國立暨南國際大學
National Chi Nan University

BioMedical Electronics Laboratory
生醫電子實驗室

生醫感測實驗室

中區103年度資源整合分享計畫推動方案

協助高中優質化方案—特色課程設計

日常生活中的醫學電子訊息

程德勝 副教授

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學歷

- 生物醫學工程博士
  - 英國史翠斯克萊德大學
- 生物醫學工程哲學碩士
  - 香港理工大學
- 義肢矯型學理學士（一級榮譽畢業）
  - 香港理工大學

現職

- **國立暨南國際大學**
  - 電機工程學系 *副教授*
  - 光電科技碩士學位學程在職專班 *執行長*
  - 應用材料與光電工程學系 *合聘副教授*
  - 通識教育中心自然科學組 *組長*
- **海外聯合招生委員會**
  - 宣導組 *組長*

經歷

- **助理教授**（08/2008~08/2011）
  - 國立暨南國際大學 生物醫學科技研究所
- **助理教授**（02/2007~08/2008）
  - 亞洲大學 光電與通訊學系
- **博士後研究**（02/2006~02/2007）
  - 英國史翠斯克萊德大學 生物醫學工程研究所
- **博士後研究**（08/2005~12/2005）
  - 美國科羅拉多丹佛大學及醫療科學中心
- **義肢矯型師**（10/1999~04/2001）
  - 香港環宇復康中心

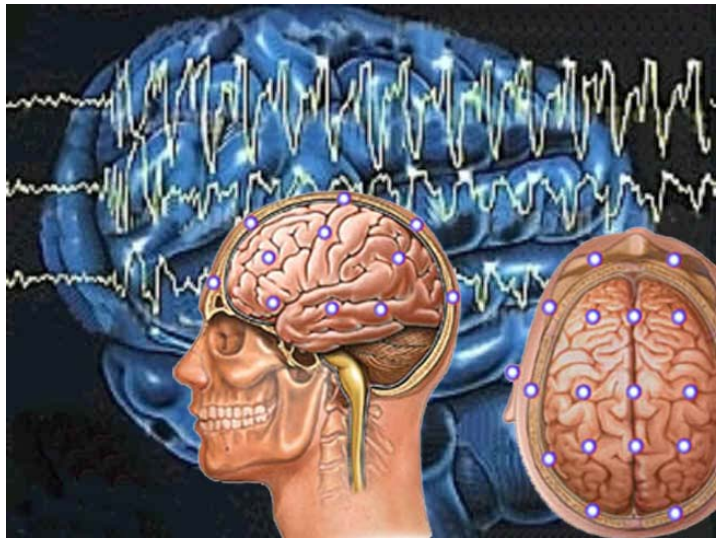
專業資格

- 生物醫學工程師

Today's Talk

- 生理訊號的起源
- 生理訊號量測電路
- ECG(心電圖)講解與實驗

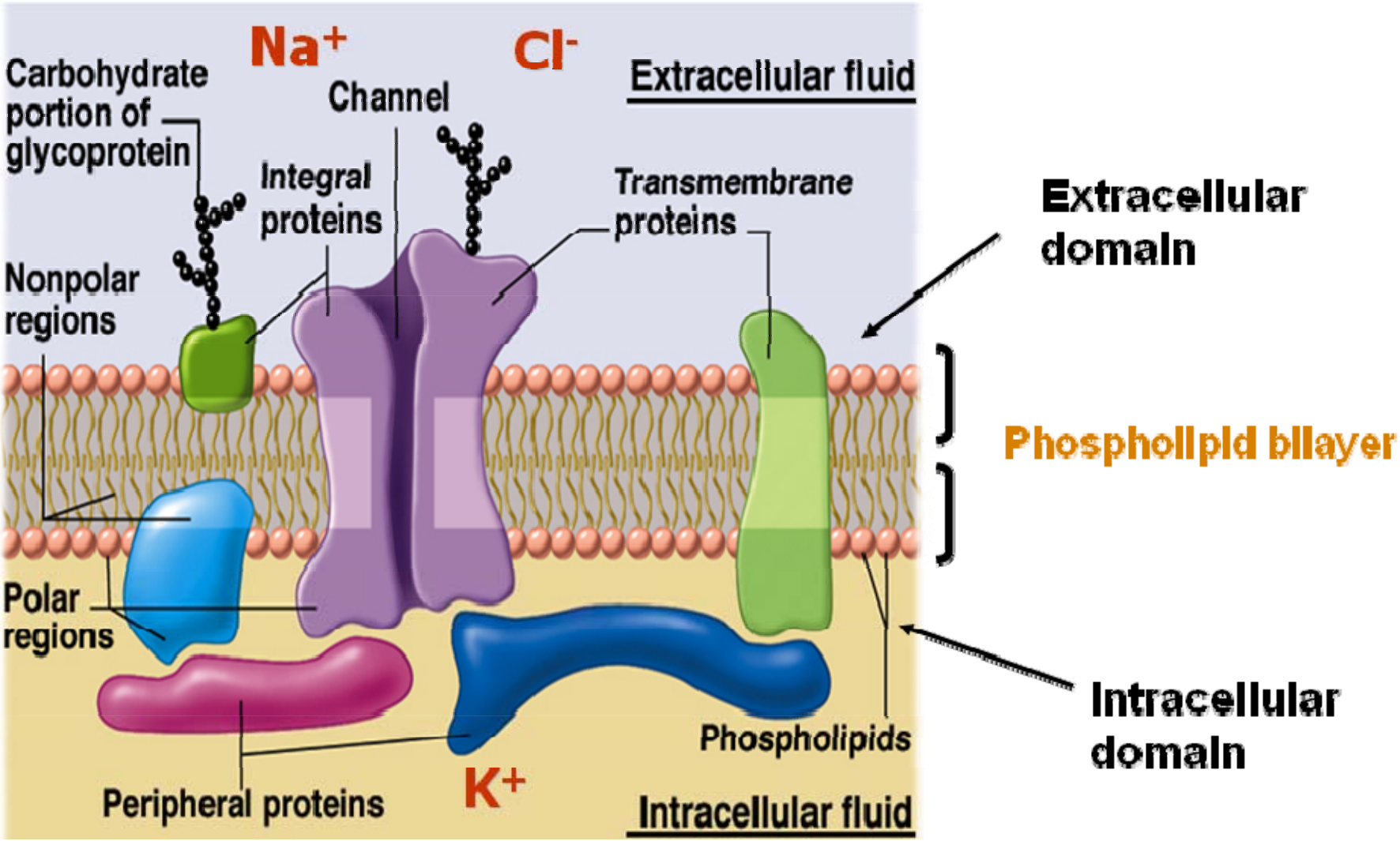
生理訊號的起源



Biopotentials

- Action Potentials from Cells
  - Neuronal action potential
- Biopotentials from the organ/body
  - Electrocardiogram (ECG) from heart ⇒ use in heart attack, pacemakers
  - Electroencephalogram (EEG) from brain ⇒ use in epilepsy, brain trauma
  - Electromyogram (EMG) from muscle ⇒ use in muscle diseases, prosthesis
  - Others…

Origin of Membrane Potential



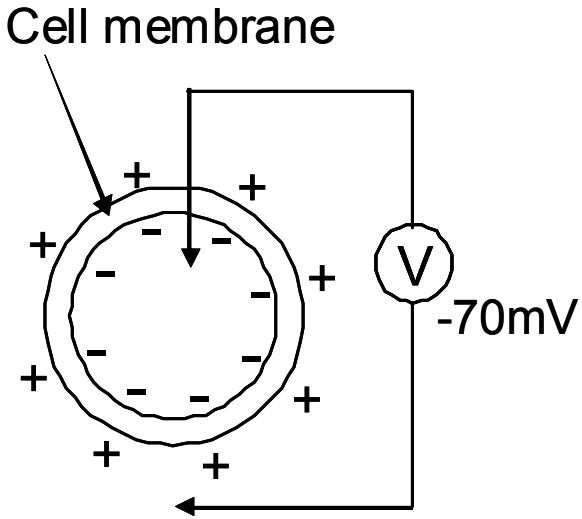
What Ions are there?

Cell

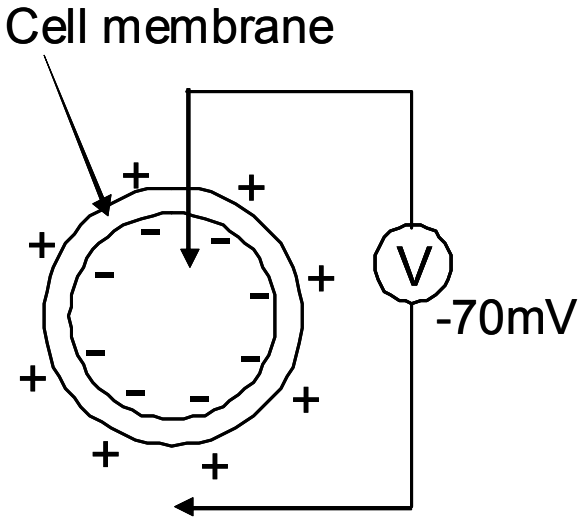
108 mM [anions]
12 mM [Na^+]
125 mM [K^+]
5 mM [Cl^-]

Extracellular Fluid

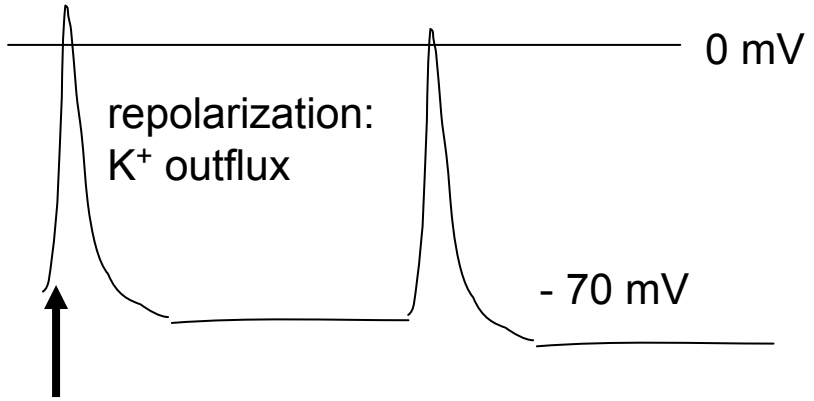
120 mM [Na^+]
5 mM [K^+]
125 mM [Cl^-]



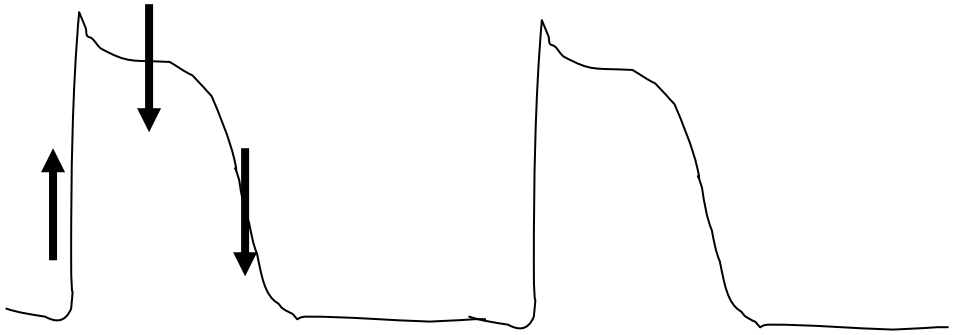
Electrical Activity of Excitable Cells



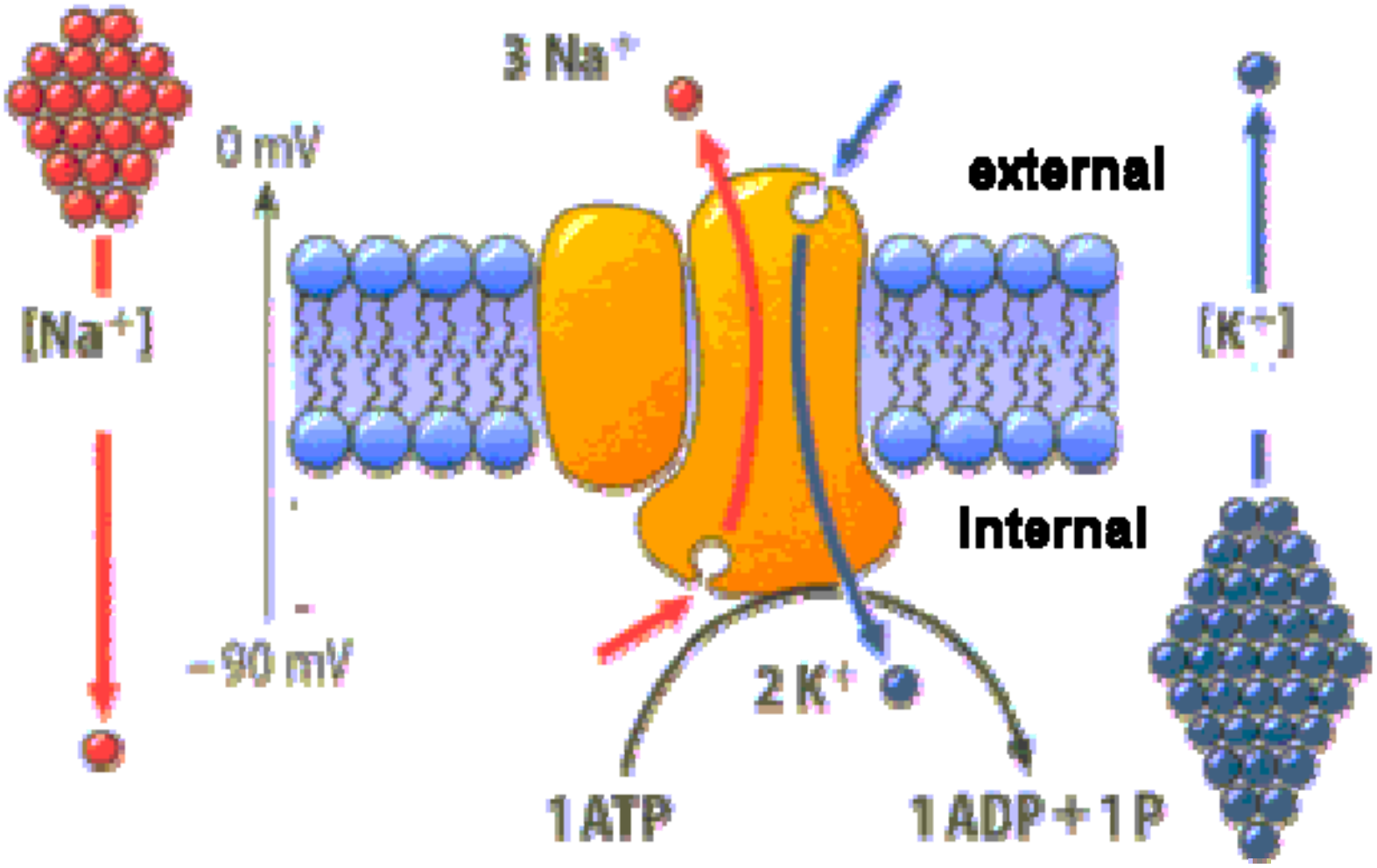
Neuronal action potential



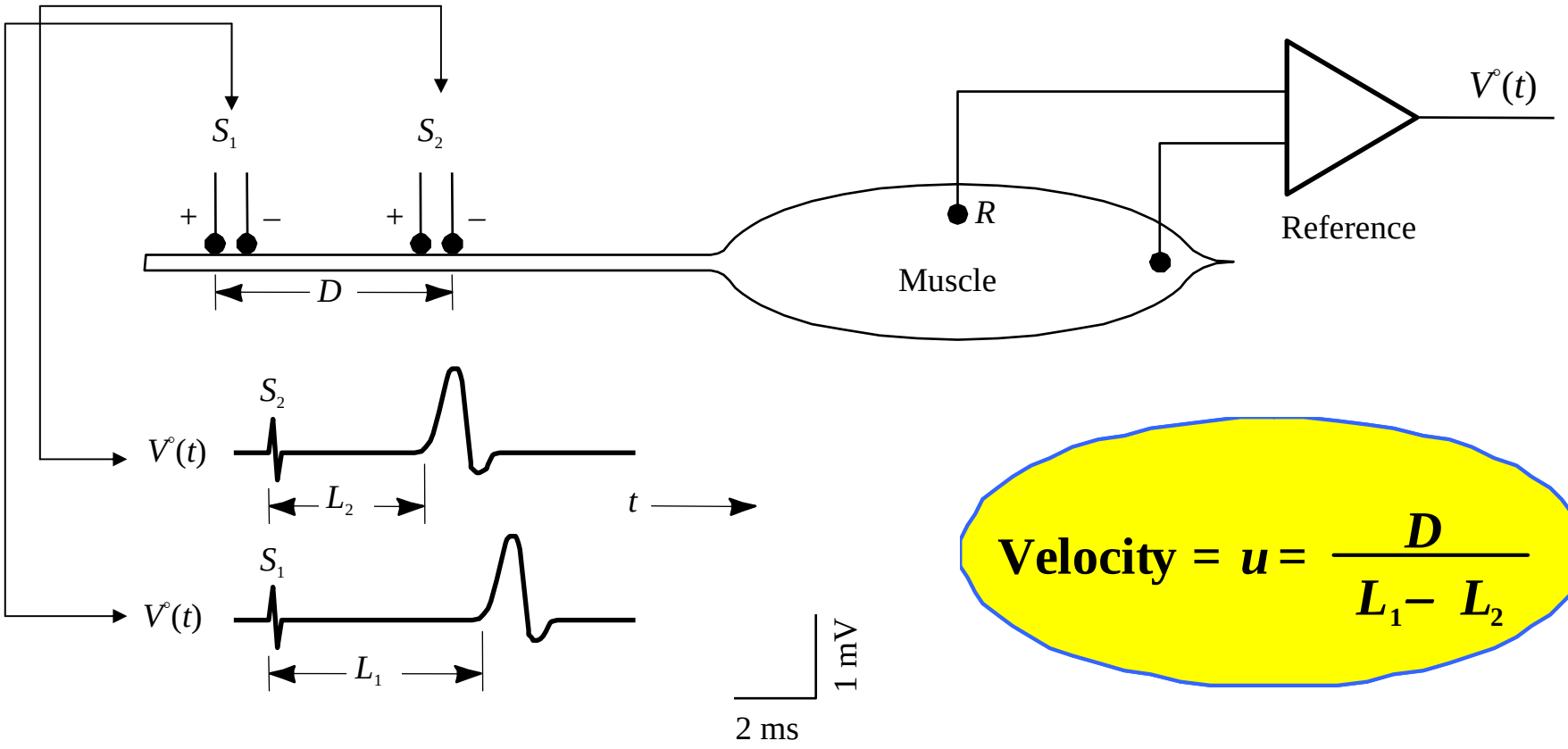
Cardiac action potential



Resting Potential and Ion Pumps



Electroneurogram (ENG)

