Goldman equation

- The Goldman–Hodgkin–Katz (GHK) voltage equation, more commonly known as the Goldman equation.
- is used in cell membrane physiology to determine the reversal potential across a cell's membrane.
- The discoverers of GHK are David E. Goldman of Columbia University, and the English Nobel laureates Alan Lloyd Hodgkin and Bernard Katz
    - Goldman's equation seeks to determine the voltage E_m across a membrane. A Cartesian coordinate system is used to describe the system, with the z direction being perpendicular to the membrane. Assuming that the system is symmetrical in the x and y directions, only the z direction need be considered; thus, the voltage E_m is the integral of the z component of the electric field across the membrane.
    - According to Goldman's model, only two factors influence the motion of ions across a permeable membrane:
    - the average electric field and
    - the difference in ionic concentration from one side of the membrane to the other.

The GHK voltage equation for M monovalent positive ionic species and A negative:

$$E_m = \frac{RT}{F} \ln \left(\frac{\sum_i^n P_{M_i^+} [M_i^+]_{\text{out}} + \sum_j^m P_{A_j^-} [A_j^-]_{\text{in}}}{\sum_i^n P_{M_i^+} [M_i^+]_{\text{in}} + \sum_j^m P_{A_j^-} [A_j^-]_{\text{out}}} \right)$$

This results in the following if we consider a membrane separating two $K_zNa_{1-z}Cl$-solutions:

$$E_{m,K_zNa_{1-z}Cl} = \frac{RT}{F} \ln \left(\frac{P_{Na}[Na^+]_{\text{out}} + P_K[K^+]_{\text{out}} + P_{Cl}[Cl^-]_{\text{in}}}{P_{Na}[Na^+]_{\text{in}} + P_K[K^+]_{\text{in}} + P_{Cl}[Cl^-]_{\text{out}}} \right)$$

It is "Nernst-like" but has a term for each permeant ion:

$$E_{m,Na} = \frac{RT}{F} \ln \left(\frac{P_{Na}[Na^+]_{\text{out}}}{P_{Na}[Na^+]_{\text{in}}} \right) = \frac{RT}{F} \ln \left(\frac{[Na^+]_{\text{out}}}{[Na^+]_{\text{in}}} \right)$$

- E_m = The membrane potential (in volts, equivalent to joules per coulomb)
- P_{ion} = the permeability for that ion (in meters per second)
- $[ion]_{\text{out}}$ = the extracellular concentration of that ion (in moles per cubic meter, to match the other SI units)
- $[ion]_{\text{in}}$ = the intracellular concentration of that ion (in moles per cubic meter)
- R = The ideal gas constant (joules per kelvin per mole)
- T = The temperature in kelvins
- F = Faraday's constant (coulombs per mole)

