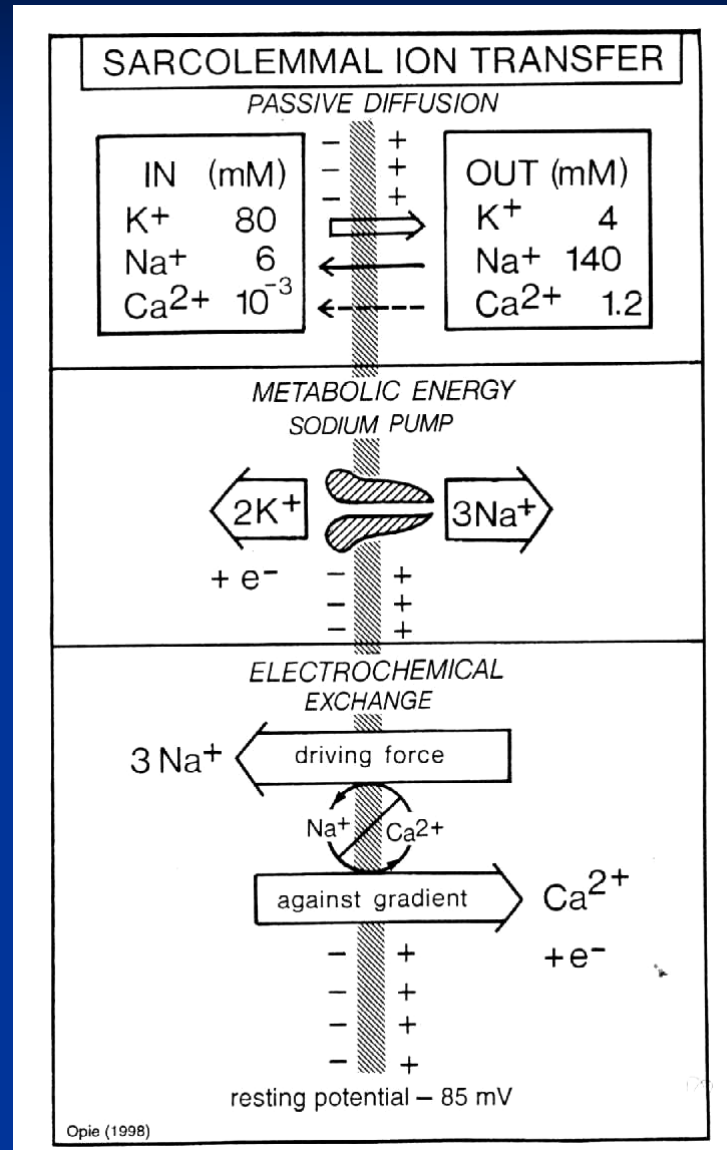


Basic Electrophysiology

Michael Eldar, M.D.
Heart Institute
Sheba Medical Center

Caesaria 2010

Transmembrane Ion-Transfer Modes

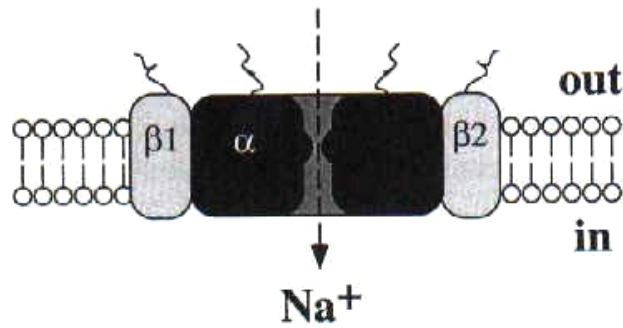


Ion Channel

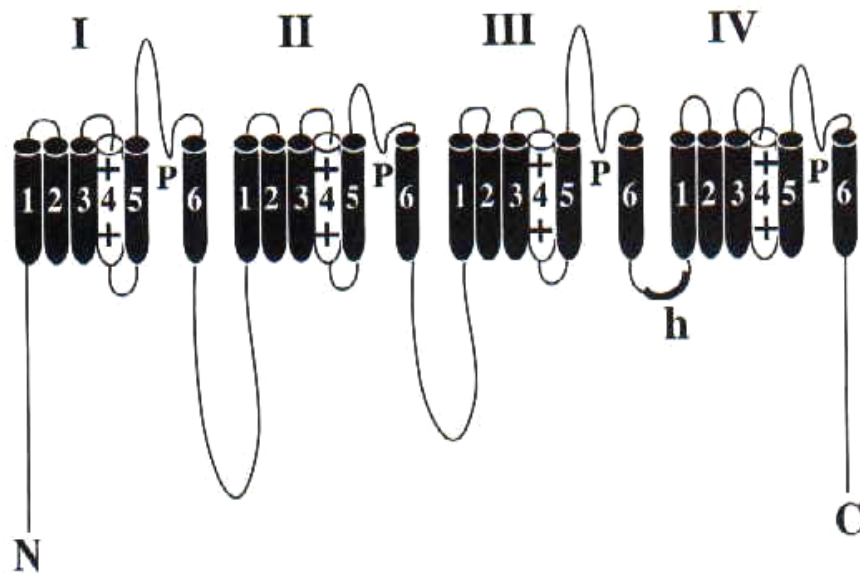
Pump

