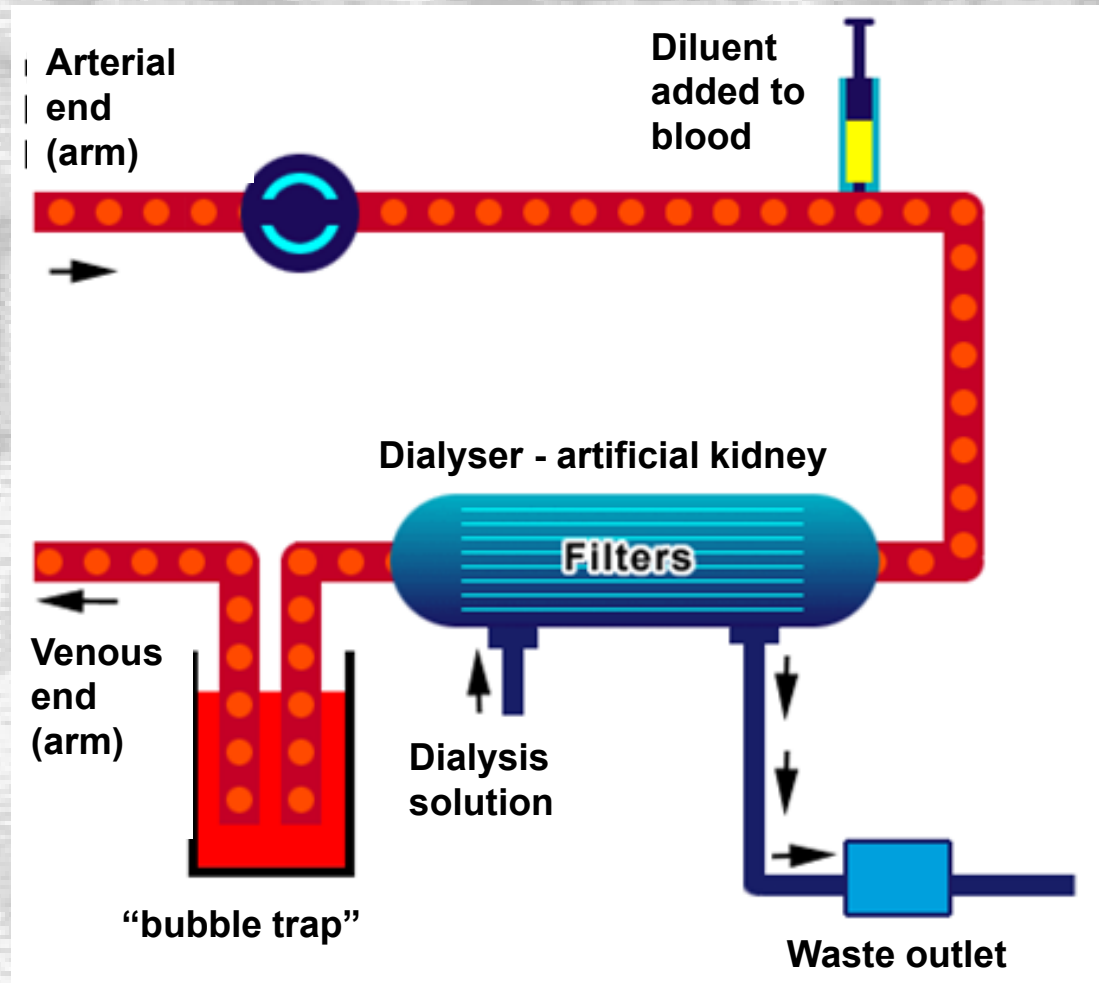
- Ventilation is performed with air pressure or volume limit



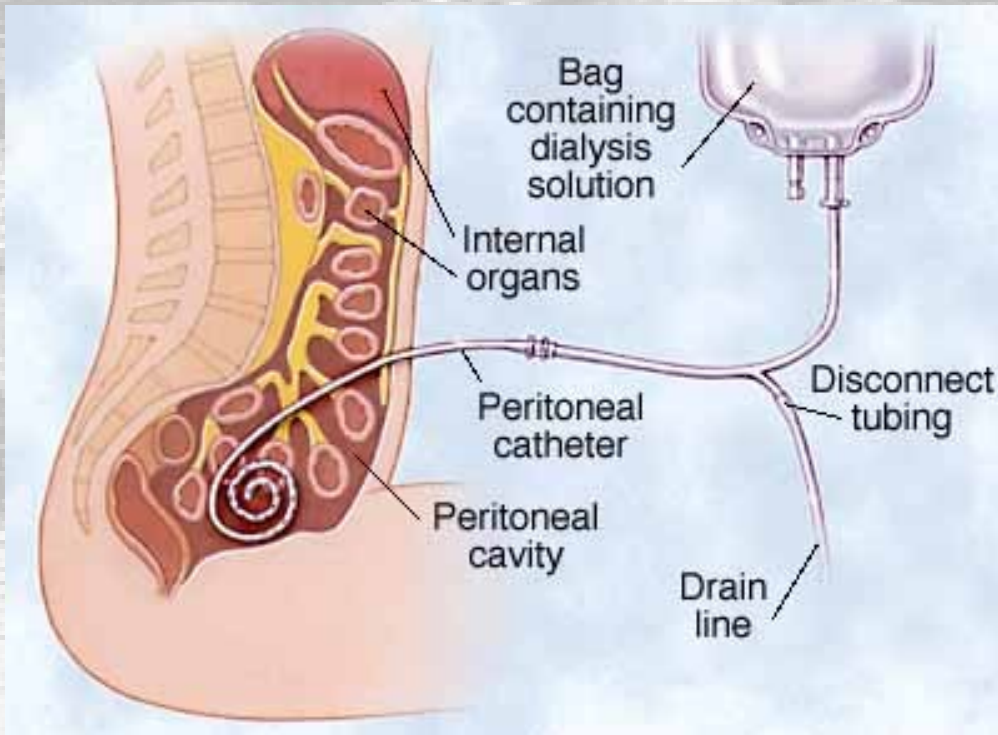
# Artificial kidney - haemodialysis



Superfluous volume of blood can be removed by underpressure in the dialysis solution