Automaticity

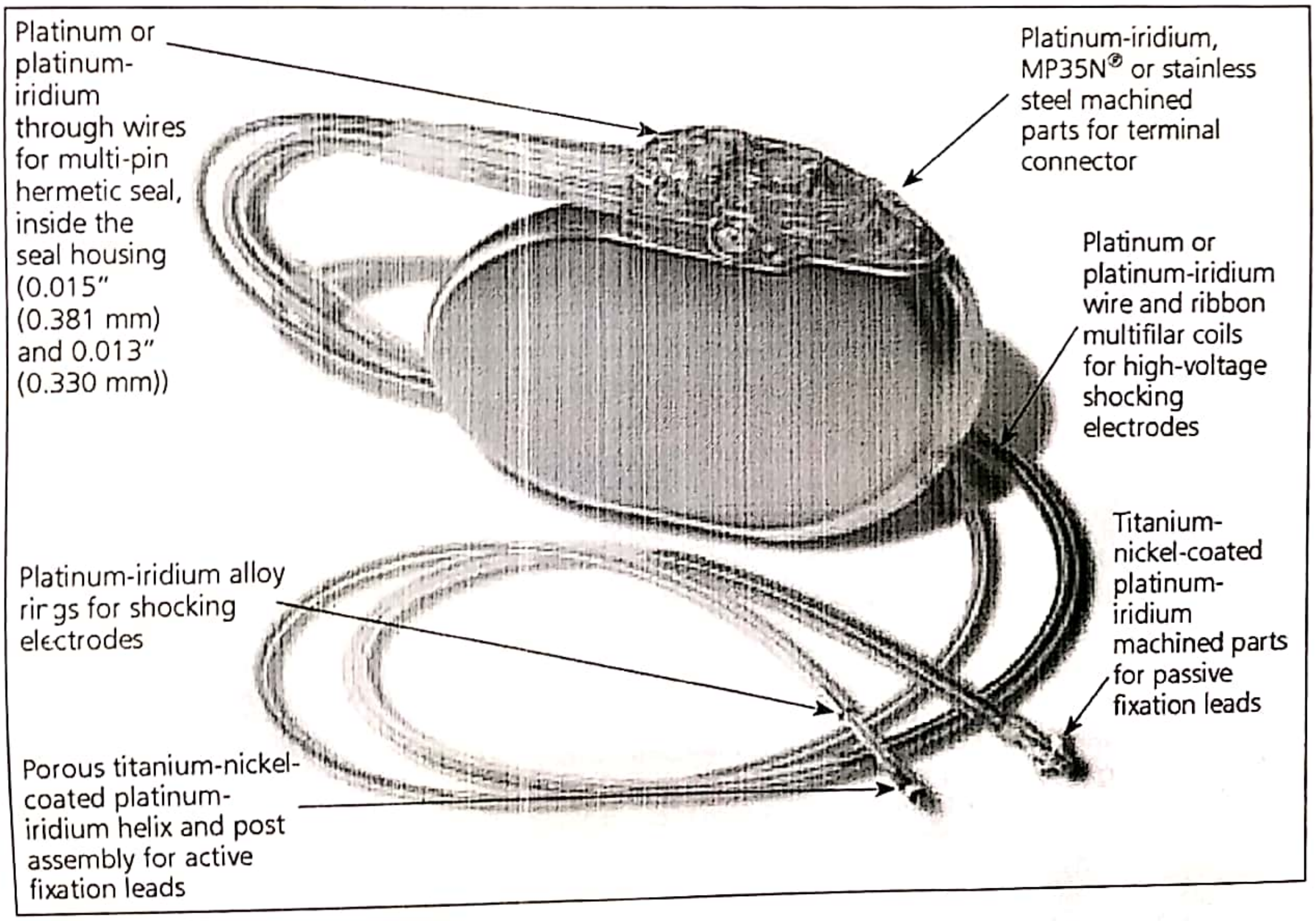
- Automaticity is the ability to do things without occupying the mind with the low-level details required.
- Allowing it to become an automatic response pattern or habit.
- It is usually the result of learning, repetition, and practice.
- Examples of automaticity are common activities such as walking, speaking, bicycle-riding, assembly-line work, and driving a car.
- Characteristics:
    1. Awareness: A person may be unaware of the mental process that is occurring.

