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Physiological Basis of ECG

M1 – Cardiovascular/Respiratory Sequence

Louis D'Alecy, Ph.D.

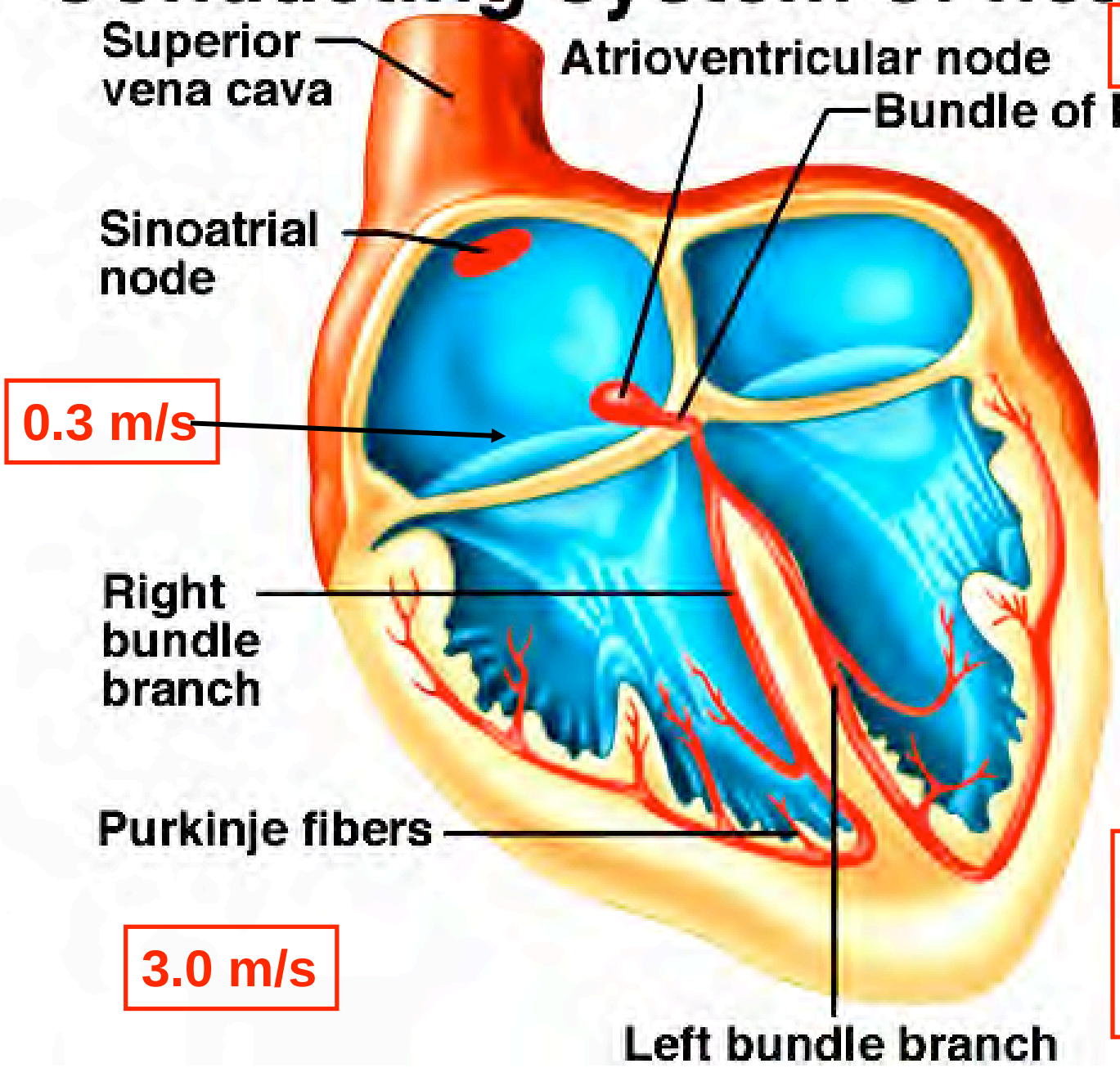
Fall 2008

Friday 10/31/08, 10:00
Physiological Basis of ECG 1

16 slides, 50 min.

1. Wave of depolarization
2. Pacemaker potentials
3. LV action potential
4. Mechanical event
5. Surface electrical (ECG) event

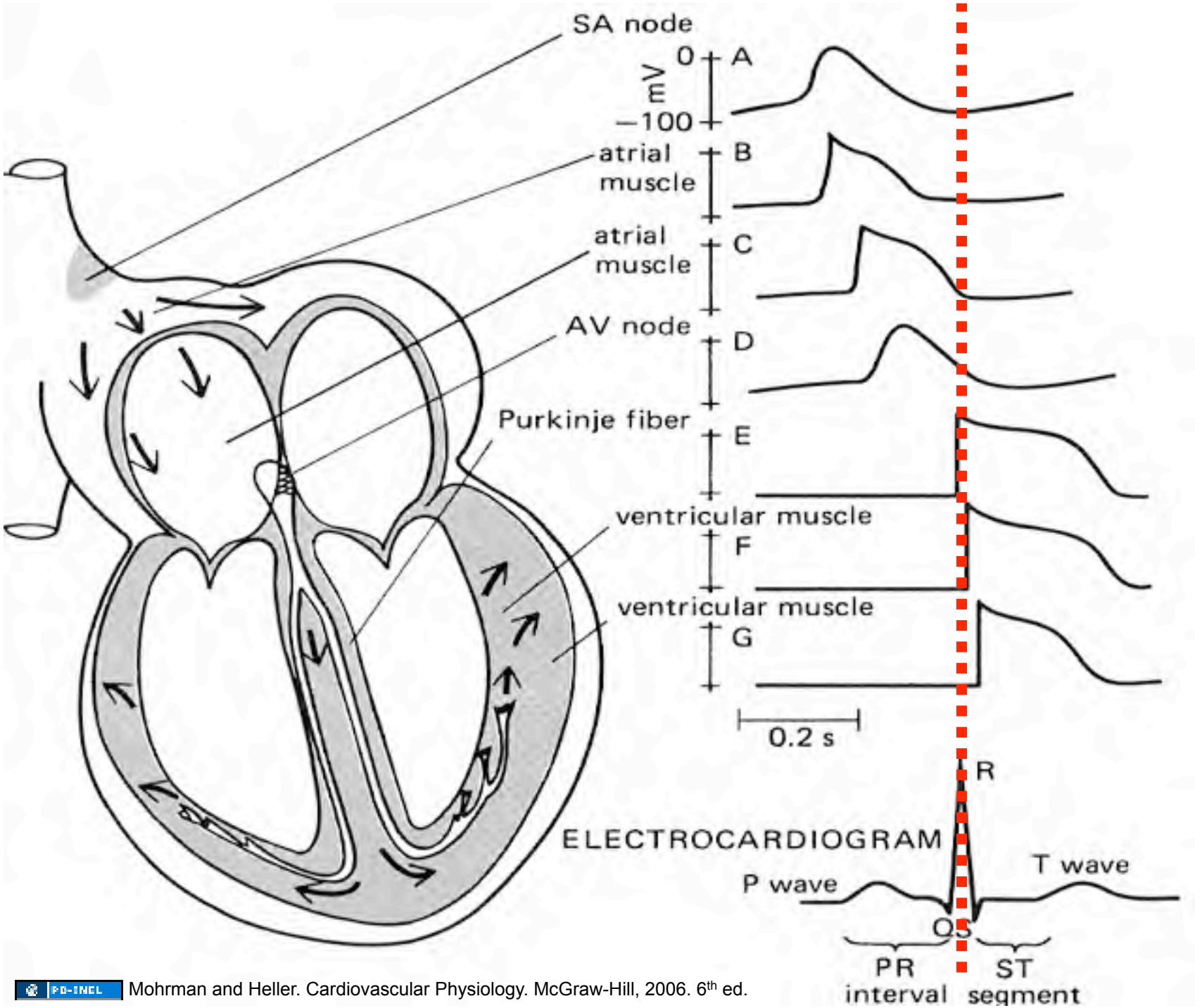
Conducting system of heart



0.05 m/s

Delay

Ventricular Muscle 0.5 m/s



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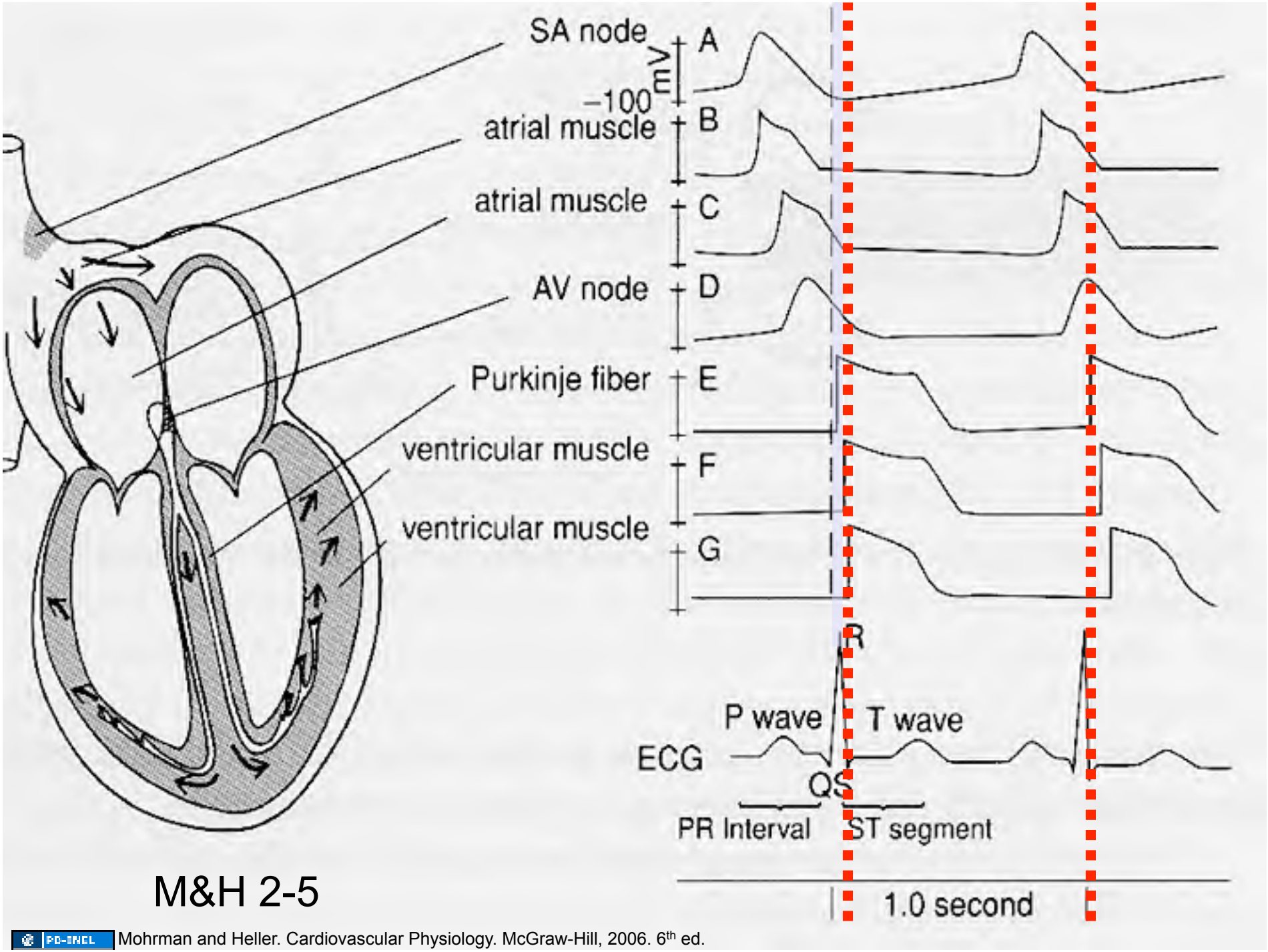
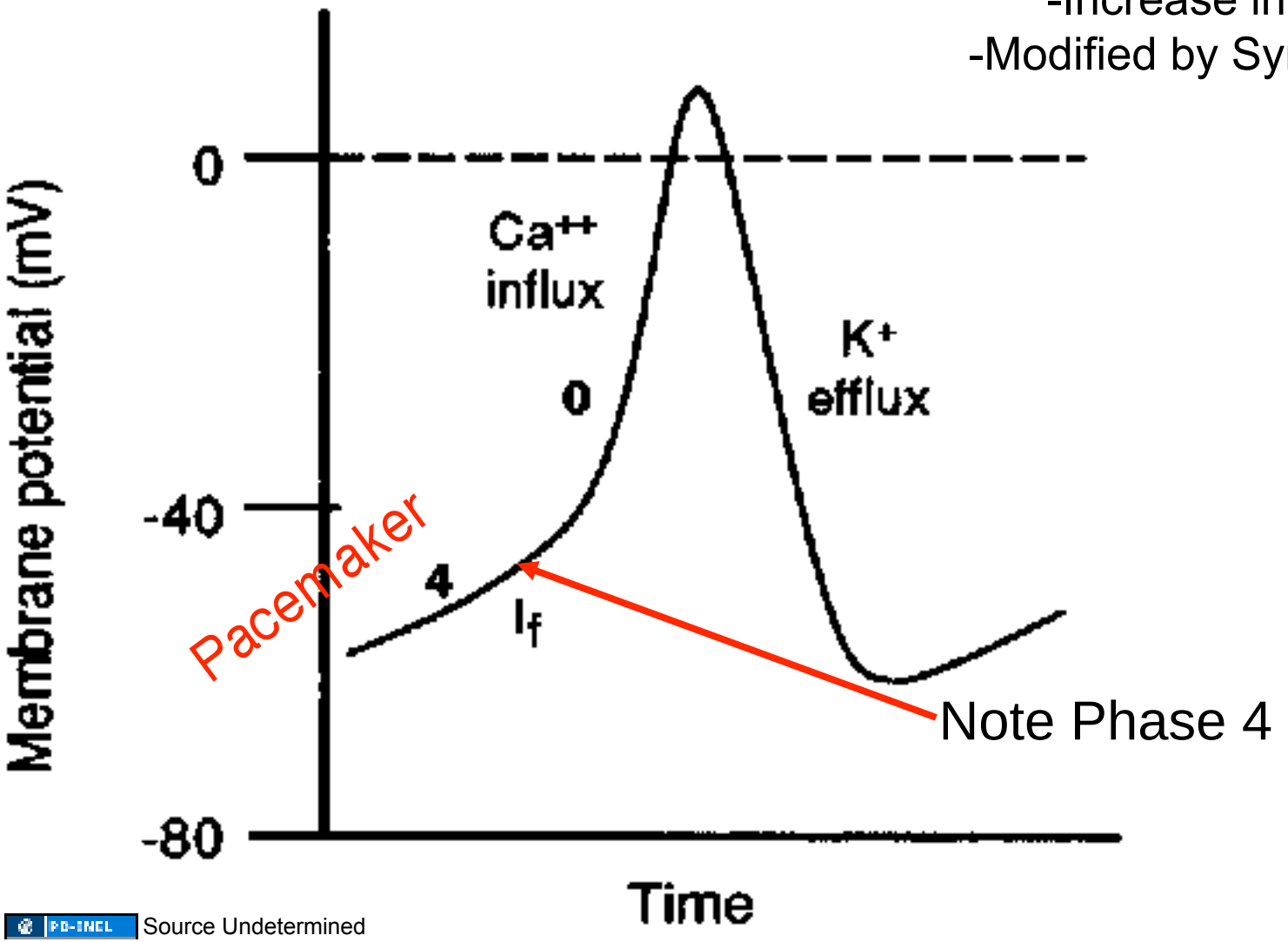