Exchanger

A

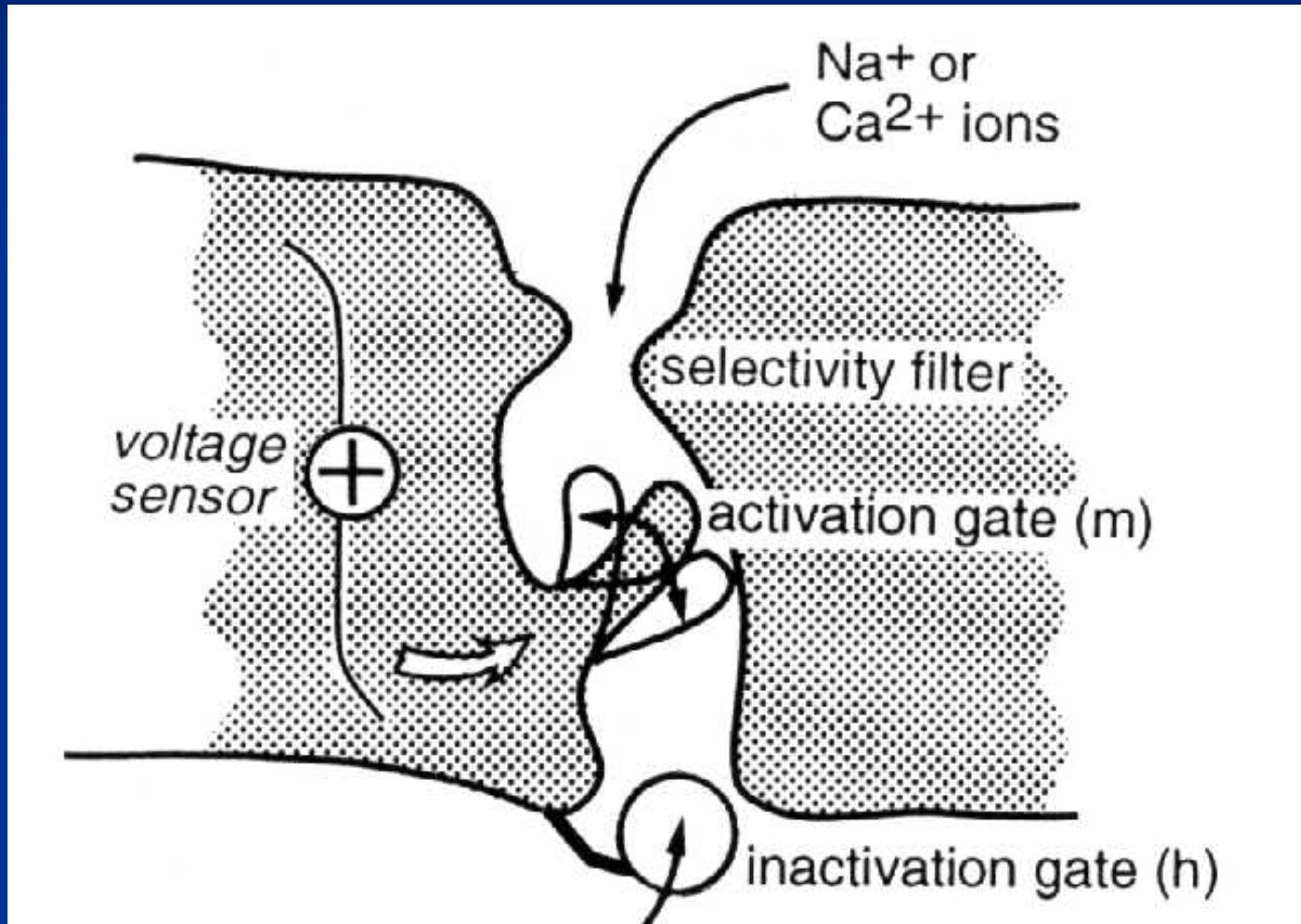


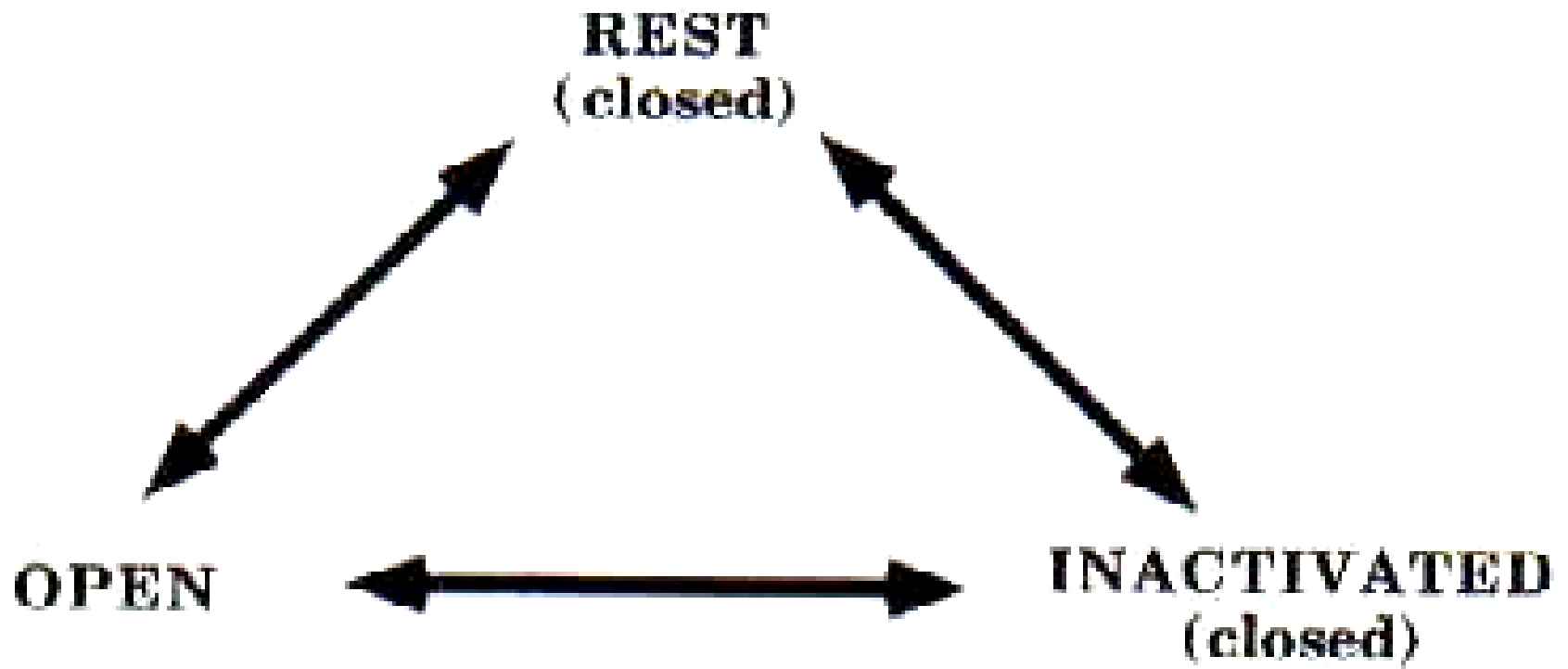
B



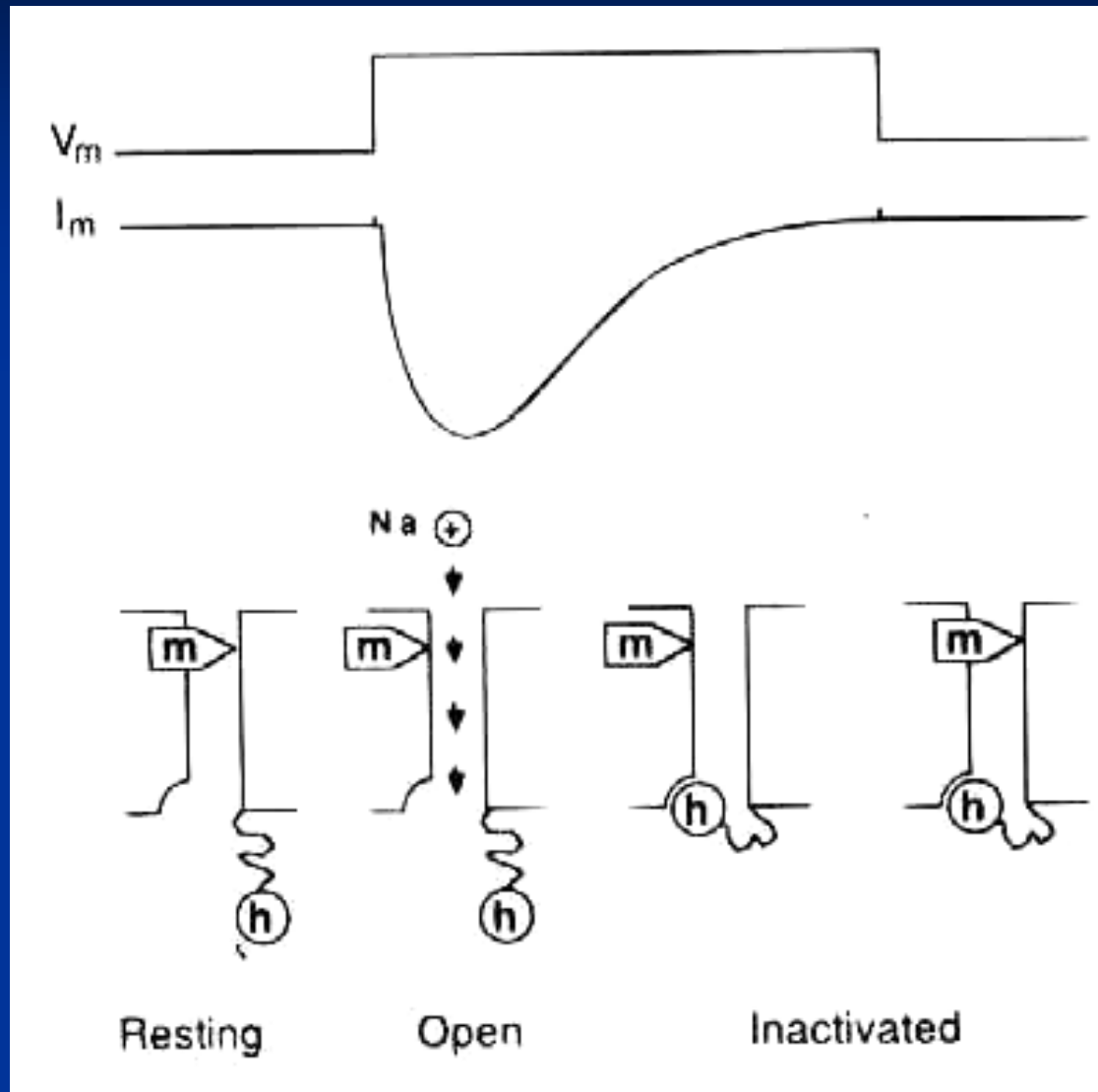
Voltage-Gated Sodium channel

Channel Pore Model

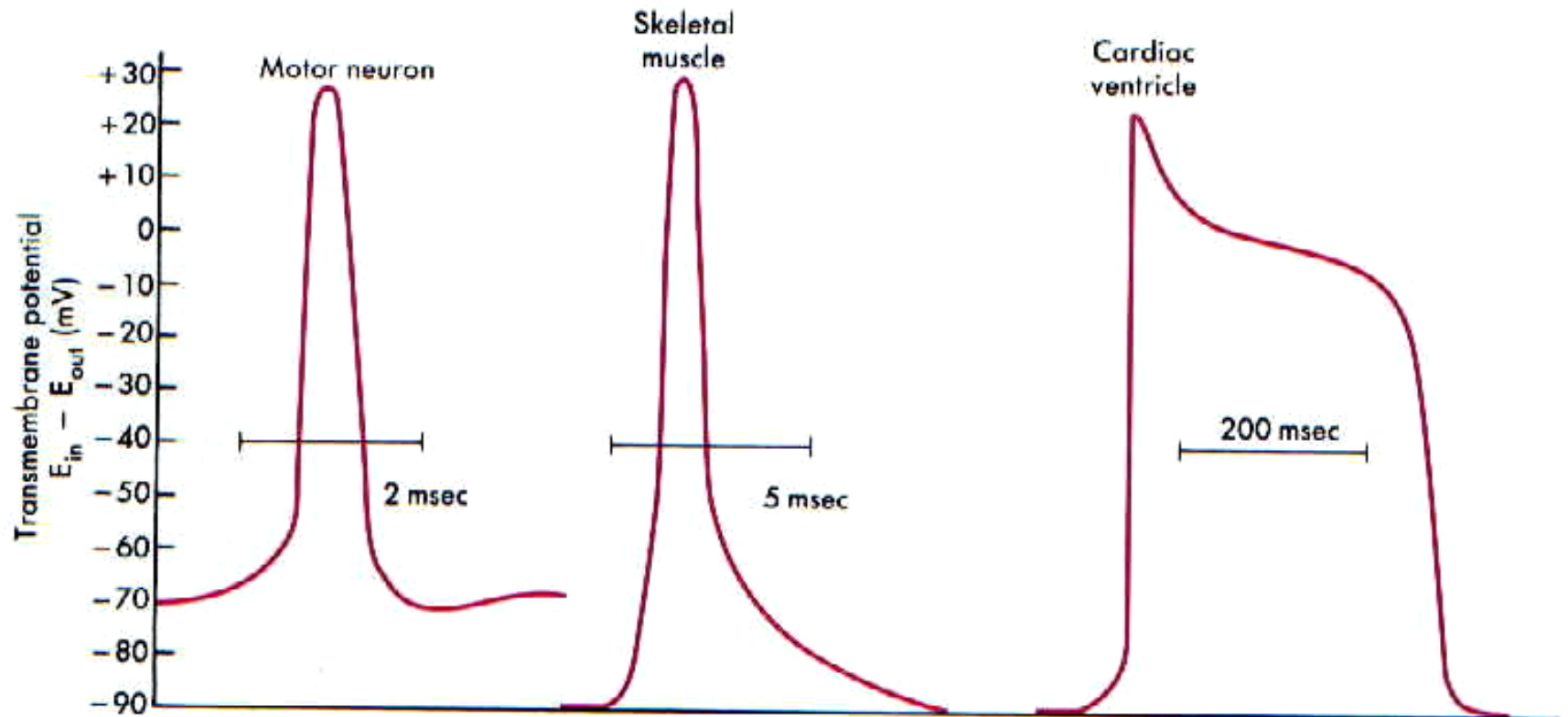




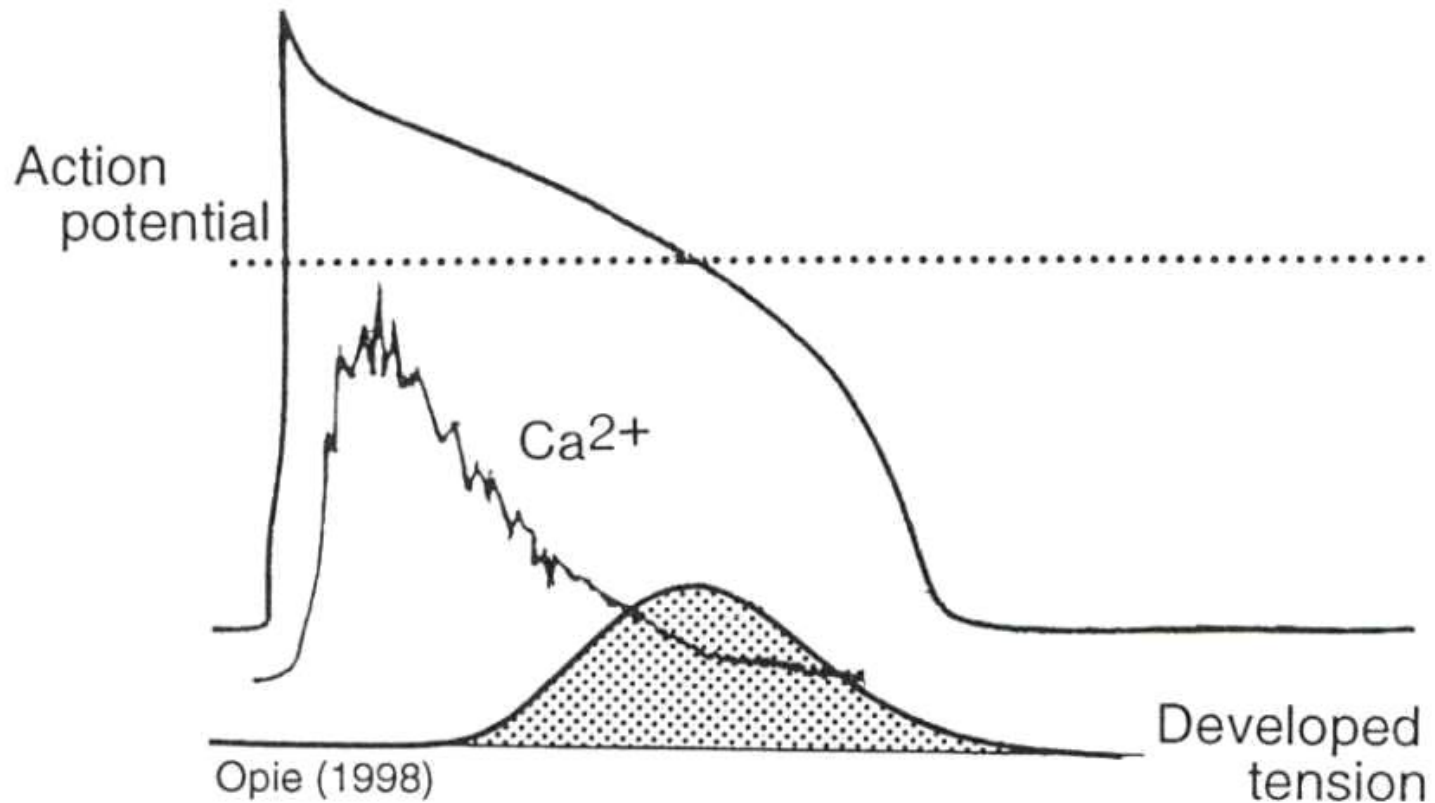
