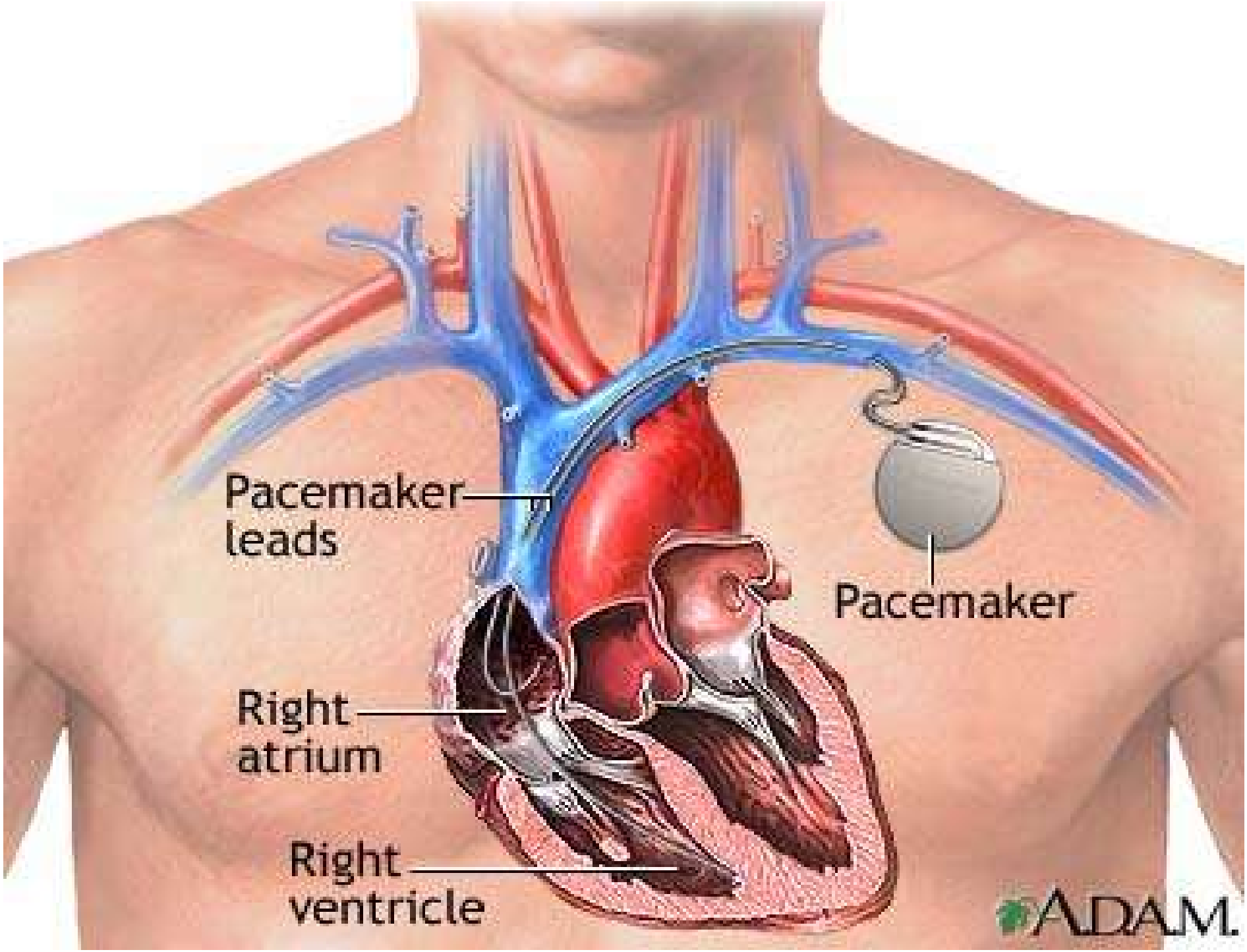
جامعة الانبار
كلية العلوم التطبيقية – هيت
قسم الفيزياء الحياتية

الاجهزة الطبية

Pacemaker

Mohammed Qasim Taha


Pacemaker leads
Pacemaker
Right atrium
Right ventricle
A.D.A.M.

Pacemaker

this small medical device, like a pocket watch in size, which is inserted under the skin to correct a heartbeat that's become too slow or fast due to aging, injury or other reasons. There are two types of pacemakers **Natural** and **Artificial**.

Natural pacemaker

To appreciate how a pacemaker works, it helps to understand the heart and the electrical system that makes it beat

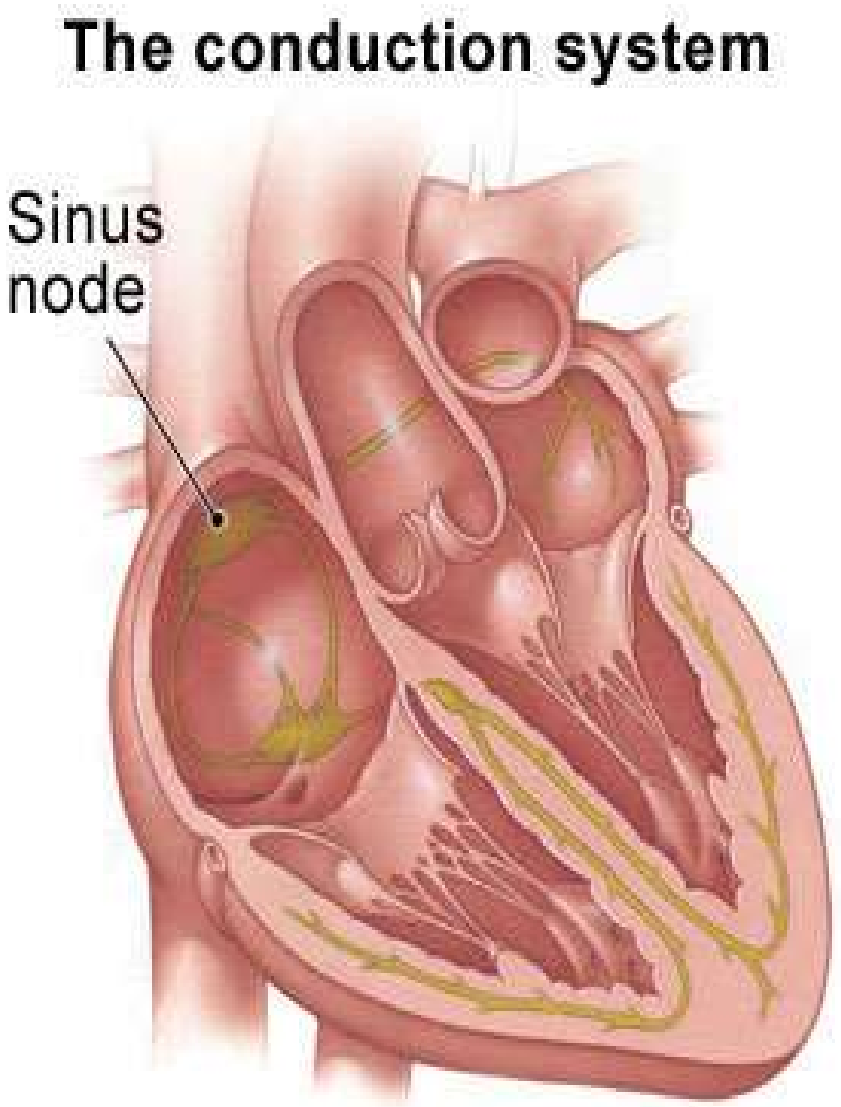
The heart is a muscular, fist-sized pump with four chambers, two on the left side and two on the right. The upper chambers are the right and left atria. The lower chambers are the right and left ventricles For the heart to function properly, the heart's chambers must operate in a coordinated fashion. In addition, heart must beat at an appropriate rate — normally from 50 to 100 beats a minute in adults