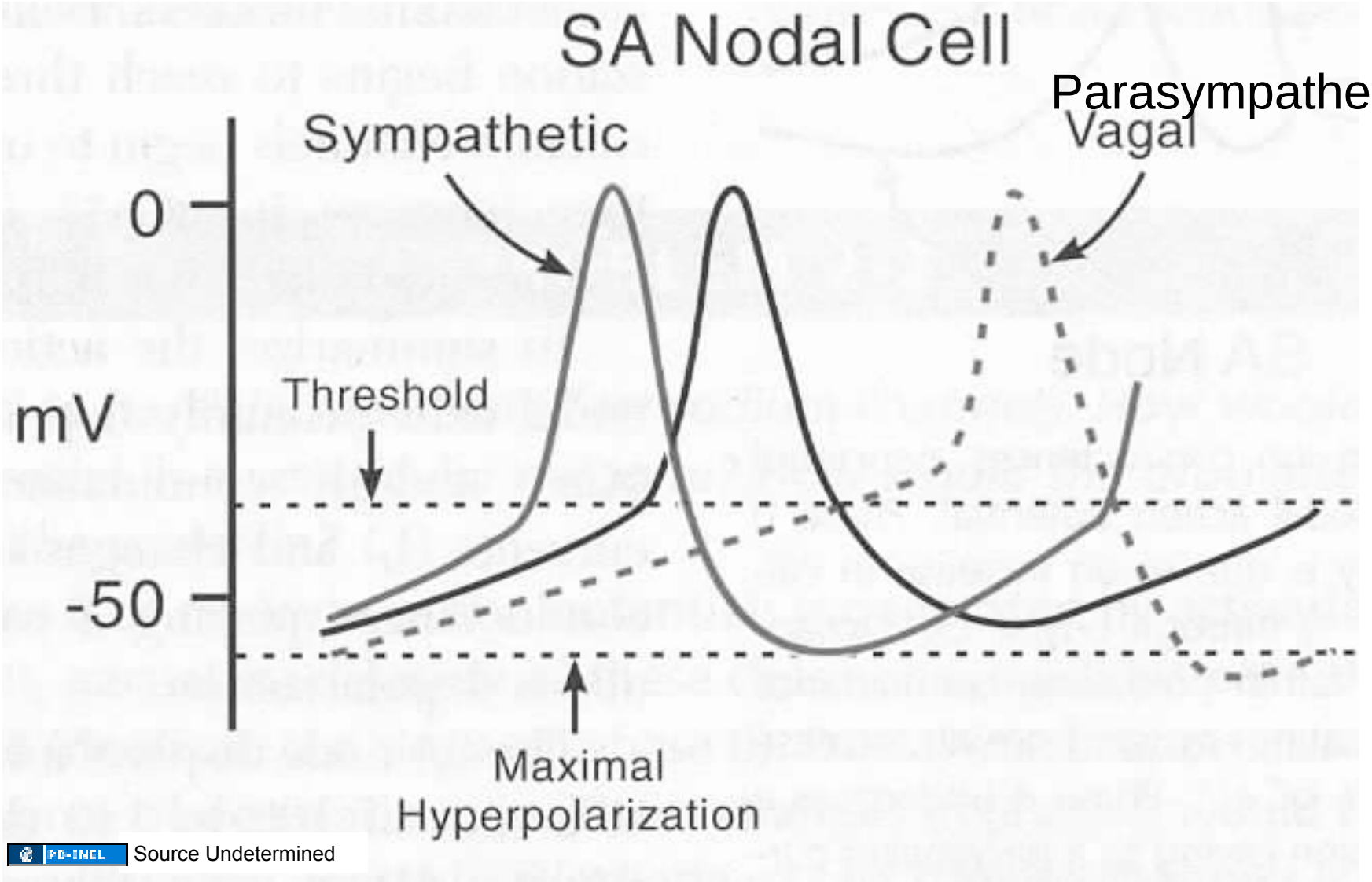
M&H 2-5

 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

SA Node Action Potential = Primary Pacemaker

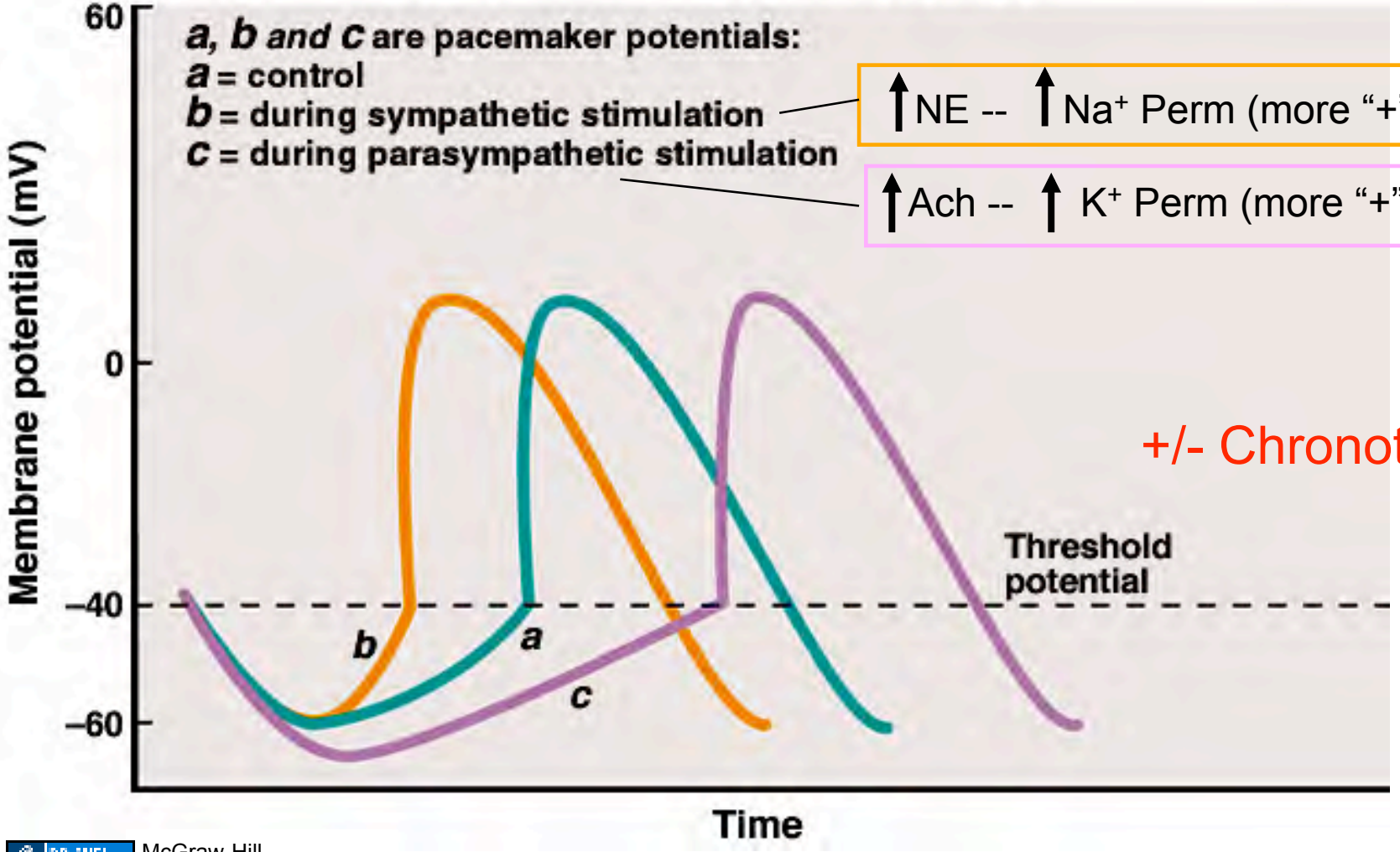
-Phase 4 :
-progressive decrease K+ perm
-Increase in Na+ perm
-Modified by Sym & Para Sym





Similar to M&H Fig 2.6

Sympathetic/parasympathetic nerve stimulation

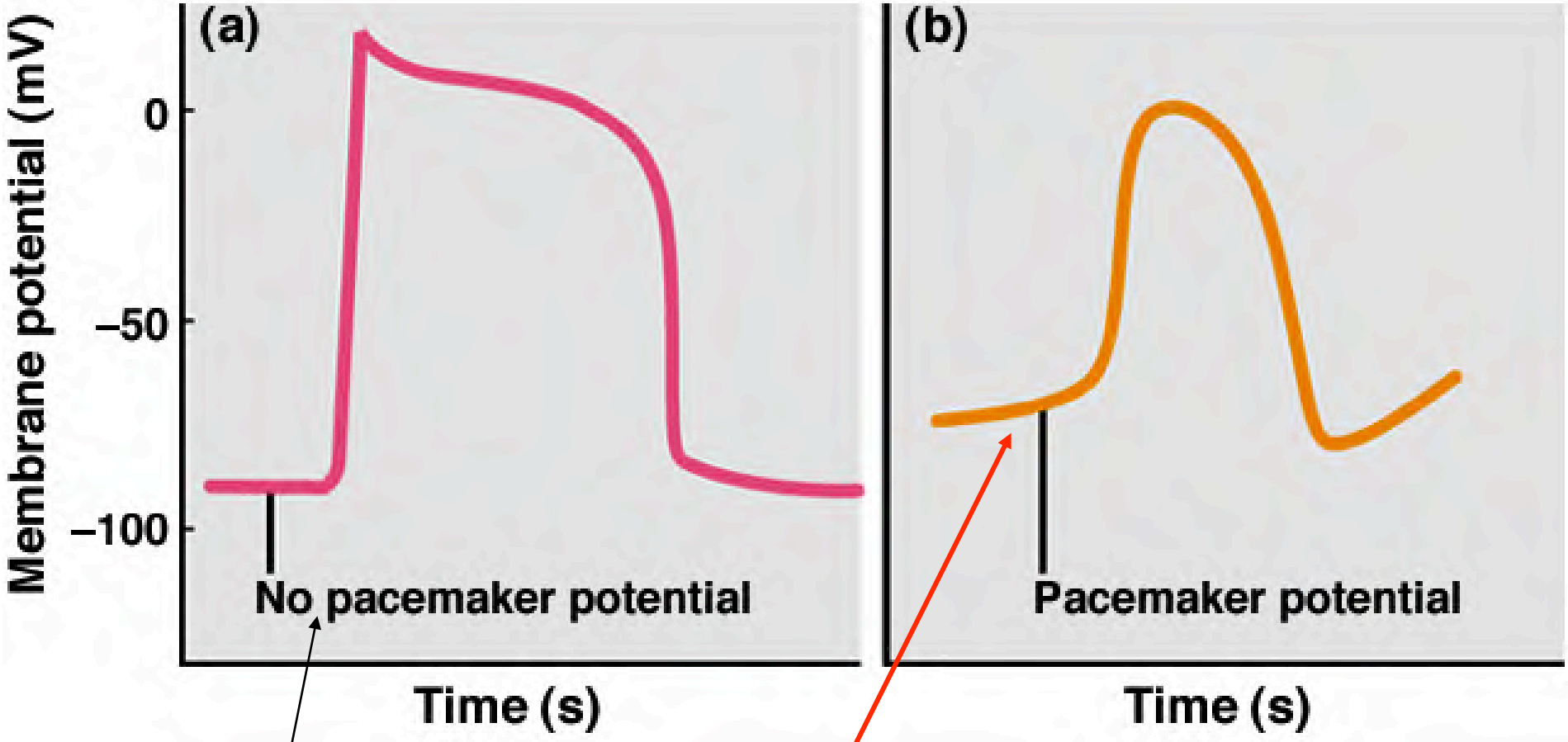


↑NE -- ↑Na^+ Perm (more "+" leak in)