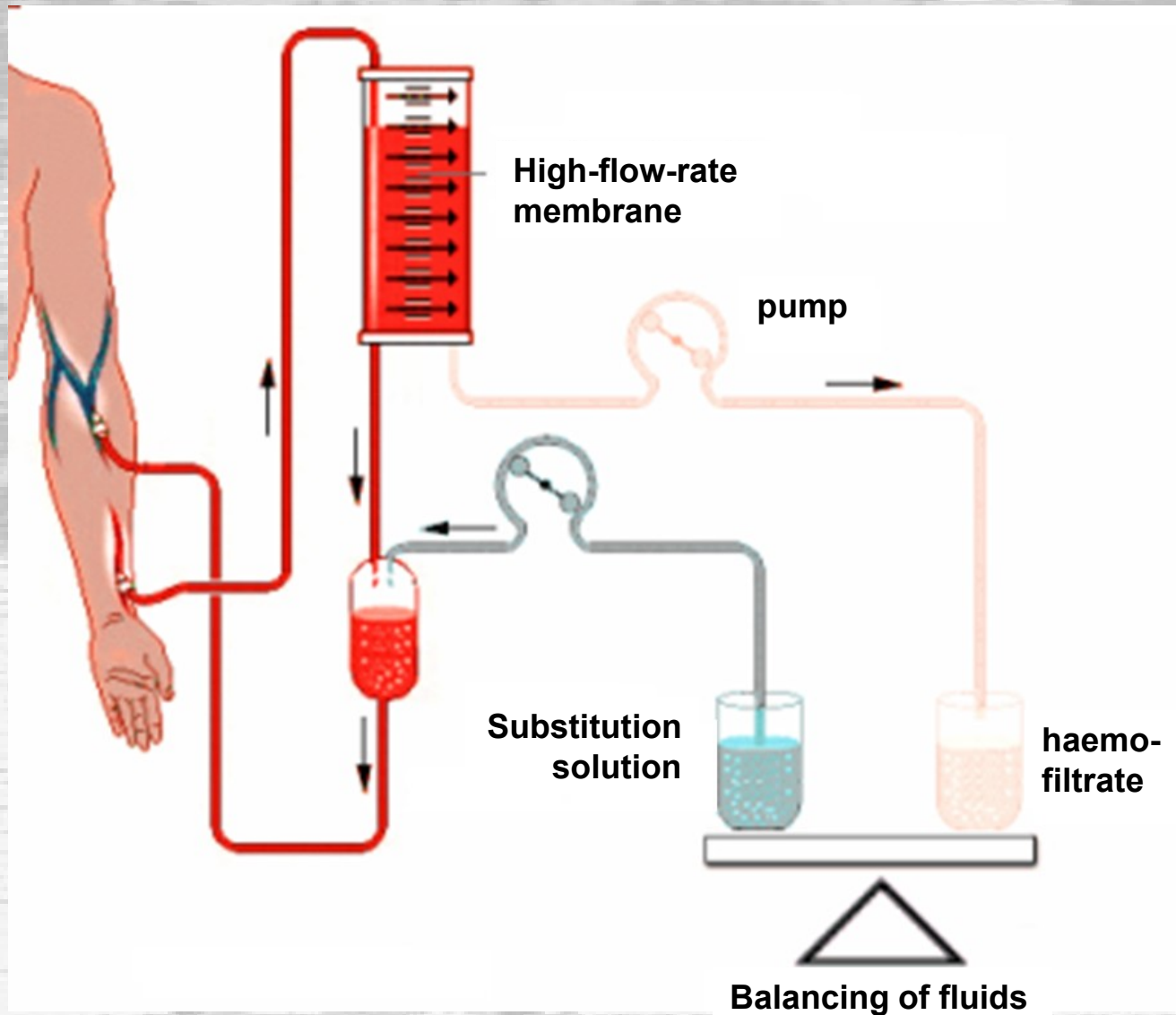


# Peritoneal dialysis



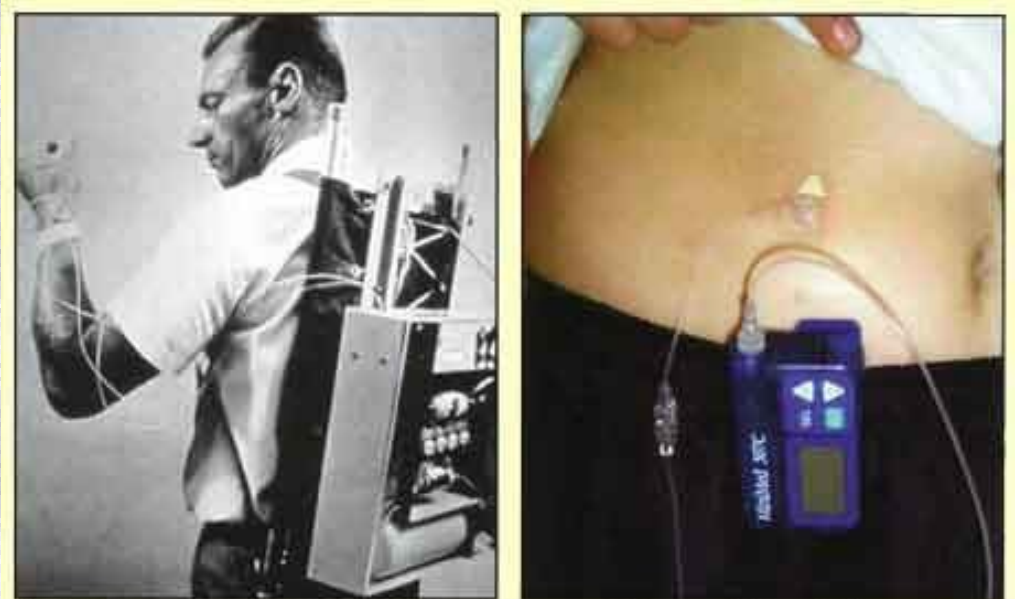
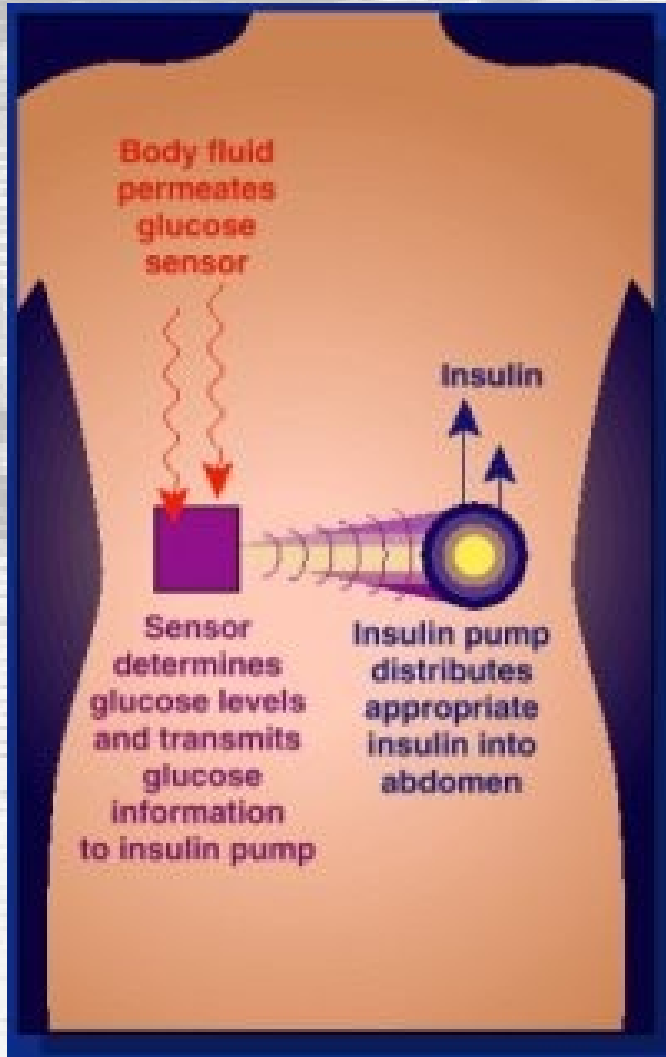
Peritoneal dialysis can be done by the patient at home. A catheter is permanently inserted into the peritoneal cavity serves for application as well as removal of dialysis solution. The procedure can be automated and performed during sleep.

# Haemofiltration



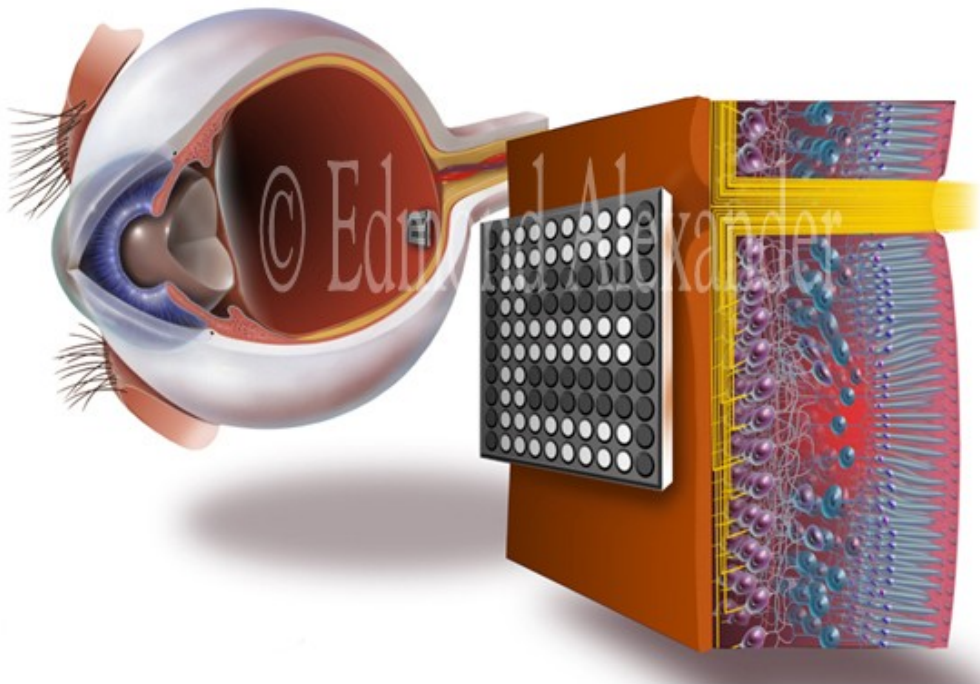
