Medical and Biological Engineering

From Ideas to Successful Medical Products

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Hippokrates (about 400 B.C.)

The relations among the elements that comprise the universe (earth, fire, air, water), their qualities (dry, hot, moist, cold), and the humors present in the human (black bile, yellow bile, blood, phlegma) according to the ancient model.

Model of the human individual as it is embedded in the universe
Treatment of fracture of spinal column recommended by Hippocrates and applied until the middle of the 19th century.
Galen (129 – 199 A.C.)

Model of anatomical and physiological systems

1. The peripheral circulation is not closed.

2. The physiological systems are:
   * Brain and nerves for sensation and thoughts
   * Heart and arteries for live-giving energy
   * Liver and veins for nutrition and growth
William Harvey (1578 – 1657)
1616 / 1628

Harvey has postulated (or hypothesized) that there must be a connection between the arterial and the venous branches of the circulatory system.

The existence of capillaries had been proven experimentally by Marcellus Malpighi (1661)

The model of closed circulation
René Descartes (1596 – 1650)

For Descartes the human was functioning like a mechanical machine. This is demonstrated by the model for sensation conduction from the foot (heat, pain) to the brain via a tube filled with liquid.

This model was developed in 1632, but published only after Descartes' death in 1662.

The mechanical model of sensation conduction
Model for circulatory overall regulation (without ANS control)
Mobility aid – Walking stick (Egypt, 2nd century B. C.)
Mobility aids (painter: Brueghel the Older, 1559)
Tools for surgery (1st century A.C.)
Device for measuring the blood lost during phlebotomy (Al-Jazari, 1206, device reconstructed 1977)
Reading glasses (1466)
Dreibeiniges Instrument („Böcklein“) zur Entfernung von Bruchstücken der Schädelkapsel, die durch den Druck auf die Hirnoberfläche Krampfanfälle („Wüten des Hirns“) ausgelöst hatten.

Special tool for the removal of skull bone fragments and the lowering of elevated intracranial pressure (published 1517)
Special device for the treatment of skull fracture (used about 1600)
Im reich bebilderten Werk des Ulmer Wundarztes Johann Sculetus findet sich auch die Konstruktionszeichnung eines "Sägleins", das dazu diente, zwischen Bohrlöchern im Schädeldach den Knochen aufzusägen, so daß Öffnungen von beliebiger Form und Größe geschaffen werden konnten. Die Darstellung ist so sorgfältig erfolgt, daß ein interessierter Chirurg leicht einen Nachbau veranlassen konnte.
Removal of ascites (about 1672)
Operating theater and surgery (about 1495): Transplantation of a leg
Operating theater and surgery (about 1774): Amputation of a leg
Teeth are made from ivory with springs for coupling the two parts.

Tooth of hippopotamus as carrier and supplied with some human teeth.

Dentures of the former US president George Washington (1789)
Tabula X.

Fig. I.

Fig. II.

Fig. III.

Fig. IV.

Fig. V.

Fig. VI.

Fig. VII.

Fig. VIII.

Fig. IX.

Fig. X.

Jonas Arnoldi Delinavit.
Dentist’s chair (about 1850)
Pedal-driven drill for dentistry by JB Morrison (patented 1871)
Stereotaxic instrument for the introduction of electrodes into the brain (1902)
Orthopaedic stretching apparatus for the treatment of spondylitis

(published 1900)
Instruments for cauterization, developed by Ambroise Paré
(Father of modern surgery about 1550)
Tool for the thermal cutting of tissue or the stopping of bleeding (described 1876 and used until about 1950). The heat is generated by the burning of petrol.
Apparatus (pendulum) for the determination of the speed of nerve impulses by H. Helmholtz (1850)
Direct measurement of the arterial blood pressure by St. Hales (1726)
Das Sphygmomanometer von Riva-Rocci mit Quecksilbermanometer, Fahrradschlauch als Oberarmmanschette und Gummiballon zum Aufblasen.

Original device developed by S. Riva-Rocci for blood-pressure measurement in 1896
Design of a total leg prothesis by Ambroise Paré and manufactured by a French smith (1552)
Prothesis for lower-leg amputees (1901, left, and 1920, right: a mass product for first world war victims)
Arm prothesis, rendering possible gripping functions (about 1500)
Construction draft for a movable hand prothesis (Ambroise Paré, about 1550)
Basic metabolic research (Santorio Santorino, 1614). The test person was sitting for months on a balanced scale.
Hearing aids (No 3 was used by the German composer Ludwig van Beethoven, about 1800)
Sonometer (audiometer), i.e. measuring device for hearing defects, battery-powered and provided with a telephone loudspeaker (1910)
Induction Coil Stimulator by **Emil du Bois-Reymond** (1848). This regularly repeating stimulator may be the first electro-medical device, later on produced by Werner von Siemens (and used by him for tooth pain-suppression in his brother).
Induction generator for electrotherapy (1880)
Solenoid for magnetic stimulation: Schematic and experimental arrangement

(J-A. D‘Arsonval himself?, 1893, based on research work by N. Tesla)
Capillary electrometer invented by G. Lippmann (about 1875)