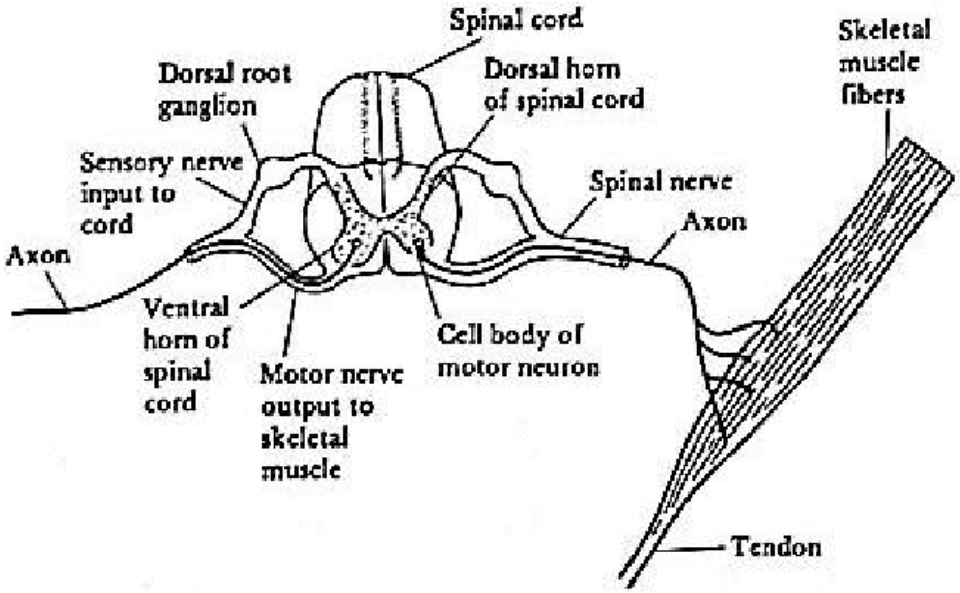


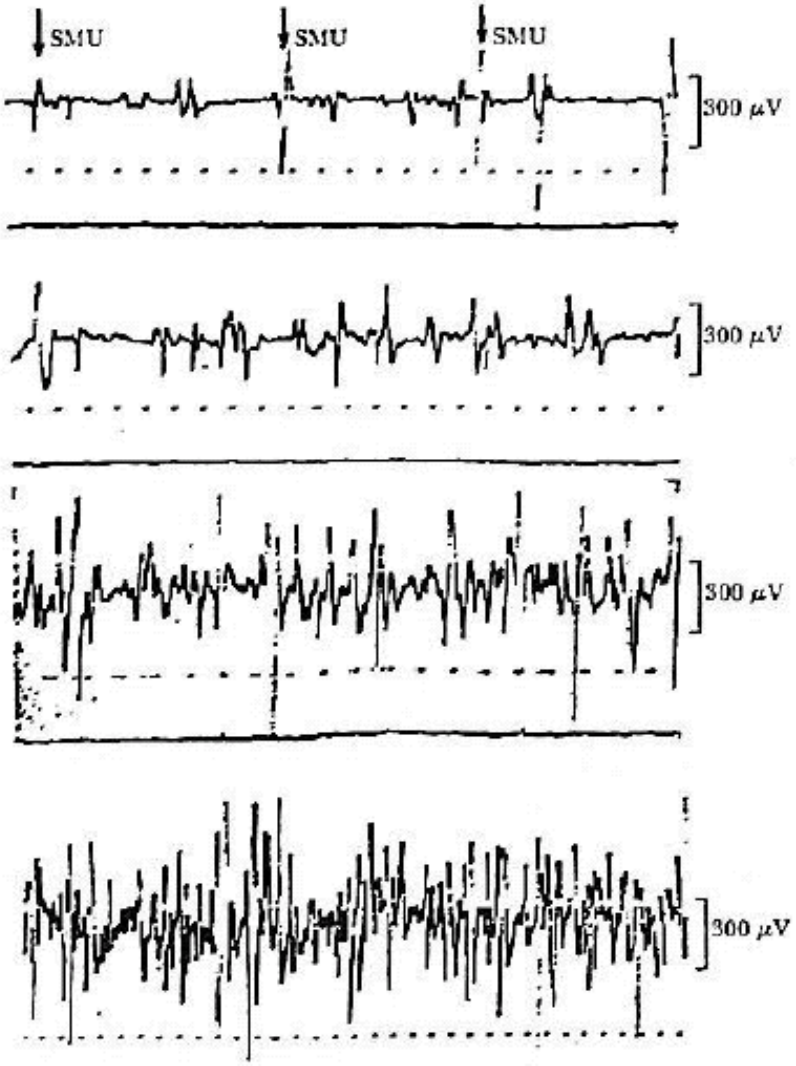
$$\text{Velocity} = u = \frac{D}{L_1 - L_2}$$

Application of ENG

Sources: http://video.google.co.uk/videoplay?docid=-8863382870241068751&ei=CtlwS4GvCoeYwgP0xvzFDA&q=Electromyography&hl=zh-TW#

Electromyogram (EMG)



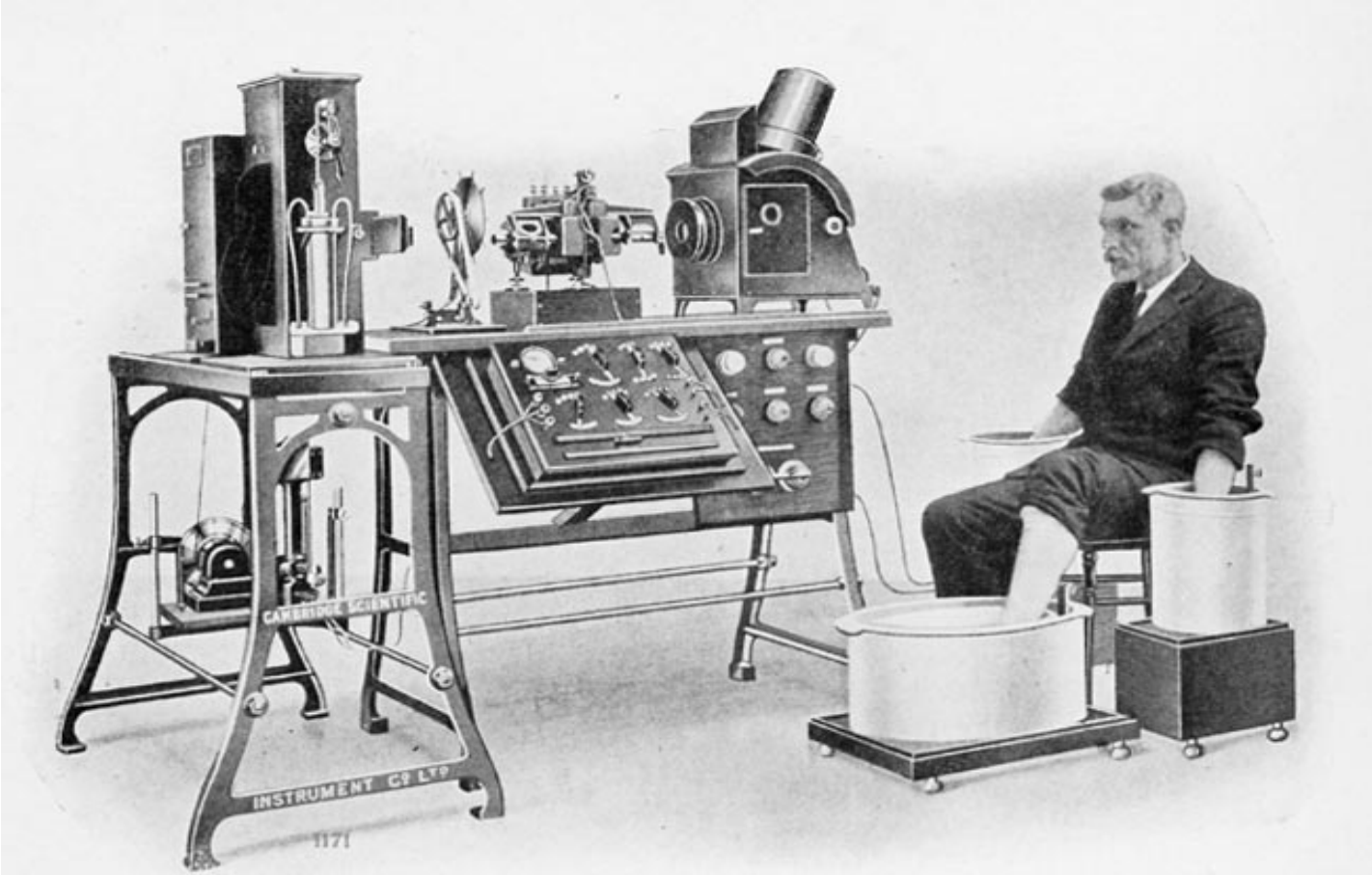


Application of EMG in Daily Life

影 片

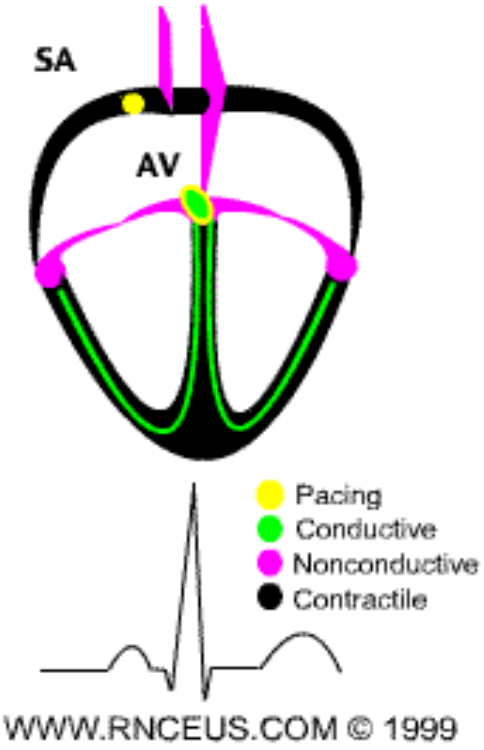
Sources: http://www.youtube.com/watch?v=PMFrL7xt7kI&feature=related

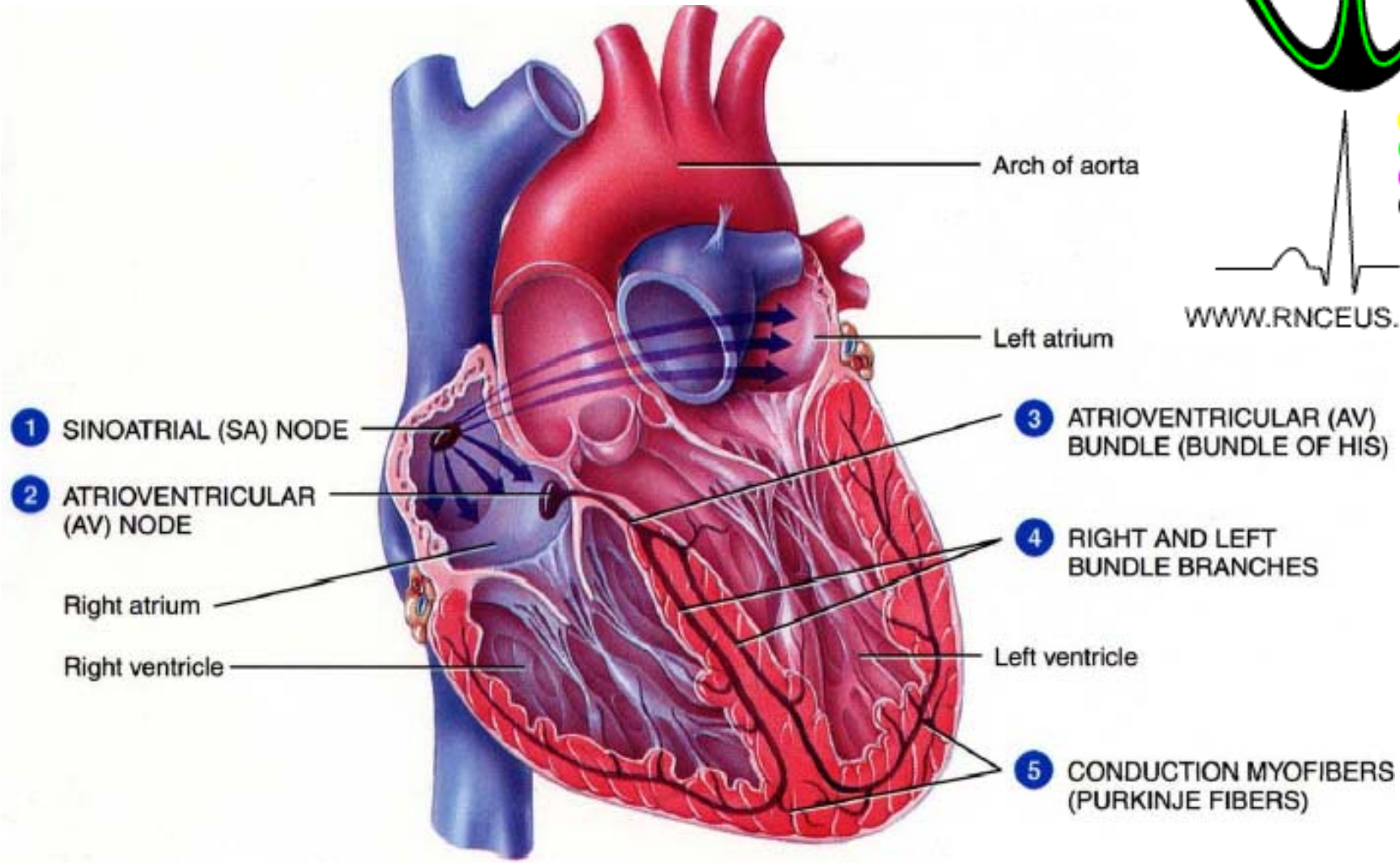
Electrocardiogram (ECG)



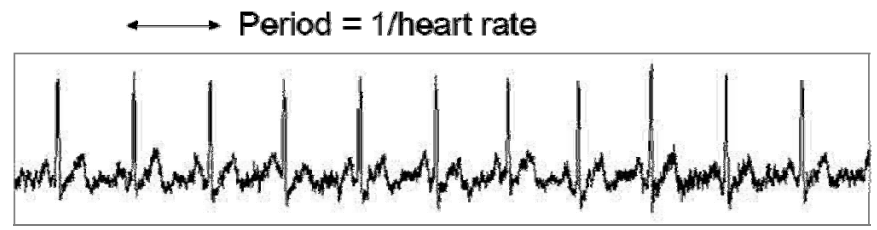
PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