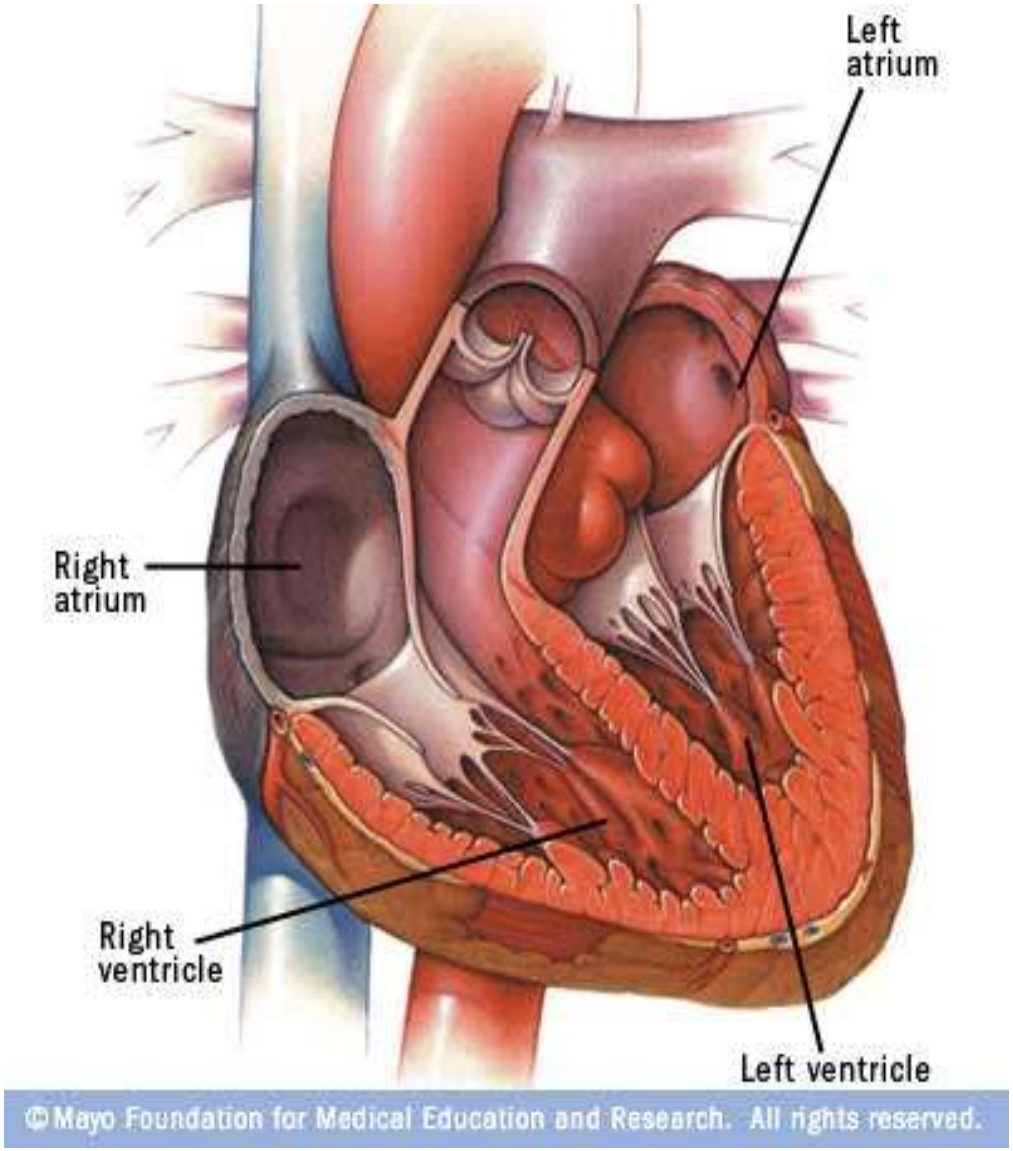
. If the heart beats too slowly or rapidly, not enough blood is pumped to the internal organs, leading to fatigue, fainting, shortness of breath, confusion and other symptoms.

Patient heart's electrical system controls the chambers' pumping action. A normal heartbeat begins in right atrium, in the sinus node. This cluster of cells —natural pacemaker — acts like a spark plug, generating regular electrical impulses that travel through specialized muscle fibers.

When an electrical impulse reaches the right and left atria, they contract and squeeze blood into the ventricles. After a split-second delay to allow the ventricles to fill, the impulse reaches the ventricles, making them contract and pump blood to the rest of the body.

Natural pacemaker





Artificial pacemaker

A pacemaker is an electronic device used to treat patients who have symptoms caused by abnormally slow heartbeats. A pacemaker is capable of keeping track of the patient's heartbeats. If the patient's heart is beating too slowly, the pacemaker will generate electrical signals similar to the heart's natural signals, causing the heart to beat faster. The purpose of the pacemaker is to maintain heartbeats so that adequate oxygen and nutrients are delivered through the blood to the organs of the body

Types of Artificial pacemaker

The artificial pacemaker has two type permanent (internal) and temporary (external)

1) **Temporary pacemakers:** are usually used first, especially if the abnormally slow heart rate is believed to be transient (lasting only days) and caused by conditions that are reversible or correctable. Temporary pacemakers are easily disconnected if the heart rate returns to normal

2) Permanent pacemakers: are necessary when the slow heart rate becomes chronic (lasting more than a few days) or is believed to be irreversible. In some patients who need permanent pacemakers for abnormally slow heart rates, fluctuations of the heart rate can occur. The pacemaker is capable of "listening" to the natural electrical signals from the heart. When the heart is beating normally, the pacemaker does nothing. When the heart stops beating or beats too slowly, the pacemaker takes over generating electrical signals for the heart at a frequency set by the doctor

Design of permanent pacemaker

A permanent pacemaker has two parts; the pacemaker chamber and the lead(s).

1) The pacemaker chamber contains a timing device for setting the pacing rate, a circuitry that detects electrical signals from the heart, and a battery

permanent pacemakers are implanted inside the body and therefore need their own batteries. Most of the modern permanent pacemaker chambers are small, weighing less than 30 grams. These small, lightweight devices are comfortable to wear inside the body and are barely visible. The small batteries inside the pacemaker chambers are also durable. Most implanted pacemakers have batteries that will last 7-10 years before needing to be replaced

2) The conducting wire(s) that carry electrical signals between the heart and the pacemaker is usually made of platinum. These wires are insulated with silicone or polyurethane. The insulted wires are called **leads.**

In the **permanent pacemakers** , in addition for chambers and leads there is a Programmer device which is placed outside of the body

Programmer

The Programmer is kept in a hospital or clinic. Which is a specialized computer to monitor and adjust the settings of a pacemaker .