↑Ach -- ↑ K^+ Perm (more "+" leak out)

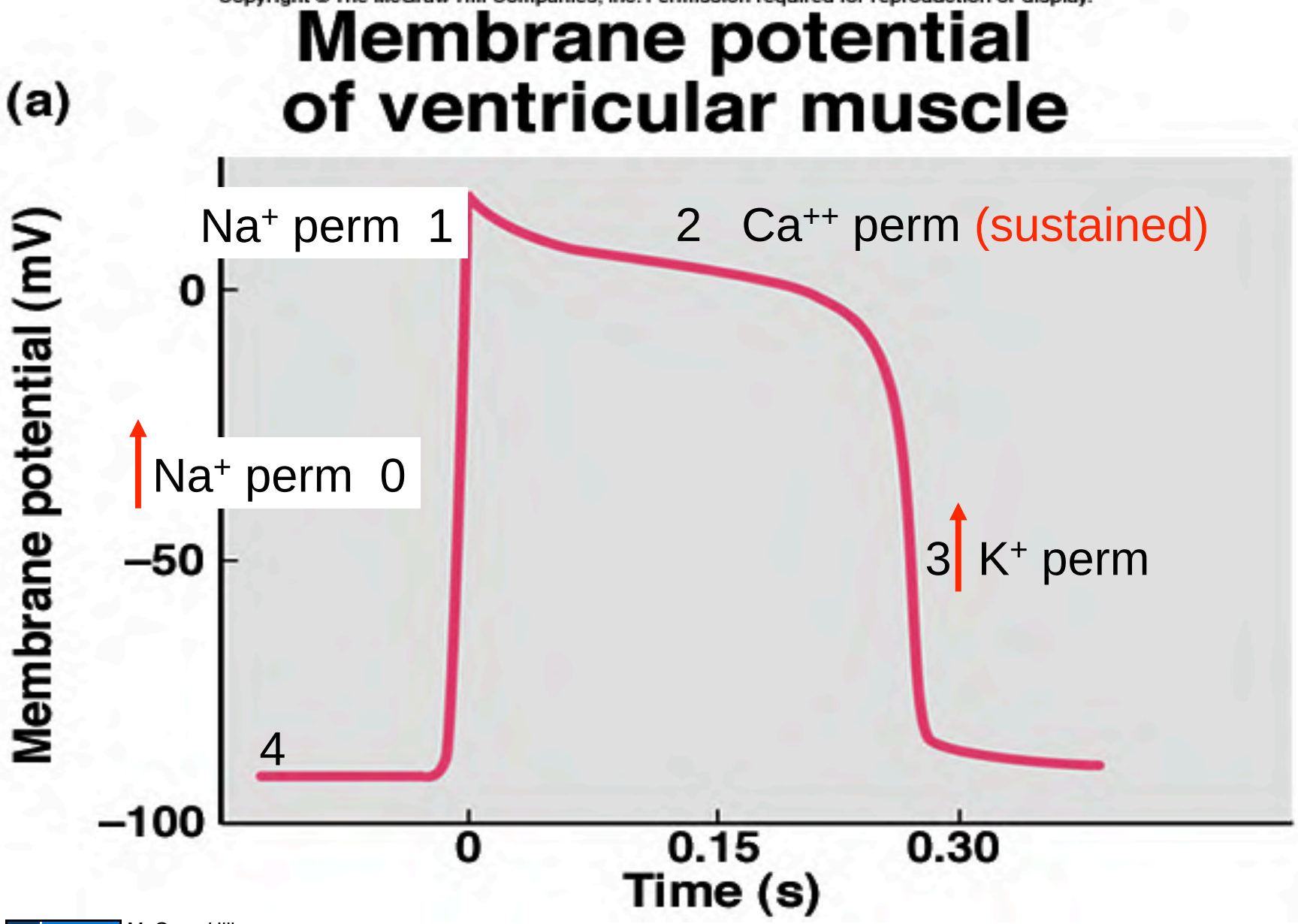
+/- Chronotropic

Comparison of action potentials

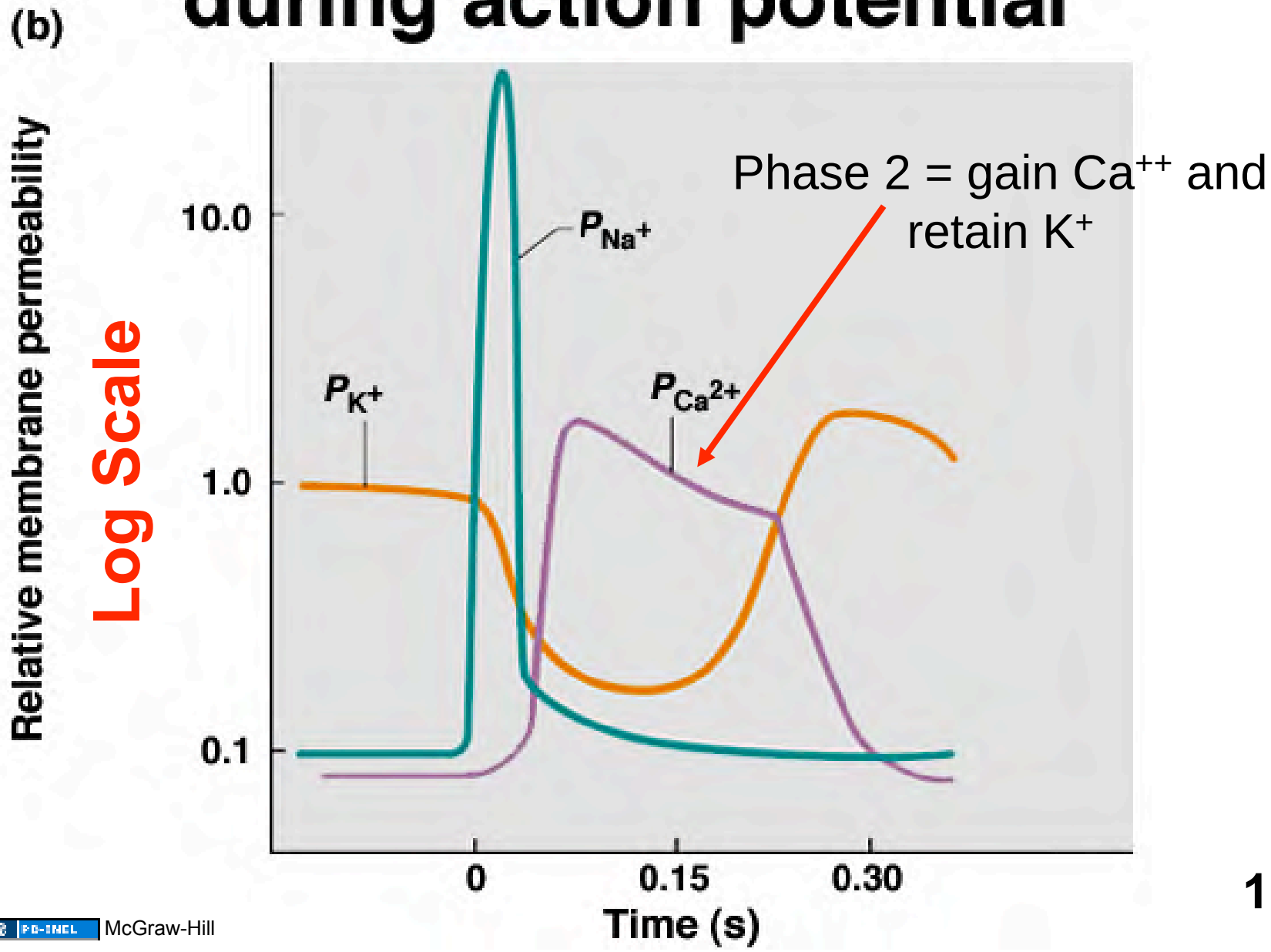


"apparent"

Phase 4 diastolic depolarization



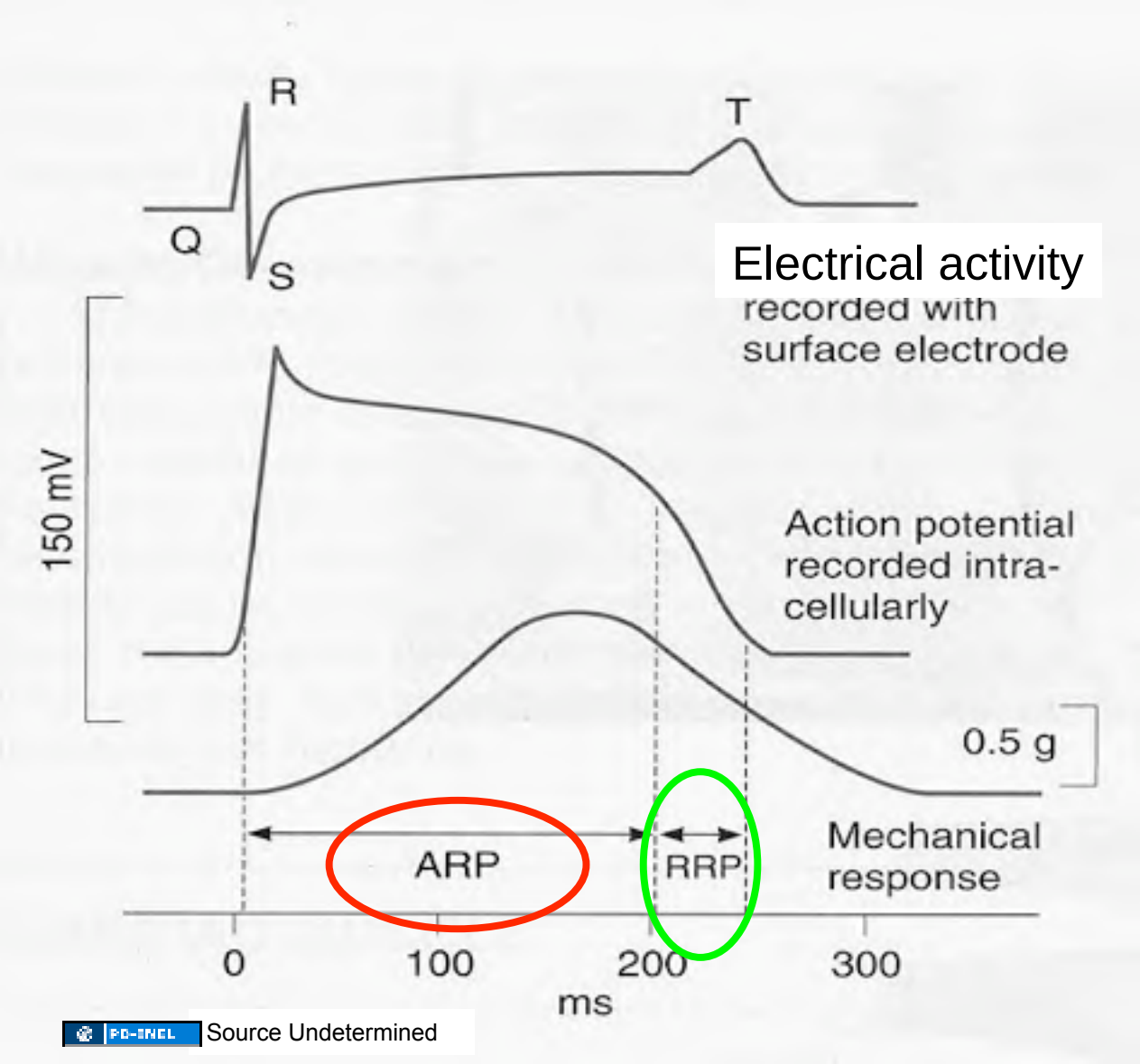
Relative permeability during action potential