The Sodium Channel

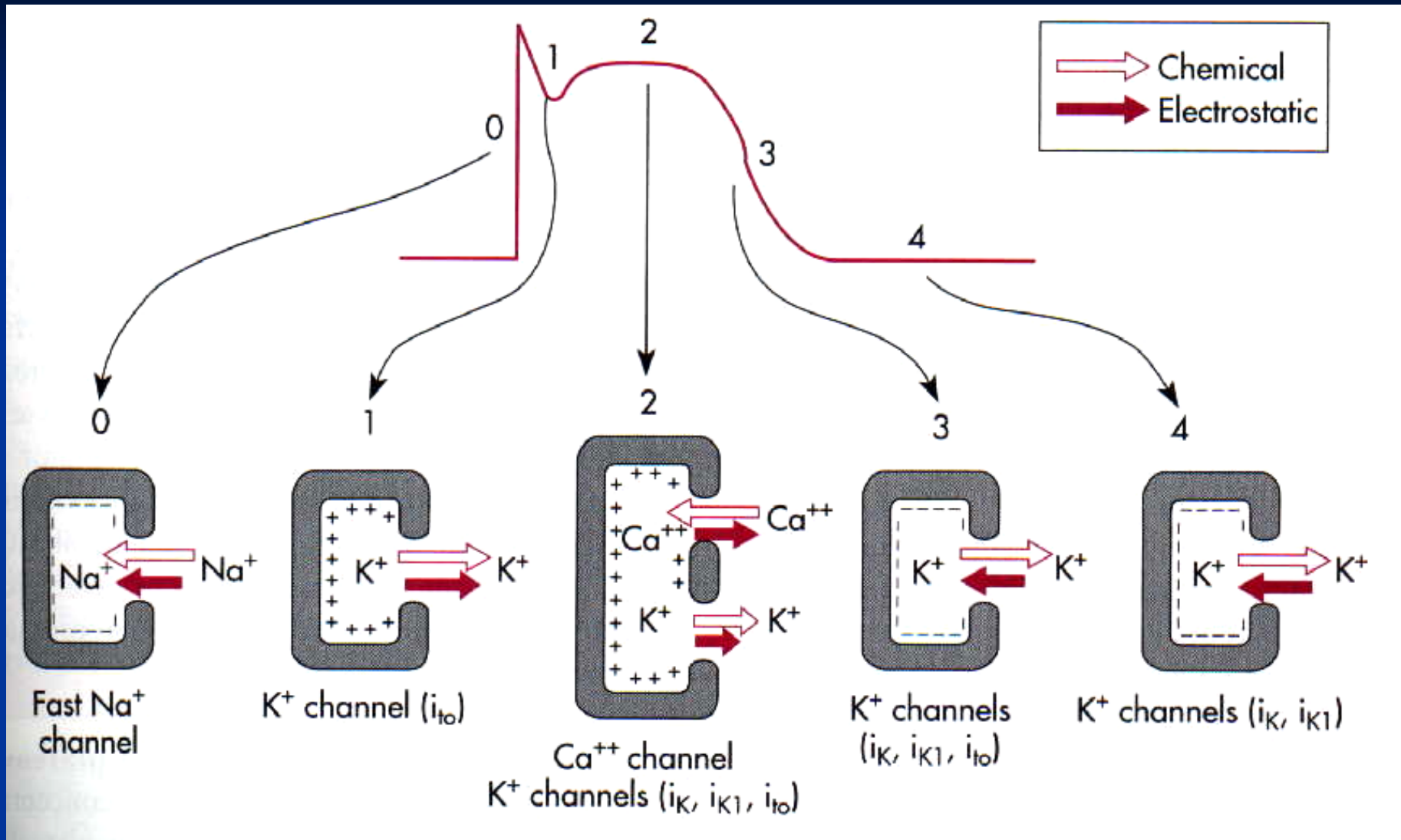


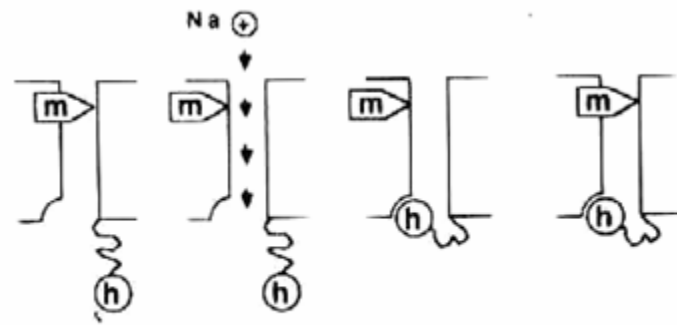
The Action Potential



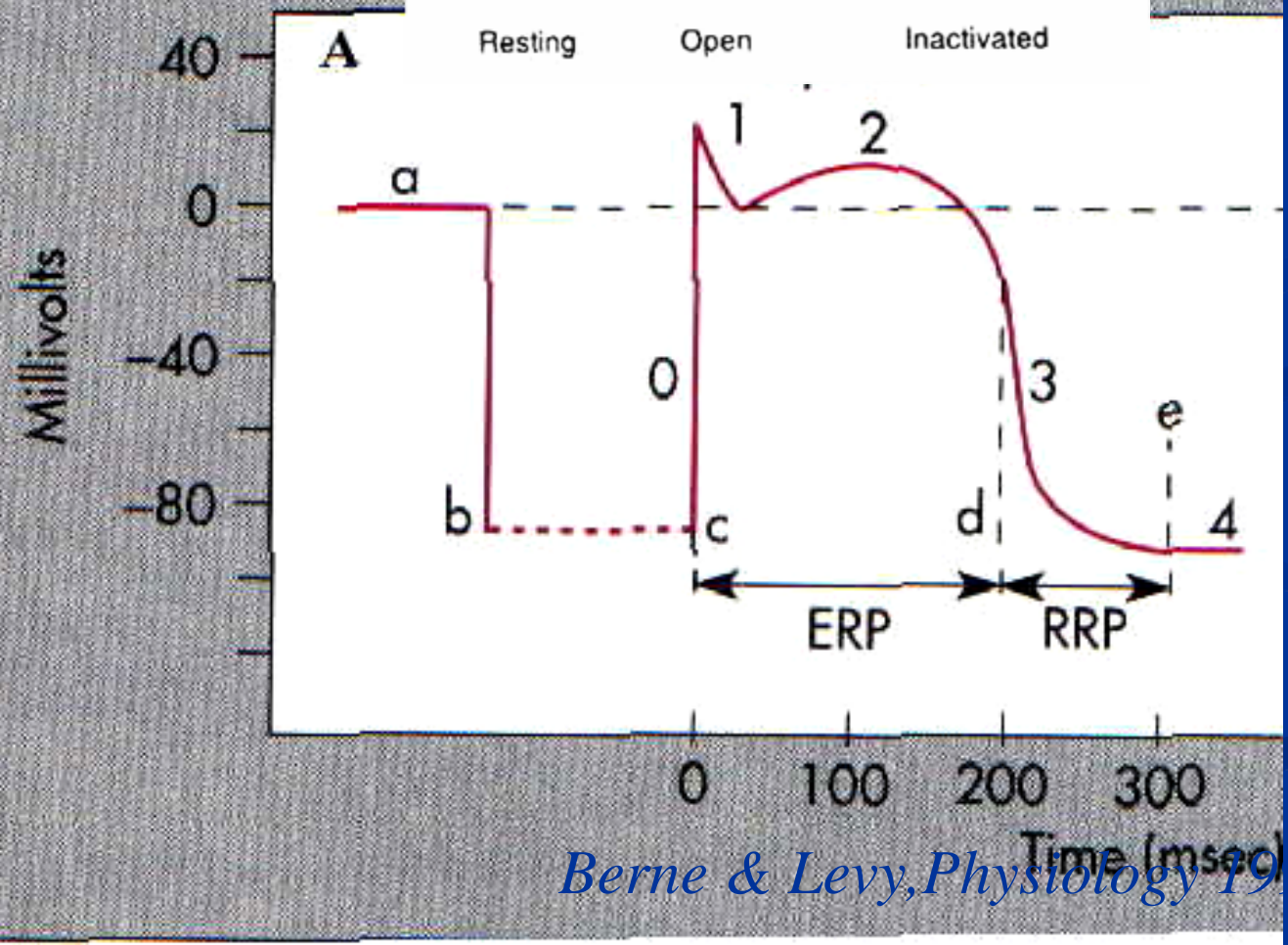
Electro-Mechanical Relation

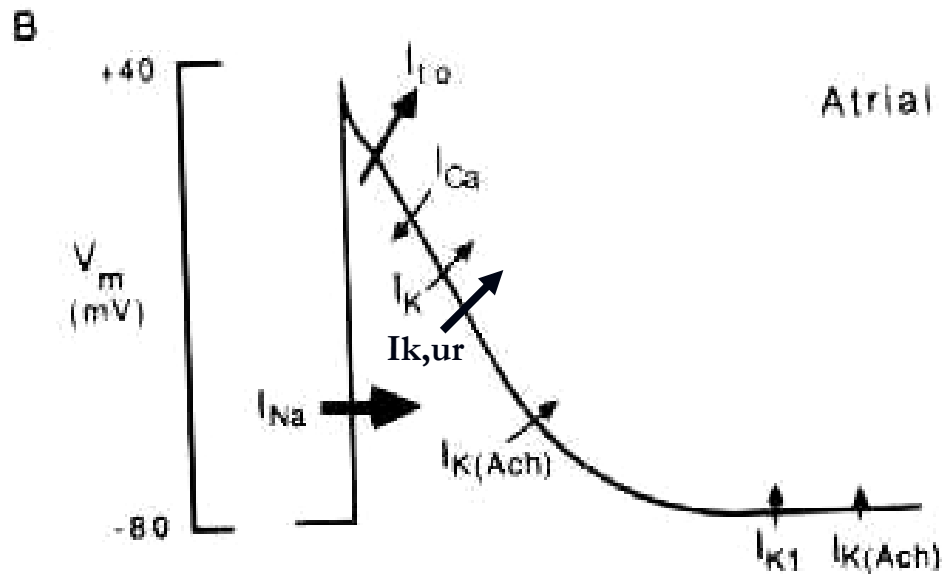
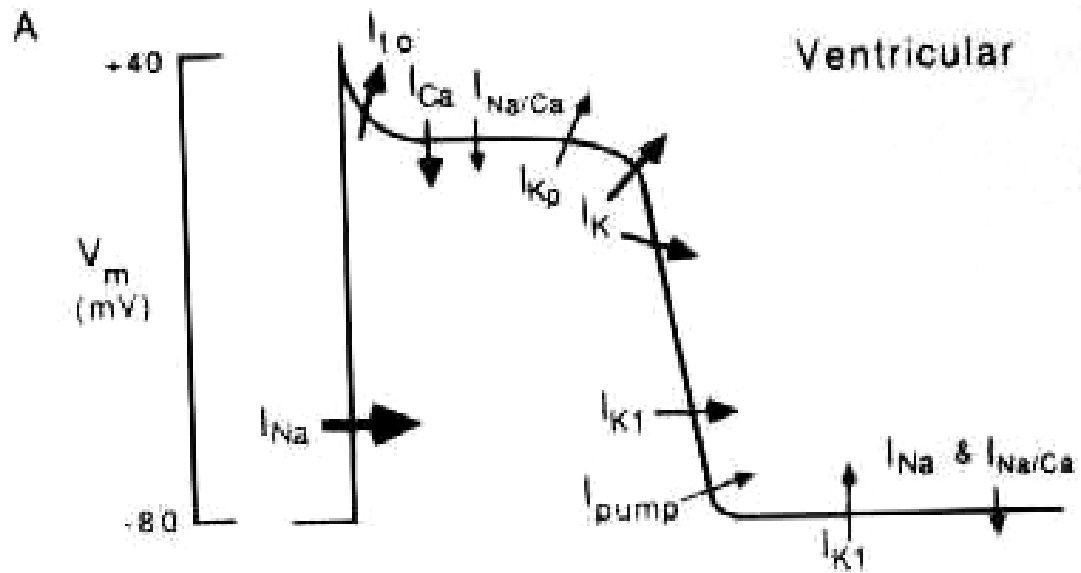