Haemofiltration is an alternative of dialysis. It is very useful in some poisonings. Haemofiltrate with toxic substances is replaced by substitution solution added to blood in necessary amount.

# Artificial pancreas – insulin pump

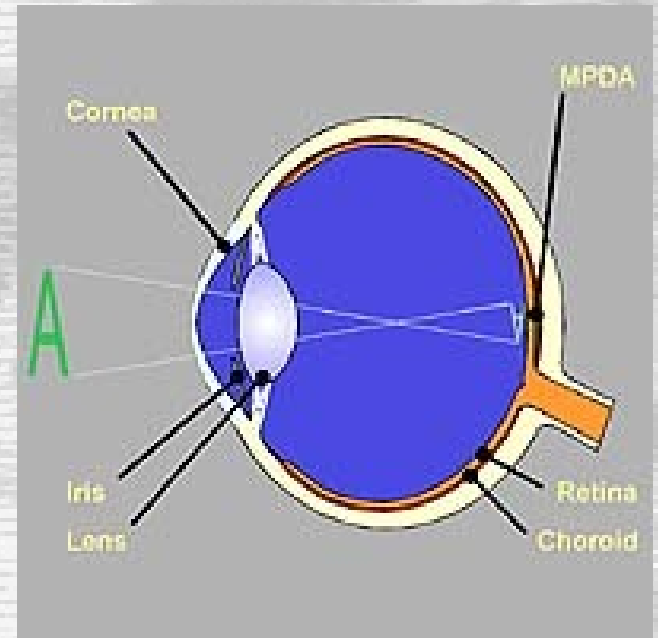


**LEFT:**The earliest protoType of an insulin pump which also delivered glucagon. Whitehall Laboratory, Indiana, 1963. **RIGHT:** 14-year-old Canberra pump-wearer, 2002. The device weighs 100g.