During a follow-up visit, or during a hospital stay, a doctor may place the programming head over the pacemaker. This allows the programmer to :

Receive information from the pacemaker

.The information received from the pacemaker shows how pacemaker and the heart have been working. Based on this information, .

Send instructions to pacemaker

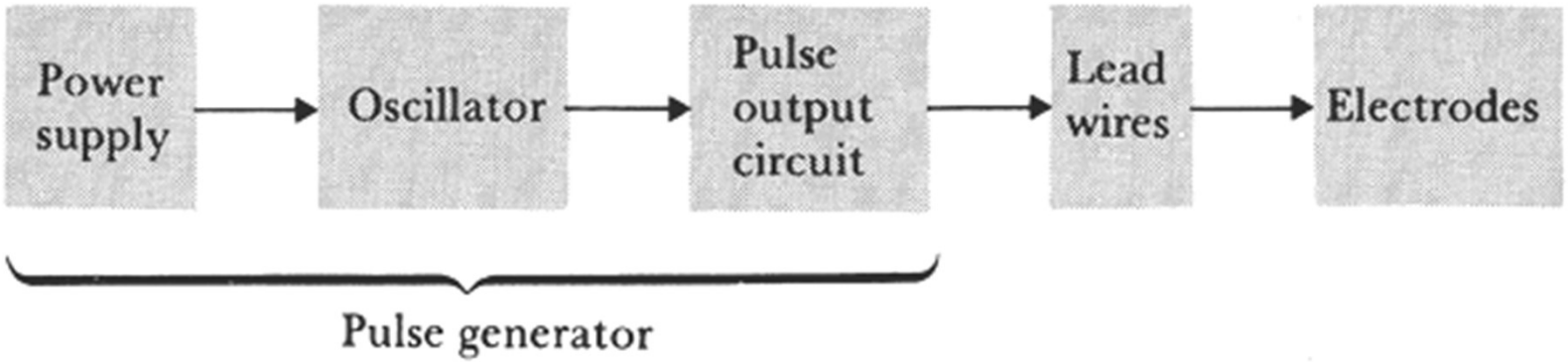
.When the therapy needs to change, the doctor can send the new instructions to the pacemaker - without any surgery.

Pacing modes of Artificial Pacemaker

There are general categories of pacemaker:

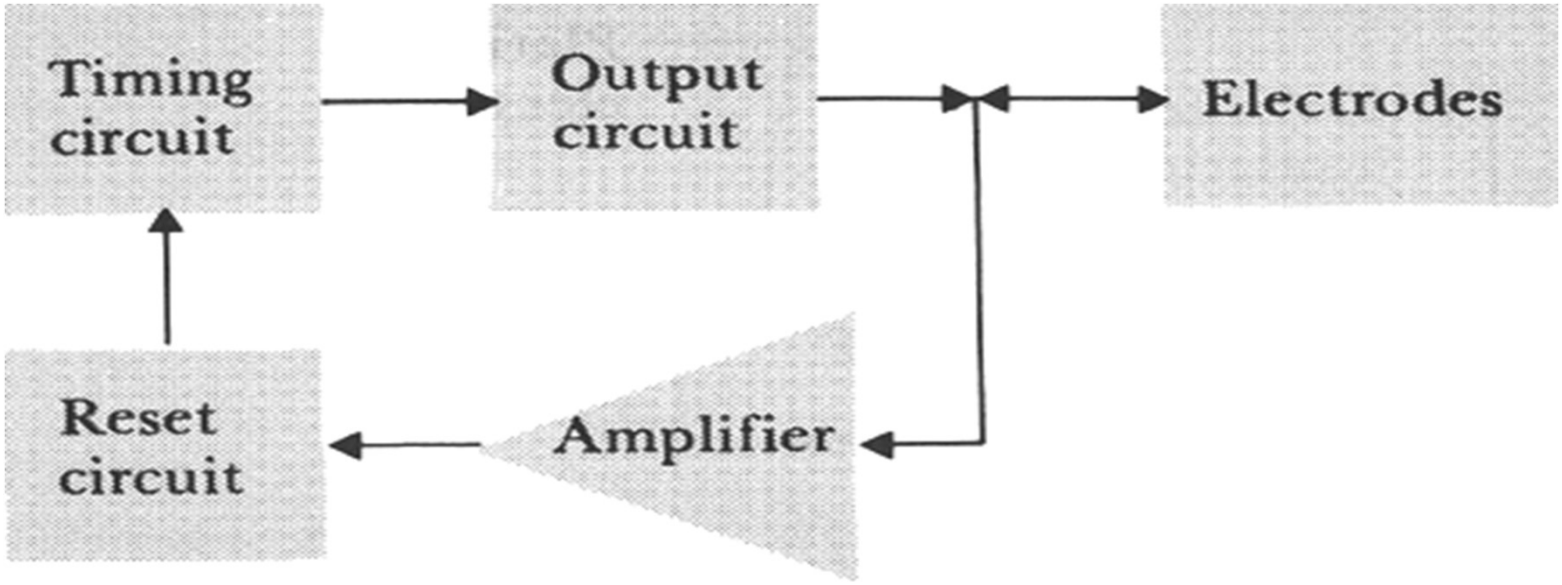
1) **Asynchronous pacemaker:** this was the first type of pacing used ,its produces pulses at a fixes rate. It was soon discovered that in some cases, atrioventricular conduction occurs spontaneously , casing dangerous competition between the pacemaker and the heart's own pacing system ,this could be dangerous since the pacemaker could issue a pulse to the ventricles during the vulnerable period and cause ventricle fibrillation .to prevent this problem ,a noncompetitive or demand mode of operation was developed.