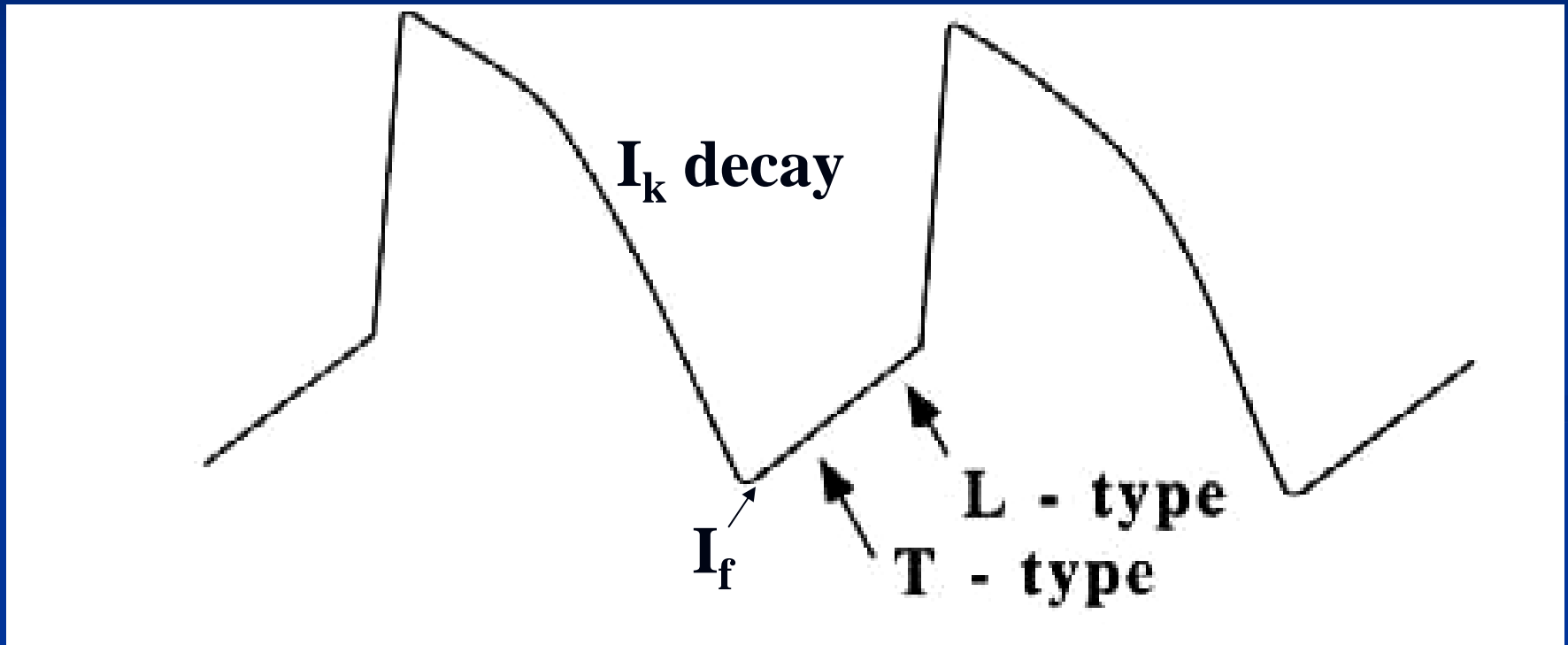


Resting Open Inactivated



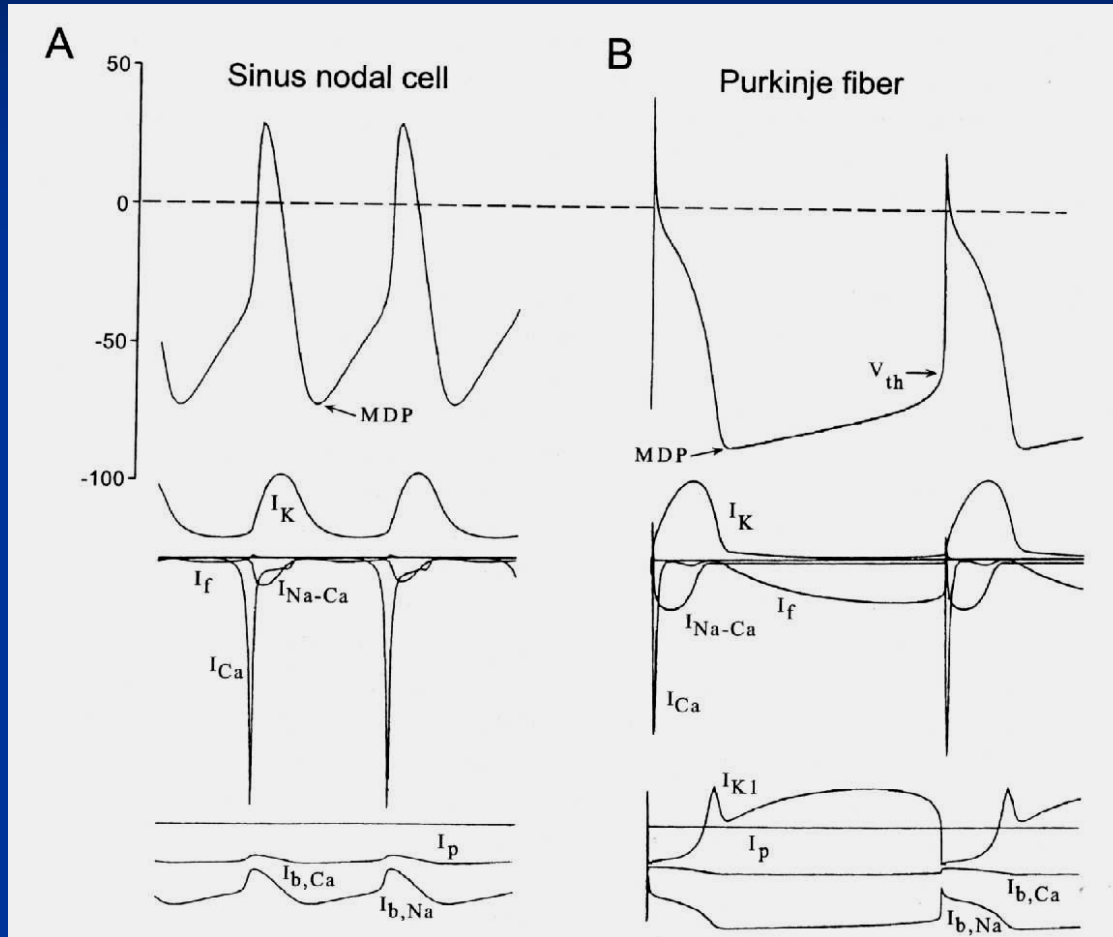


Normal Automaticity

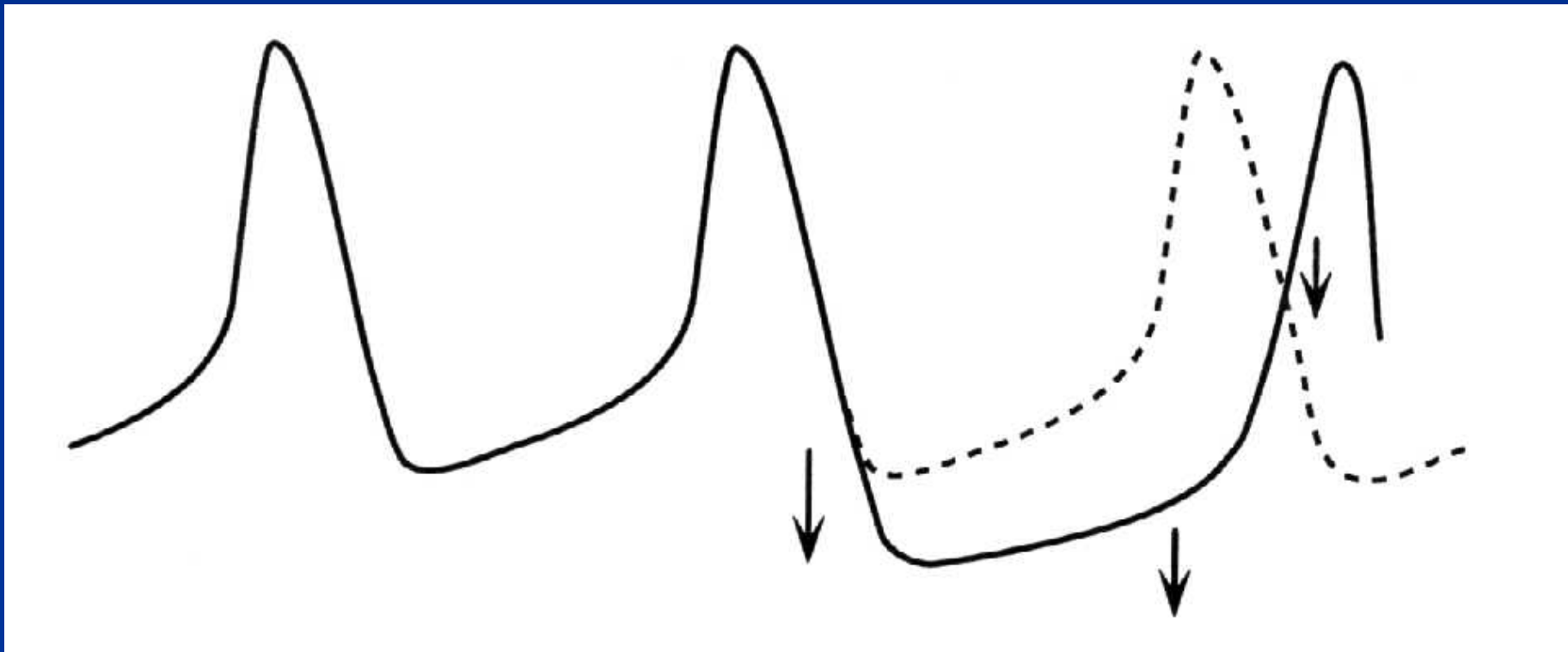


Jalife et al. Basic Cardiac Electrophysiology for the Clinician, 1998:55

Normal Automaticity

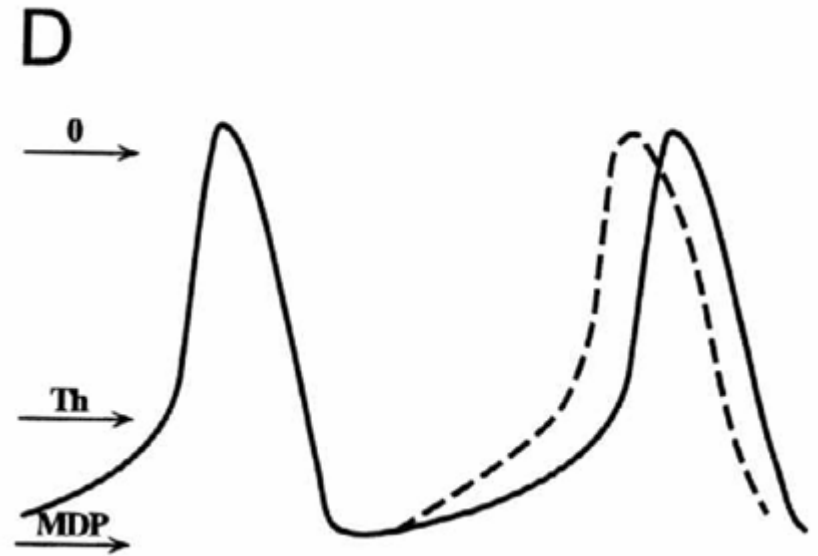


ACh and Automaticity



Jalife et al. Basic Cardiac Electrophysiology for the Clinician, 1998:202

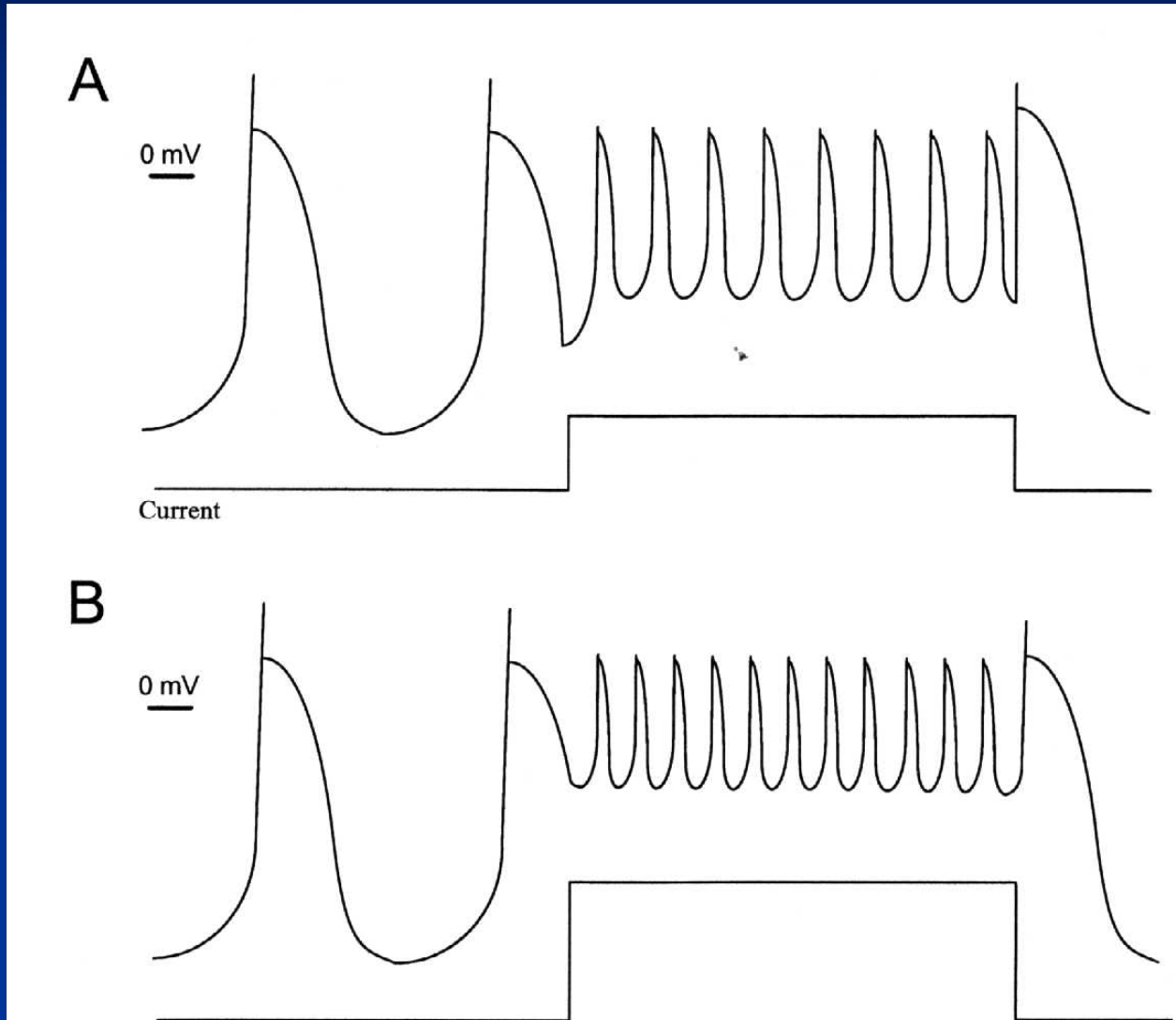
Catecholamines & Normal Automaticity



Abnormal automaticity