# Retinal implant



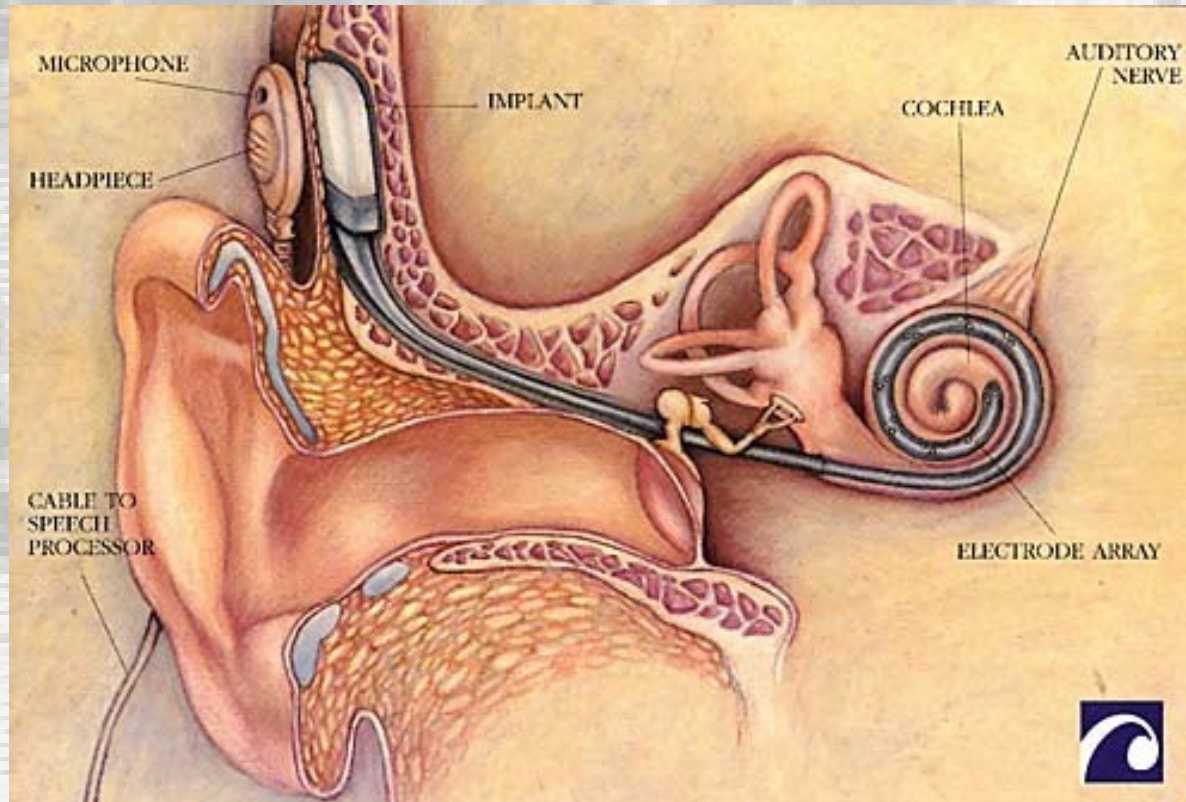
RETINAL IMPLANT  
*Bionic implant in retina simulates vision.*  
For *Popular Mechanics Journal*, © Edmond Alexander



*MPDA – micro-photo-diode-array*

This device comes in clinical testing. It should enable basic spatial orientation.