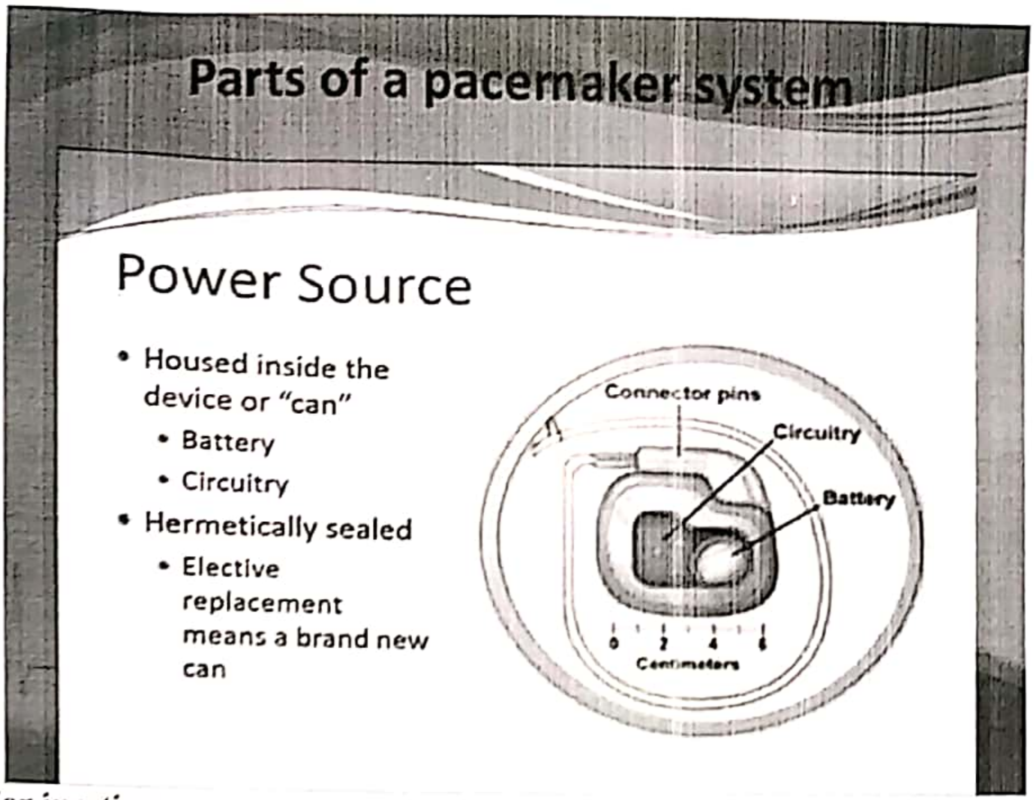
2. **Intentionality: A person may not be involved with the initiation of a m... process.**
3. **Efficiency: Automatic mental processes tend to have a low <u>cognitive load,</u> requiring relatively low mental resources.**
4. **Controllability: A person may not have the ability to stop or alter a process after initiation.**
5. **Bargh states that these are simply common characteristics; not all are needed for a process to be considered automatic.**

<u>Pacemakers</u>

- **A pacemaker is a small device that's placed in the chest or abdomen to help control <u>abnormal heart rhythms</u>.**
- **This device uses electrical pulses to prompt the heart to beat at a normal rate.**
- **Pacemakers are used to treat <u>arrhythmias</u>.**
- **Arrhythmias are problems with the rate or rhythm of the heartbeat.**
- **During an arrhythmia, the heart can beat too fast, too slow, or with an irregular rhythm.**
- **A heartbeat that's too fast is called tachycardia.**
- **A heartbeat that's too slow is called bradycardia.**
- **During an arrhythmia, the heart may not be able to pump enough blood to the body.**
- **This can cause symptoms such as fatigue (tiredness), shortness of breath, or fainting.**
- **Severe arrhythmias can damage the body's vital organs and may even cause loss of consciousness or death.**
- **A pacemaker can relieve some arrhythmia symptoms, such as fatigue and fainting.**
- **A pacemaker also can help a person who has abnormal heart rhythms resume a more active lifestyle.**