Conduction System of the Heart

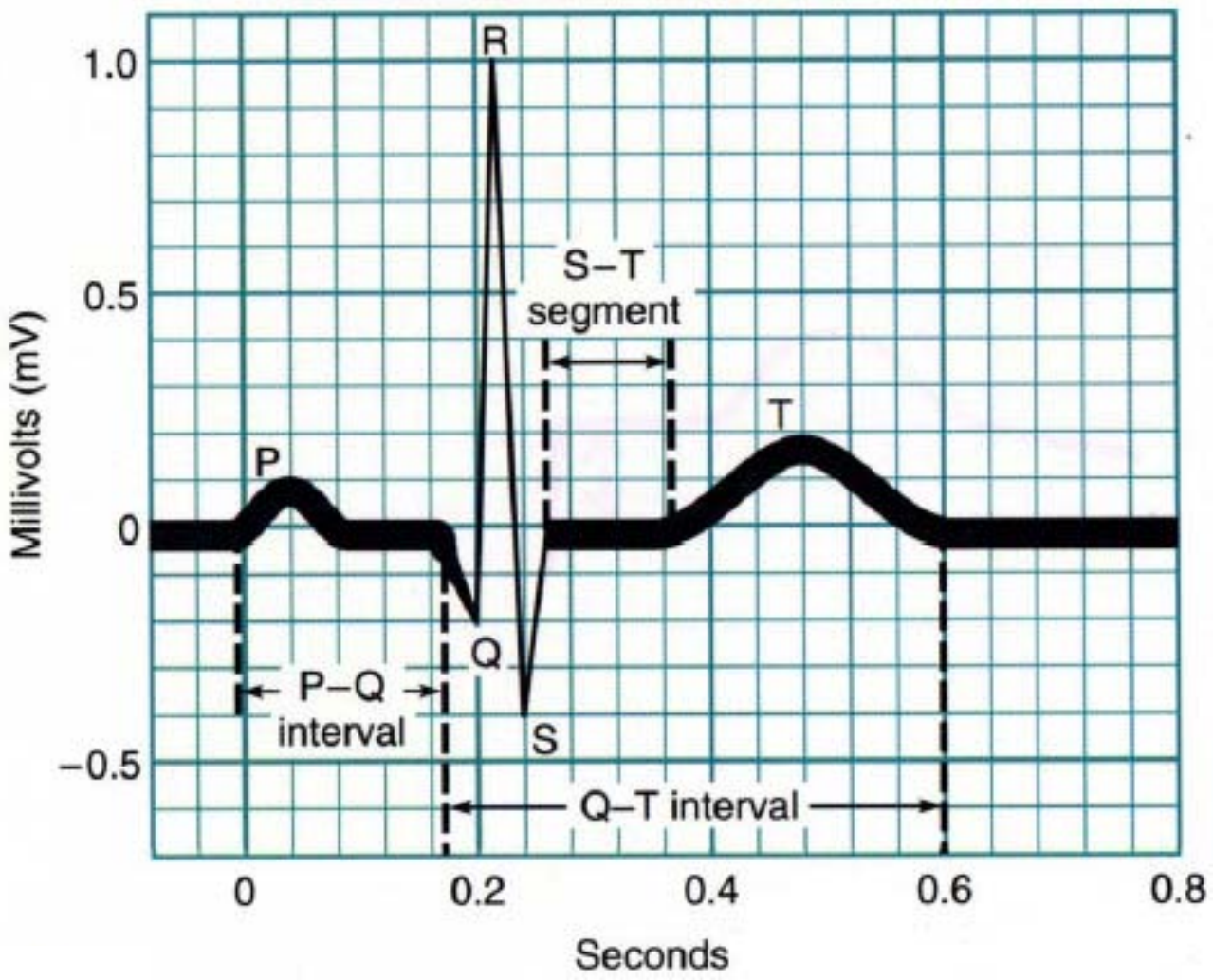




Normal ECG

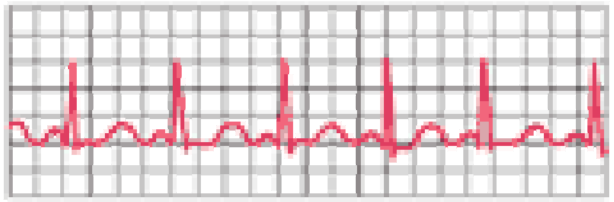


PQRST pattern

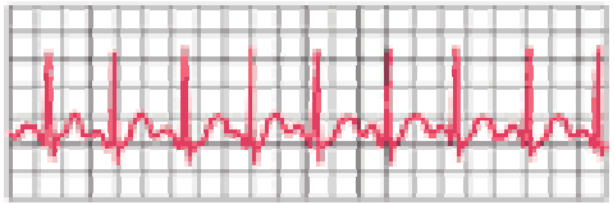


ECG Applications

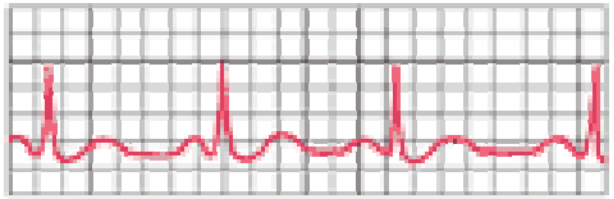
Normal Heartbeat



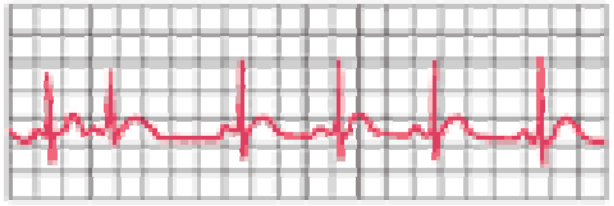
Fast Heartbeat



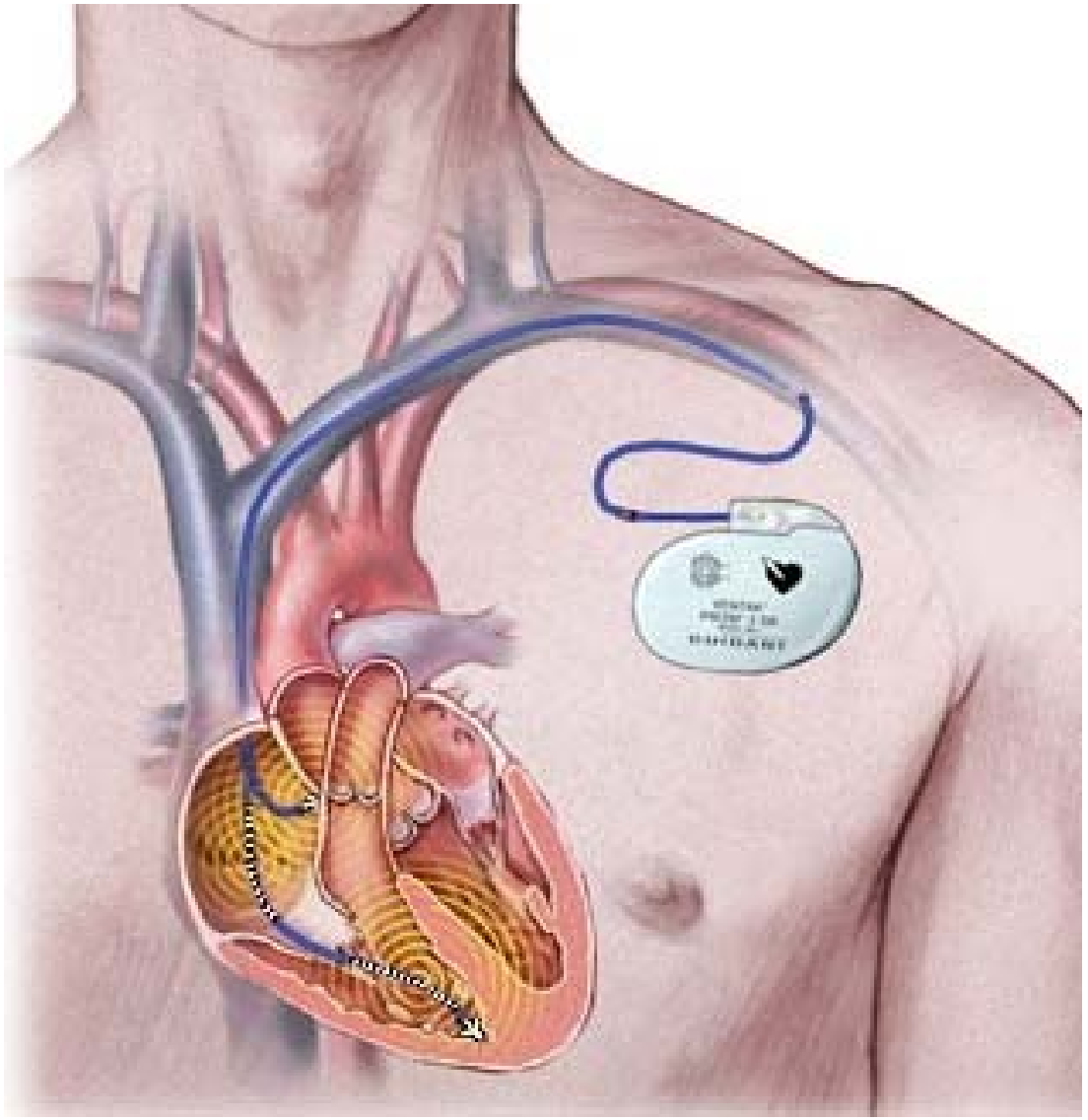
Slow Heartbeat



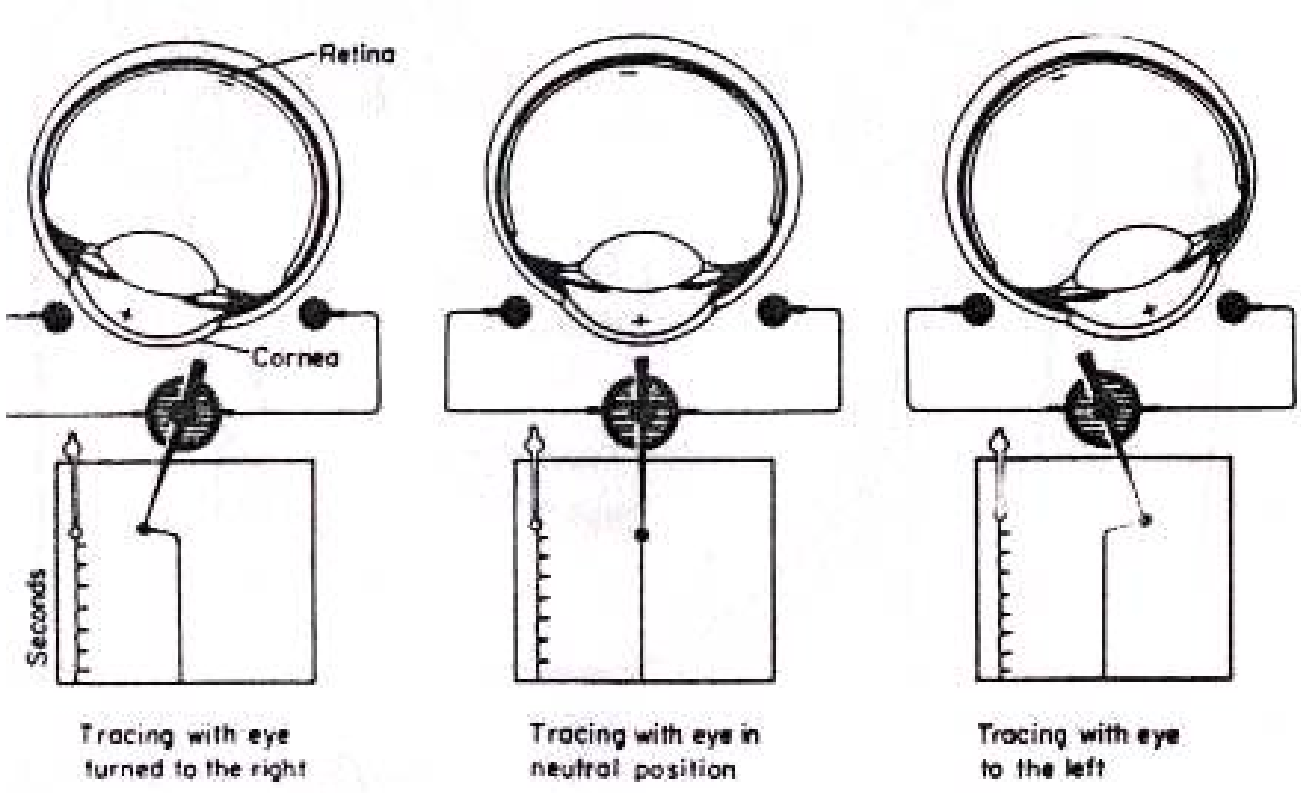
Irregular Heartbeat



ECG Applications



Electro-oculogram (EOG)

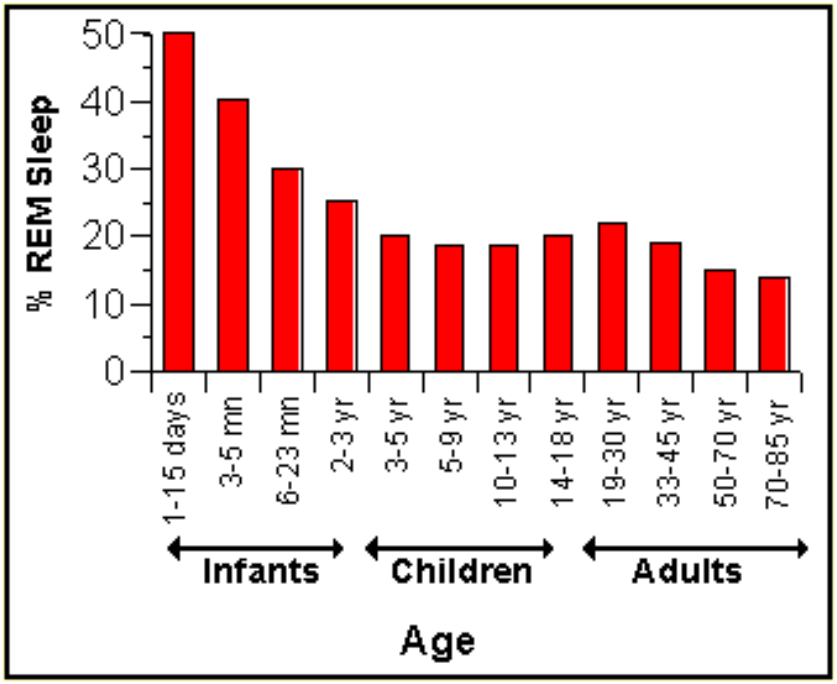


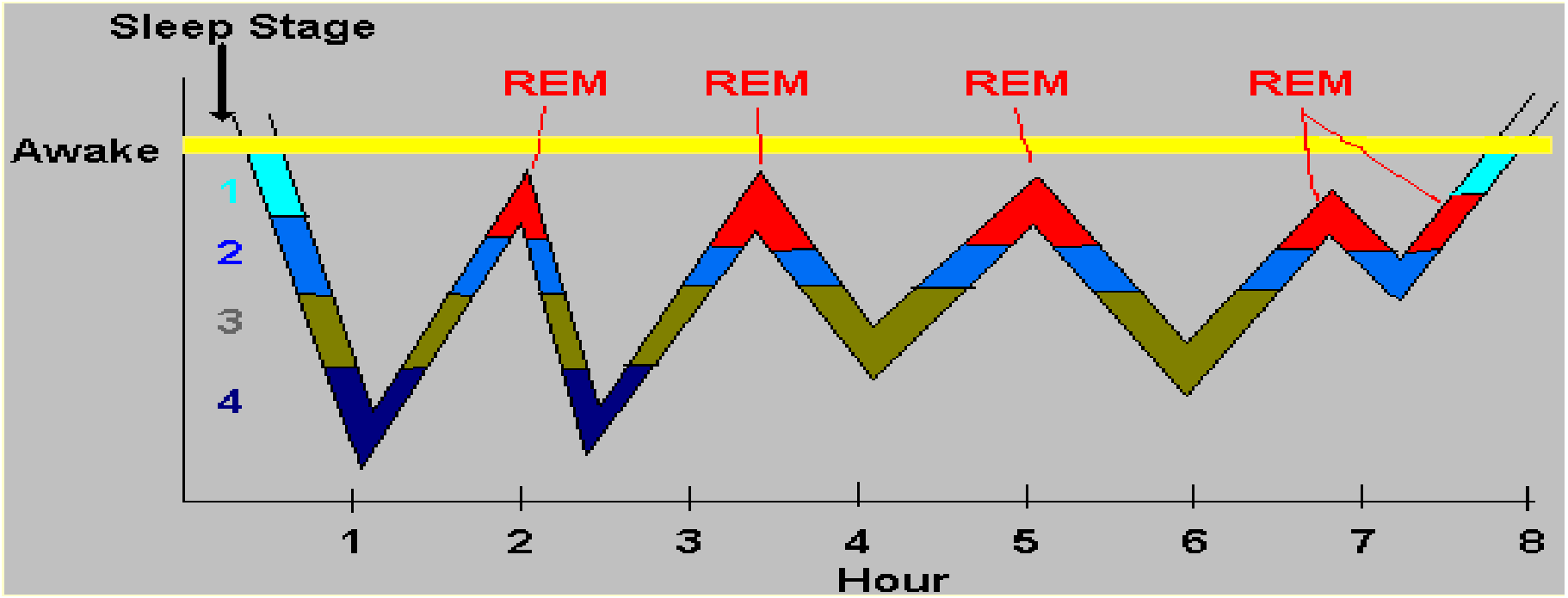
The EOG is frequently the method of choice for recording eye movements in sleep and dream research, in recording eye movements from infants and children, and in evaluating reading ability and visual fatigue