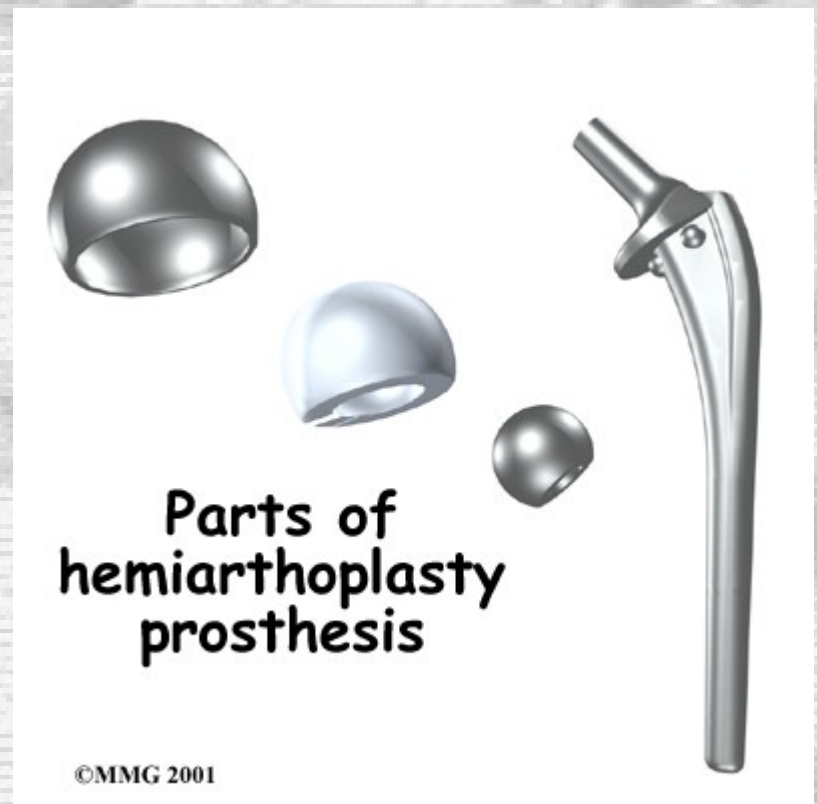
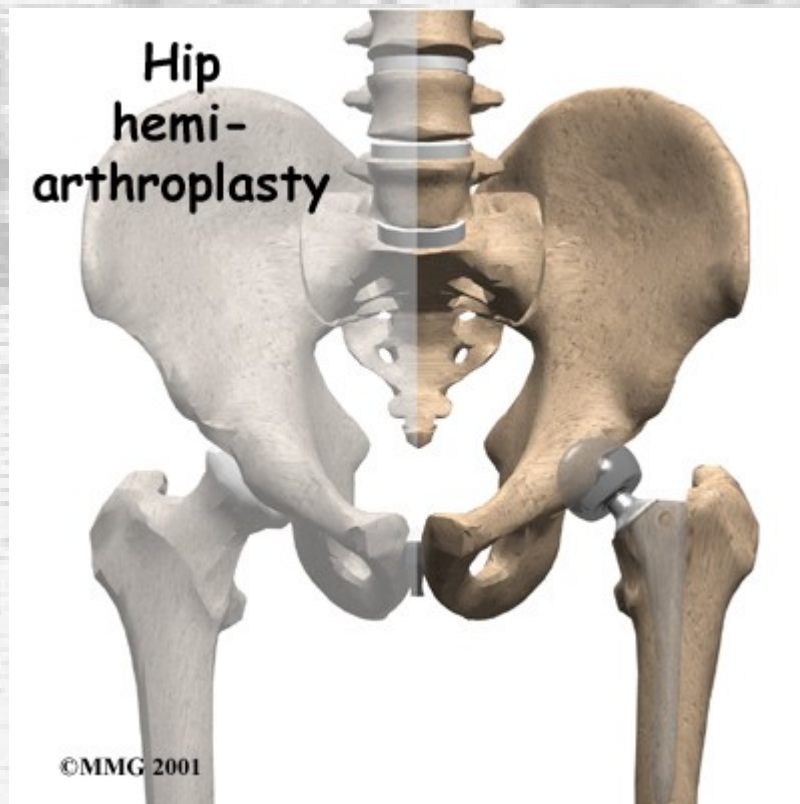
# Cochlear implant



The electronic cochlear implants can partly replace the Corti's organ, mainly in children which have intact auditory nerve. It is an electrode system implanted into cochlea, which can stimulate the nerve by impulses generated in the so-called speech-processor.

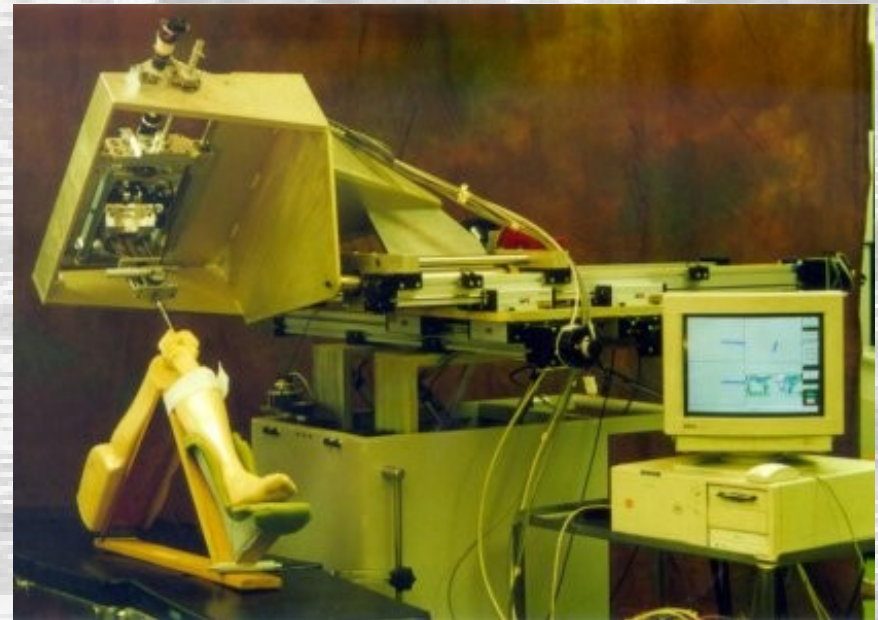
# Hip joint substitution

Hip or other joint substitutions were originally made of stainless steel, today are used combinations of plastics and ceramics or titanium and its alloys. Titanium surface is porous, which enables the bone to grow inside the implant surface - lowering need of bone cement.