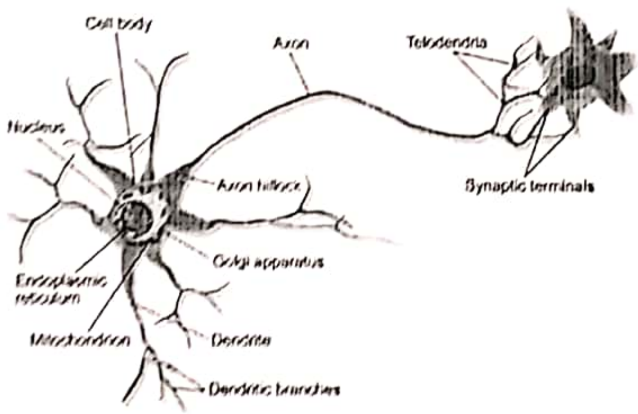
<u>Components of Pacemakers</u>



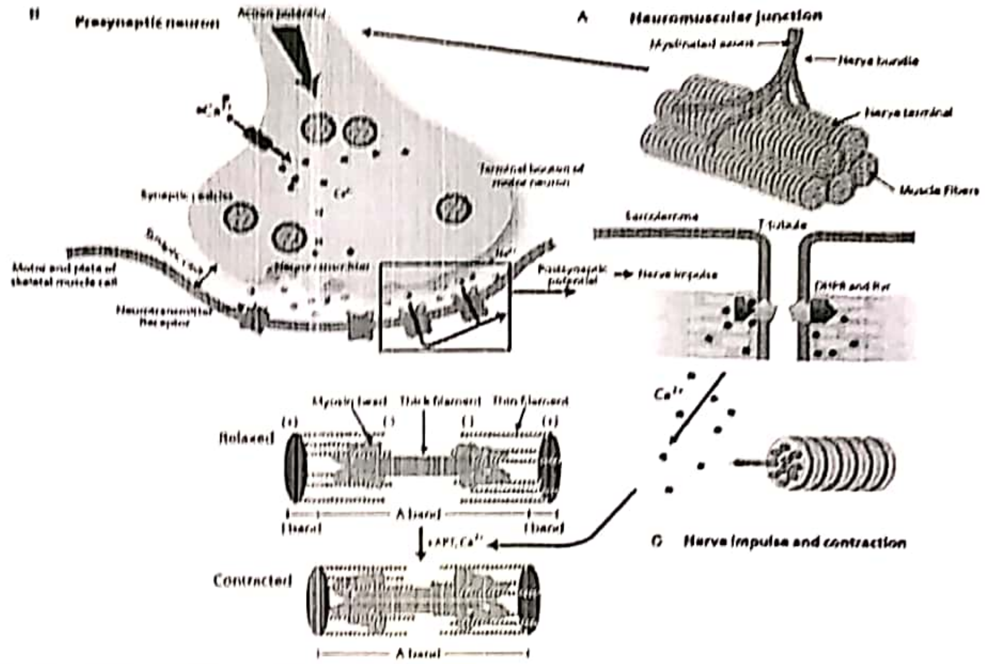


Neuromuscular junction

- A neuromuscular junction (or myoneural junction) is a <u>chemical synapse</u> formed by the contact between a <u>motor neuron</u> and a <u>muscle fiber</u>.
- It is at the neuromuscular junction that a motor neuron is able to transmit a signal to the muscle fiber, causing <u>muscle contraction</u>.



- Synaptic transmission at the neuromuscular junction begins when an <u>action potential</u> reaches the presynaptic terminal of a motor neuron, which activates <u>voltage-dependent calcium channels</u> to allow calcium ions to enter the neuron.
- Calcium ions bind to sensor proteins (<u>synaptotagmin</u>) on synaptic vesicles, triggering vesicle fusion with the cell membrane and subsequent <u>neurotransmitter</u> release from the motor neuron into the <u>synaptic cleft</u>.
- In <u>vertebrates</u>, motor neurons release <u>acetylcholine</u> (ACh), a small molecule neurotransmitter, which diffuses across the synaptic cleft and binds to <u>nicotinic acetylcholine receptors</u> (nAChRs) on the cell membrane of the muscle fiber, also known as the <u>sarcolemma</u>.
- nAChRs are <u>ionotropic</u> receptors, meaning they serve as <u>ligand</u>-gated <u>ion channels</u>. The binding of ACh to the receptor can depolarize the muscle fiber, causing a cascade that eventually results in muscle contraction.



Mechanism of action of Neuromuscular junction

- The neuromuscular junction is where a neuron activates a muscle to contract.
- Upon the arrival of an action potential at the presynaptic neuron terminal, voltage-dependent calcium channels open and Ca^{2+} ions flow from the extracellular fluid into the presynaptic neuron's cytosol.
- This influx of Ca^{2+} causes neurotransmitter-containing vesicles to dock and fuse to the presynaptic neuron's cell membrane through SNARE proteins.
- Fusion of the vesicular membrane with the presynaptic cell membrane results in the emptying of the vesicle's contents (acetylcholine) into the synaptic cleft, a process known as exocytosis.
- Acetylcholine diffuses into the synaptic cleft and can bind to the nicotinic acetylcholine receptors on the motor endplate.