Acquisition and monitoring of the electrocardiogram with a capillary electrometer (filled with mercury) before W. Einthoven by A.D. Waller (1887)
Recording of the electrocardiogram with the string galvanometer developed by W. Einthoven (1903, Nobelprize 1924), used by H. Berger for the EEG (1920s)
Zinc-Zinc Sulphate non-polarizable electrodes (1905)
First „artificial“ pacemaker with spring-driven pulse generation and with 3 different pacing rates (30 min⁻¹, 60 min⁻¹, 120 min⁻¹) by A.S. Hyman (1932)
Historical X-ray image depicting the chest of W.T.O. Forssmann (Nobel Prize 1956). The first catheterization of the living human heart. The catheter is running through the antecubital vein of his left arm to the heart (1929)
Two „early“ programming devices for implanted cardiac pacemaker with the nicknames (a) „coffee grinder“ (manually operated, only stimulus intensity) and (b) „iron“ (stimulus intensity, stimulus rate)
Apparatus for the recovery of apparently dead persons (i.e. by „defibrillation),
Ch. Kite (1788)
First extracorporeal defibrillator applied (1947)
Portable Holter-recorder with 80 lbs (1947, with N.J. Holter himself?), using audiotapes and FM-modulated sub-carrier for analogue recording
Drum kidney 1943 (William Kolff, died Feb. 14, 2009)
Microscope with horizontal beam path and burning candle as „light source“ (1691)
Electron microscope by Ernst Ruska, Nobel Prize winner in physics 1986 (1931)
Rigid gastro-endoscope for introduction into the stomach (1890)
The first endoscope has been invented by Ph. Bozzini, a medical doctor, 1806 in Frankfurt
Schematics and details of early rigid and flexible gastro-endoscopes with ocular
First photographed image taken with a flexible endoscope (1957)
W.C. Roentgen‘s workplace (reconstruction) for the detection of X-rays (1893)
First X-ray image, taken by W.C. Roentgen (Nobel Prize 1901) from the left hand of his wife with an exposure time of 15 minutes (1895)
Memory wheel (diameter 40 cm, 50 revolutions per second) for video recording,
Philips (1957)
X-ray testing of jaw and teeth with free running cables (Siemens 1911)
Ultrasound B-mode image of a foetus in the 38th week (1973)
First echocardiograph (Siemens-Reiniger, 1953)
Ink-writing 4-channel recorder (Siemens, 1973)
G. Hounsfield (Nobel Prize 1979) with the first EMI-CT-prototype (water-bag around the head) and the first brain scan of Hounsfield himself? (1972)
First MR-image from the brain (1980)
Whole body Gamma scan: dark spots (e.g. in the ribs) show the metastases (1988)
Regional cerebral blood flow (rCBF) determined from 133-Xenon washout curves Acquired with a 254 channel multidetector scintillation camera, N.A. Lassen (1976)
Heart catheterization workplace with two-way image intensifier, Philips (1956)
Radiation therapy (about 1905)
HV-based X-ray generator (Siemens 1919)
Wheelchair for rich people (18th century)
Extracorporeal disintegration of kidney stones – schematics (1975)
The patient is positioned in a water-filled bathtub ("the most expensive bathtub ever built")
Shockwave generator for animal experiments (Dornier, 1977)
Patient transport vehicles pulled by horses (used until 1920s)
Manually adjustable operating table with flexible joints (about 1890)
First machine for anesthesia by vaporized ether (Draeger, 1903)
Two different types of iron lungs or cabinet respirators (1920 – 1970)
Ventilator driven manually with a crank working on a rotating plate

(H. Draeger, 1907)
Low pressure generator for the treatment of tuberculosis by pneumothorax
(invented by C. Forlanini in 1892 and employed until 1950)
Blood gas measurement (D.D. van Slyke, 1917). The shown device was built 1939. The measurement procedure (gas elimination and chemical binding) was employed until the 1960s.
Polarography with the dropping mercury electrode by J. Heyrovsky (Nobel Prize 1959): Principle and measurement schematics
Polarography with the dropping mercury electrode by J. Heyrovsky (Nobel Prize 1959): First polarograph
The first appliance for the measurement of the pH-value in blood (Radiometer, 1952)
Blood cell counting using the Thoma-plate and a microscope. Invented and introduced 1878 by R. Thoma and used until the 1960s. Required time about 10 minutes.
Electric photometer for in-vitro diagnostic testing (1973)
Manually operated centrifuge for two containers and samples, introduced 1890s and used until 1940s
Measurement of hemoglobin concentration, based on colour assessment

a. Sahli (1905)
b. Autenrieth (about 1925)
Measurement of the erythrocyte sedimentation rate, proposed by R. Fåhraeus (1918), device built by A. Westergren (about 1950)
Blood glucose measurement by colorimetry
First programmable automaton (Al-Jazari 1206): Four automatic musicians sitting in a boat that floated on a lake to entertain guests at royal drinking parties: Two drummers, a harpist and a flautist.
Elektro and his dog Sparko (Westinghouse, 1939)

„Humanoid“ remotely controlled roboter (Switzerland, 1945)
First right coronary angiogram acquired by injection of a contrast agent via a right aortic root catheter by Sones (1958)