Block diagram of an asynchronous cardiac pacemaker



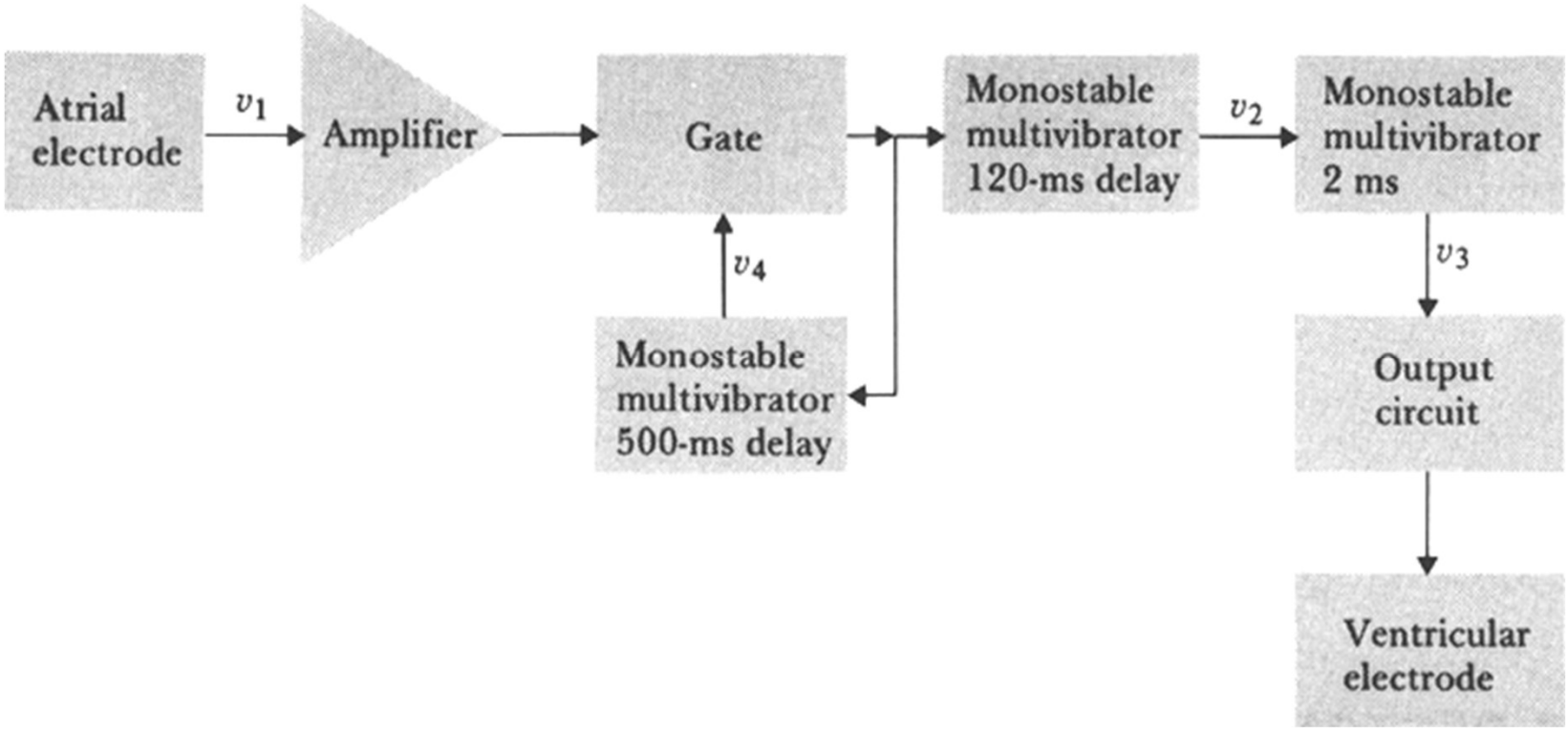
2) A Demand pacemaker : adjust its firing rate to the patient's heart rate . It contains circuitry that senses the ECG R-wave and measure the R-R interval. During the first quarter of this period ,the pacemaker is dormant ,in order to prevent response to the t wave feature of the ECG. But during the last three quarters of the R-R interval it is in a sense mode .if an R-wave is not sensed within this period , then the pacemaker emits a pulse.

A Block diagram of demand pacemaker



Electrodes serve as a means of both applying the stimulus pulse and detecting the electric signal from spontaneously occurring ventricular contractions that are used to inhibit the pacemaker's timing circuit.

Atrial -synchronous cardiac pacemaker



An atrial-synchronous cardiac pacemaker, which detects electric signals corresponding to the contraction of the atria and uses appropriate delays to activate a stimulus pulse to the ventricles.

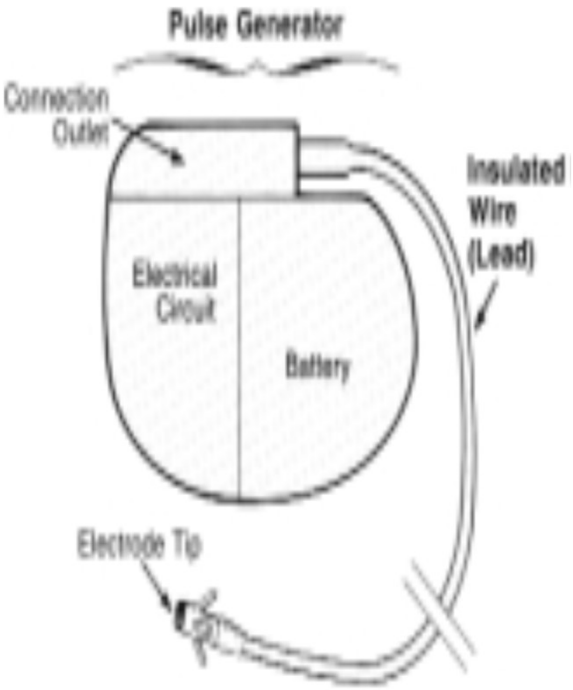
3) Atrial synchronous mode :here the depolarization of the atrium is sensed and, after an appropriate delay , the ventricle is stimulated. This mode has the advantage of retaining the use of the body's autonomic and sympathetic control of heart rate.

How Does a Pacemaker Work?

A pacemaker consists of a battery, a computerized generator, and wires with electrodes on one end.

The battery powers the generator, and a thin metal box surrounds both it and the generator. The wires connect the generator to the heart .

The pacemaker's generator sends the electrical pulses that correct or set heart rhythm. A computer chip figures out what types of electrical pulses to send to the heart and when those pulses are needed. To do this, the computer chip uses the information it receives from the wires connected to the heart. It also may use information from sensors in the wires that detect the movement, blood temperature, breathing, or other factors that indicate in level of physical activity. .



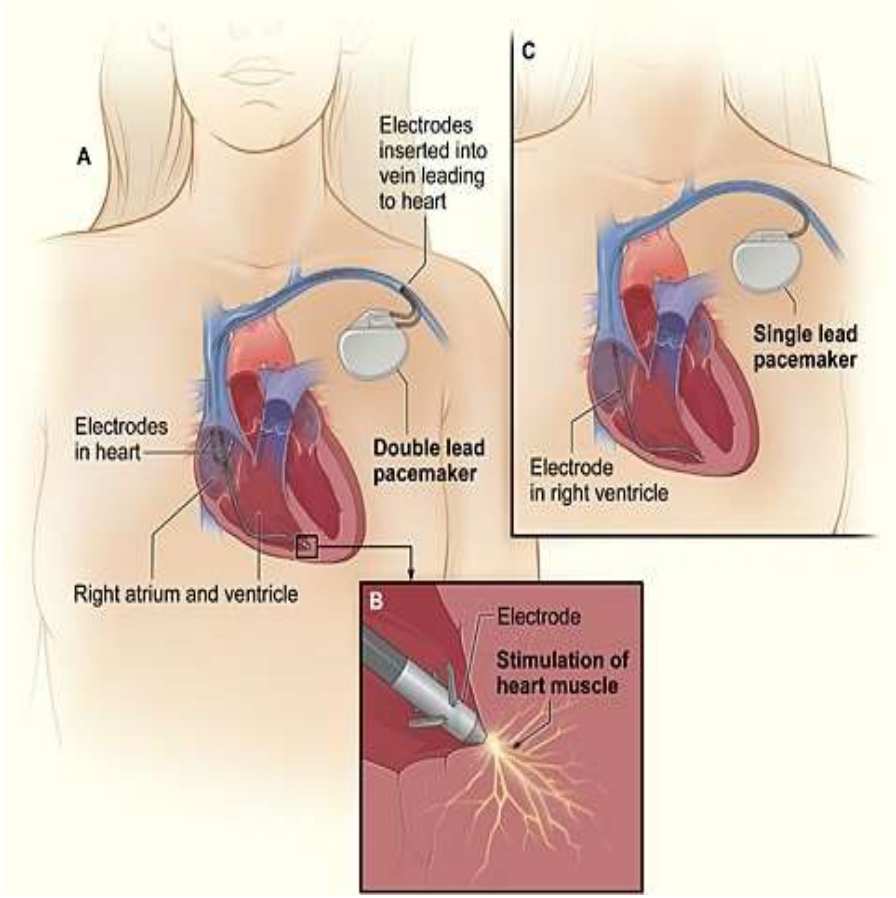
The wires in the pacemaker send electrical pulses to and from the heart and the generator. Pacemakers have one to three wires that are each placed in different chambers of the heart .