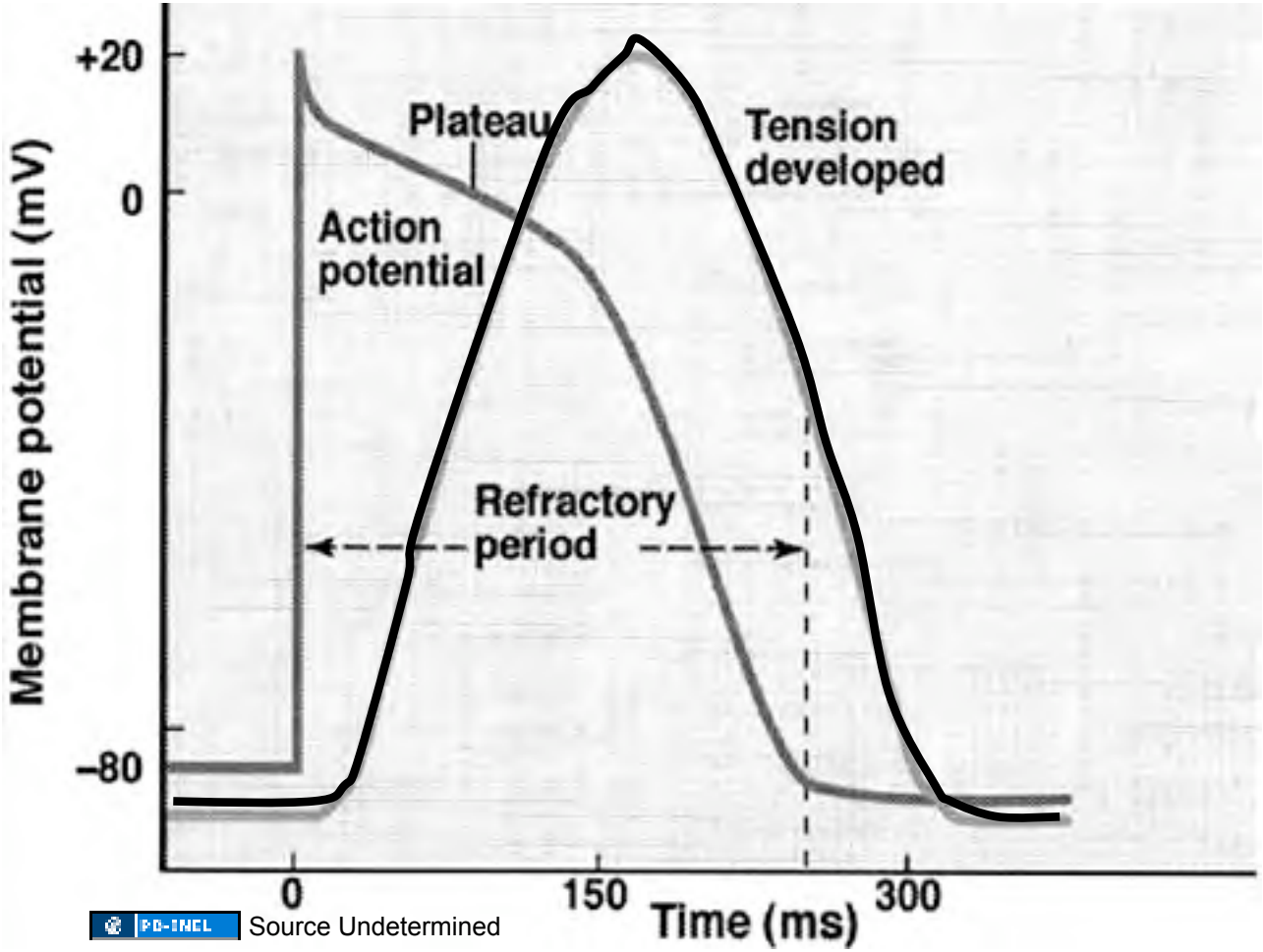
Phase 2 = gain Ca^{++} and retain K^+

Absolute Refractory Period (ARP)

Relative Refractory Period (RRP)



So why can't heart muscle develop tetanic contractions?

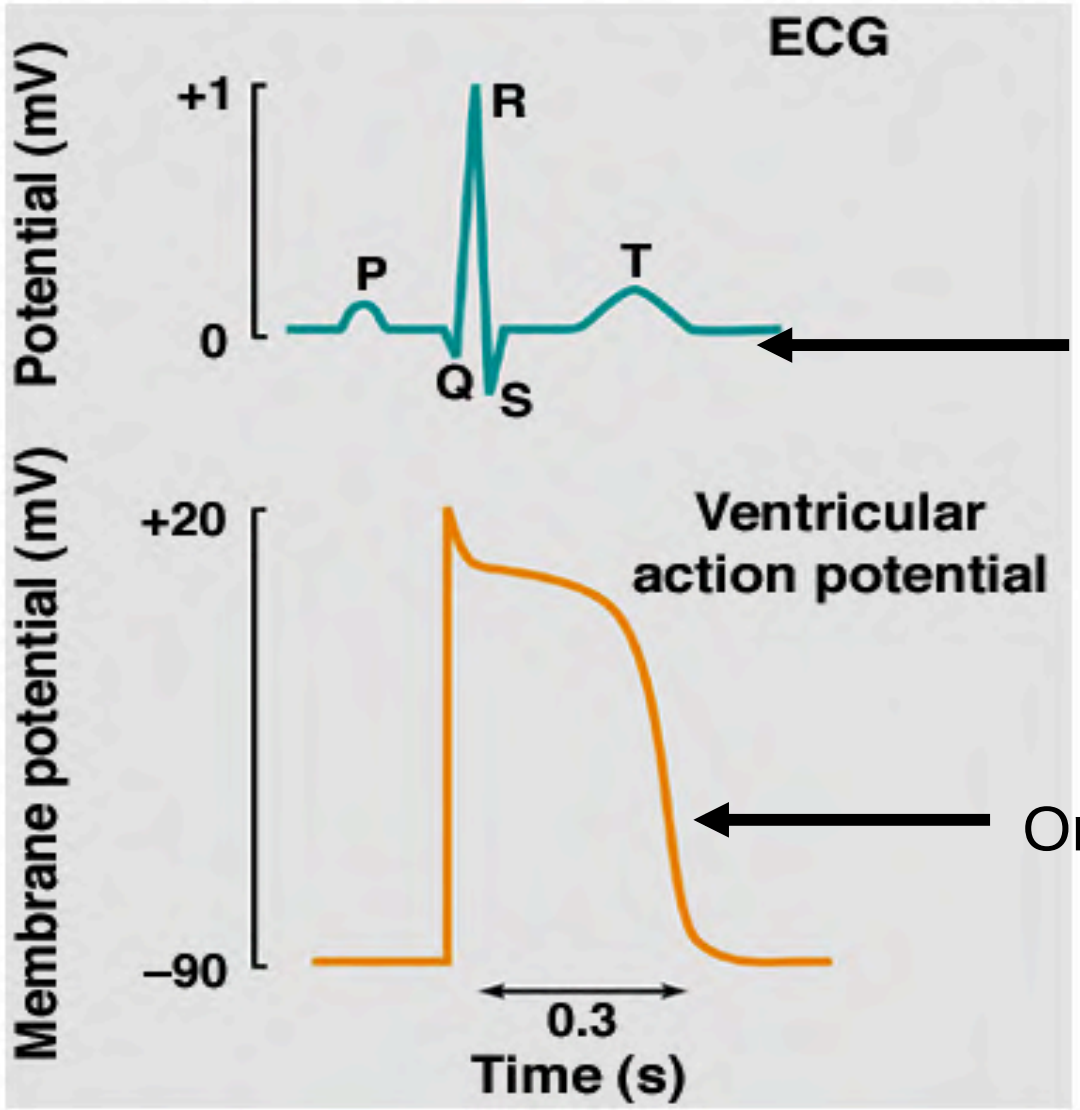


PD-INCL Source Undetermined

Ventricular action potential lasts almost as long as the mechanical tension development so there is little or no tension left (after Refractory period) to build upon.

So why is the ECG so small (1 mv) and action potential so big (110 mv)?

?Bag of batteries?
AC and DC Coupling



Entire heart At Body Surface = 1 MV

One LV cell AP = 110 MV

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What are the waves of the ECG?