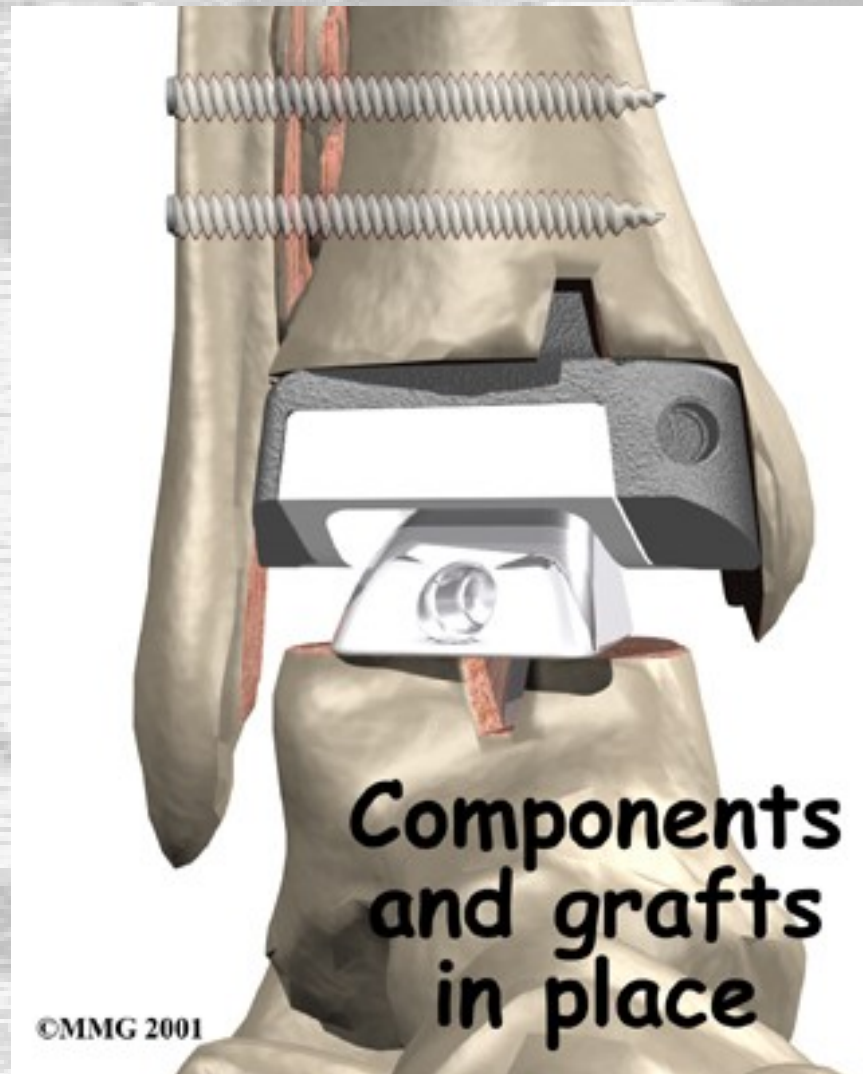


# Knee joint substitution

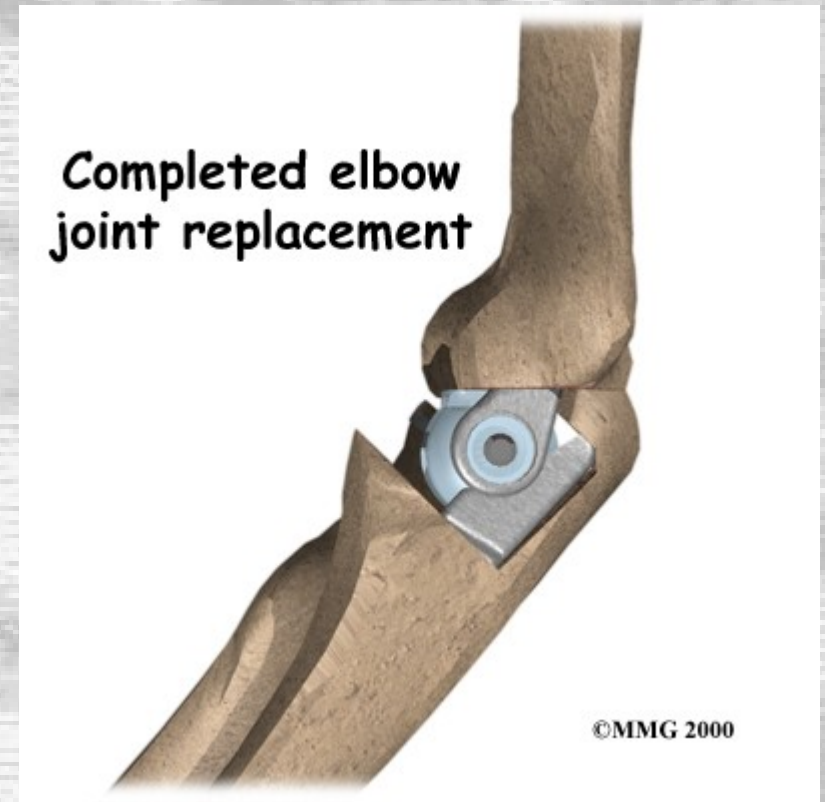
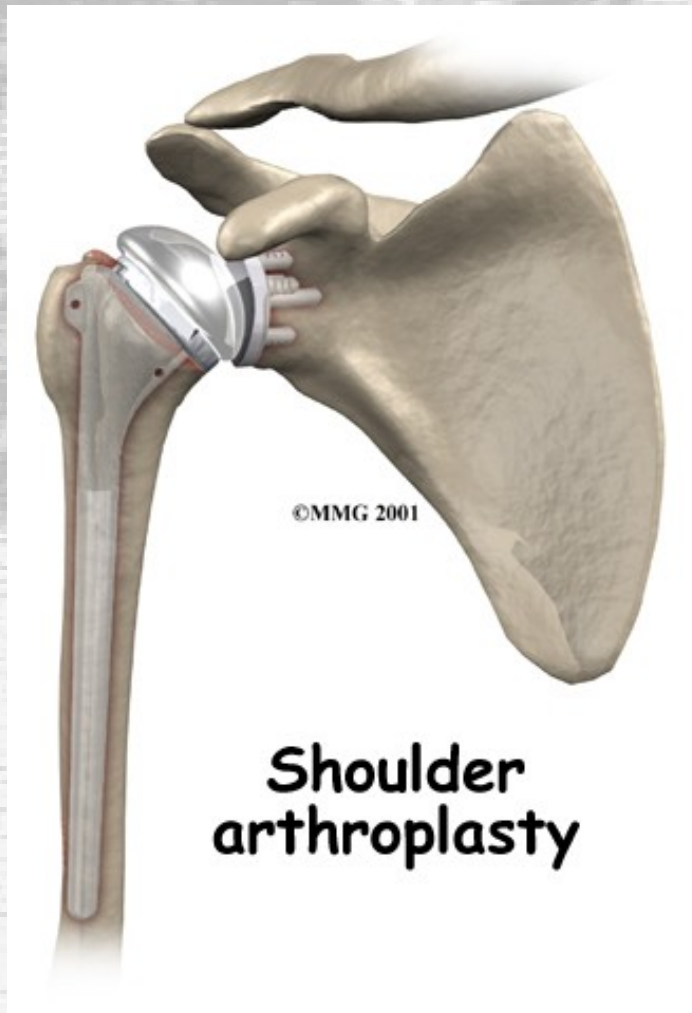


Robots in orthopaedic surgery. Namely the knee endoprosthesis must be positioned (oriented) with great angular precision.