The wires in a single-chamber pacemaker usually carry pulses between the right ventricle (the lower right chamber of your heart) and the generator .

The wires in a dual-chamber pacemaker carry pulses between the right atrium and the right ventricle and the generator. The pulses help coordinate the timing of these two chambers' contractions .

The wires in a triple-chamber pacemaker are used for heart muscle weakness and carry pulses between an atrium and both ventricles and the generator. The pulses help coordinate the timing of the two ventricles with each other .

The illustration shows a cross-section of the chest with a pacemaker. Figure A shows the location and general size of a double chamber, or double lead, pacemaker in the upper chest. The wires with electrodes are inserted into the right atrium and ventricle of the heart through a vein in the upper chest. Figure B shows the electrode electrically stimulating the heart muscle. Figure C shows the location and general size of a single chamber, or single lead, pacemaker in the upper chest. The wire with the electrode is inserted into the right ventricle of the heart through a vein in the upper chest



Cross-Section of the Chest With a Pacemaker

Warning in pacemaker

These are Some medical procedures that can disrupt the pacemaker

@) Magnetic resonance imaging (MRI).

@) Diathermy

@) High source of radiation

@) External defibrillation

@) Lithotripsy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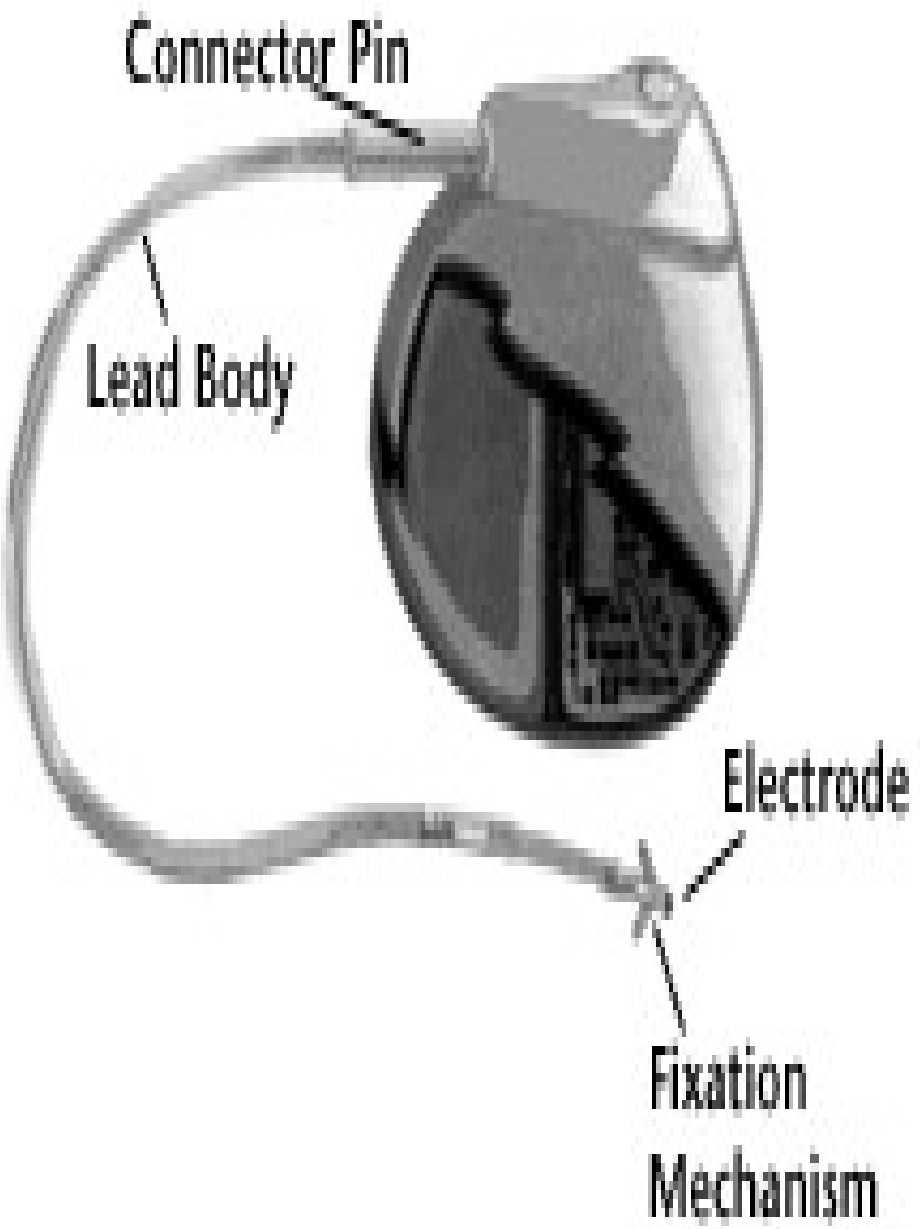
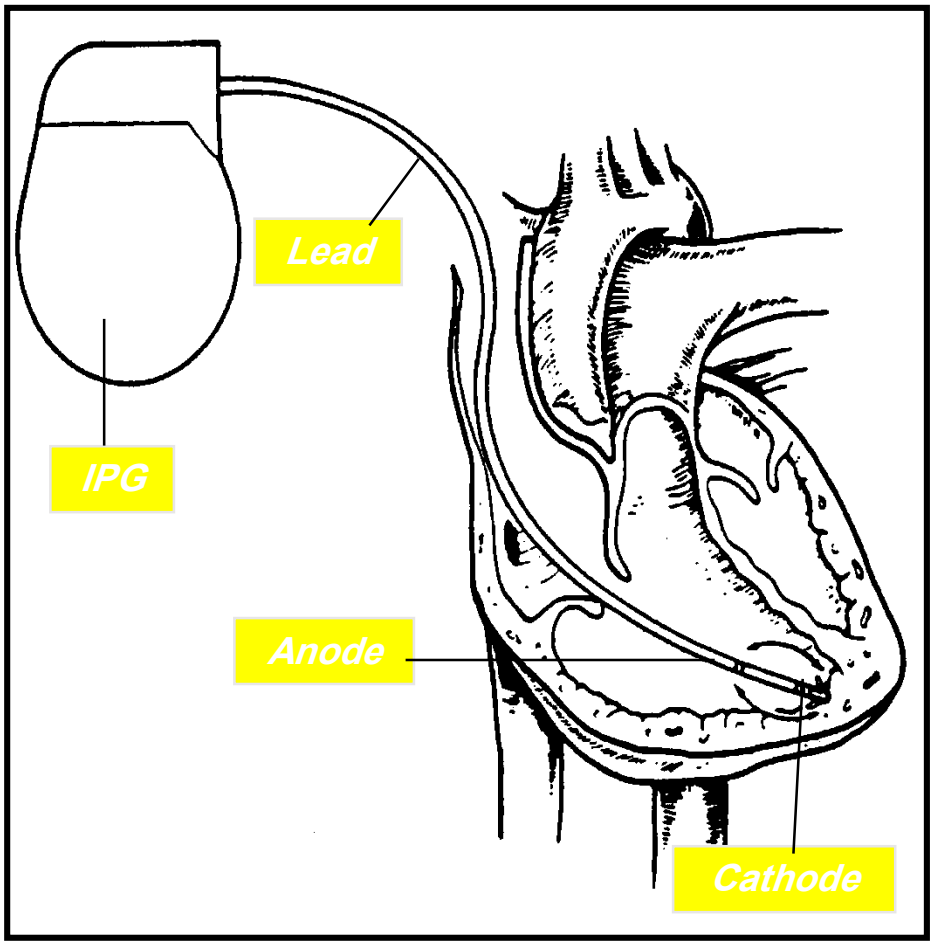