- Depolarized myocytes
(-60 → -10 mV)
- ↓ pH
- ↓ [O₂]
- ↑ [K⁺]_o

Depolarization-induced Automaticity



Abnormal automaticity

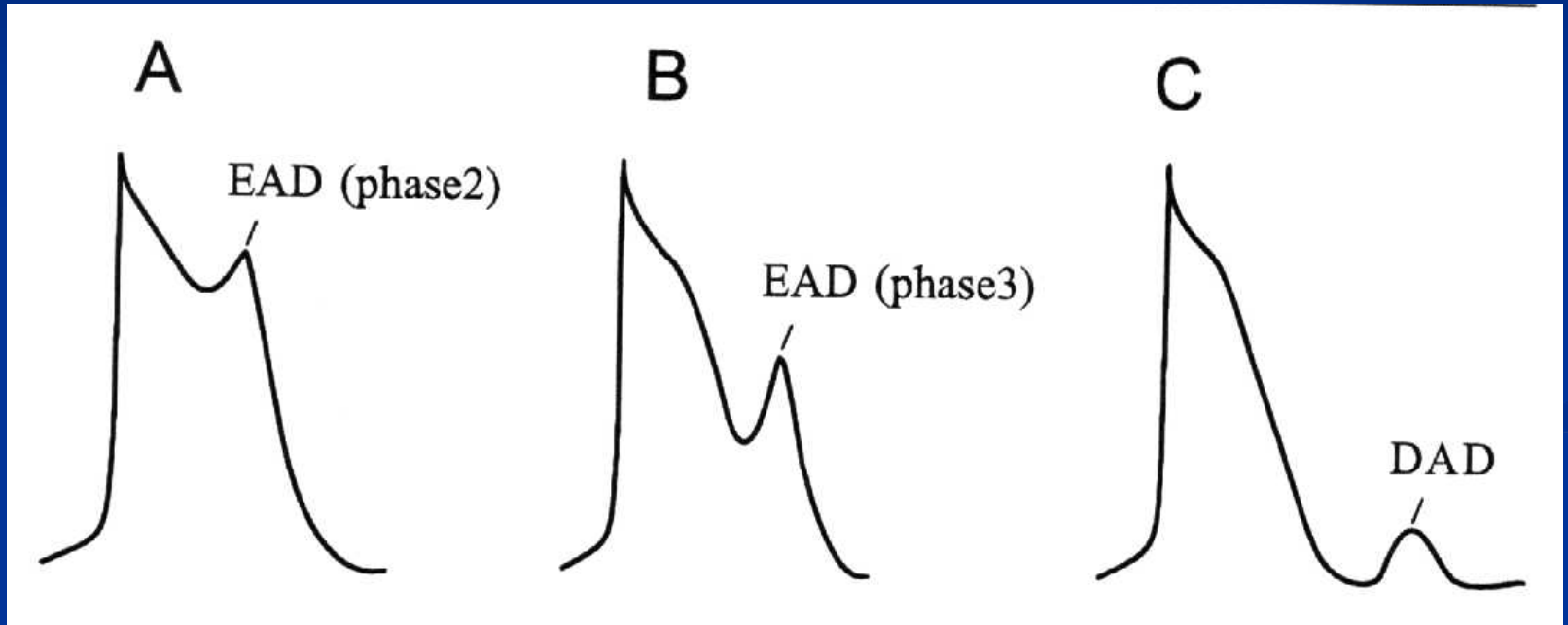
Clinical Arrhythmias

- Myocardial infarction
 - 15-30 minutes
 - 24-72 hours
- AIVR
- $\uparrow[K^+]_o$
 - Ischemia
 - Injury currents

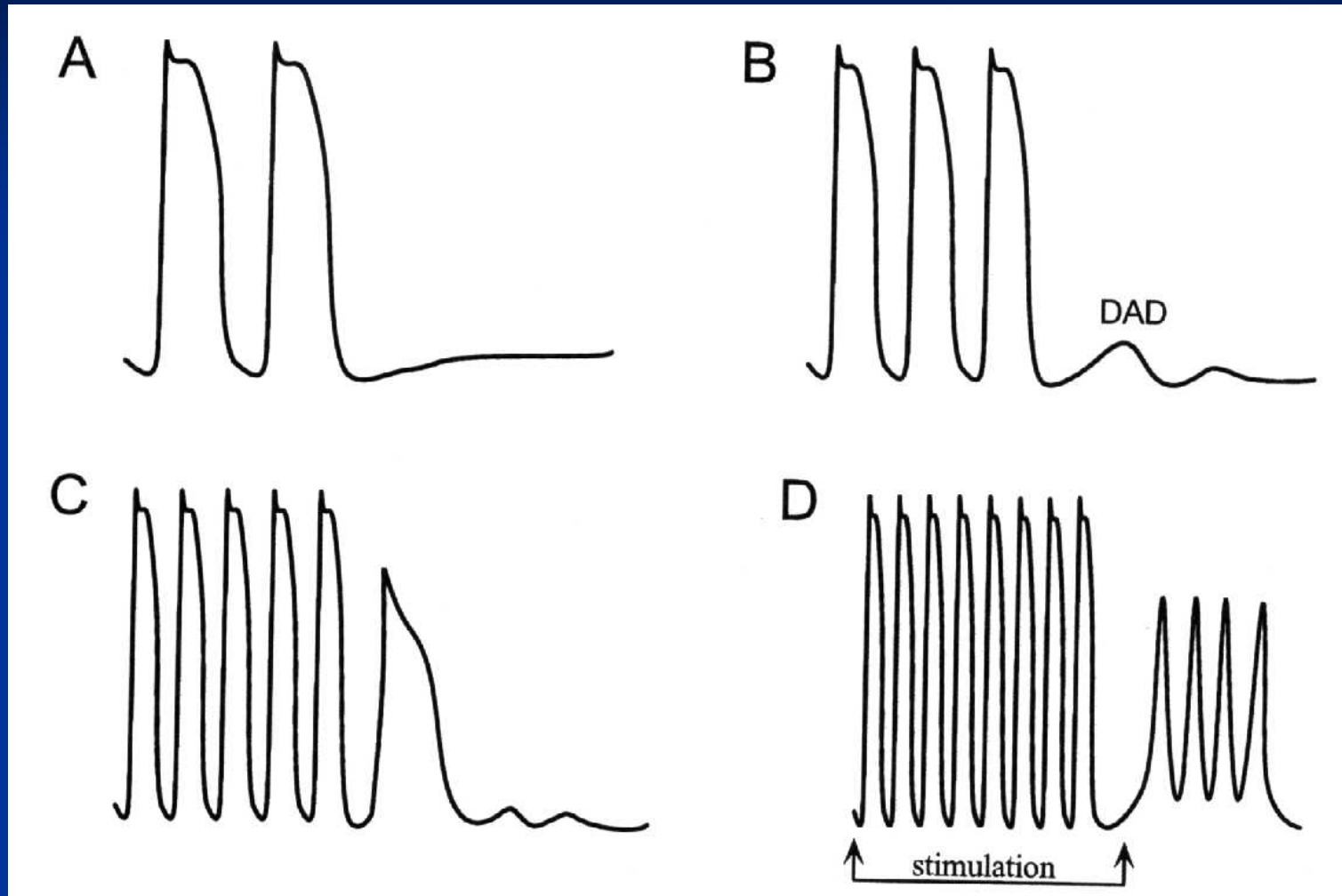
Triggered Activity

- activity arising from membrane potential oscillations during or immediately following an AP
- Should occur following a previous AP (spontaneous or driven)