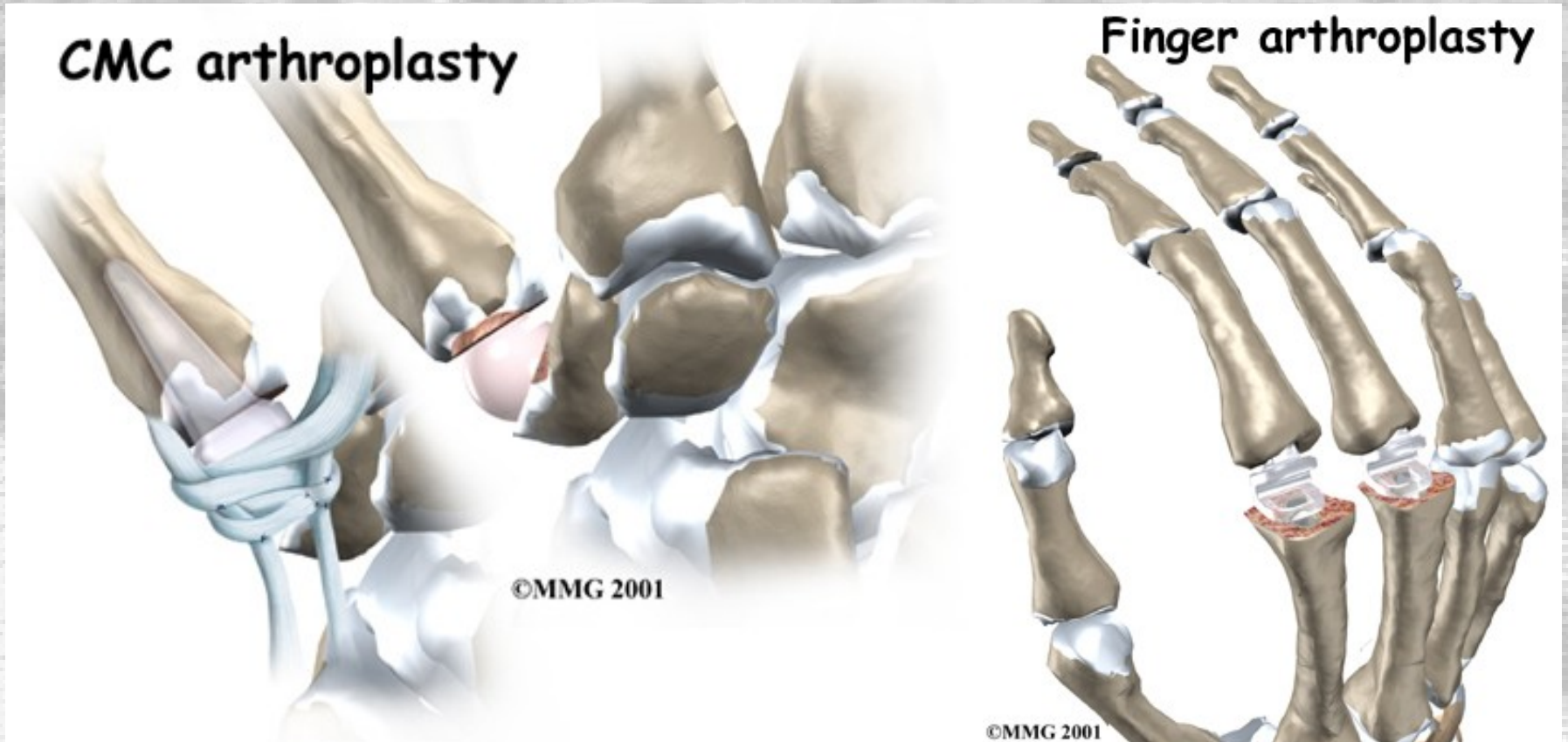
# Ankle joint



# Elbow and shoulder joint substitution

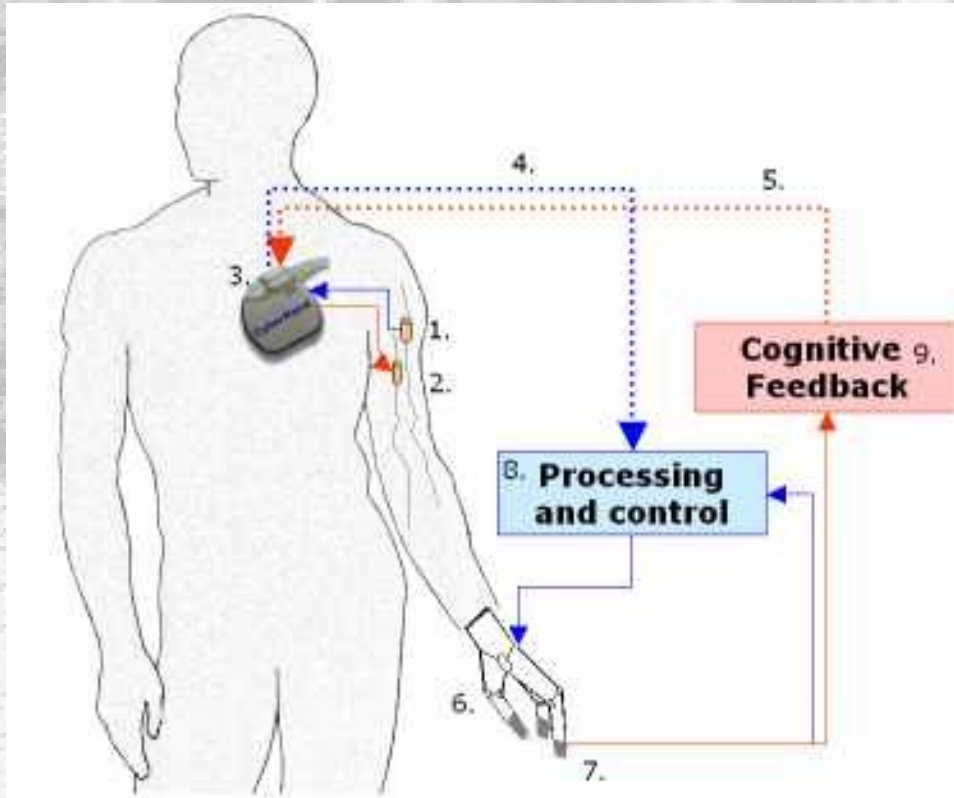


# Joints of thumb and fingers



CMC = carpometacarpal

# Bioprosthesis of hand – emerging reality



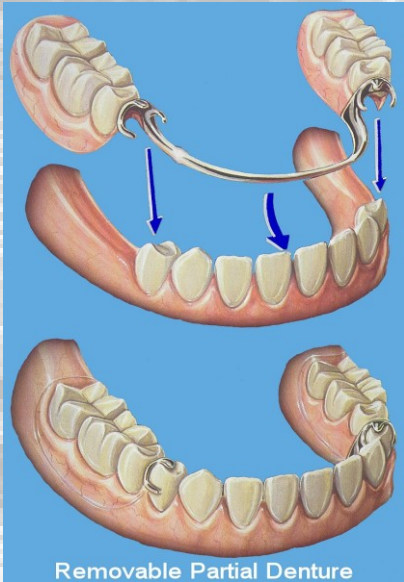
1. Electrode on efferent nerve;
2. Electrode on afferent nerve;
3. Implanted part for recording of nervous activity and nerve stimulation;
4. Efferent telemetric connection;
5. Afferent telemetric connection;
6. Bionic hand;
7. sensors;
8. Decoder of patient's intentions and control of prosthesis;