Connector Pin
Lead Body
Electrode
Fixation
Mechanism

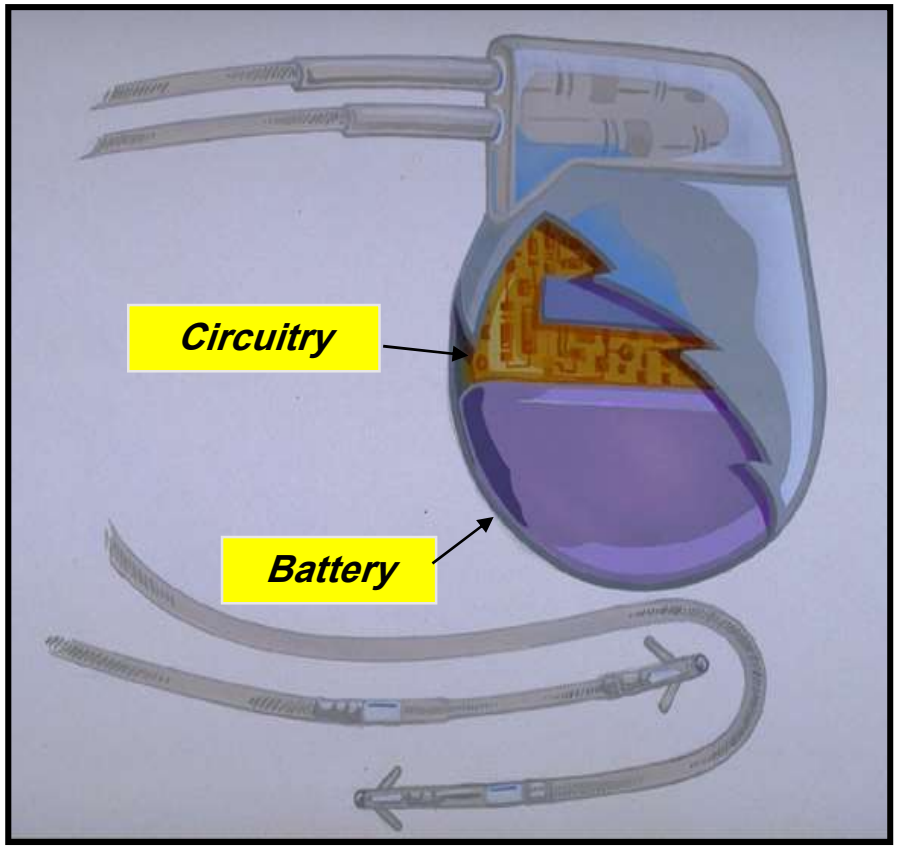
Implantable Pacemaker Systems Contain the Following Components:

- Pulse generator: power source or battery
- Leads or wires
- Cathode (negative electrode)
- Anode (positive electrode)
- Body tissue

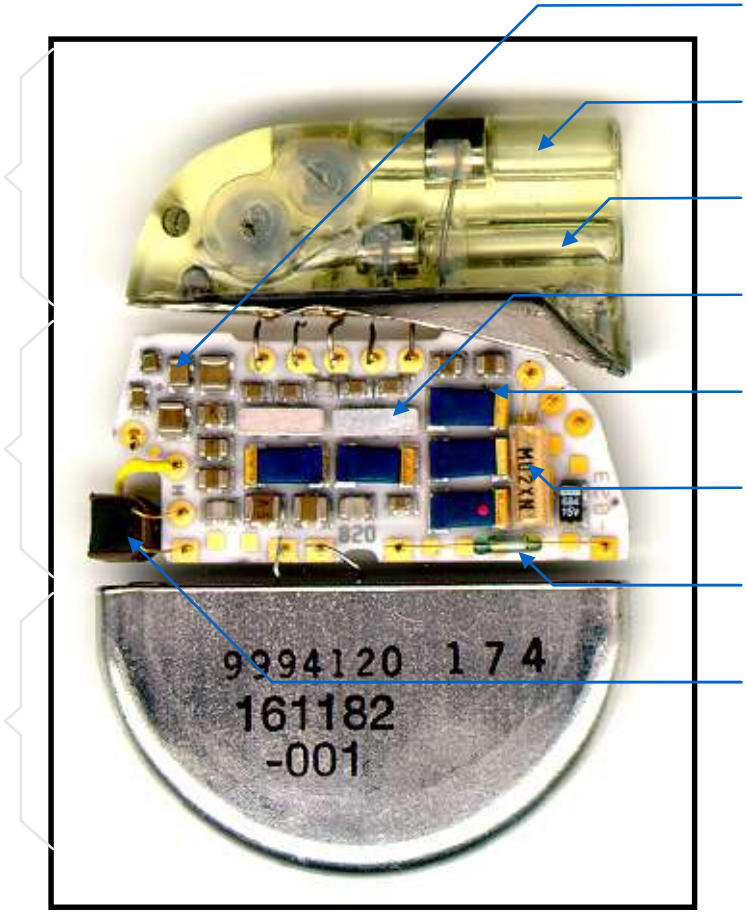


The Pulse Generator:

- Contains a battery that provides the energy for sending electrical impulses to the heart
- Houses the circuitry that controls pacemaker operations