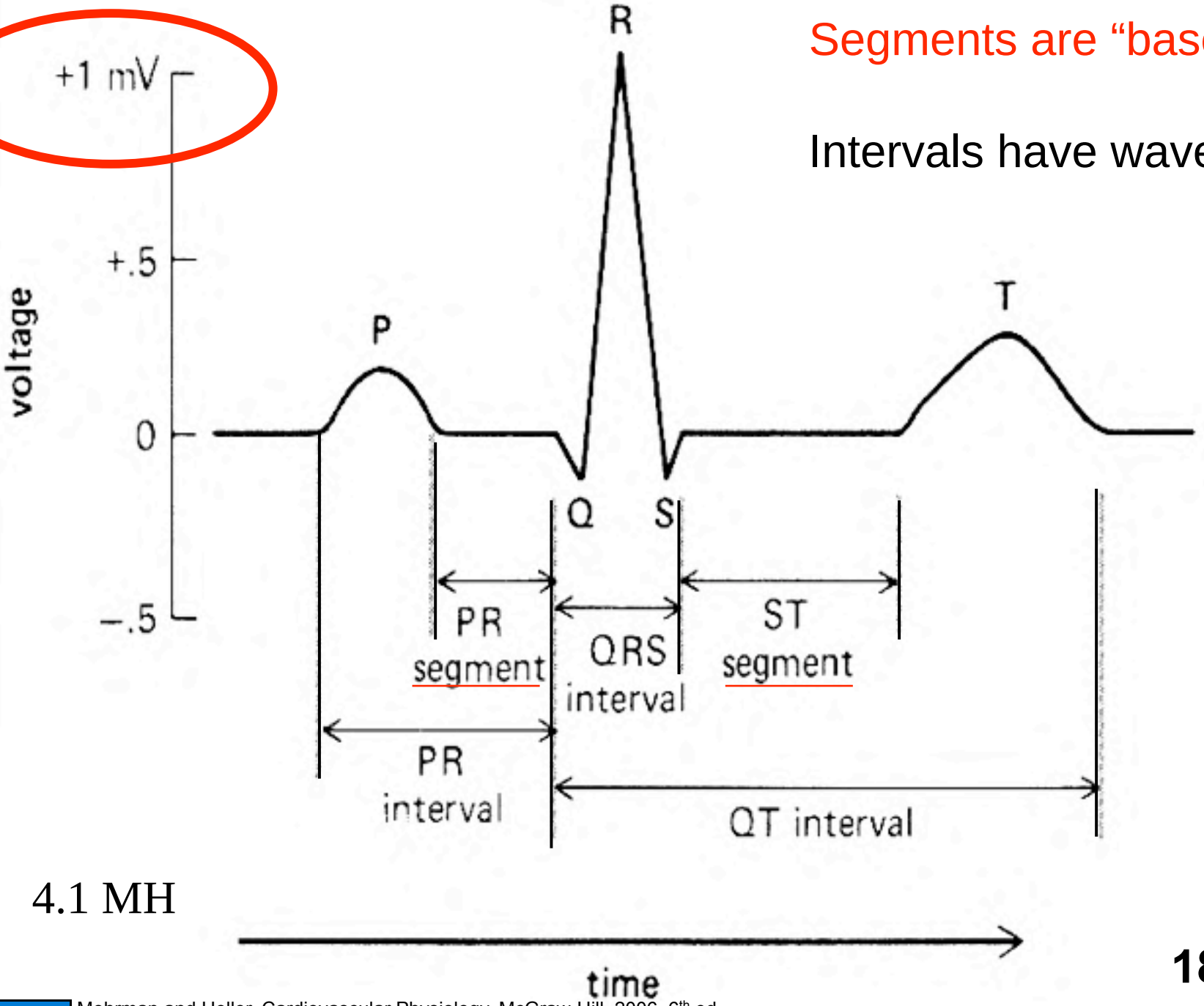
P wave = atrial depolarization

QRS = ventricular depolarization

T = ventricular repolarization

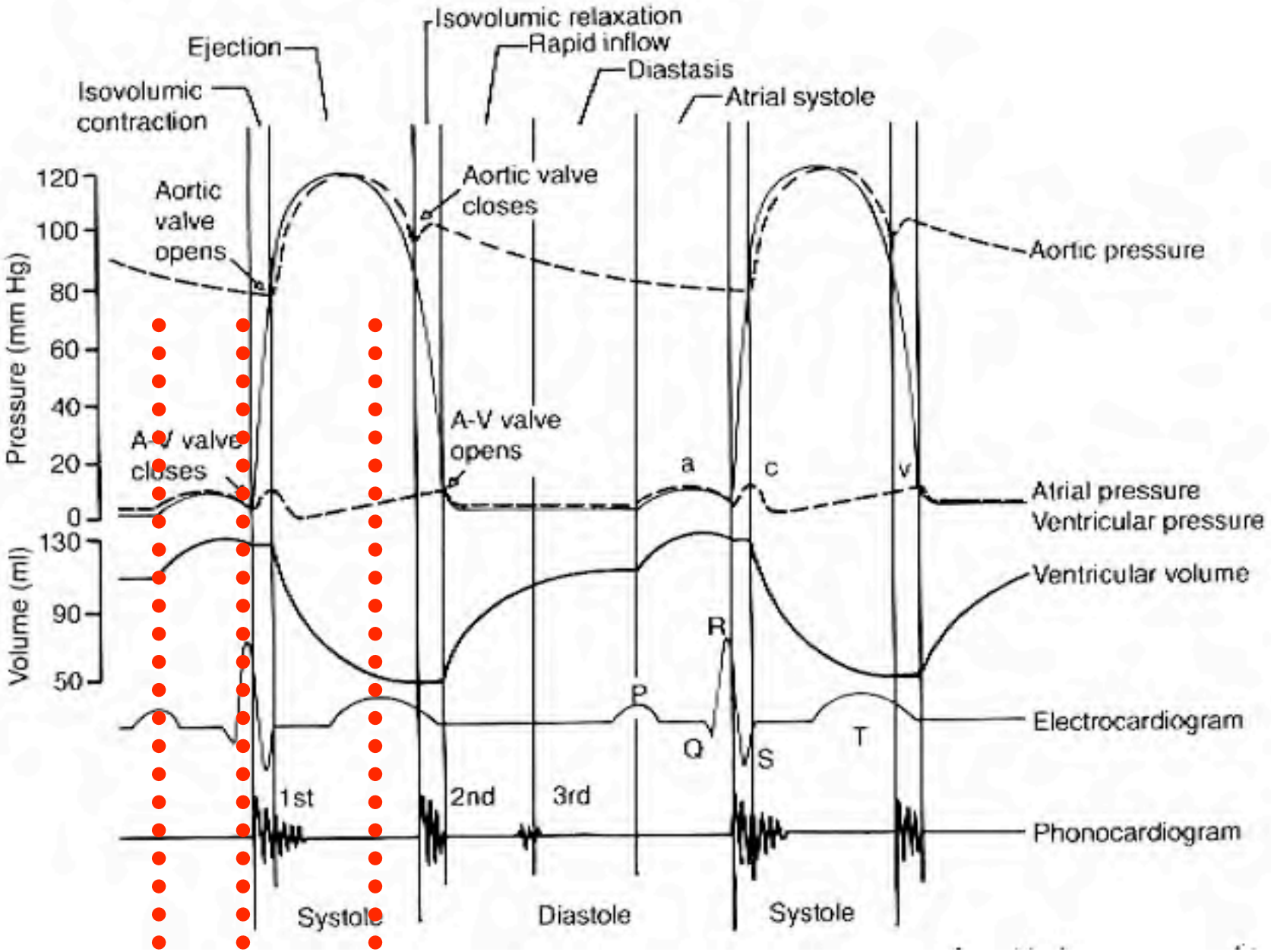
Segments are “baseline

Intervals have waves



4.1 MH

 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.



P QRS T

Friday 10/31/08, 11:00
Physiological Basis of ECG 2

22 slides , 50 min

1. Limb leads
2. Hidden assumptions
3. Rate and Rhythm
4. Axis
5. 12 Lead = 6 Frontal + 6 Precordial
6. Basic examples

12 Lead

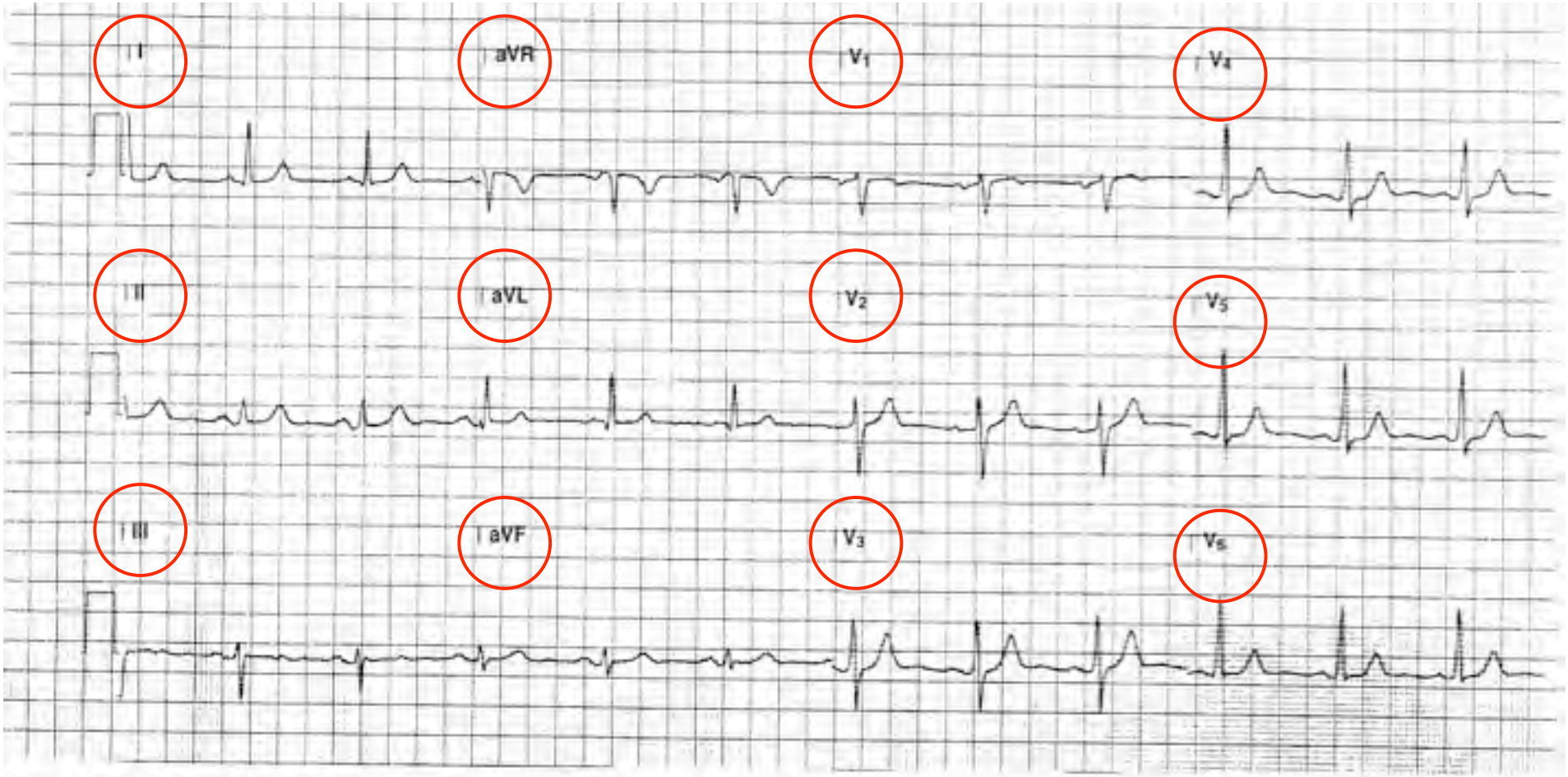
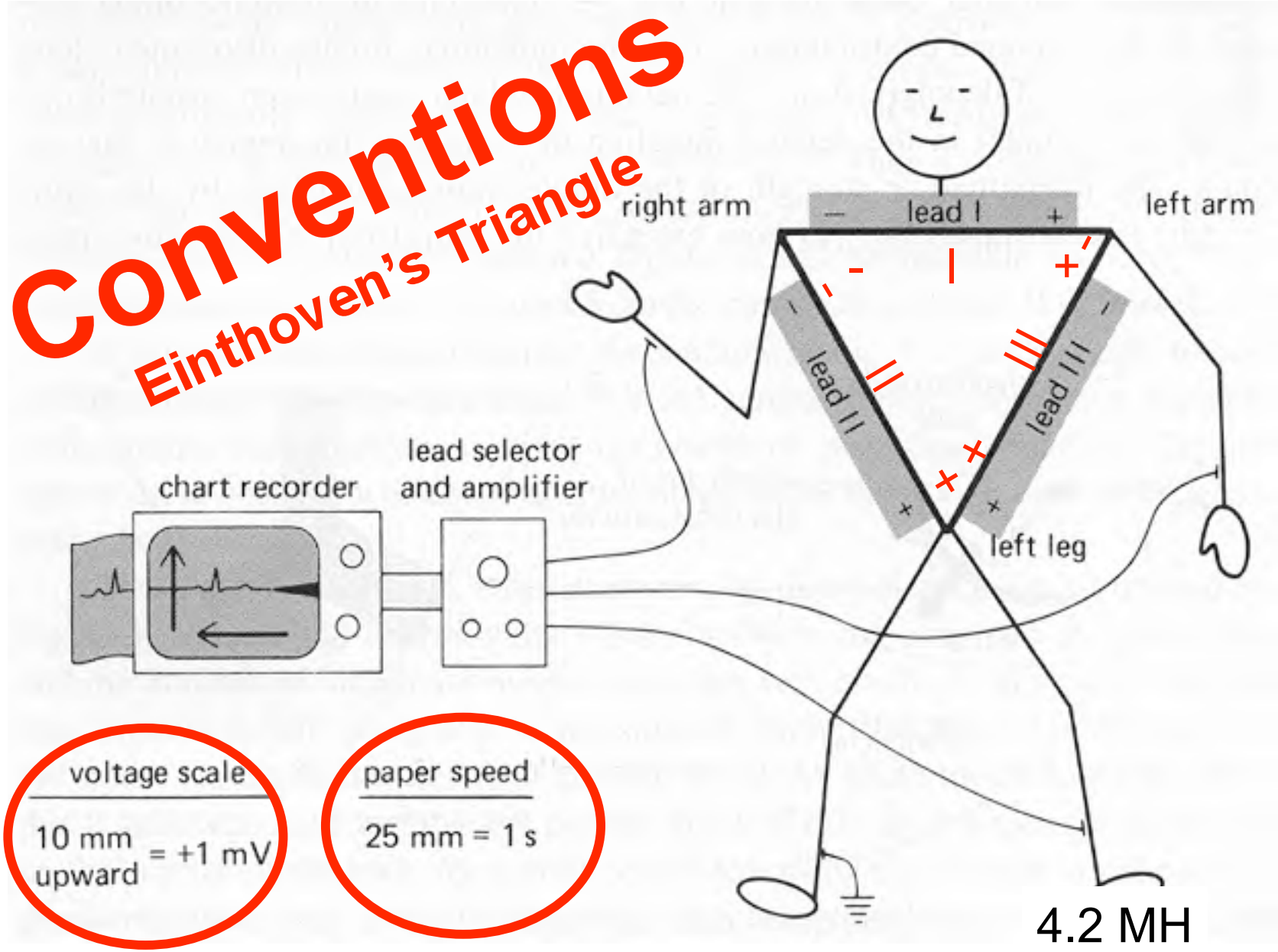


Figure 4.28. **12-lead ECG (normal).** The rectangular upward deflection at the beginning of each line is the voltage calibration signal (1 mV). *Rhythm:* normal sinus. *Rate:* 70 bpm. *Intervals:* PR, 0.17; QRS, 0.06; QT, 0.40 sec. *Axis:* 0° (QRS is isoelectric in lead aVF). The P wave, QRS complex, ST segment, and T waves are normal. Notice the gradual increase in R wave height between leads V_1 through V_6.

PD-INCL Lilly, L. Pathophysiology of Heart Disease. Lippincott, 2007. 4th ed.

Conventions

Einthoven's Triangle



4.2 MH

“Hidden” assumptions ECG:

Every lead measures voltage between two points.

Every lead has a “agreed upon” (+) and (-).

Depolarizations are set for upward deflections.

When a wave of depolarization (+) moves to (+) electrode it gives upward (+) deflection

Dubin’s “Rapid Interpretation of EKG’s”

“+ + +”

ECG

P wave = atrial depolarization

QRS = ventricular depolarization

T = ventricular repolarization

The repolarization of the ventricle or T wave must retrace the QRS in the reverse direction in order to give a positive or upward deflection!!

(see bottom of page 76)

Last to depolarize are first to repolarize!

Dubin “Rapid Interpretation of EKG’s”

Rate = beats/min

Rhythm = regularity of recurrence

Mean Electrical Axis = orientation of most intense depolarization

?? size

?? location

?? meaning

Mean Electrical Axis of the Heart:

Occurs at the instant of most intense depolarization.