EOG Applications

- Determine sleep stage
  - The sleep has two basic patterns
    - NREM : Non-Rapid Eye Movement Sleep
    - REM : Rapid Eye Movement Sleep

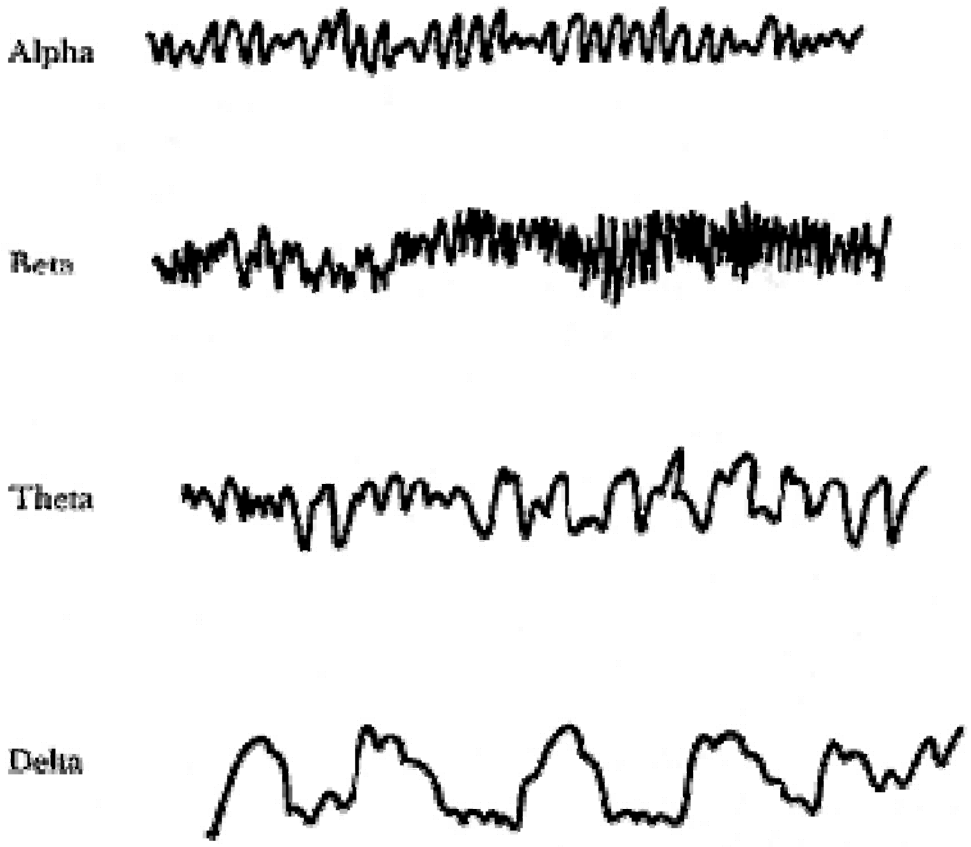
	NREM	REM
Baby	50%	50%
	↓	↓
Adult	80%	20%




Sleep Stage
REM
REM
REM
REM
Awake
1
2
3
4
1
2
3
4
5
6
7
8
Hour

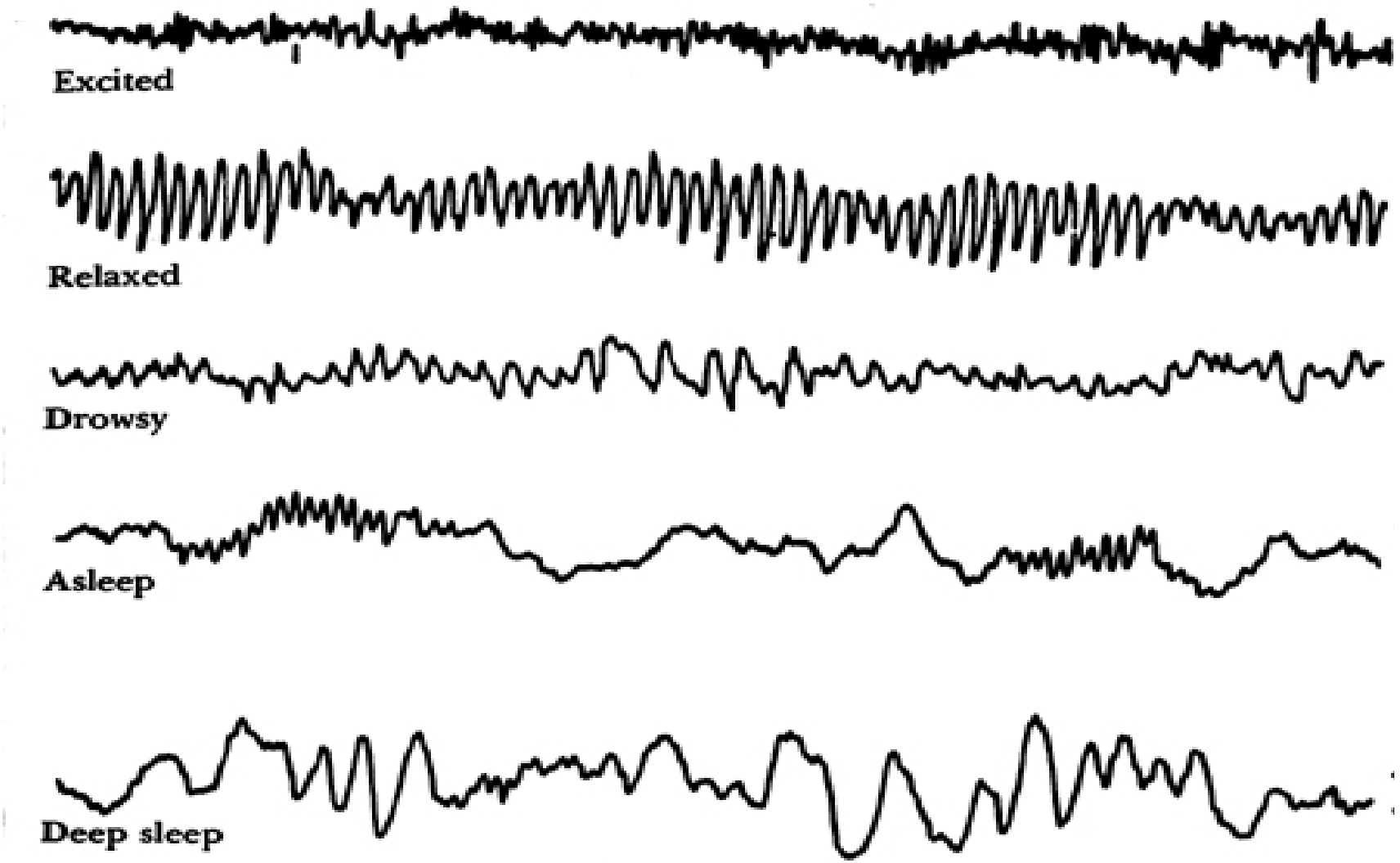
Electroencephalogram (EEG)

Different Types of Normal EEG Waves



Delta	δ	0.5-4Hz	Happen in deep sleep
Theta	θ	4-8Hz	Happen in children and adult when they are under stress
Alpha	α	8-13Hz	Happen in the situation of eyes closed and open
Beta	β	13-22Hz	Happen in the situation of thinking

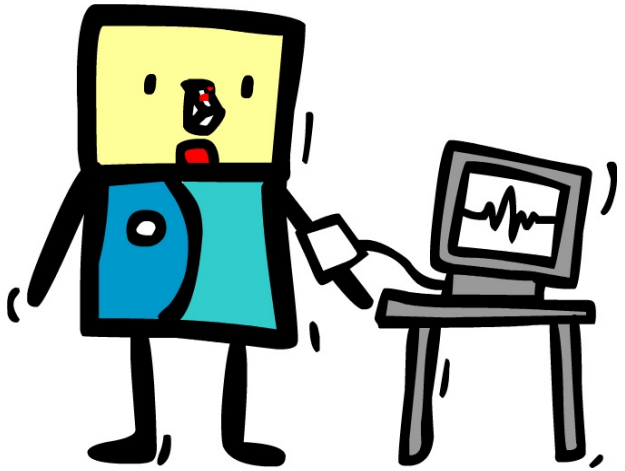
EEG Changes: Before & During Sleeping



EEG Applications

- Diagnose epilepsy
- Determine brain dead
- Determine sleeping situation

生理訊號量測電路



Biomedical Signals

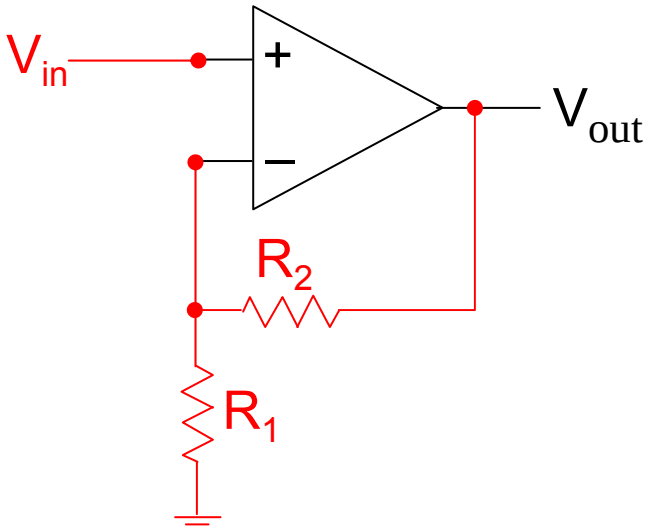
Physiological Parameters	Measurements	Sensing device	Value	Frequency Range
Brain potential	Electro-encephalogram	Scalp electrode	50μV	0.1 – 100Hz
Eye responses	Electro-retinogram	Contact lens electrode	100μV	0.1 – 10Hz
Muscle potential	Electro-myogram	Surface electrode	100mV	50 – 3000Hz
Heart potentials	Electro-cardiogram	Surface electrode	2mV	0.1 – 300Hz

Use of Op Amp

- Signal
  - Amplification
  - Signal processing
  - Buffer

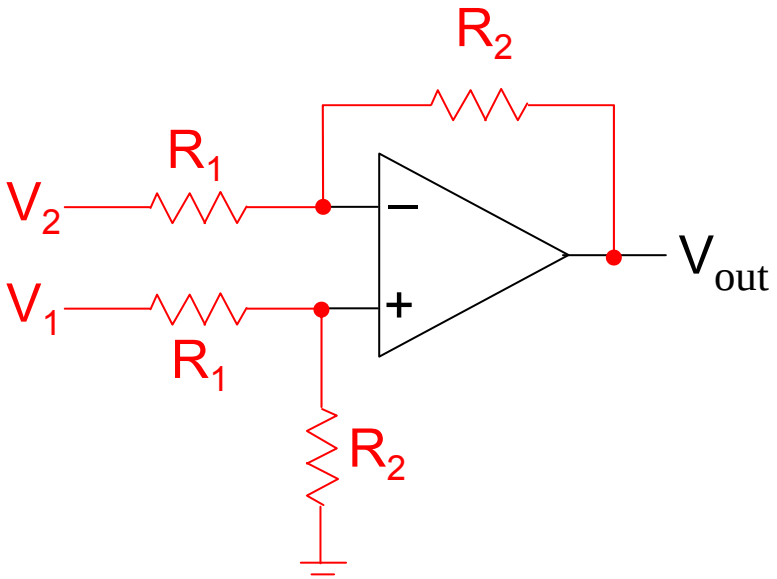
Non-Inverting Amplifier

$$\text{Gain} = V_{out}/V_{in} = 1 + R_2/R_1$$



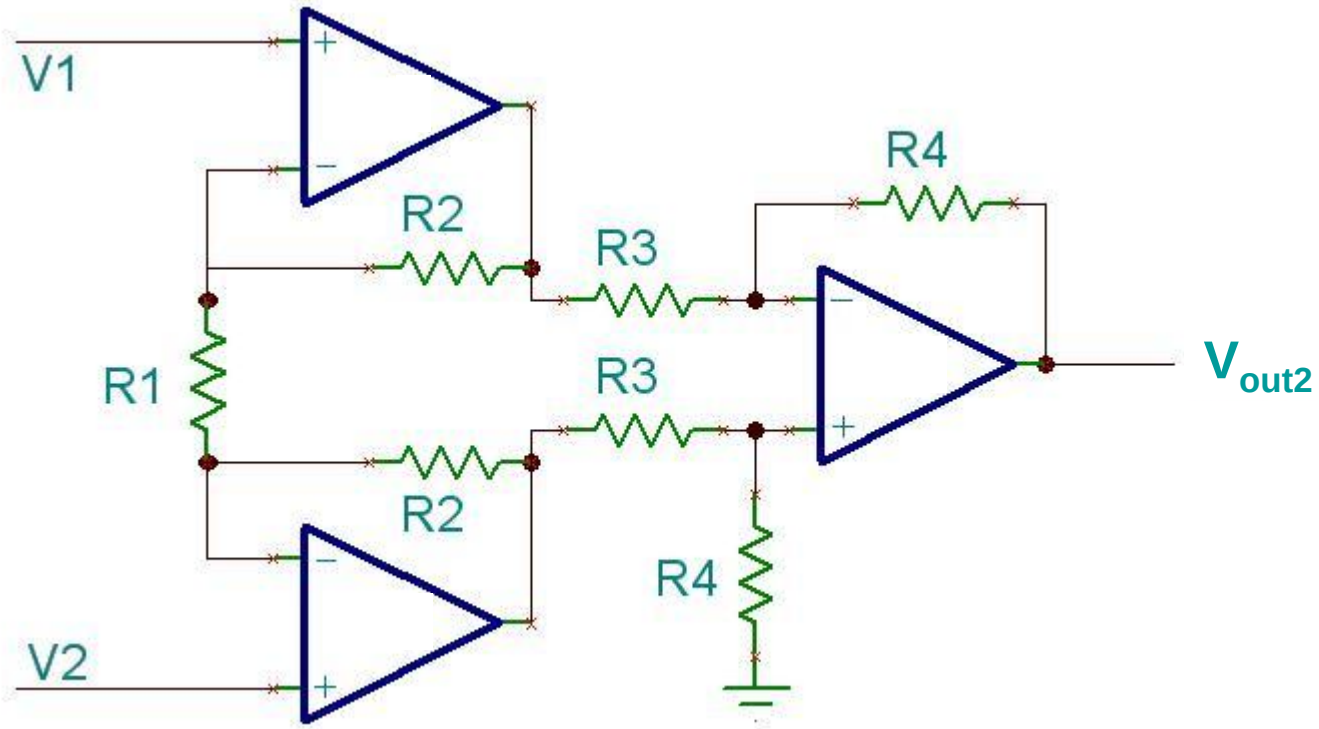
Differential Amplifier

$$V_{out} = (V_1 - V_2)R_2/R_1$$



Amplifies a difference

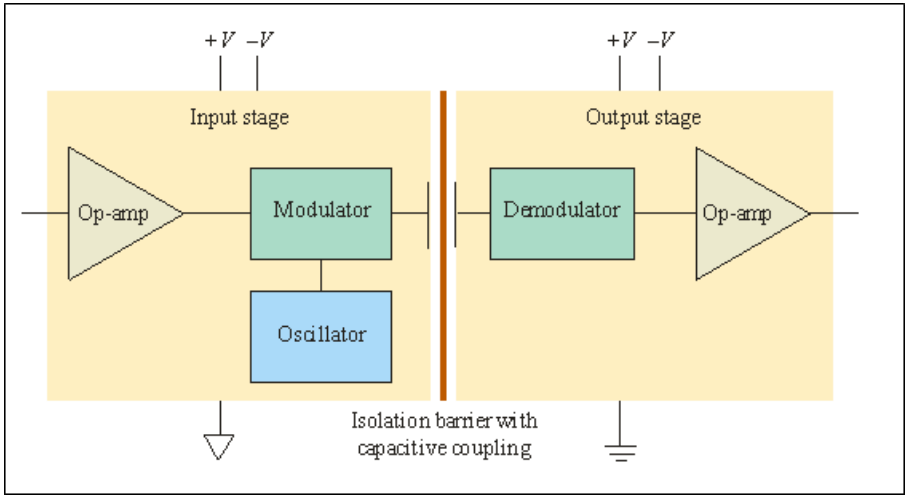
Instrumentation Amplifier



$$V_{out2} = -(V_1 - V_2)(1 + 2R_2/R_1)(R_4/R_3)$$

Isolation Amplifiers

- **Protection**
- ISO124 : Capacitively-coupled isolation amplifier
- 3656KG : Transformer coupled isolation amplifier
  - **Being suited for patient monitoring applications, such as an ECG amplifier**