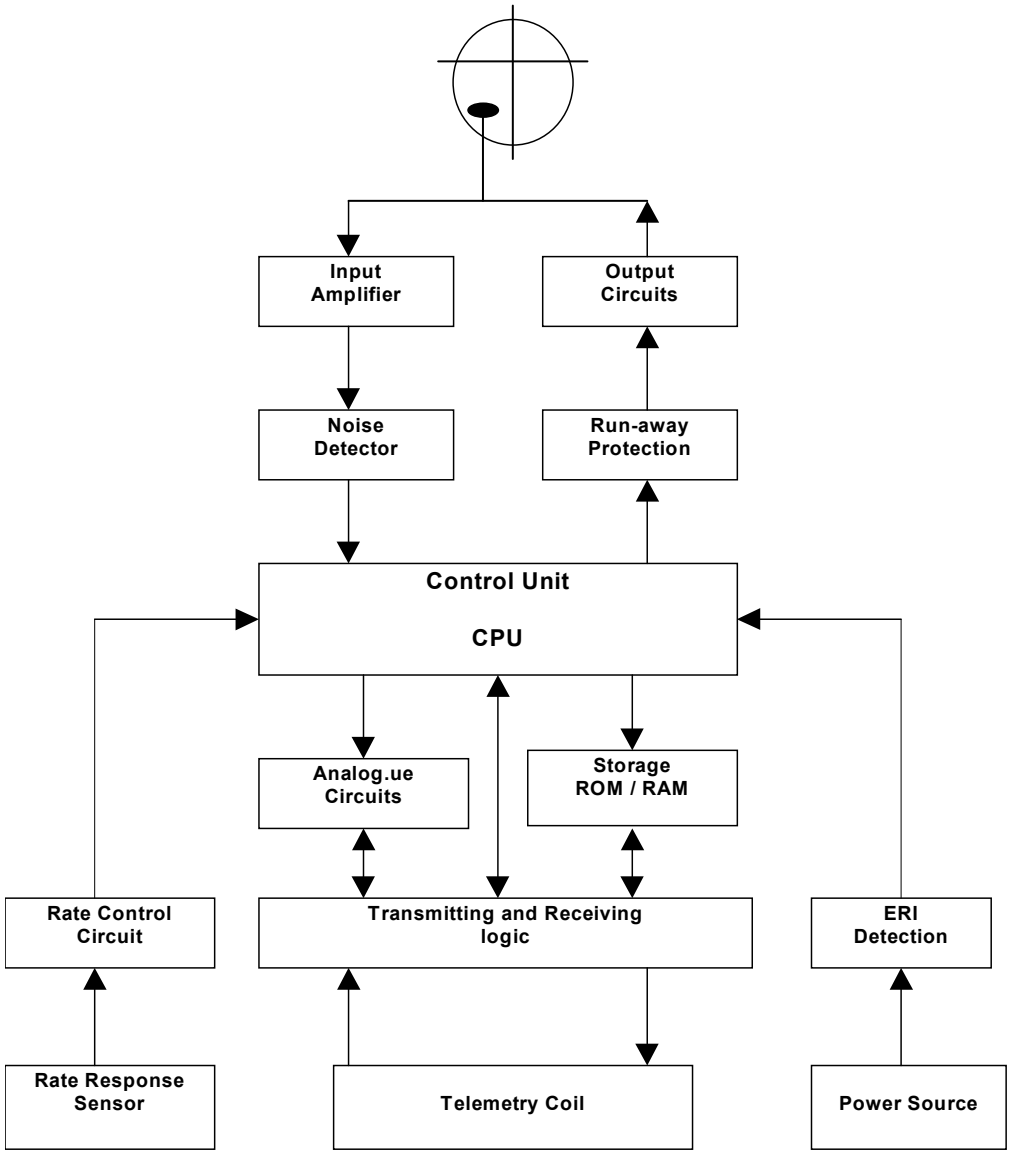


Anatomy of a Pacemaker



Stuart Allen 06

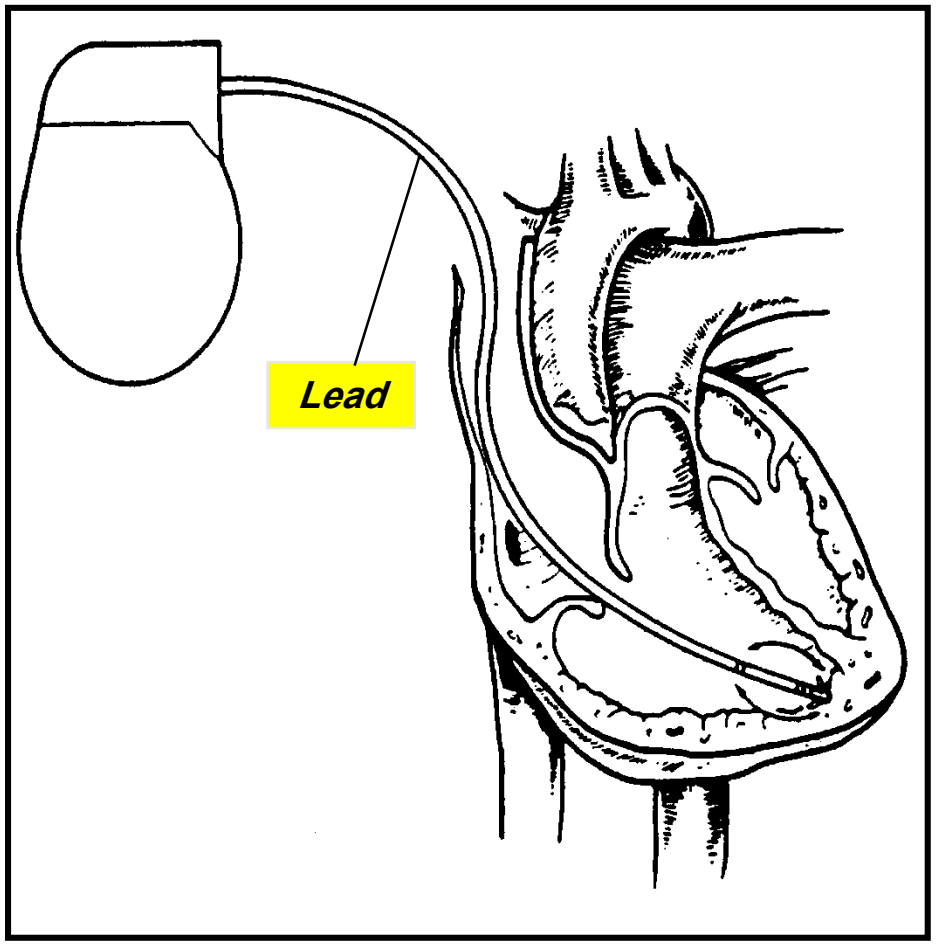
Components of an IPG



What is a Pacemaker?

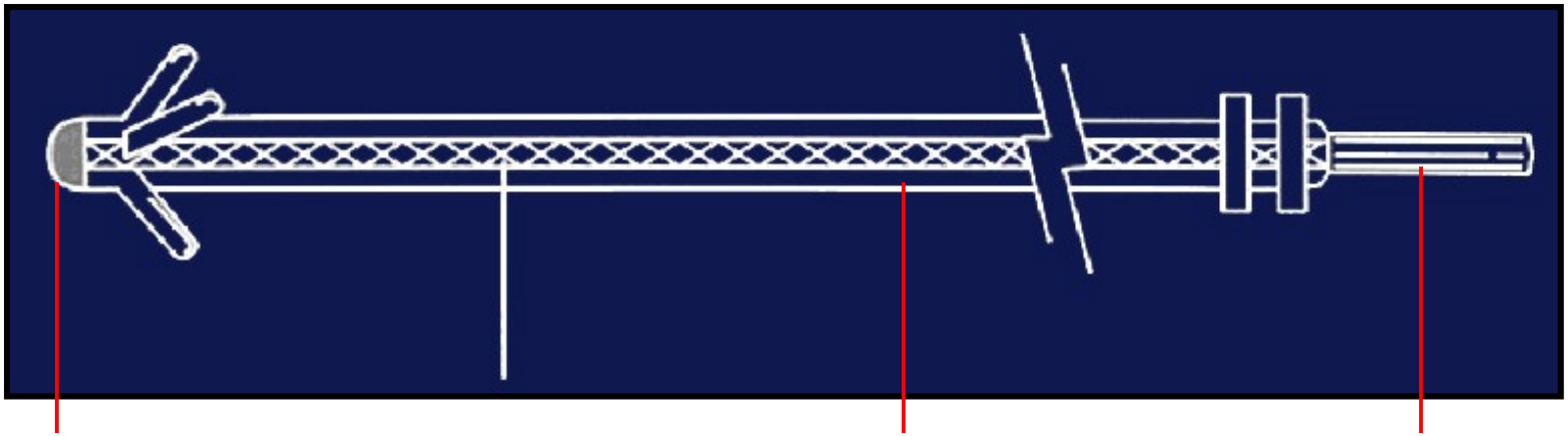
Leads Are Insulated Wires That:

- Deliver electrical impulses from the pulse generator to the heart
- Sense cardiac depolarisation



Pacing Lead Components

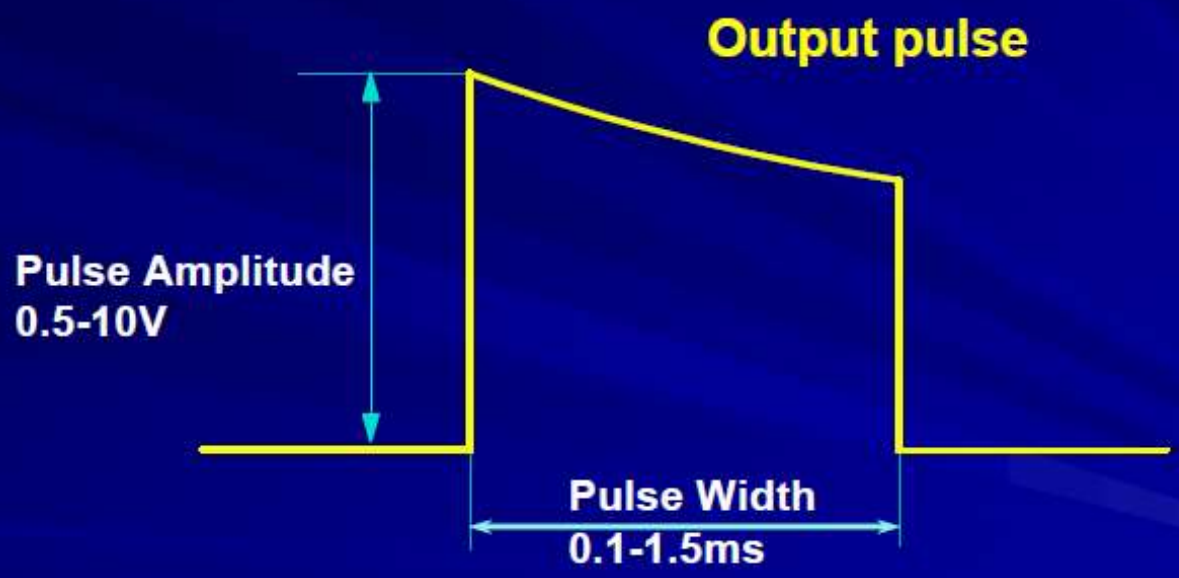
- Conductor
- Connector Pin
- Insulation
- Electrode



Most pacemakers perform 4 functions

1. Stimulate cardiac depolarisation
2. Sense intrinsic cardiac function
3. Respond to increased metabolic demand by providing rate-responsive pacing
4. Provide diagnostic information stored by the pacemaker

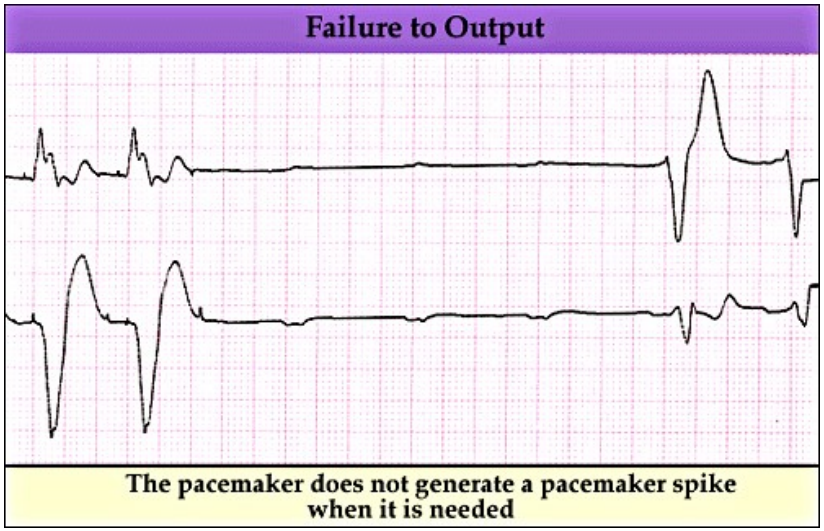
Stimulation threshold

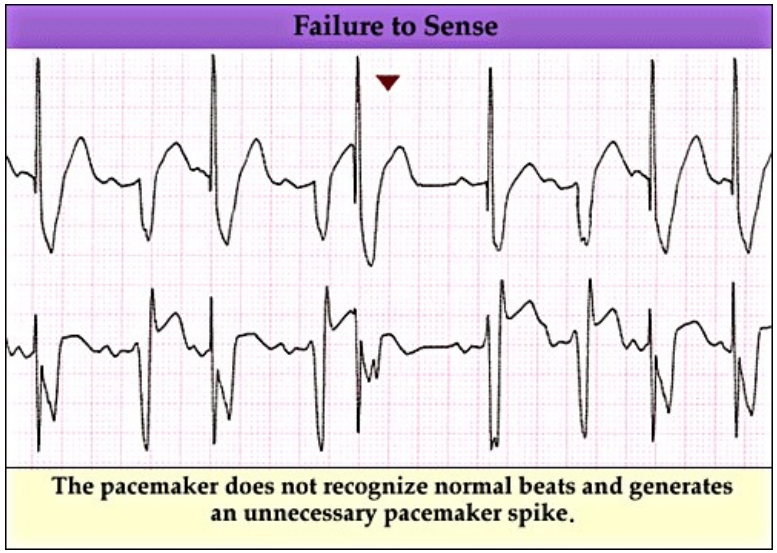


The energy is proportional to the pulse amplitude and the pulse width (=area under the curve)

Pacemaker Complications

- ECG abnormalities due to
  - Failure to output
  - Failure to capture
  - Sensing abnormalities
  - Operative failures





Pacemaker Failure to Output

- **Definition**
  - No pacing spike present despite indication to pace
- **Etiology**
  - Battery failure, lead fracture, break in lead insulation, oversensing, poor lead connection, Atrial output is sensed by ventricular lead

Pacemaker Failure to Capture

- **Definition**
  - Pacing spike is not followed by either an atrial or ventricular complex
- **Etiology**
  - Lead fracture or dislodgement, break in lead insulation, elevated pacing threshold, drugs, metabolic abnormalities, cardiac perforation, poor lead connection

Pacemaker Sensing Abnormalities

- **Oversensing**
  - Senses noncardiac electrical activity and is inhibited from correctly pacing
  - Etiology
    - Muscular activity (diaphragm or pecs), cell phone held within 10cm of pulse generator
- **Undersensing**
  - Incorrectly misses intrinsic depolarization and paces
  - Etiology
    - Poor lead positioning, lead dislodgement, magnet application, low battery states, MI

Pacemaker Operative Failures

- Due to pacemaker placement
  - Pneumothorax
  - Pericarditis
  - Perforated atrium or ventricle
  - Dislodgement of leads
  - Infection or erosion of pacemaker pocket
  - Infective endocarditis (rare)
  - Venous thrombosis