Follows the general direction of the “R” wave of depolarization

Size is determined by:

- the greater the e-wave == the greater the deflection

- the greater the mass of tissue == the greater the deflection

- the greater the coordination == the greater the deflection

Effect of Mass on Mean Electrical Axis

Mass (effective, electrical)

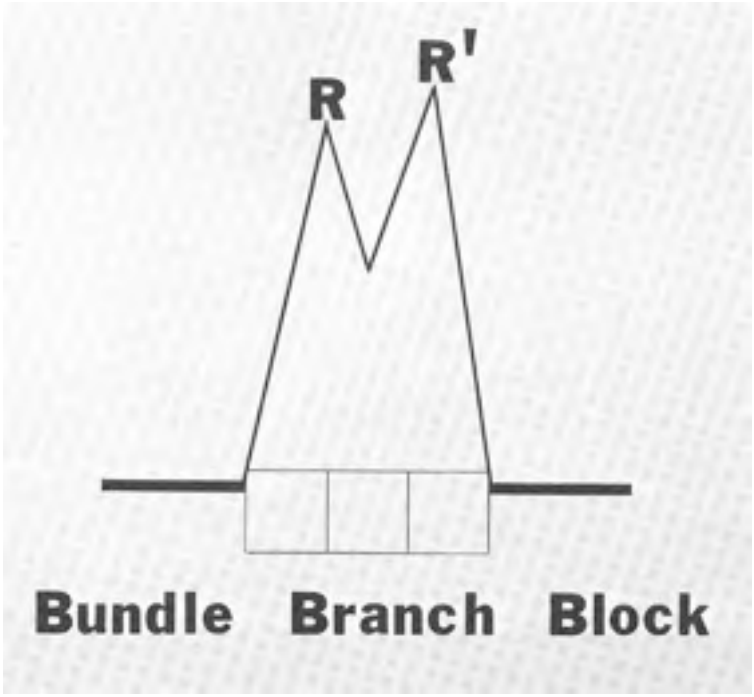
- normal anatomy, atria vs. ventricles
- hypertrophy , atrophy
- infarct (dead tissue)
- ischemia (inadequate blood flow)

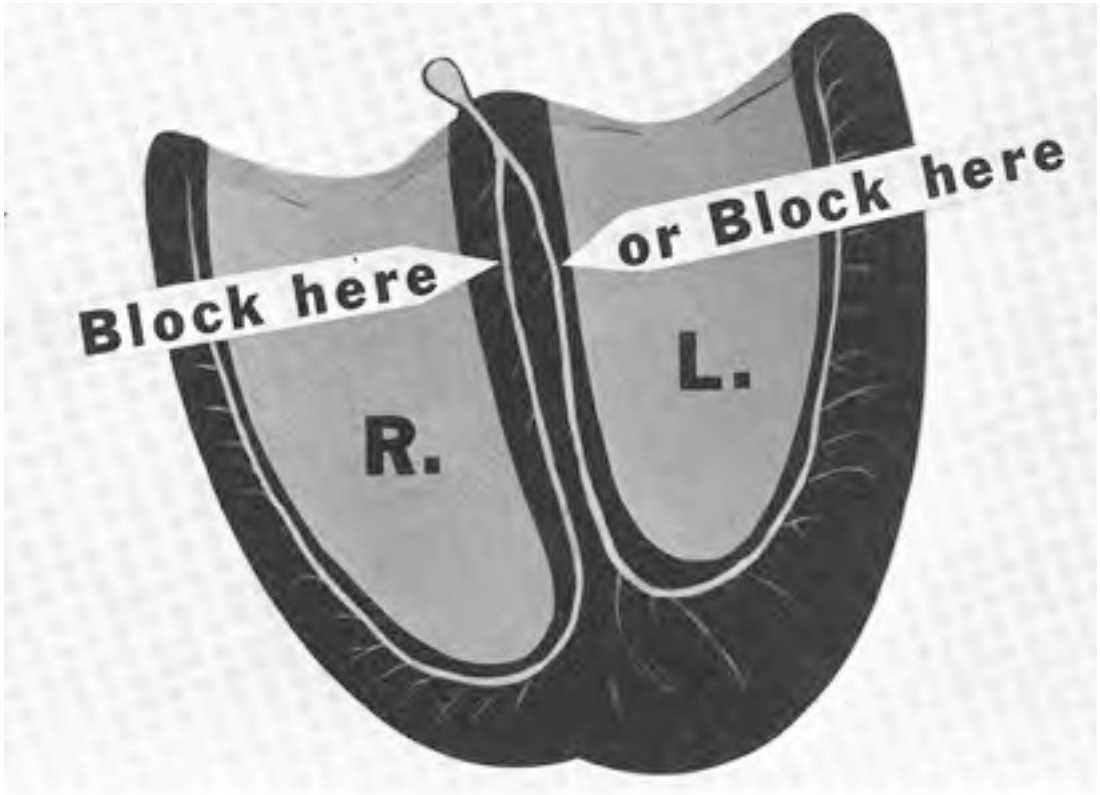
Effect of Electrical coordination on Mean Electrical Axis

Atria
Ventricles
- AV Node
- Bundle of His
- Purkinje System

Damaged Purkinje

Bundle Branch Block



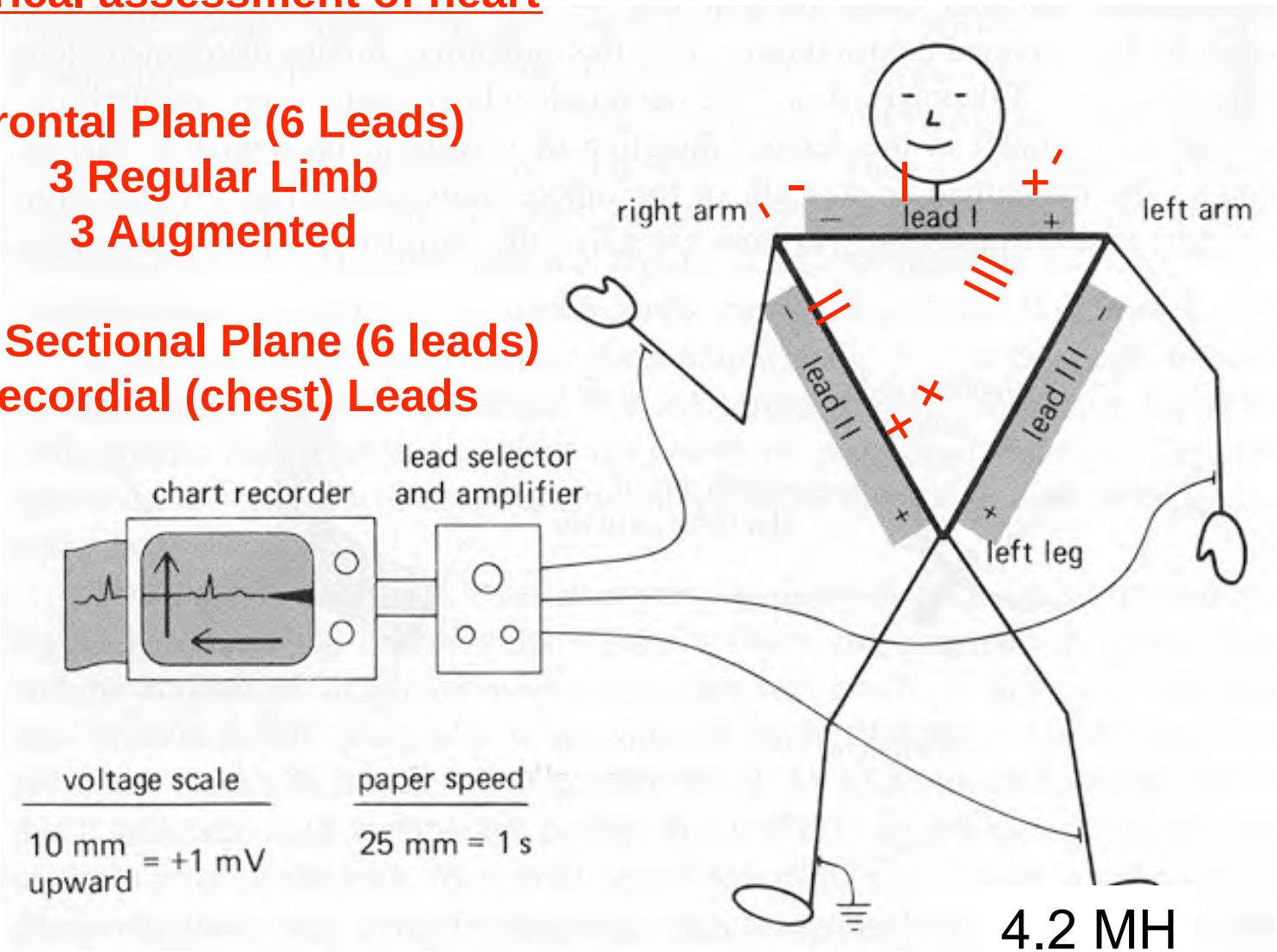


The basic 3 limb leads provide much information BUT……

12 Lead ECG allows a more detailed electrical assessment of heart

Frontal Plane (6 Leads)
3 Regular Limb
3 Augmented

Cross Sectional Plane (6 leads)
Precordial (chest) Leads



4.2 MH

Conventions for 6 Frontal Lead ECG

Lead Name	Positive Electrode +	Negative Electrode -
Lead I	Left Arm	Right Arm
Lead II	Left Leg	Right Arm
Lead III	Left Leg	Left Arm
aVR	Right Arm	Indifferent (1)
aVL	Left Arm	Indifferent (1)
aVF	Left Leg (Foot)	Indifferent (1)

Indifferent lead (1)

is the remaining two limb leads combined.

Augmented (unipolar) limb leads

To gain increased sensitivity and additional electrical perspective three “Augmented Voltage” leads have been devised from original

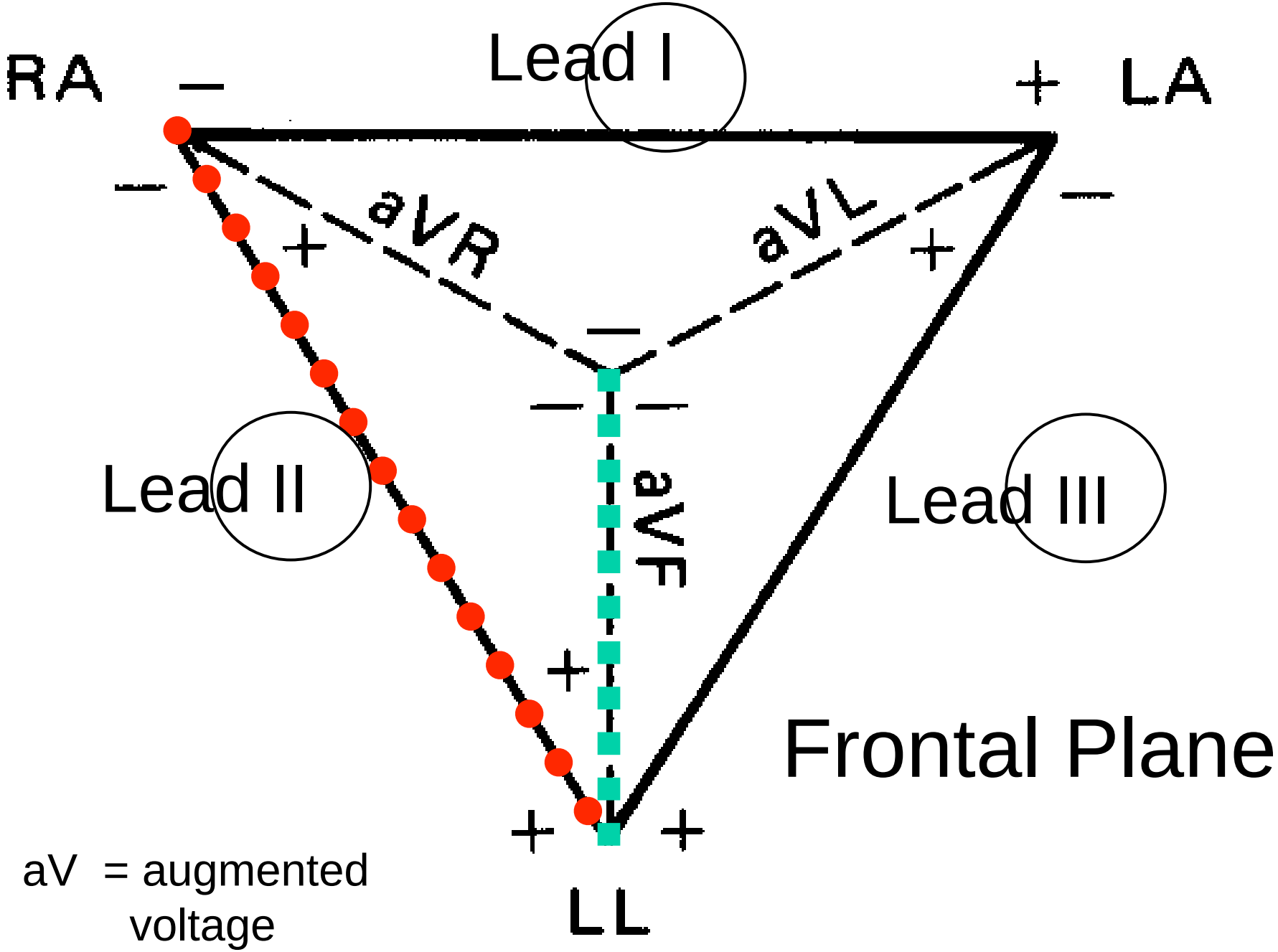
RA, LA and LL leads.