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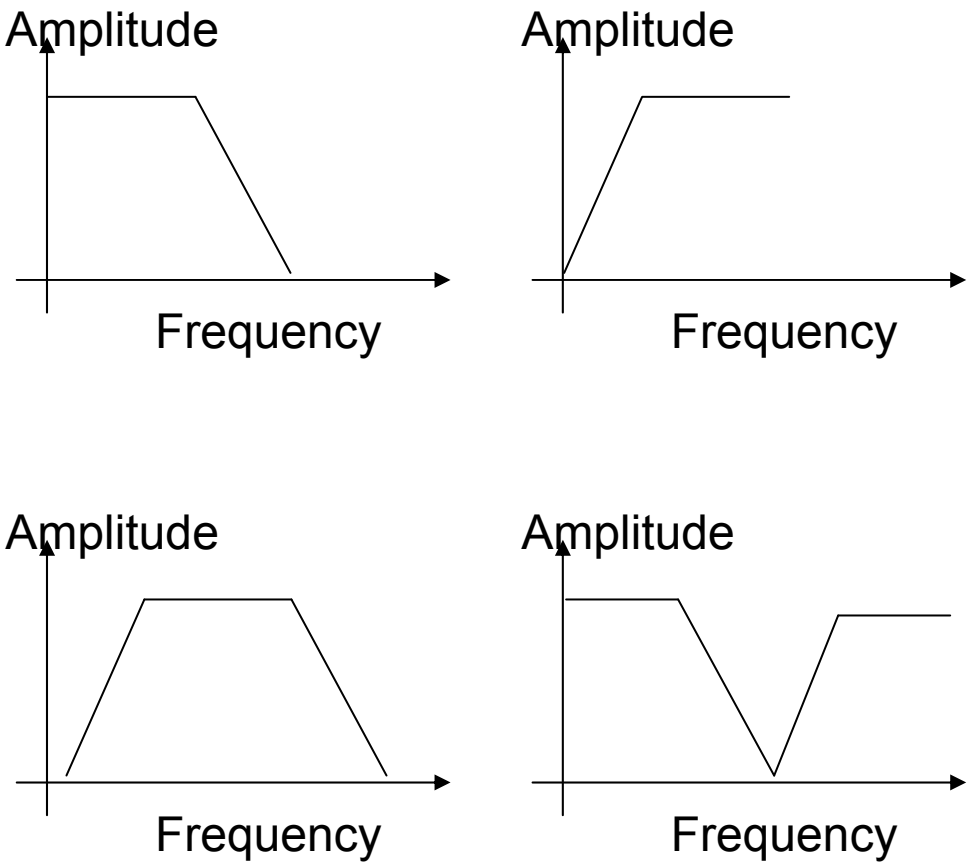
Heart potentials	Electro-cardiogram	Surface electrode	2mV	0.1 – 300Hz

Different Filters

- Low pass filter
- High pass filter
- Band pass filter
  - E.g. ECG
  - 0.1-300 Hz
- Band reject (notch) filter
  - e.g. 60 Hz



Why Frequency?

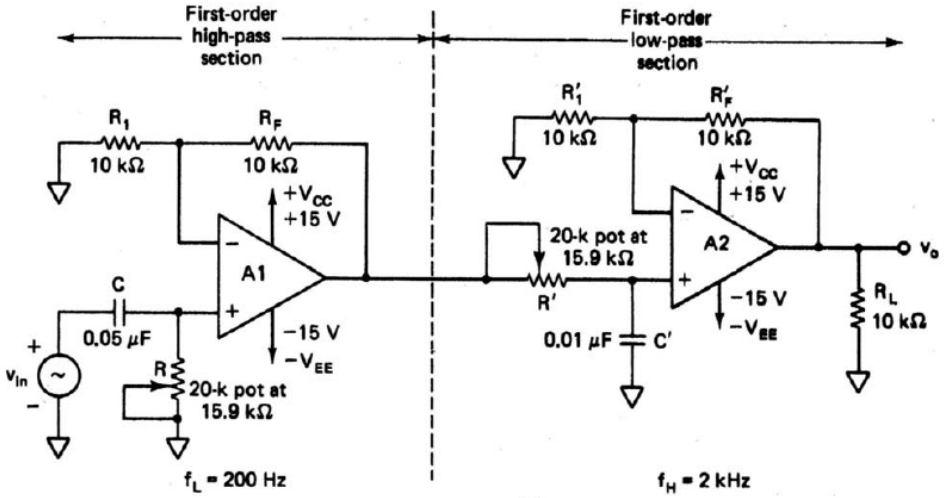
When measuring biopotentials, EVERYTHING else

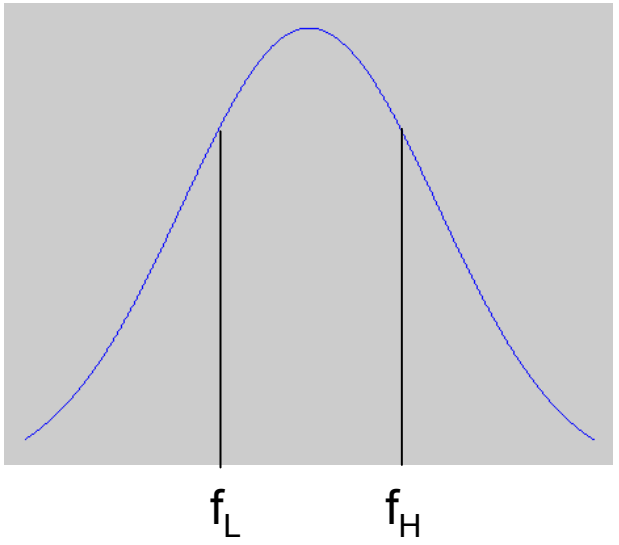
– power line interference

– even other biopotentials (like EMG)

So Band Pass Filter should be used

are noise sources. These have characteristic frequencies.





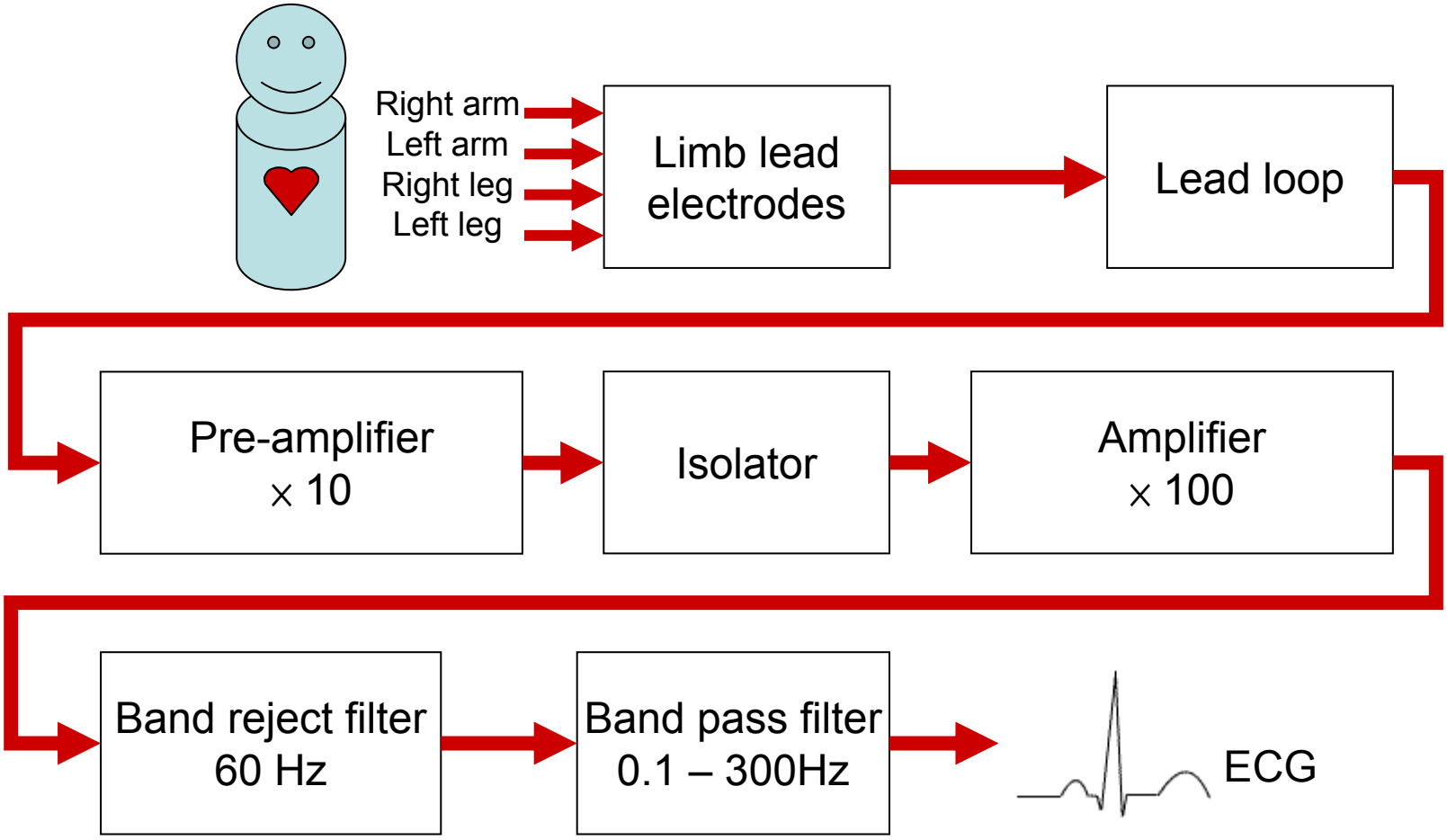
Pass only f_L to f_H attenuate the others.

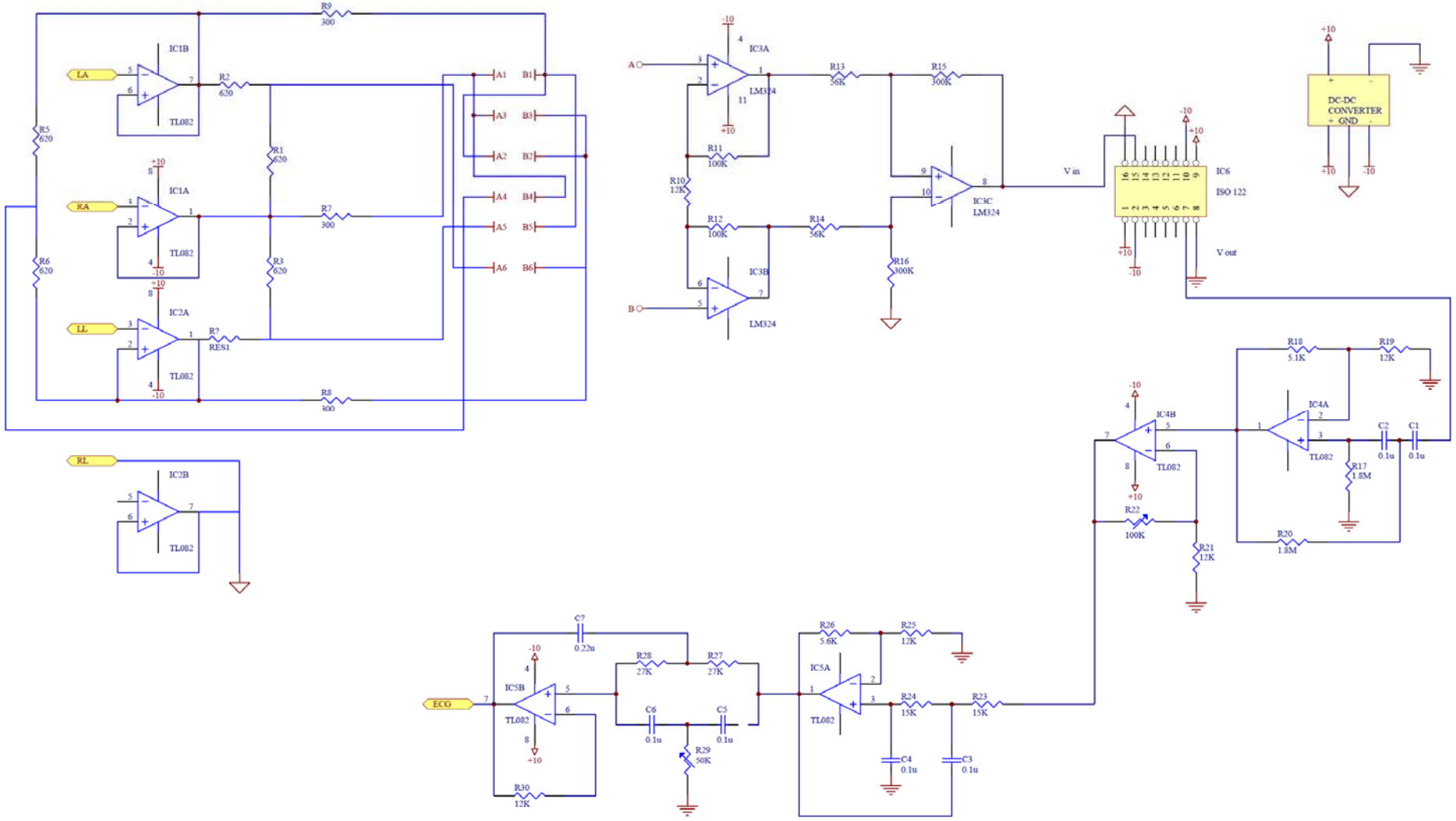
Noise

Several sources

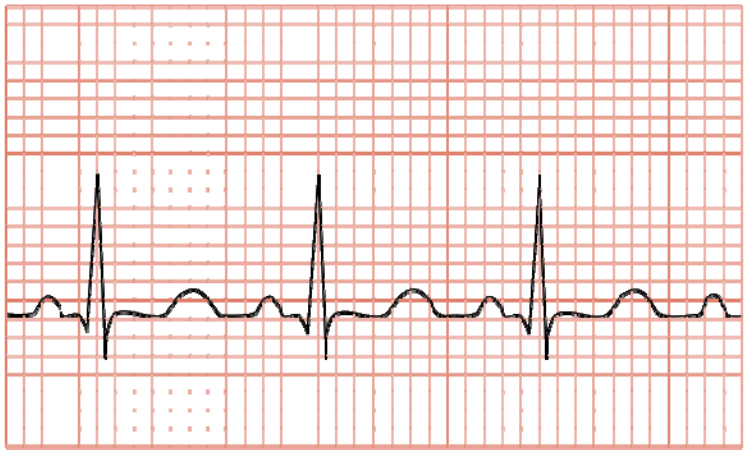
- 60Hz power lines ⇐ shielding, filtering
- Other biopotentials ⇐ filtering
- Motion artifacts ⇐ relaxed subject
- Electrode noise ⇐ high quality electrodes, good contacts
- Circuit noise ⇐ good design, good contacts

ECG Measurement Circuit: Block Diagram

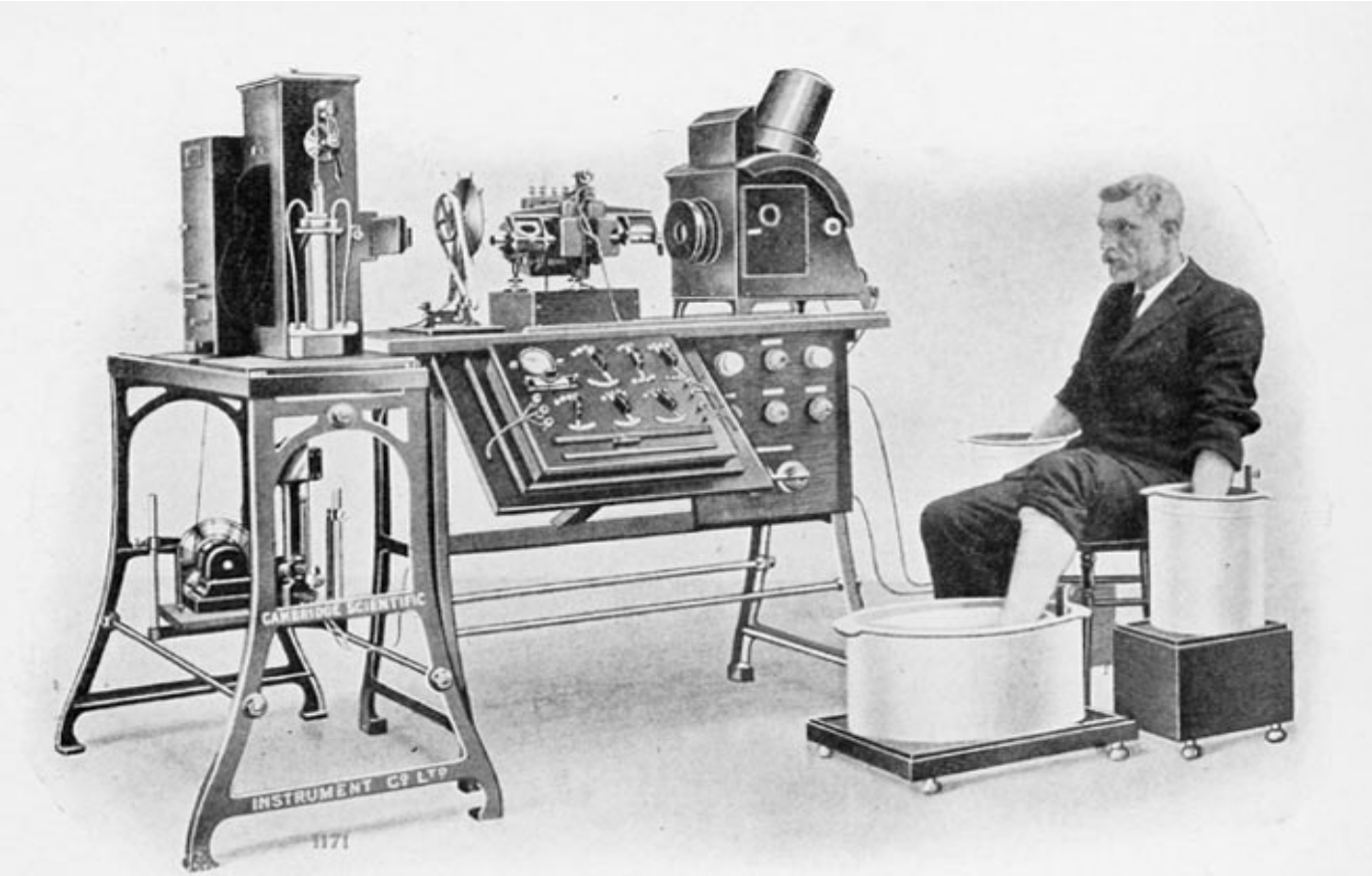



LA
RA
LL
RL
ECG
IC1B
IC1A
IC2A
IC2B
IC3A
IC3B
IC3C
IC4A
IC4B
IC5A
IC5B
IC6
TL082
LM324
ISO 122
DC-DC CONVERTER
+ GND -
V in
V out
R1 620
R2 620
R3 620
R5 620
R6 620
R7 300
R8 300
R9 300
R10 12K
R11 100K
R12 100K
R13 56K
R14 56K
R15 300K
R16 300K
R17 1.8M
R18 5.1K
R19 12K
R20 1.8M
R21 12K
R22 100K
R23 15K
R24 15K
R25 12K
R26 5.6K
R27 27K
R28 27K
R29 50K
R30 12K
C1 0.1u
C2 0.1u
C3 0.1u
C4 0.1u
C5 0.1u
C6 0.1u
C7 0.22u
A1 B1
A2 B2
A3 B3
A4 B4
A5 B5
A6 B6
+10
-10