Triggered Activity



Digoxin induced DAD



Rate-Dependence of DAD's

DAD

Clinical Arrhythmias

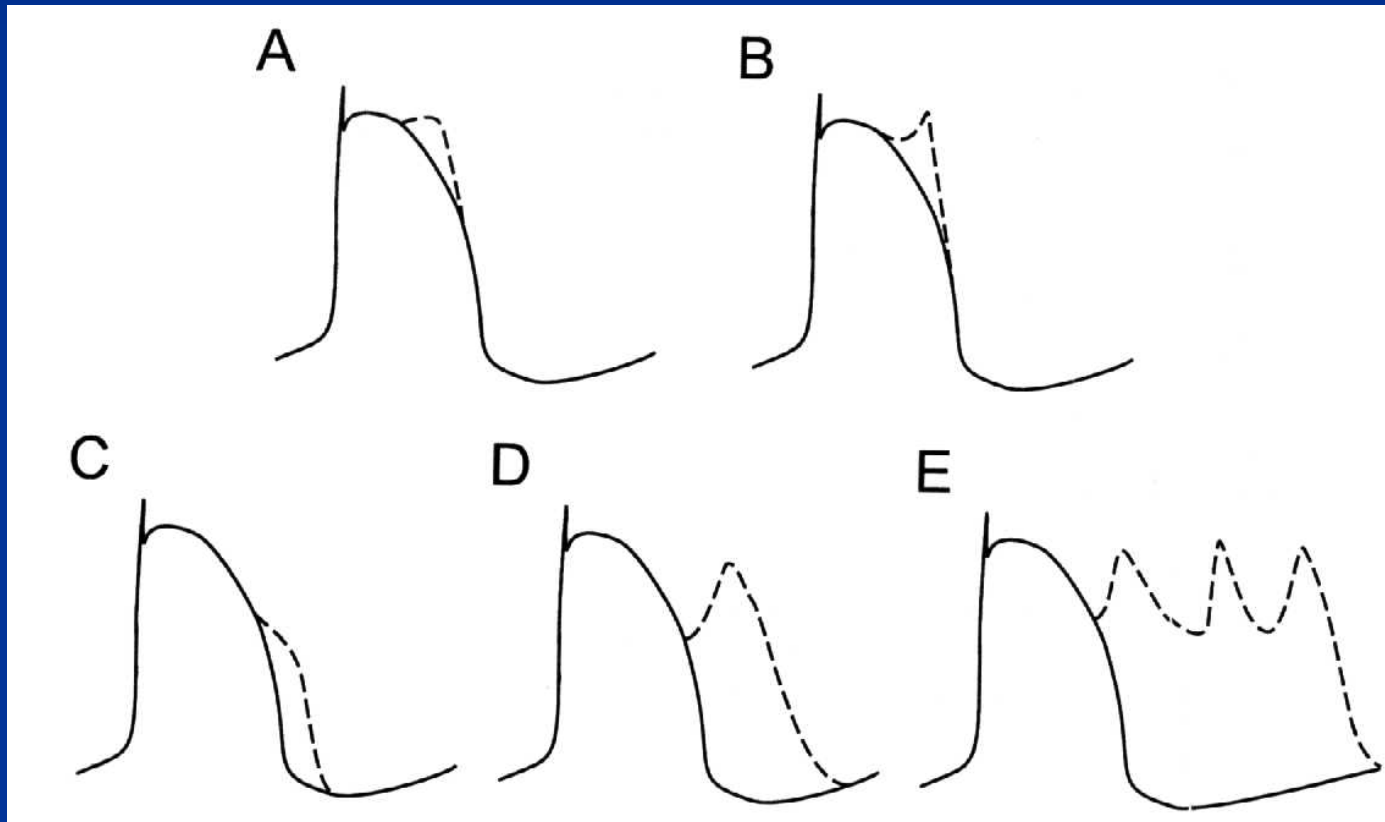
- Dig. Intoxication
 - atrial tach
 - VT
- Accelerated VT during AMI
- Reperfusion induced arrhythmias
- CPVT
- Exercise (catecholamine, cAMP dependent) induced RVOT VT

Early Afterdepolarization (EAD)