They are aVR, aVL and aVF. The abbreviation defines the positive electrode.

aVR has Right arm +

aVL has Left arm +

aVF has Foot +



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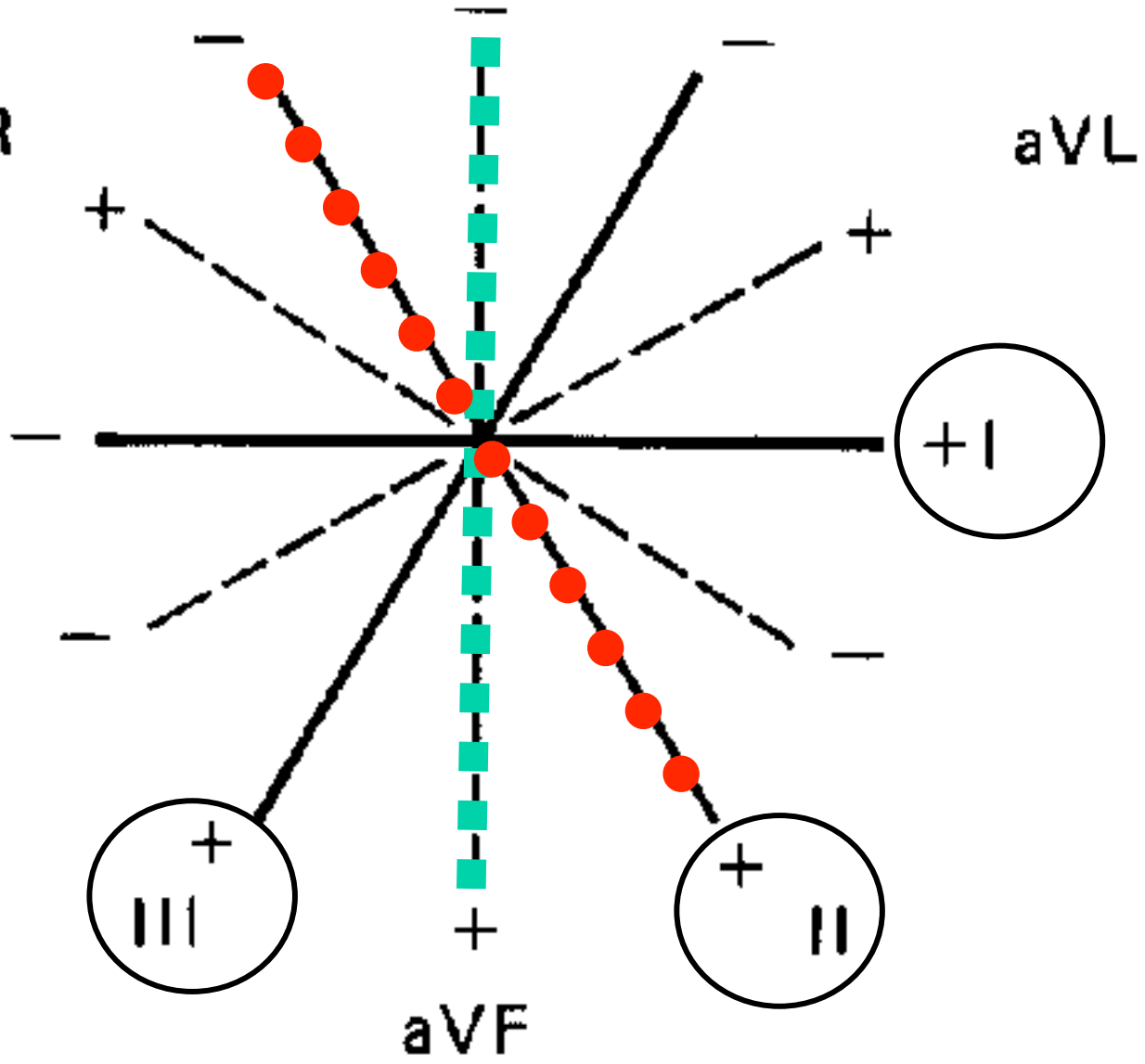

6 Frontal Plane Leads

4.7 MH

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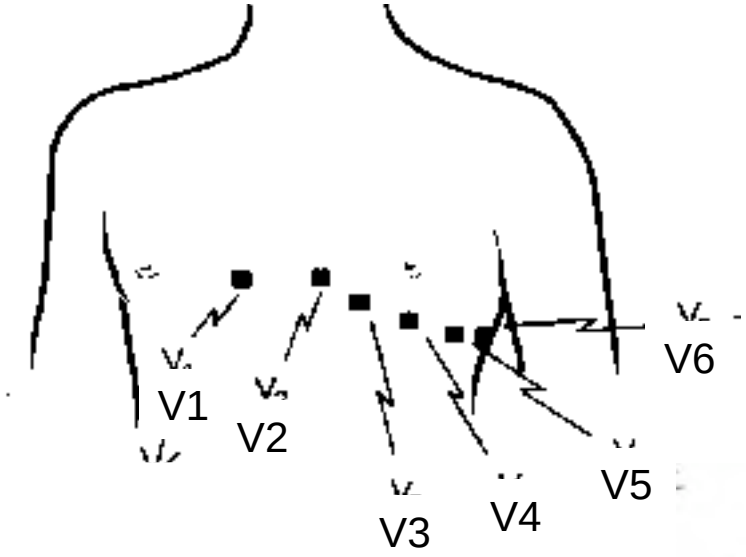
6 Precordial Leads & Conventions



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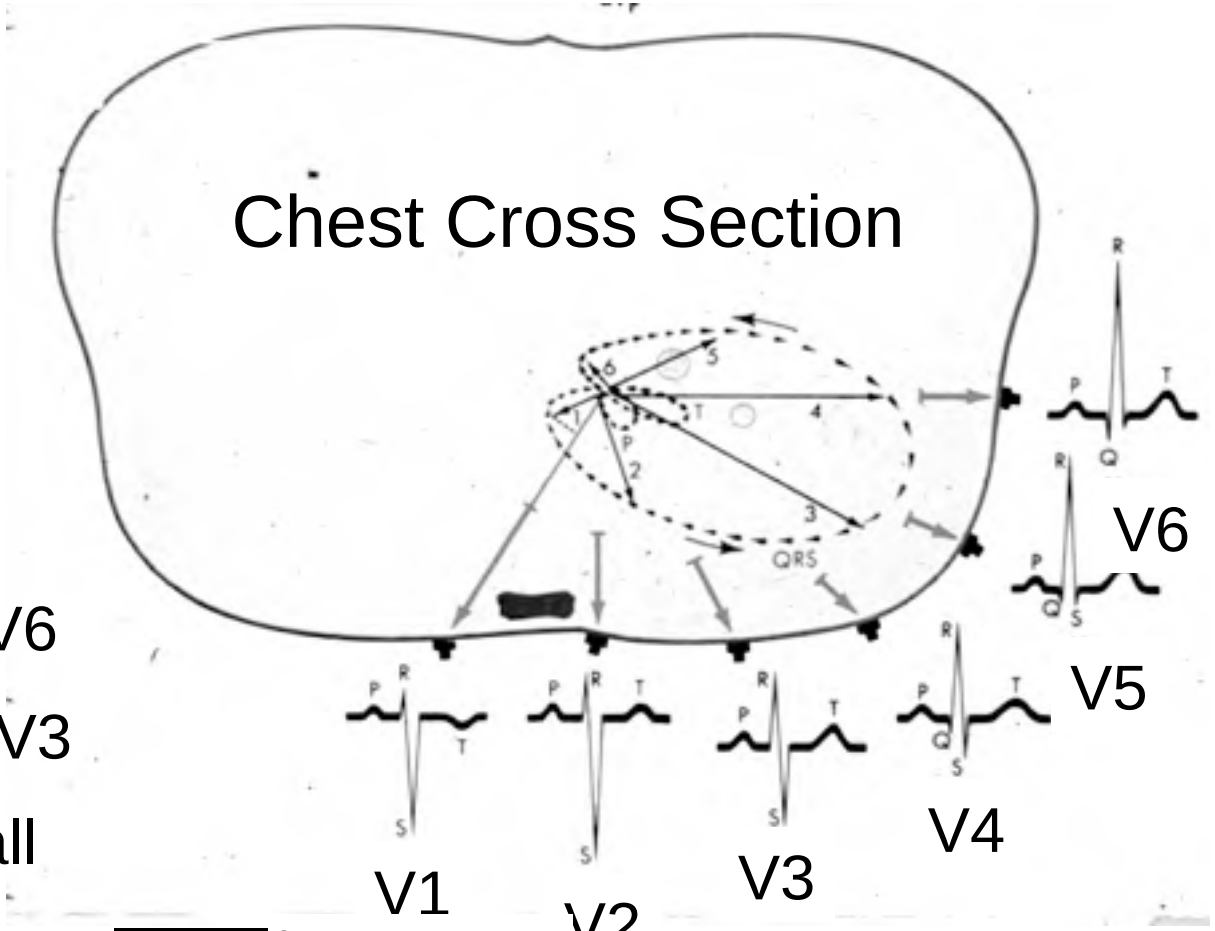
Call it:

Q if 1st ↓ e.g. V4, V5, V6

R if 1st ↑ e.g. V1, V2, V3

S if 1st ↓ after R e.g. all



PD-INCL Source Undetermined

Conventions for 6 Precordial (V1-V6) Lead ECG

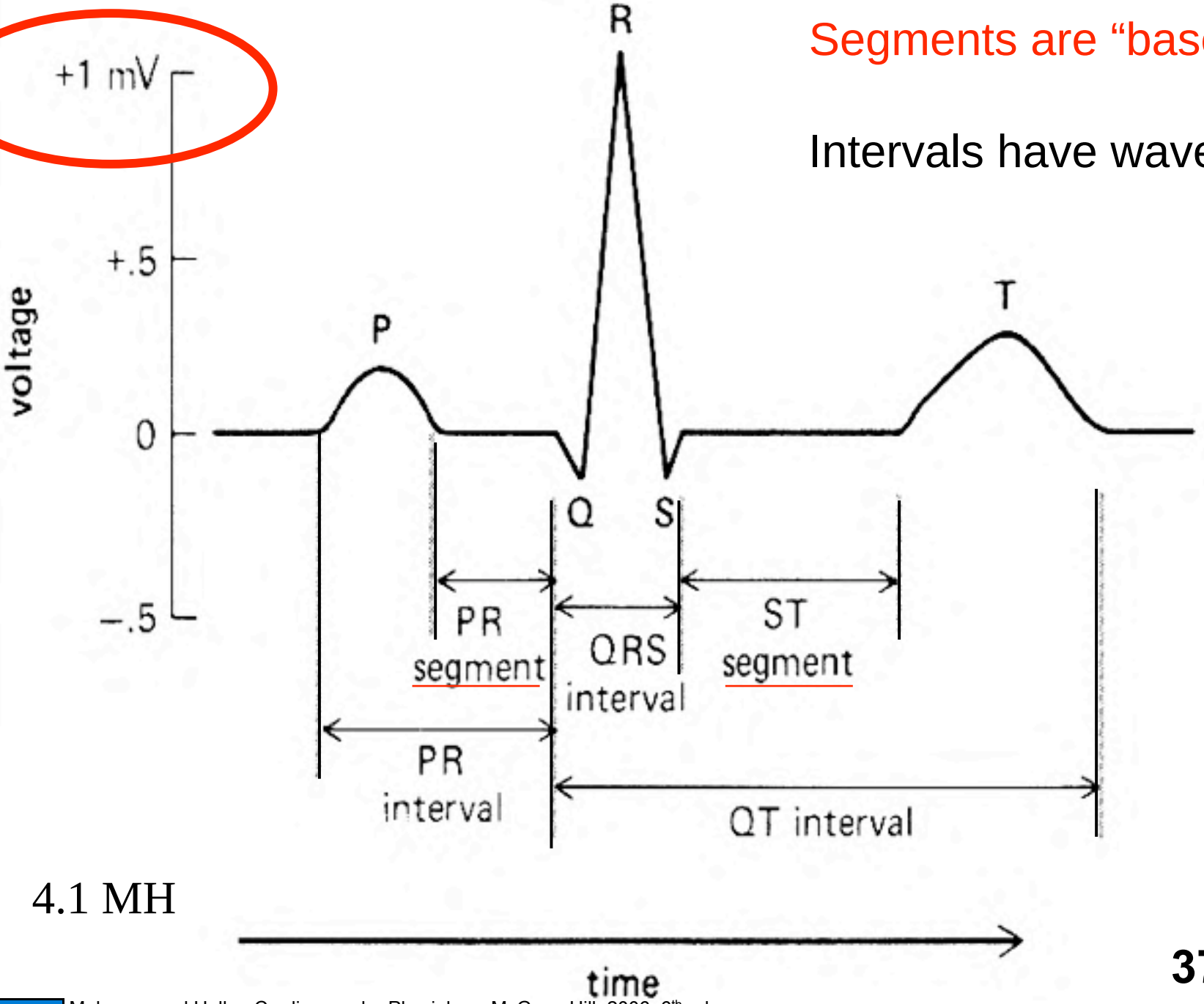
Lead Name	Positive Electrode +	Negative Electrode -
V1	V1	Indifferent (2)
V2	V2	Indifferent (2)
V3	V3	Indifferent (2)
V4	V4	Indifferent (2)
V5	V5	Indifferent (2)
V6	V6	Indifferent (2)

Indifferent lead (2)

is all three limb leads combined.