ECG(心電圖)講解與實驗



ECG



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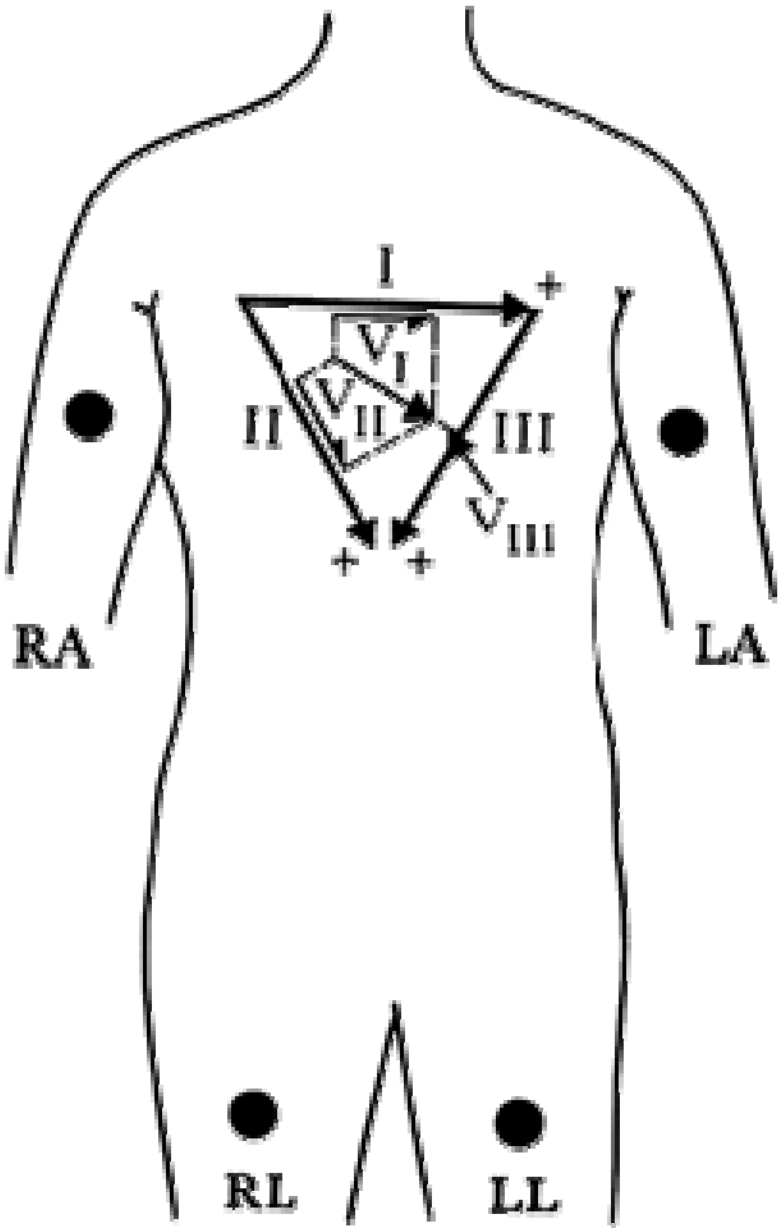
ECG Leads



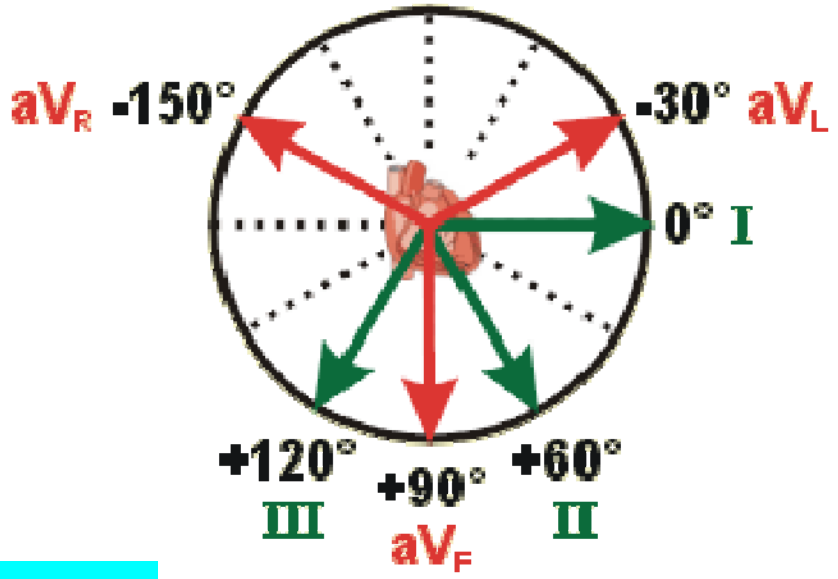
ECG Leads: Bipolar vs. Unipolar

3 Bipolar Limb Leads:

$I = LA - RA$

$II = LL - RA$

$III = LL - LA$

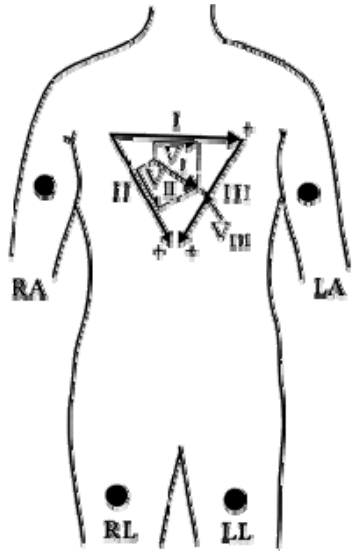


3 Augmented Limb Leads (Unipolar):

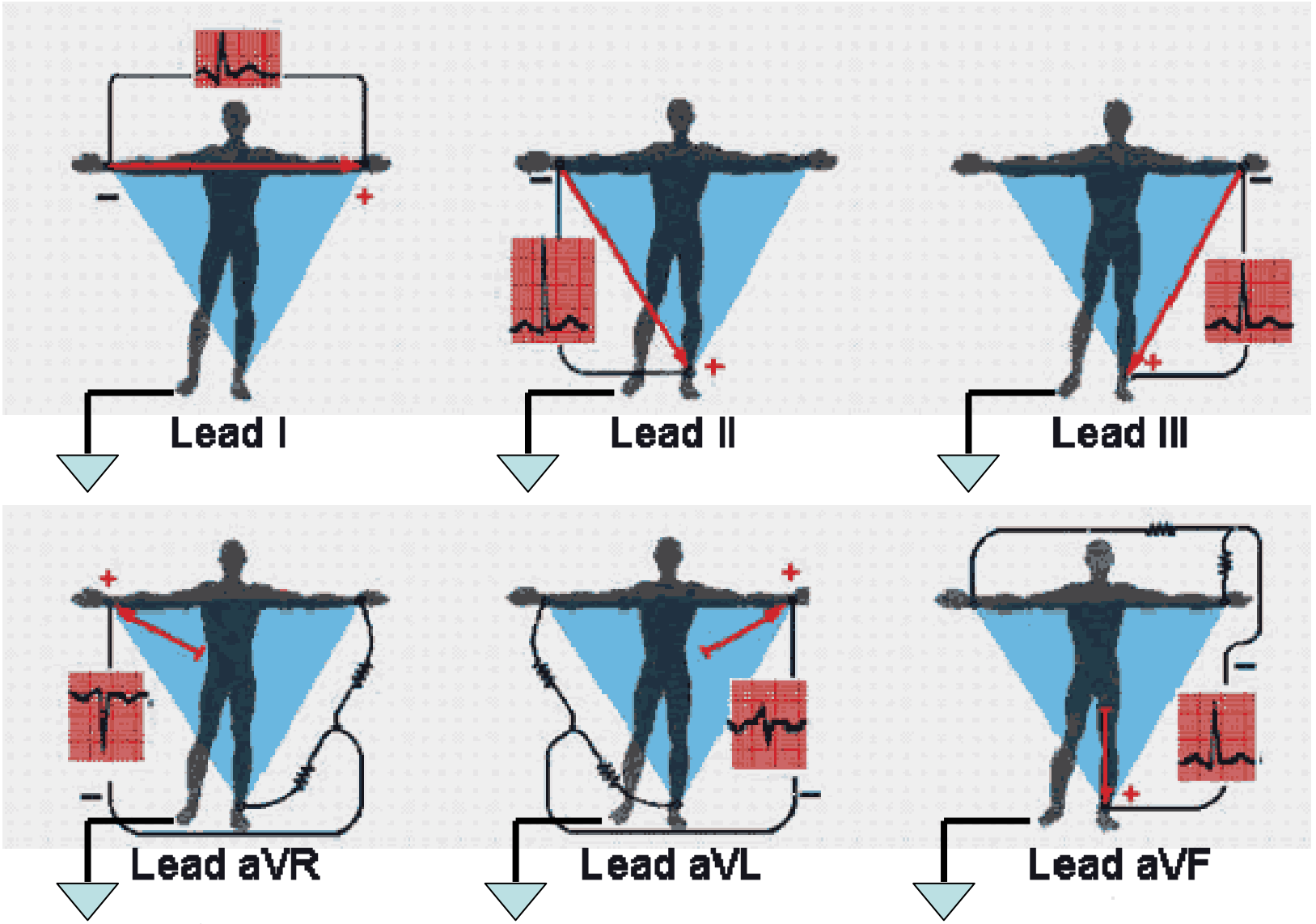
$aV_R = RA - (LL+LA)/2$

$aV_L = LA - (LL+RA)/2$

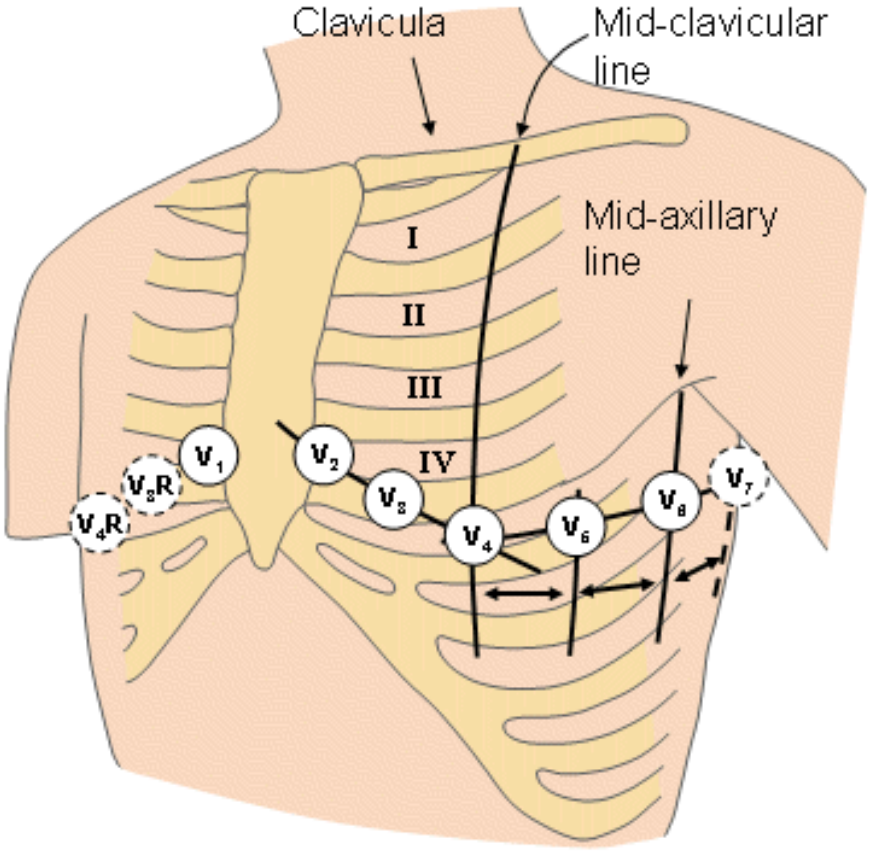
$aV_F = LL - (LA+RA)/2$



ECG Leads



ECG Leads



V_1 – fourth intercostal, right strernal border

V_2 – fourth intercostal, left sternal border

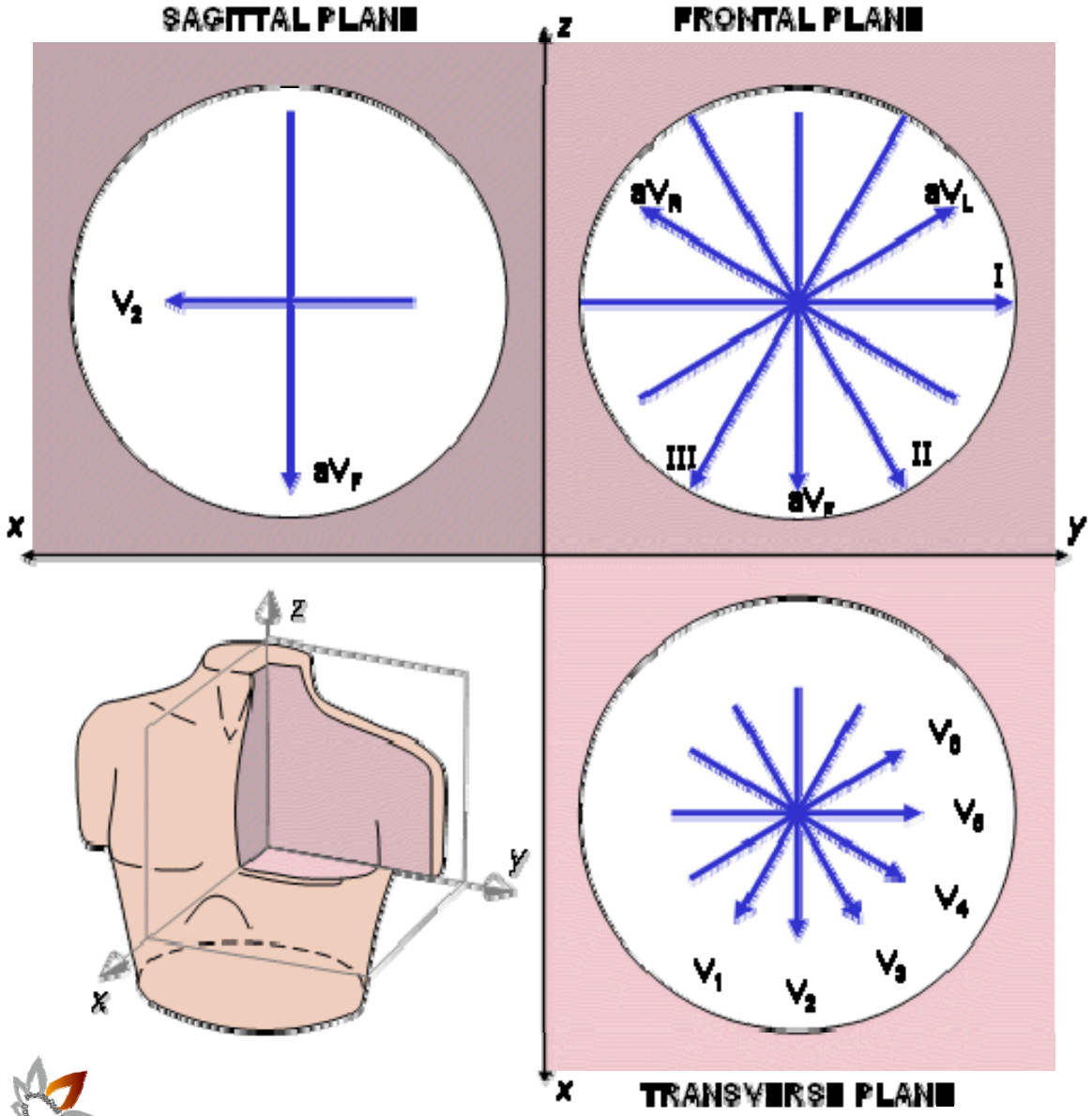
V_3 – equal distance between V_2 and V_4