9. Unit mediating the signals of sensors to the brain.
10. Subsystems 8-9 will be outside body but easy to carry.

# Stand up and walk (SUAW)



Development of the implant for neuromuscular stimulation in patients suffering from paralysis of lower limbs. It should allow to stand up and walk - now in clinical testing

# Dental prostheses



Partial prosthesis

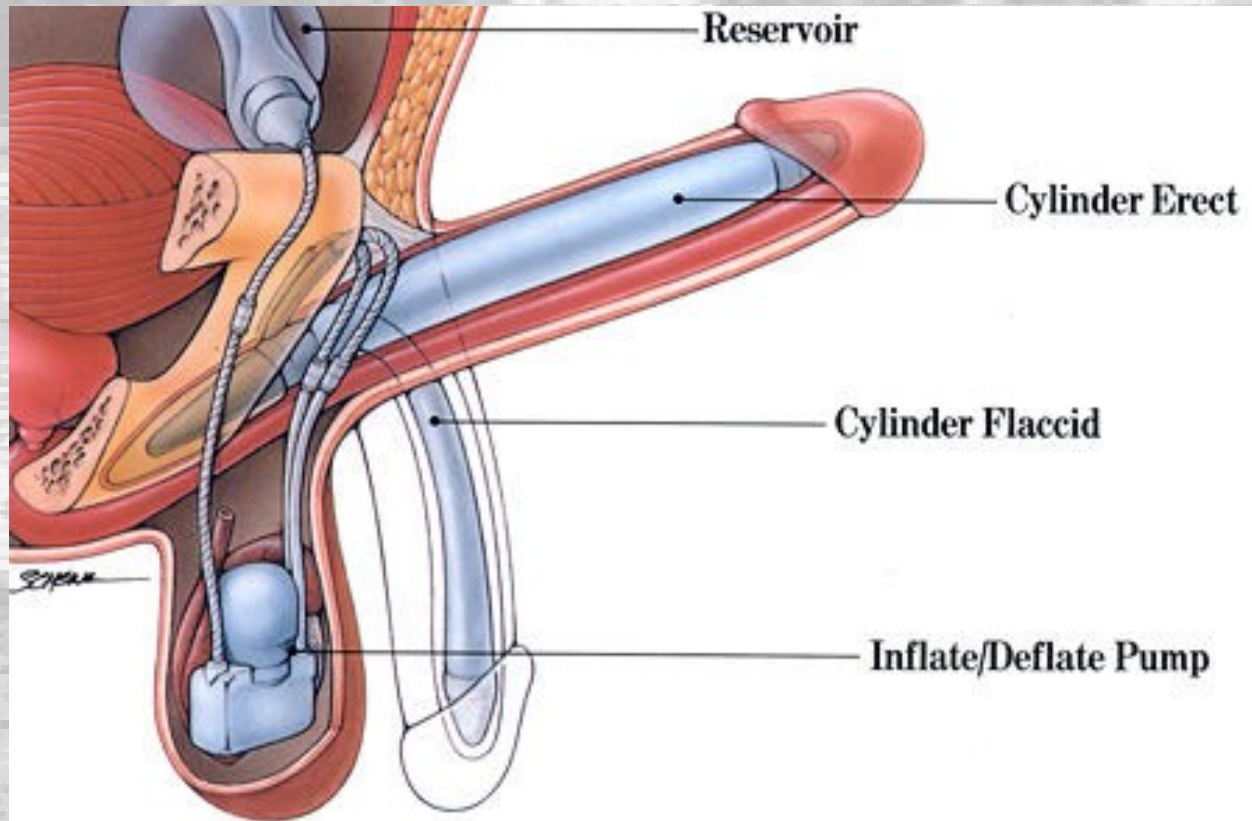


Removable upper prosthesis



Preparation of the bed for total fixed dentition substitution

# Penile endoprosthesis





Author: Vojtěch Mornstein

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