Segments are “baseline

Intervals have waves



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12 Lead

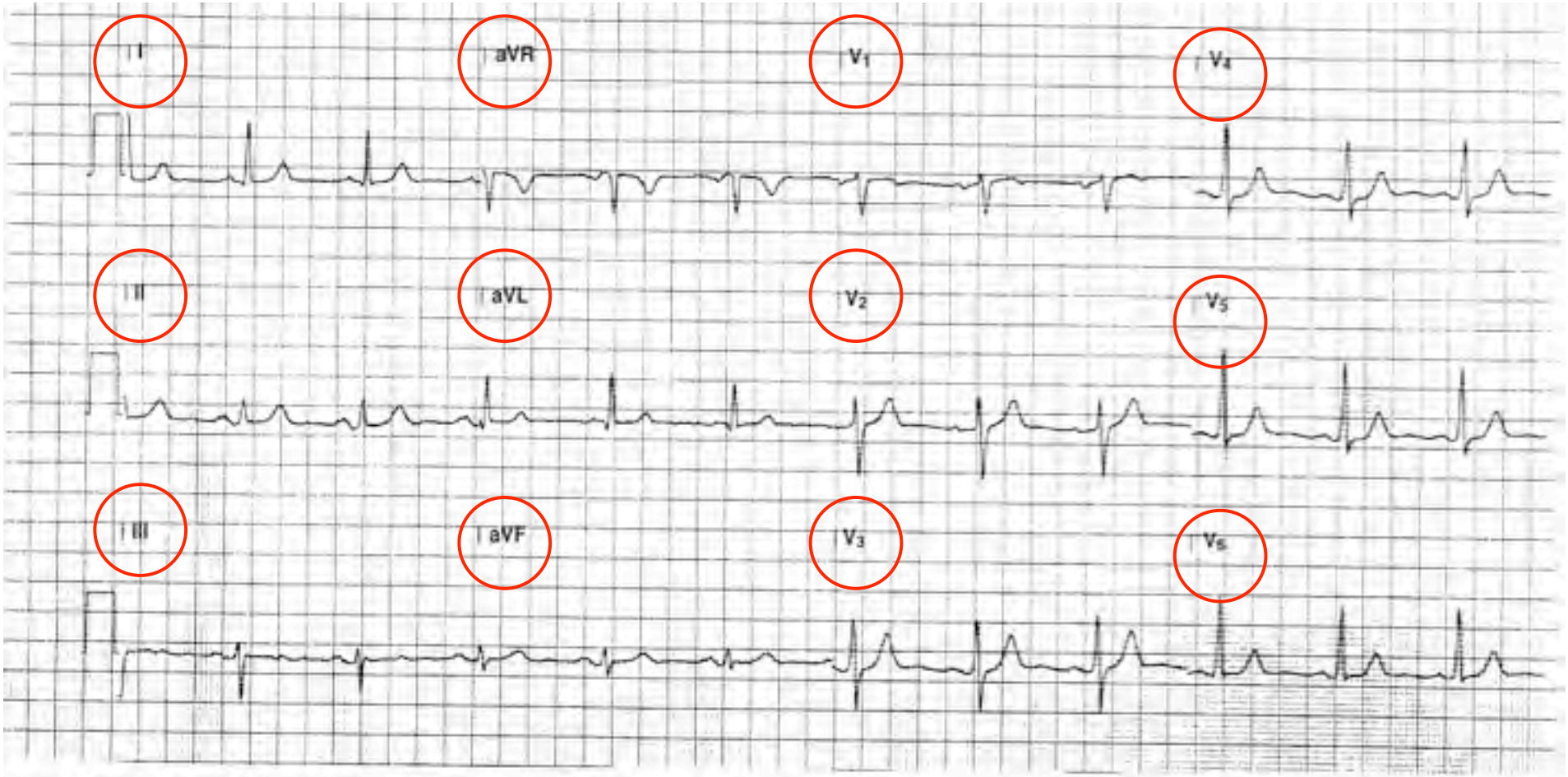

Figure 4.28. **12-lead ECG (normal).** The rectangular upward deflection at the beginning of each line is the voltage calibration signal (1 mV). *Rhythm:* normal sinus. *Rate:* 70 bpm. *Intervals:* PR, 0.17; QRS, 0.06; QT, 0.40 sec. *Axis:* 0° (QRS is isoelectric in lead aVF). The P wave, QRS complex, ST segment, and T waves are normal. Notice the gradual increase in R wave height between leads V_1 through V_6.

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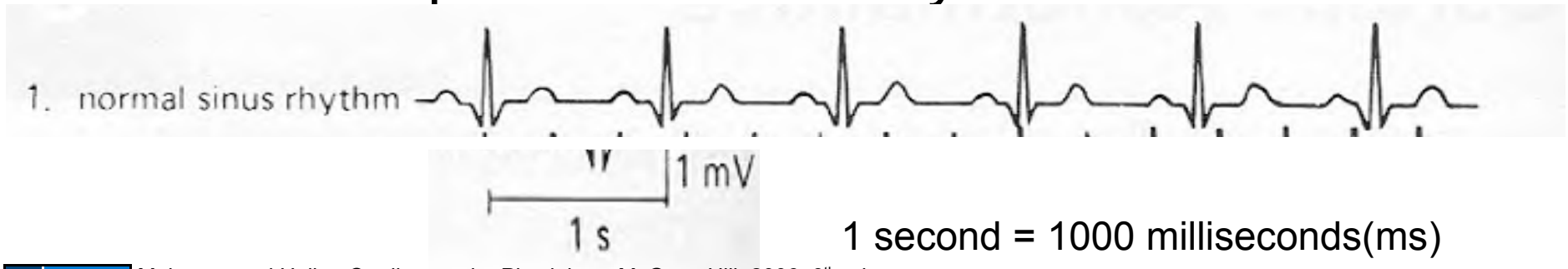
Supraventricular arrhythmias



1 second = 1000 milliseconds(ms)

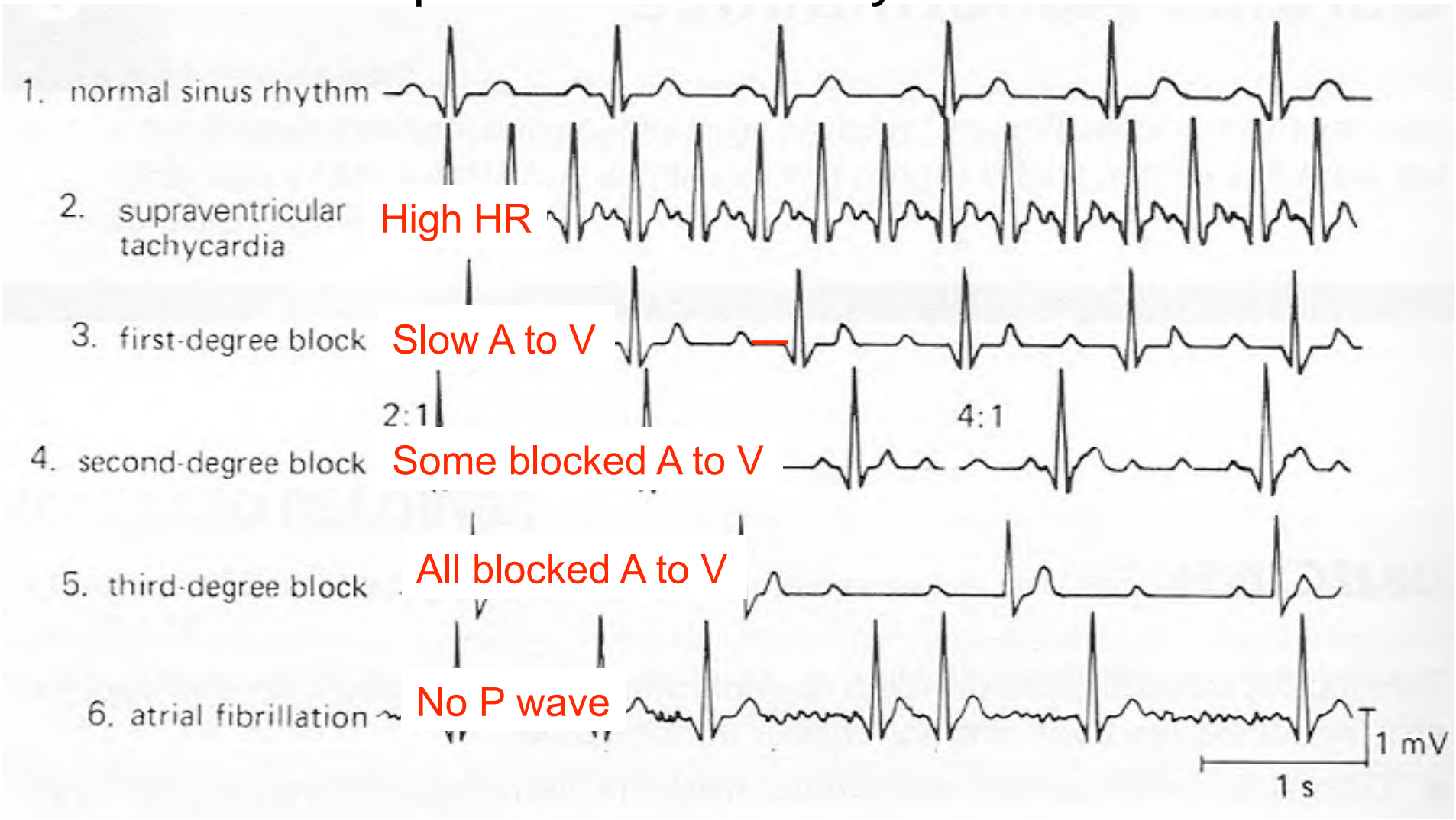
PD-INCL Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

Why is this 1. Normal sinus rhythm "Normal"

1- frequency 1/sec or 60 BPM
2- QRS "shape" normal and duration <120 ms
3- QRS preceded by P
4- PR interval < 200ms
5- QT interval < 1/2 RR interval
6- no extra P waves

MH Fig 5.1

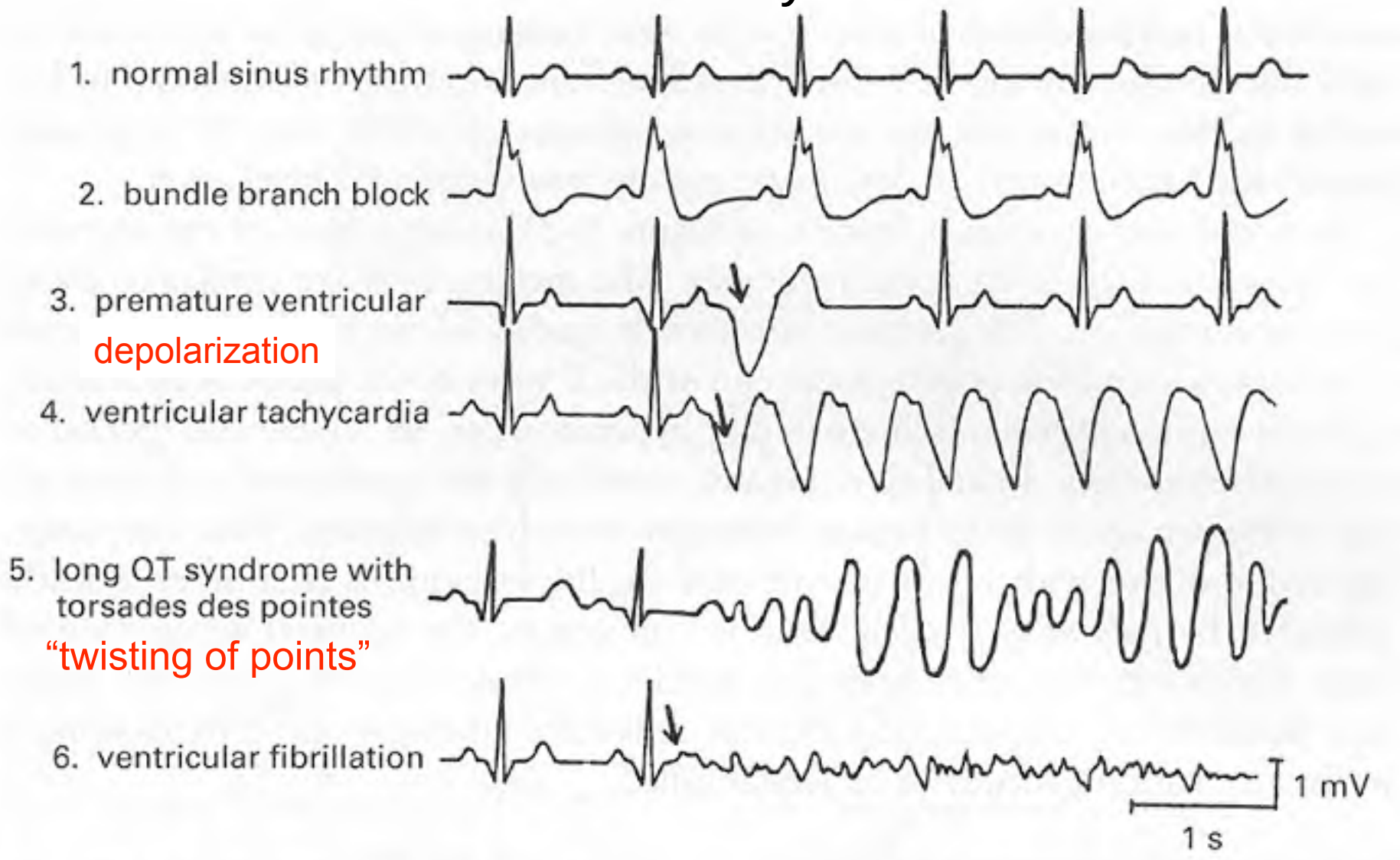
Supraventricular arrhythmias



MH Fig 5.1

 Mohrman and Heller. Cardiovascular Physiology. McGraw-Hill, 2006. 6th ed.

Ventricular arrhythmias



MH Fig 5.3

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