Pathophysiology

Outward current ↓
and/or
↑ Inward current

Quinidine-induced EAD's

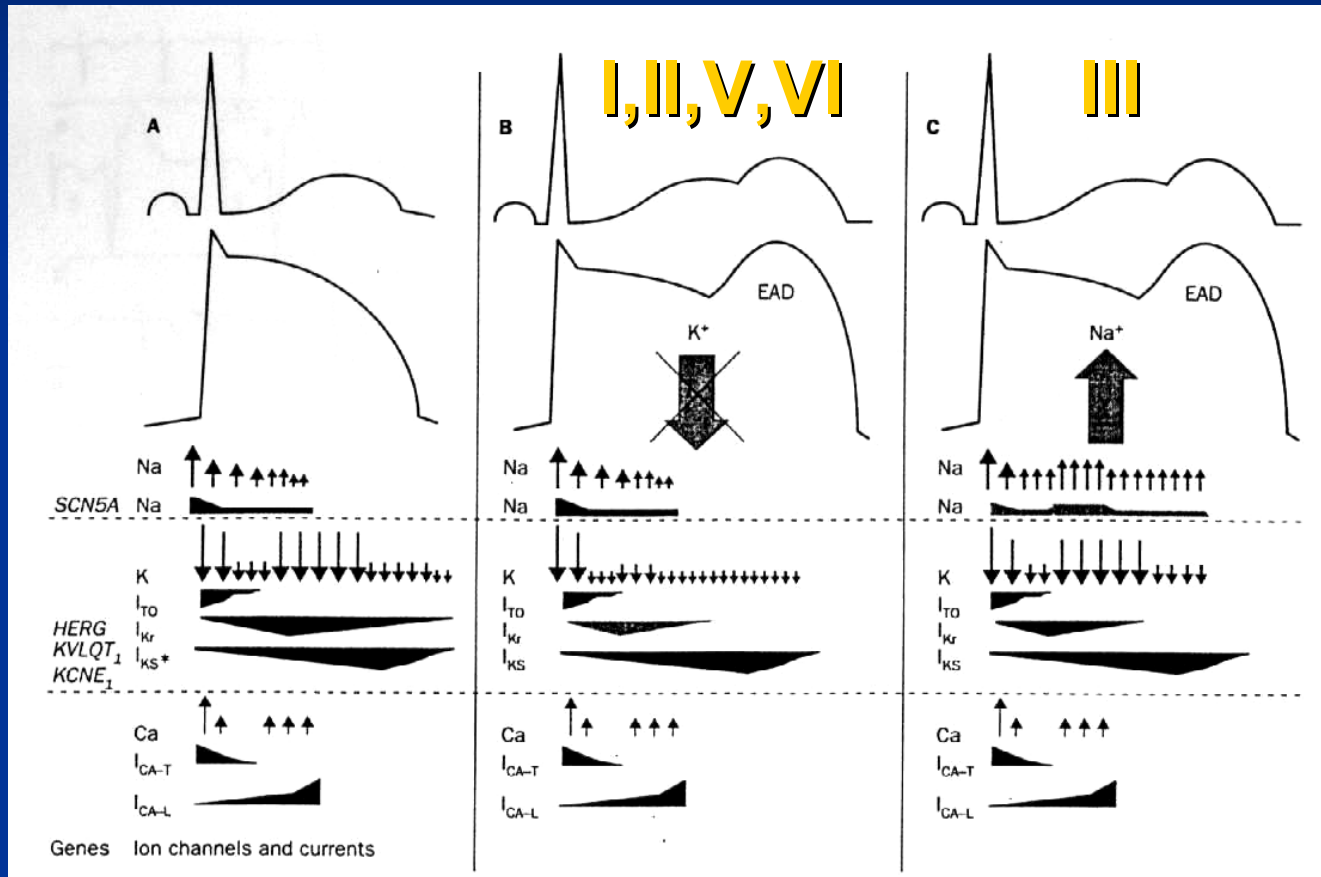


EAD

Clinical arrhythmias

- TDP
 - acquired LQTS
 - congenital LQTS

LQTS- ↓ net outward current

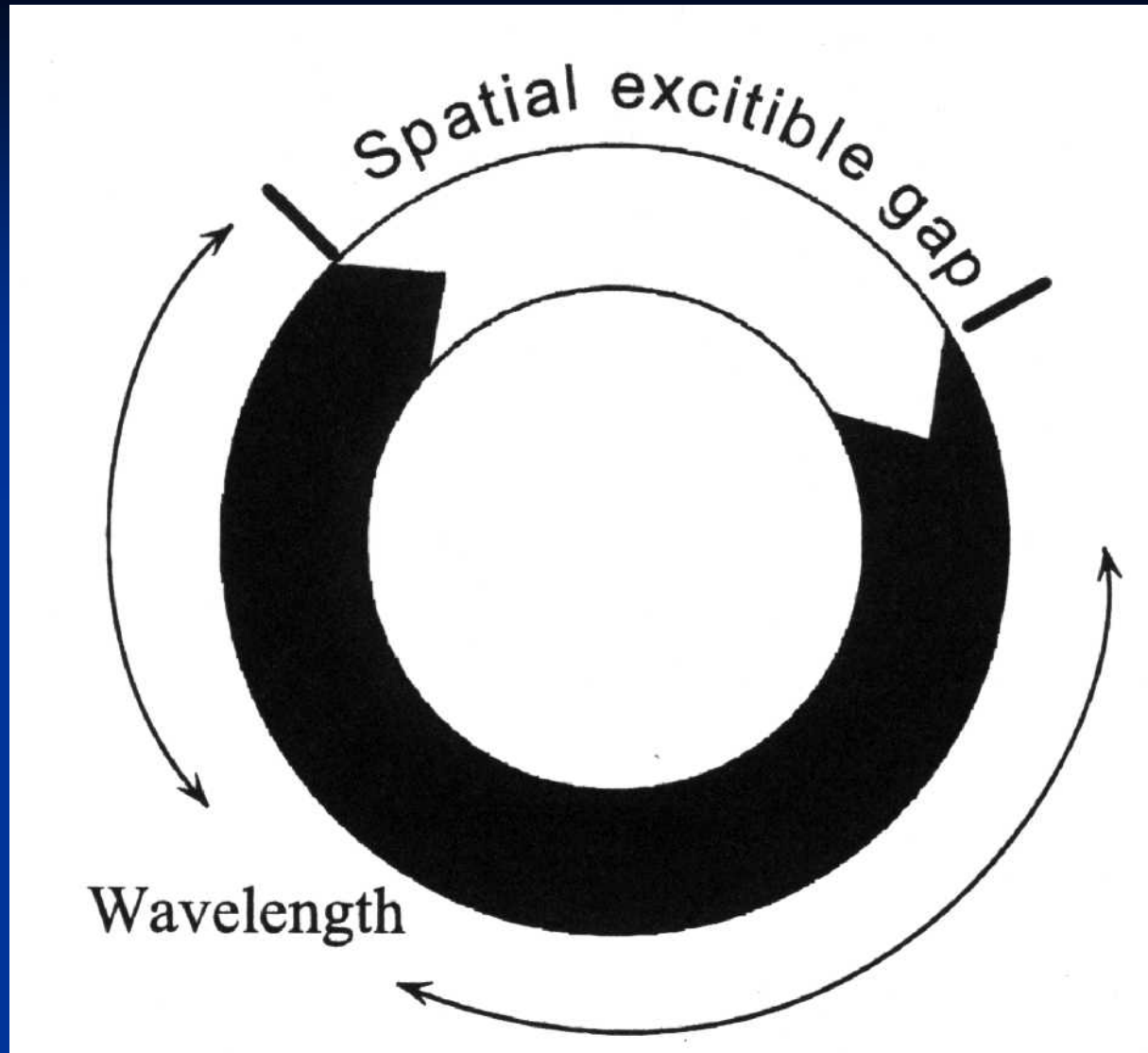


Acquired EAD

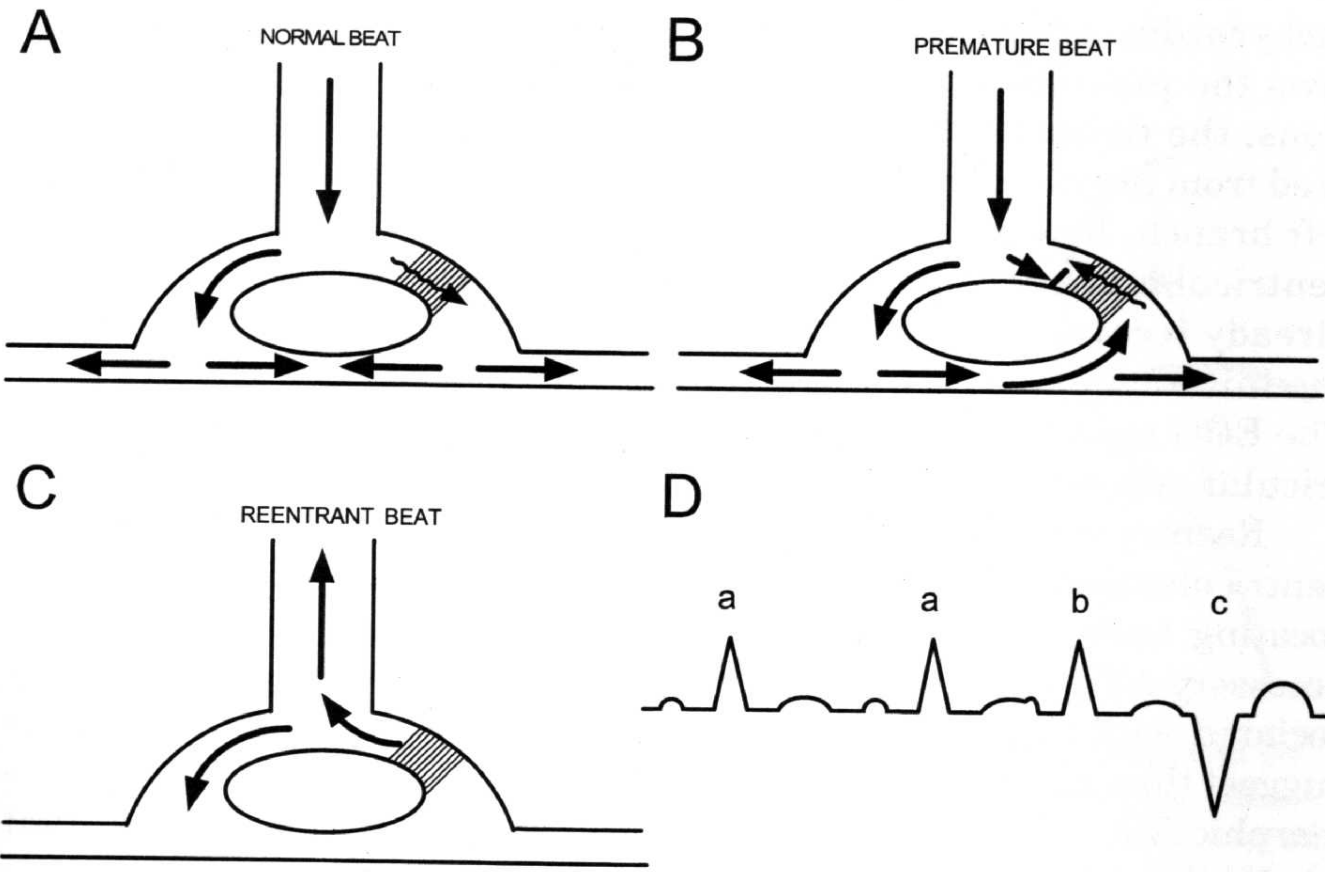
- hypokalemia (\downarrow K conductance)
- Acidosis
- Bradycardia
- Ikr blockers
 - AAD
 - Phenothiazine
 - Antihistamines
 - Antibiotics
 - antidepressants

Circus Movement Reentry

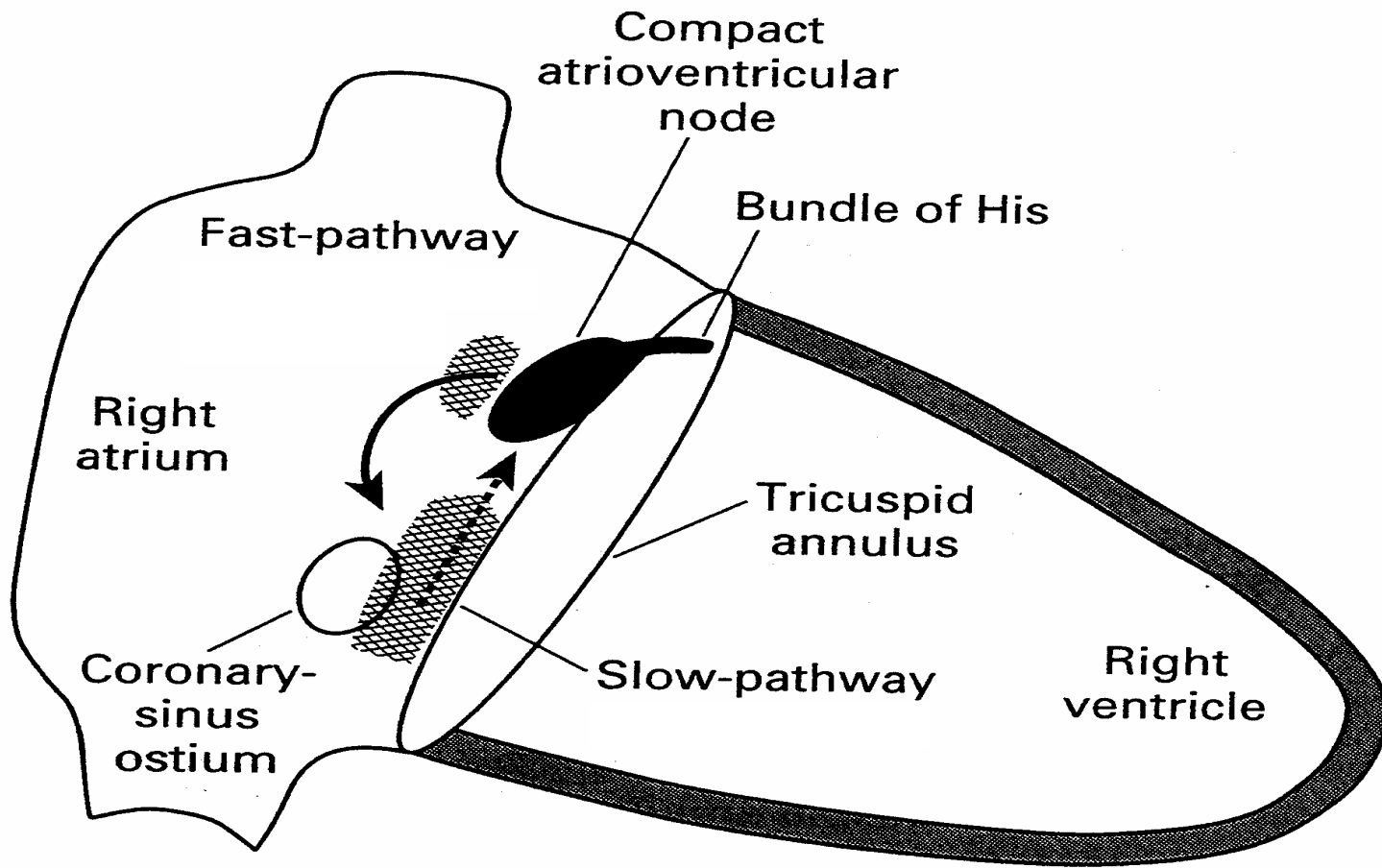
1. Intact anatomic circuit
2. Unidirectional block (onset)
3. Area of slow conduction
4. Wavelength of tach. $<$ length of circuit



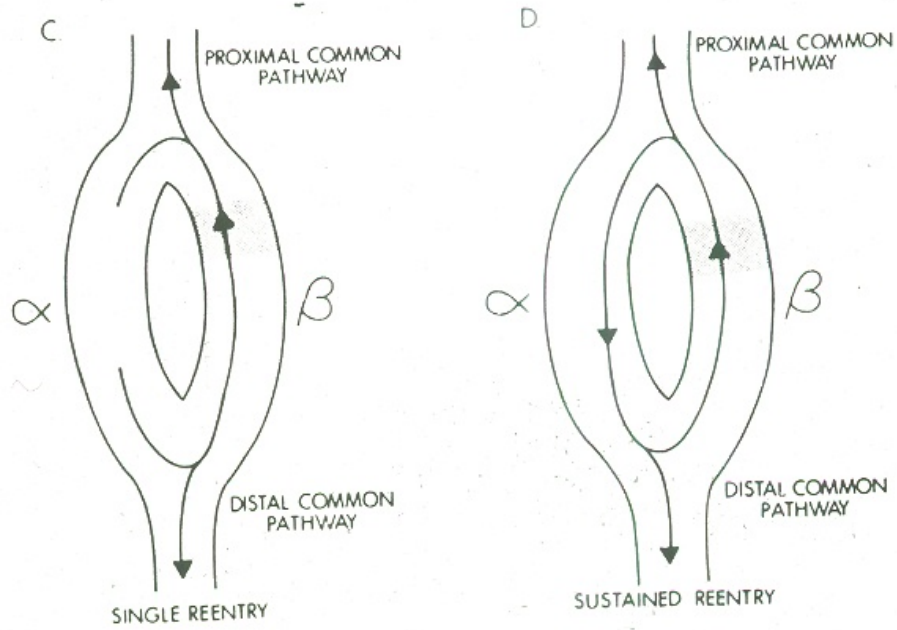
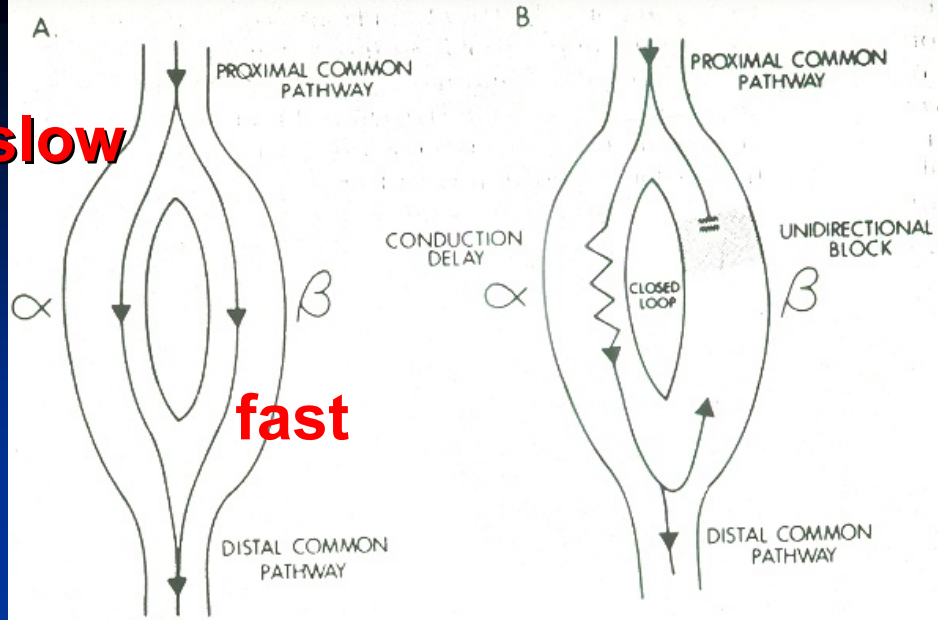
Wavelength = Conduction Velocity x Refractory Period