V_4 – fifth intercostal, left mid clavicular line

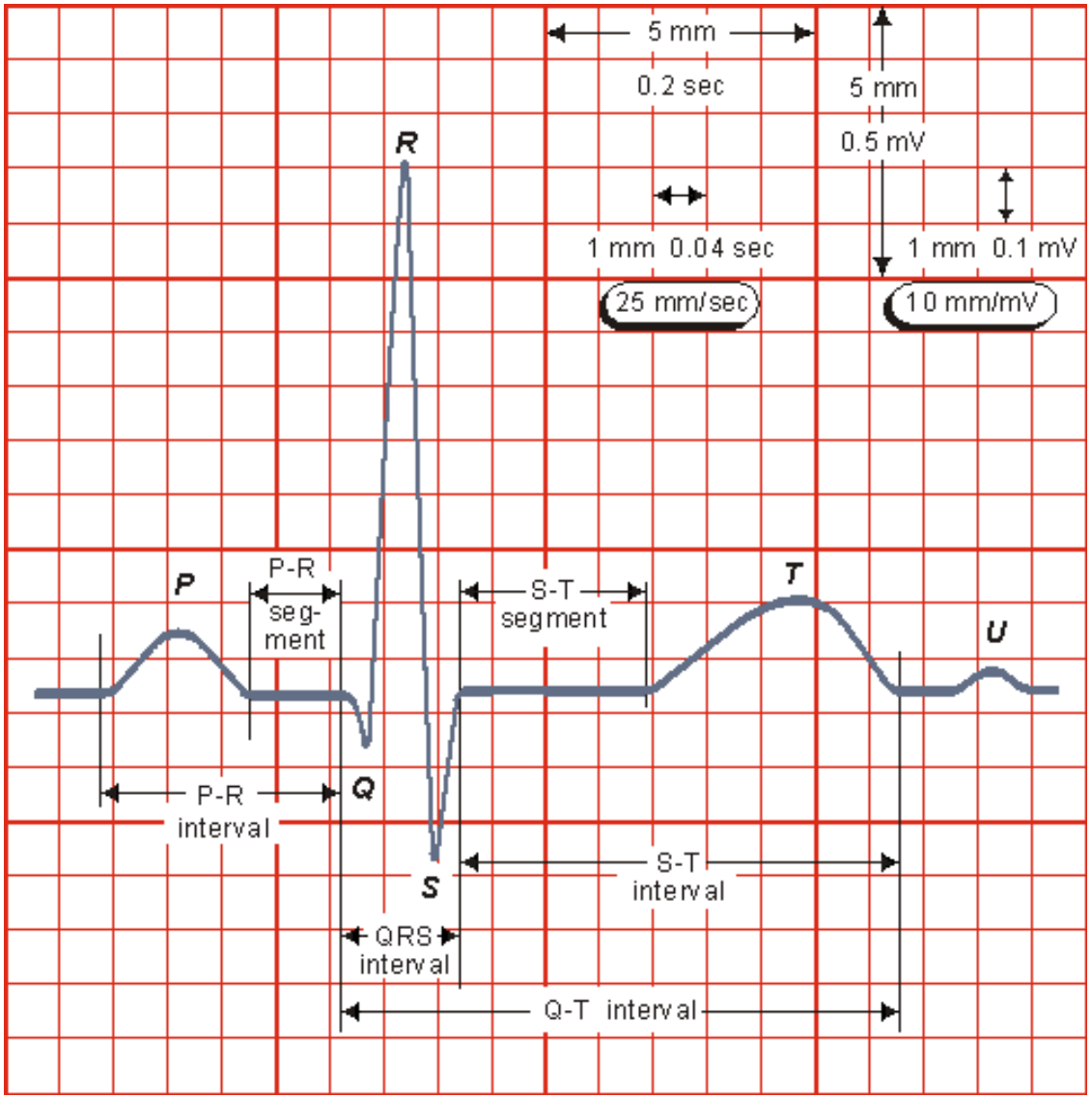
V_5 – anterior axillary line, same level with V_4

V_6 – mid axillary line, same level with V4 and V_5

ECG Information

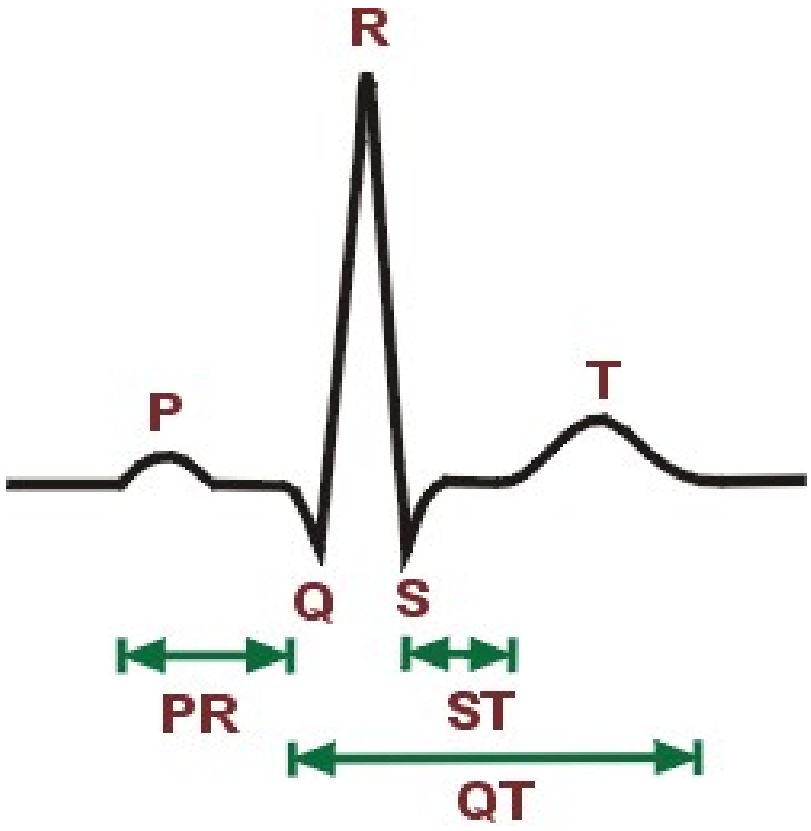


Normal ECG Signal



A "typical" ECG – P Wave

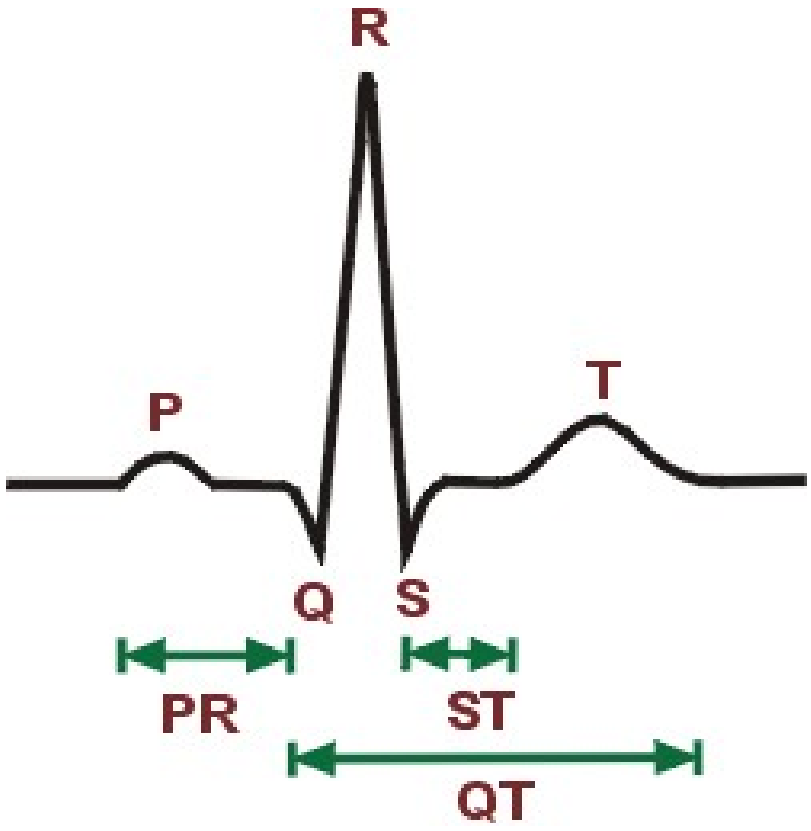
- Normal: 0.08 to 0.1 sec



A "typical" ECG – PR Interval

- Normal: 0.12 to 0.20 sec
- >0.2 sec

  → Various conduction block at AV node

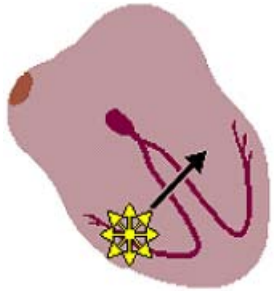


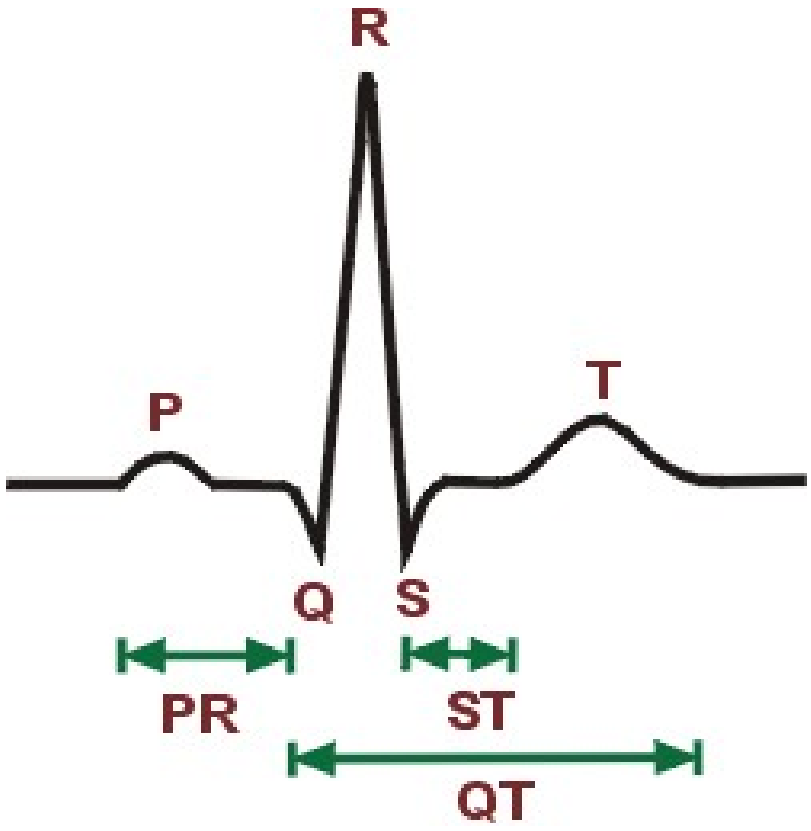
A "typical" ECG – QRS Complex

- Normal: 0.06 to 0.1 sec
- > 0.1 sec

  → Ventricular conduction impairment

  - Bundle branch blocks
  - Ventricular foci (abnormal pacemaker site) becomes the pacemaker driving the ventricle

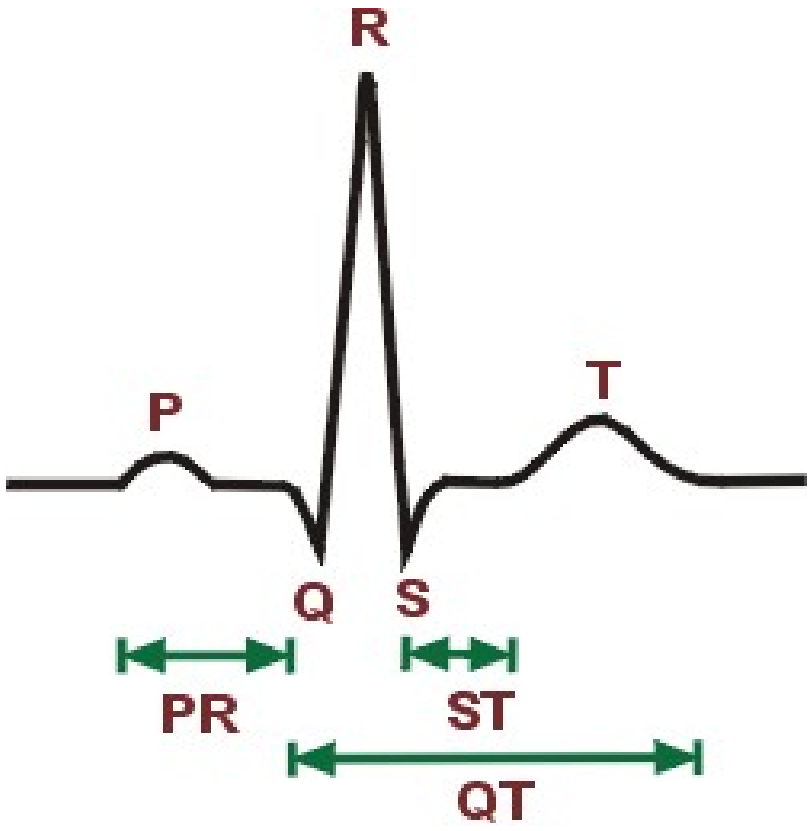




A "typical" ECG – ST Segment

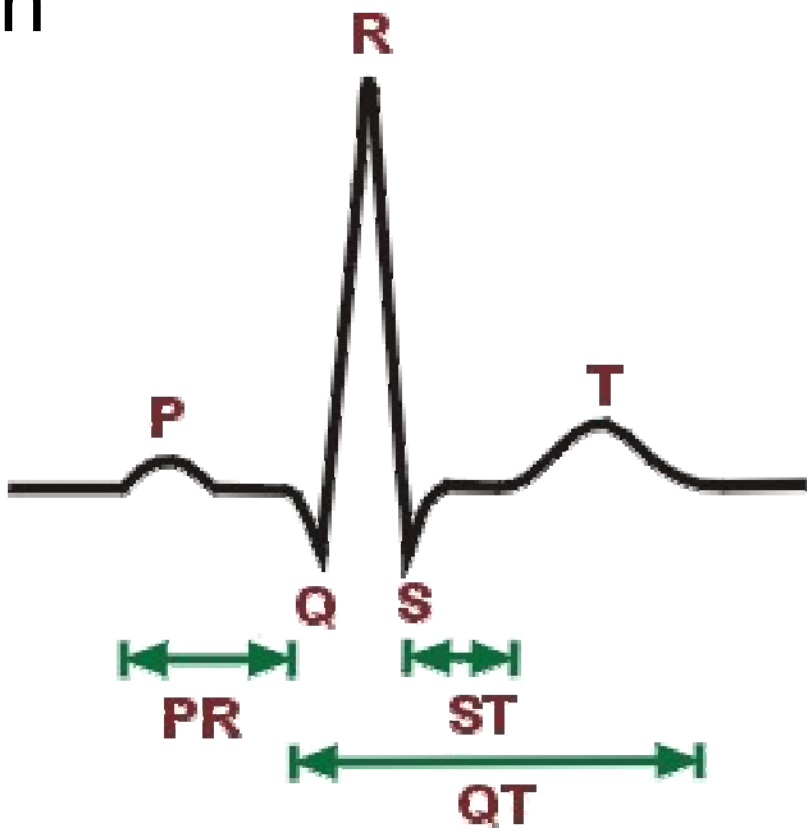
- Depressed or elevated ST segment

  → Ventricular ischemia or hypoxia



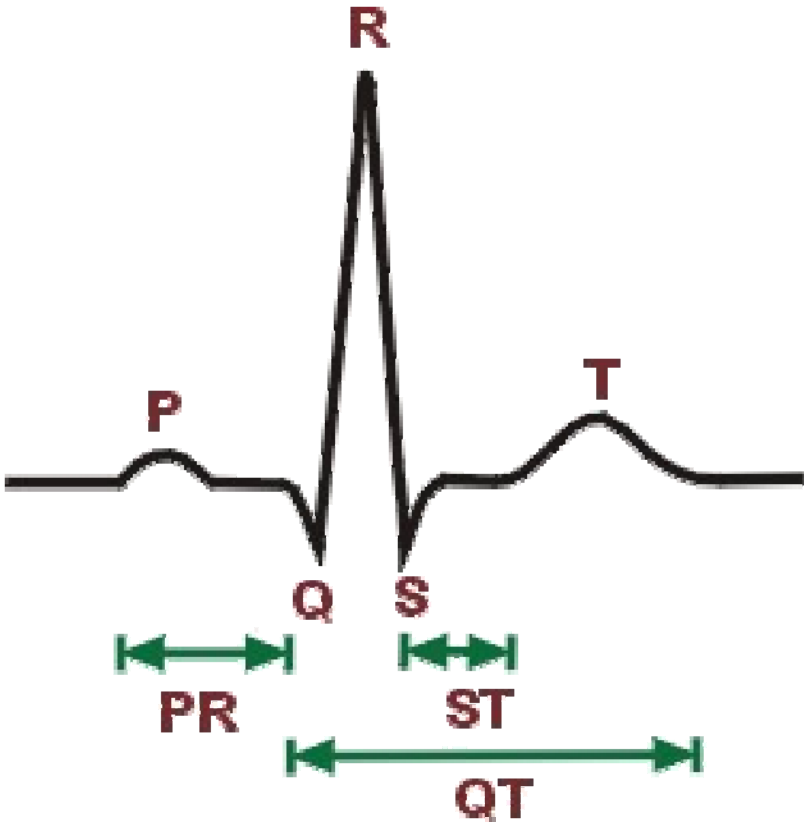
A "typical" ECG – T Wave

- Ventricular repolarization

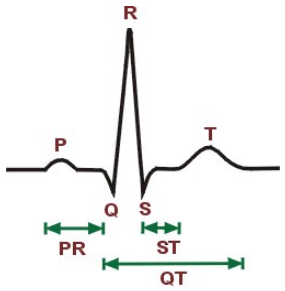


A "typical" ECG – QT Interval

- Normal: 0.2 to 0.4 sec



A "typical" ECG – Summary



WAVE		NORMAL PARAMETER	# OF SMALL SQUARES
P WAVE	Atrial depolarization/contraction	< 0.12 secs	< 3
PR SEGMENT	Conduction delay through AV node; used as baseline onto evaluate ST segment elevation or depression		
PR INTERVAL	Atrial depolarization + conduction delay through AV node	0.12 - 0.20 secs	3 – 5
QRS	Ventricular depolarization/contraction	0.08 - 0.12 secs	2 – 3
ST SEGMENT	Isolectric; ventricles still depolarized	<0.12 secs	< 3
QT INTERVAL	Ventricular depolarization + ventricular repolarization	0.30 – 0.40 secs	7 - 10
T WAVE	Ventricular repolarization	5 – 10 mm	5 – 10

心臟病起因

Sources: http://www.youtube.com/watch?v=BXCNv3MKOVw
http://www.doh.gov.tw/lane/health_edu/j4_1.gif

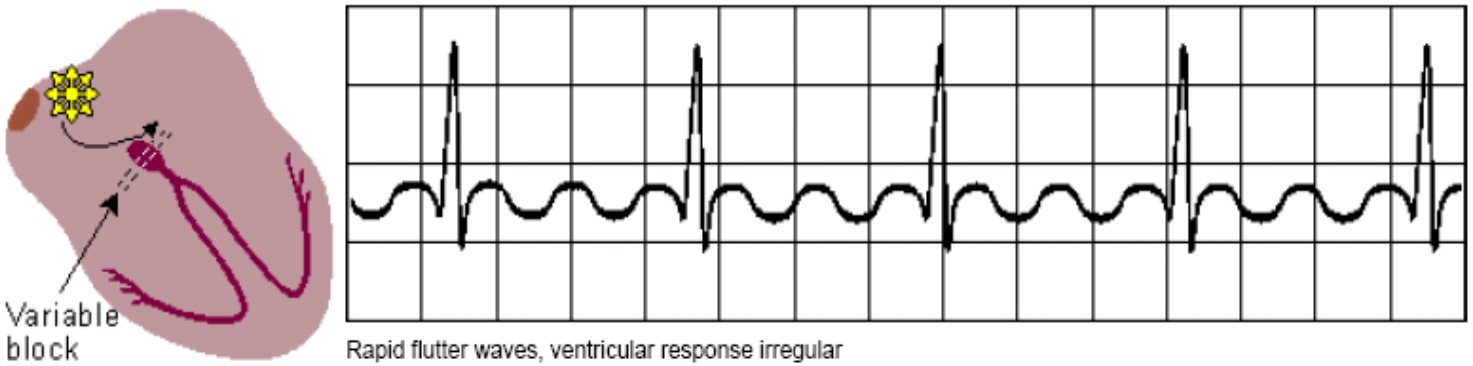
ECG Characteristics, Etiology, Treatment

- **Questions to be asked when analyzing an ECG strip**
  - Is the rate fast or slow?
  - Is the rhythm regular or irregular?
  - Are a P wave and QRS wave present with each cycle?
  - Do the P waves look alike?
  - Do the QRS wave look alike?
  - Is there a P wave preceding every QRS?
  - Is the PR interval within normal limit? (0.12 – 0.20 secs)
  - Is the QRS duration within normal limits? (0.04-0.11secs)
  - Does the rhythm come from the SA node, atria, AV node, or the ventricles?

Atrial Flutter（心房撲動）

Impulses travel in circular course in atria

All complexes normal, evenly spaced
Rate 60 - 100/min

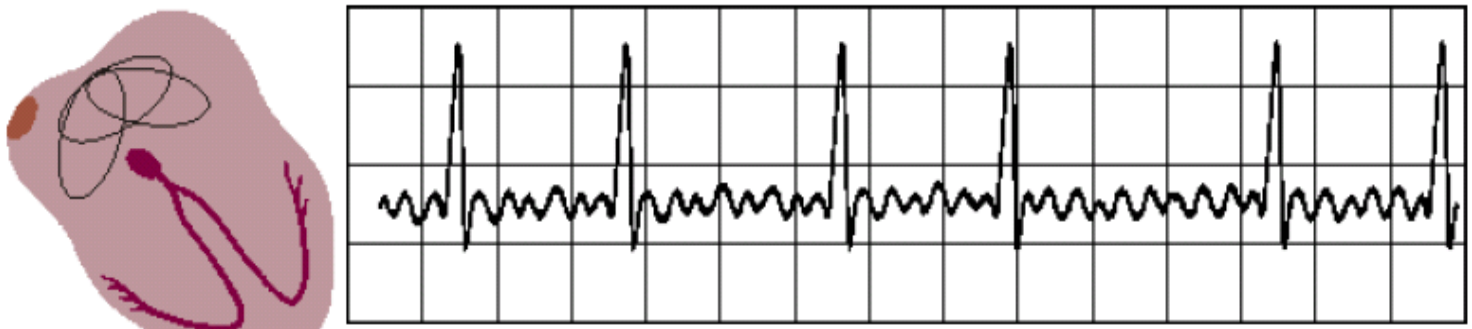


Rapid flutter waves, ventricular response irregular

Atrial Fibrillation（心房纖維顫動）

Impulses have chaotic, random pathways in atria Impulses

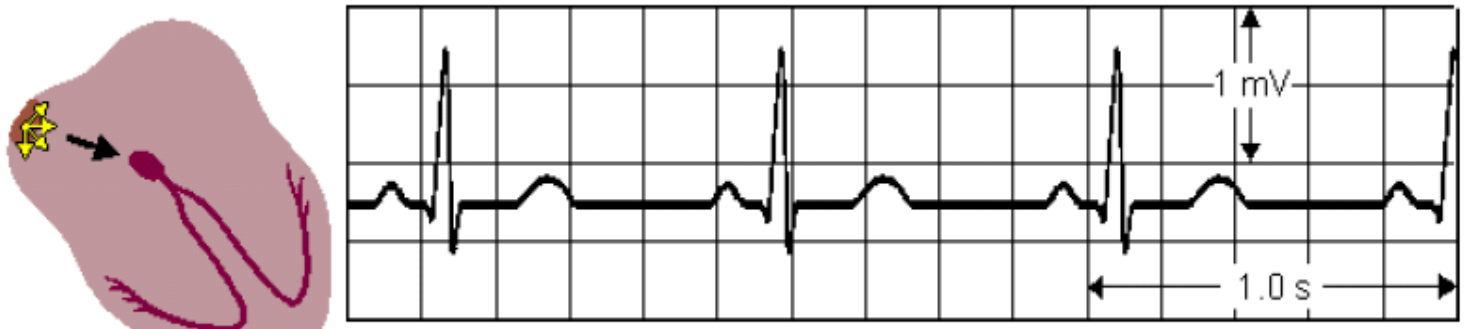
All complexes normal, evenly spaced
Rate 60 - 100/min



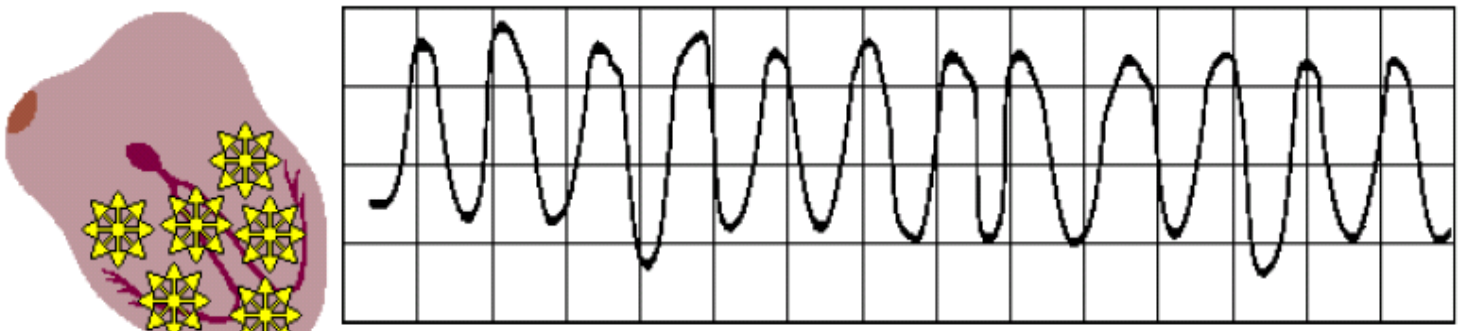
Baseline irregular, ventricular response irregular

Ventricular Fibrillation（心室纖維顫動）

Chaotic ventricular depolarization



All complexes normal, evenly spaced
Rate 60 - 100/min

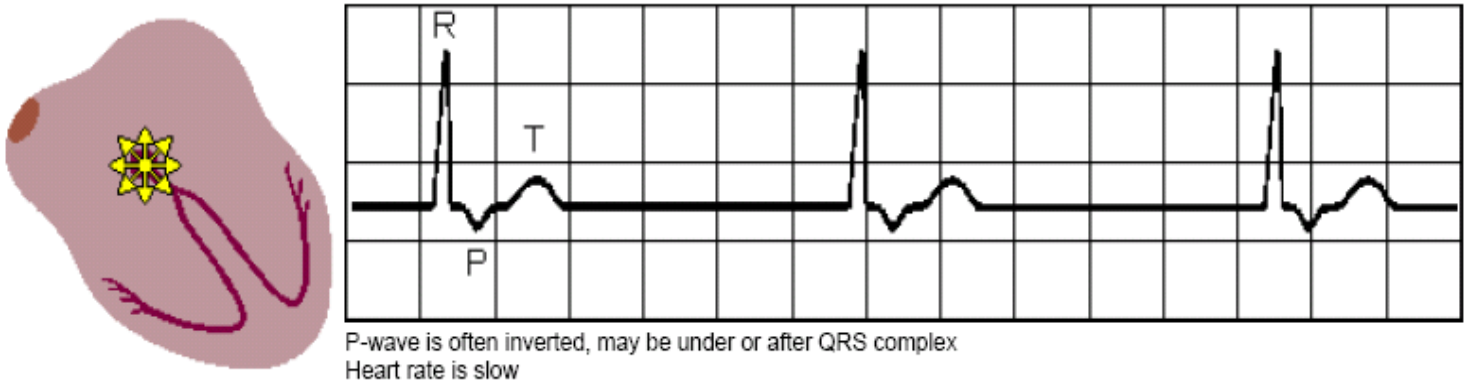


Rapid, wide, irregular ventricular complexes

Junctional Rhythm（房室交界區性心律失常）

Impulses originate at AV node with retrograde and antitrade direction

All complexes normal, evenly spaced
Rate 60 - 100/min

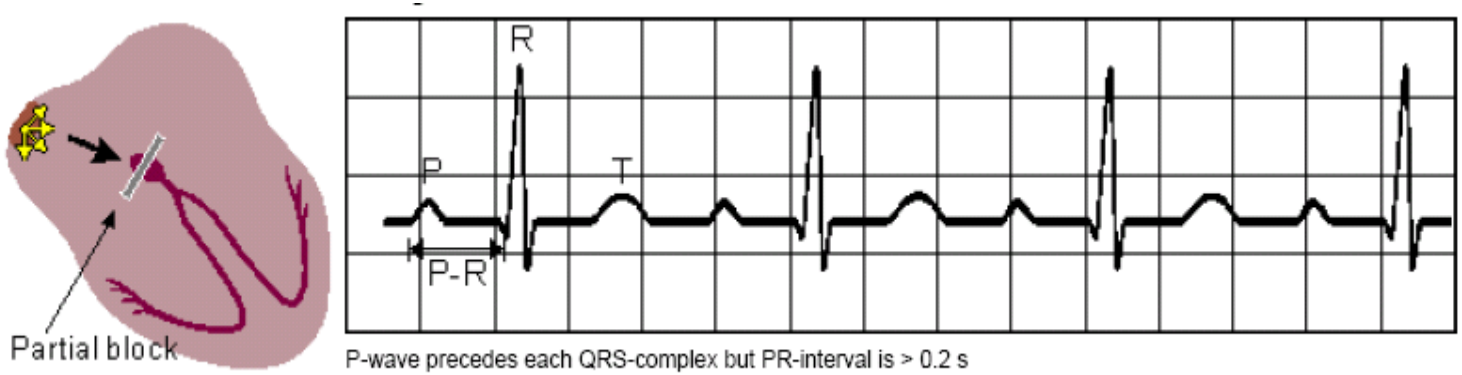


P-wave is often inverted, may be under or after QRS complex
Heart rate is slow

First-Degree Atrioventricular Block（一度房室傳導阻滯）

Atrio-ventricular conduction lengthened

All complexes normal, evenly spaced
Rate 60 - 100/min



P-wave precedes each QRS-complex but PR-interval is > 0.2 s

Second-Degree Atrioventricular Block（二度房室傳導阻滯）

Sudden dropped QRS-complex

Third-Degree Atrioventricular Block (三度房室傳導阻滯)

Impulses originate at AV node and proceed to ventricles

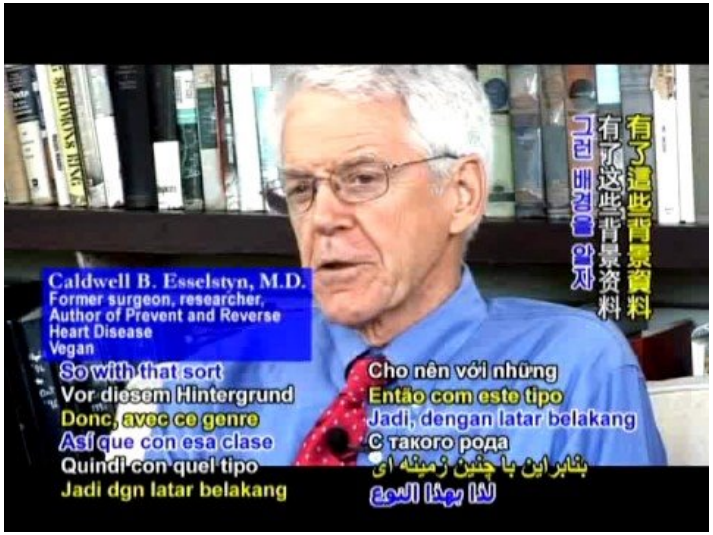
Atrial and ventricular activities are not synchronous

All complexes normal, evenly spaced
Rate 60 - 100/min

P-P interval normal and constant,
QRS complexes normal, rate constant, 20 - 55 /min

預防及治療心臟病（影片）

- 預防及治療心臟病(一) 影片
- 預防及治療心臟病(二) 影片
- 預防及治療心臟病(三) 影片
- 預防及治療心臟病(四) 影片



Sources: http://www.youtube.com/watch?v=dy244ohOZdI&feature=related
http://www.youtube.com/watch?v=gz1D1vPqlwU&feature=related
http://www.youtube.com/watch?v=QFuDw9qC3-M&feature=related
http://www.youtube.com/watch?v=mNVNs0_VY6I&feature=related
http://img.youtube.com/vi/tQPFNy8I0i0/0.jpg

Off to the ECG Measurement

Acknowledgements

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- Grant from Ministry of Education

- Teaching Assistants

Thanks for Your Attention!!!

Source:
http://www.cartoonstock.com/newscartoons/cartoonists/mba/lowres/mban1616l.jpg