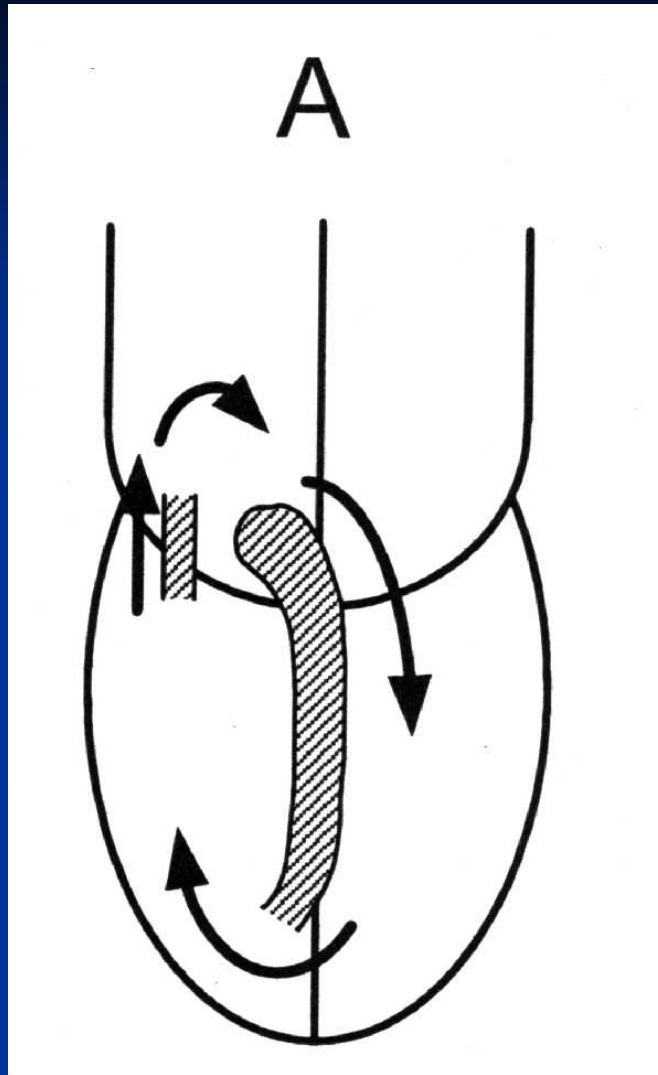


AVNRT



slow



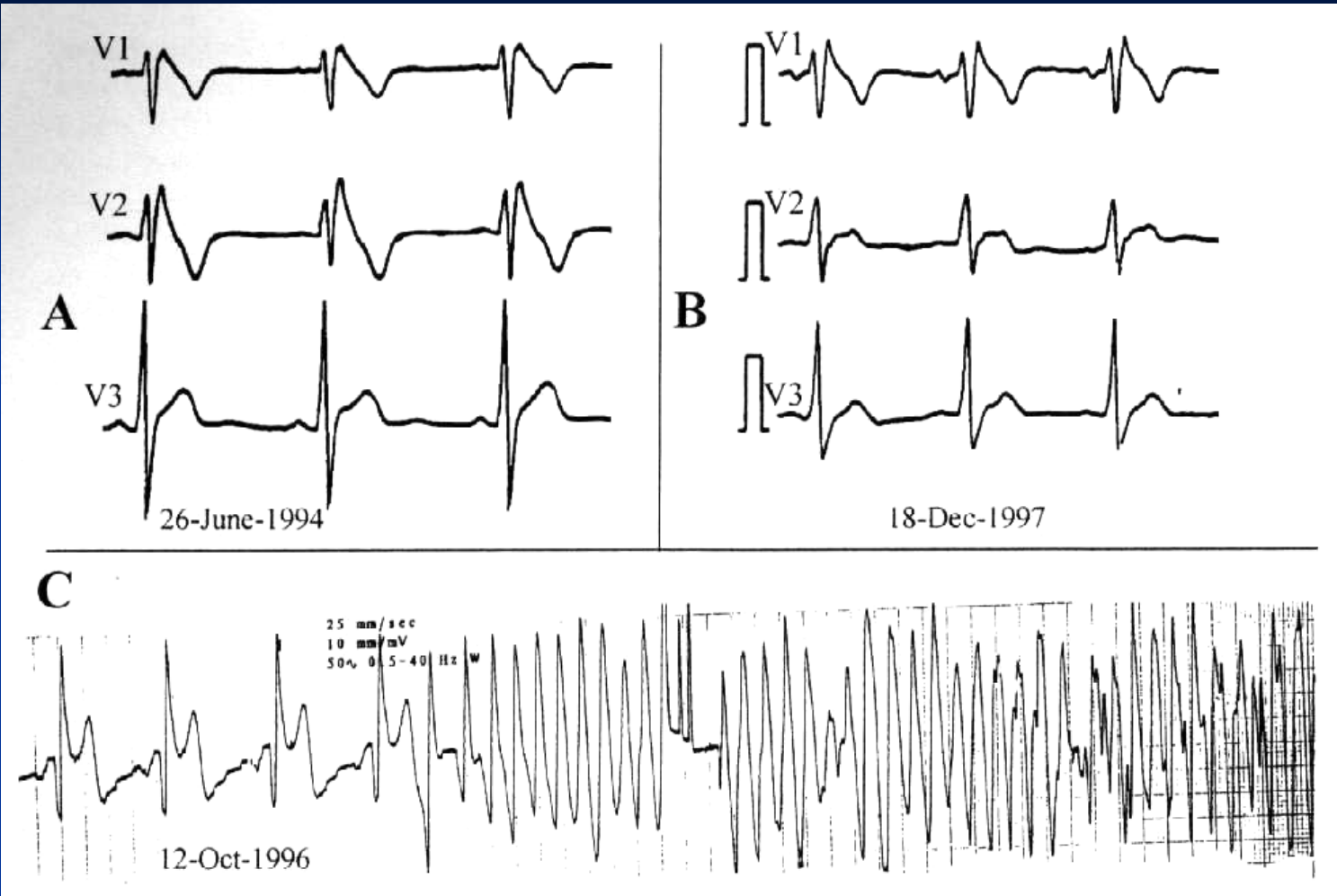


WPW Syndrome

Reentry

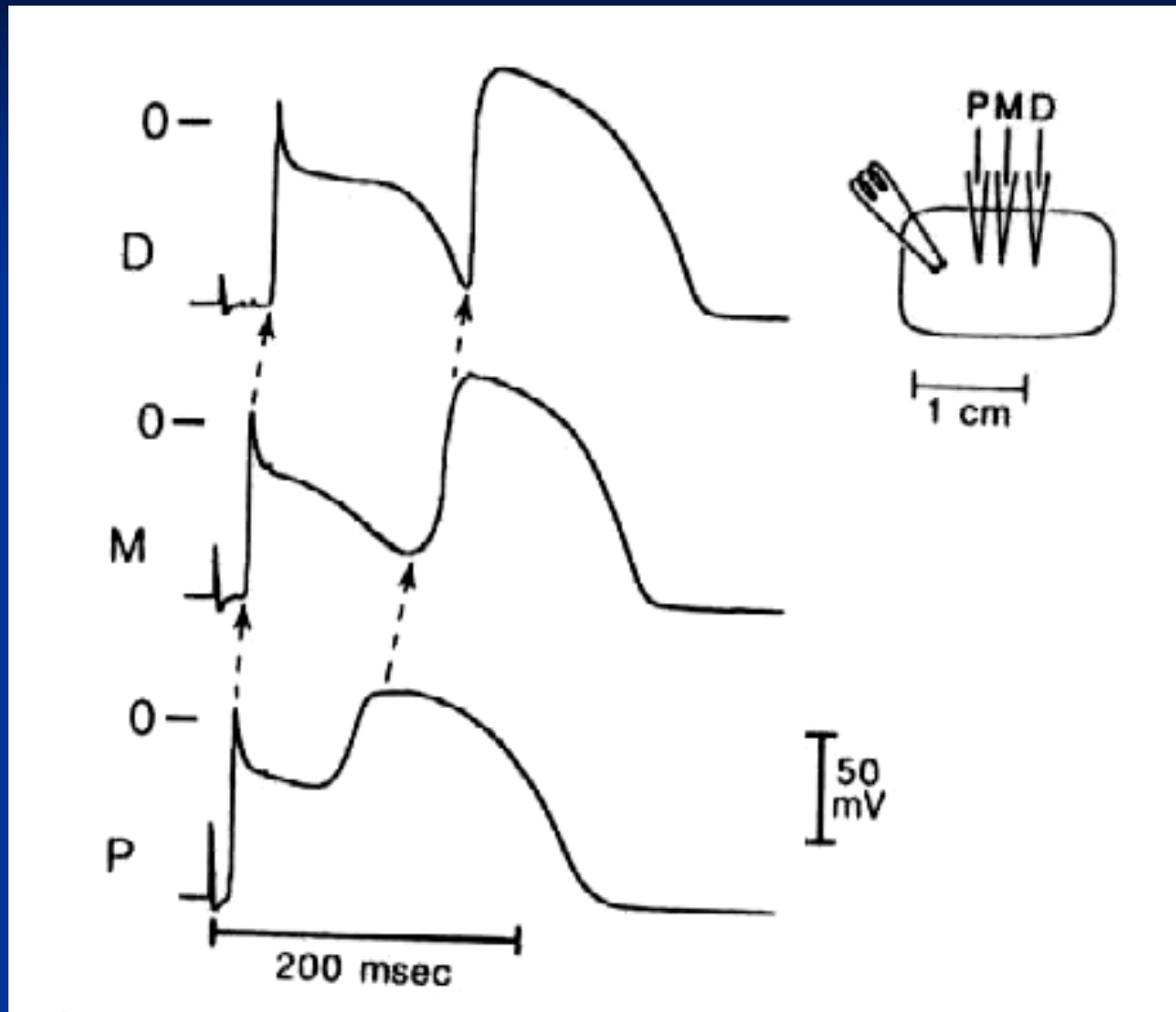
EPS-Diagnosis

1. Continuous electric activity
2. Inducibility/termination by electrical stimulation
3. Inverse relationship of C.I. of initiating extra-stimulus/1st tachycardia beat
4. Entrainment (resetting) by external stimuli

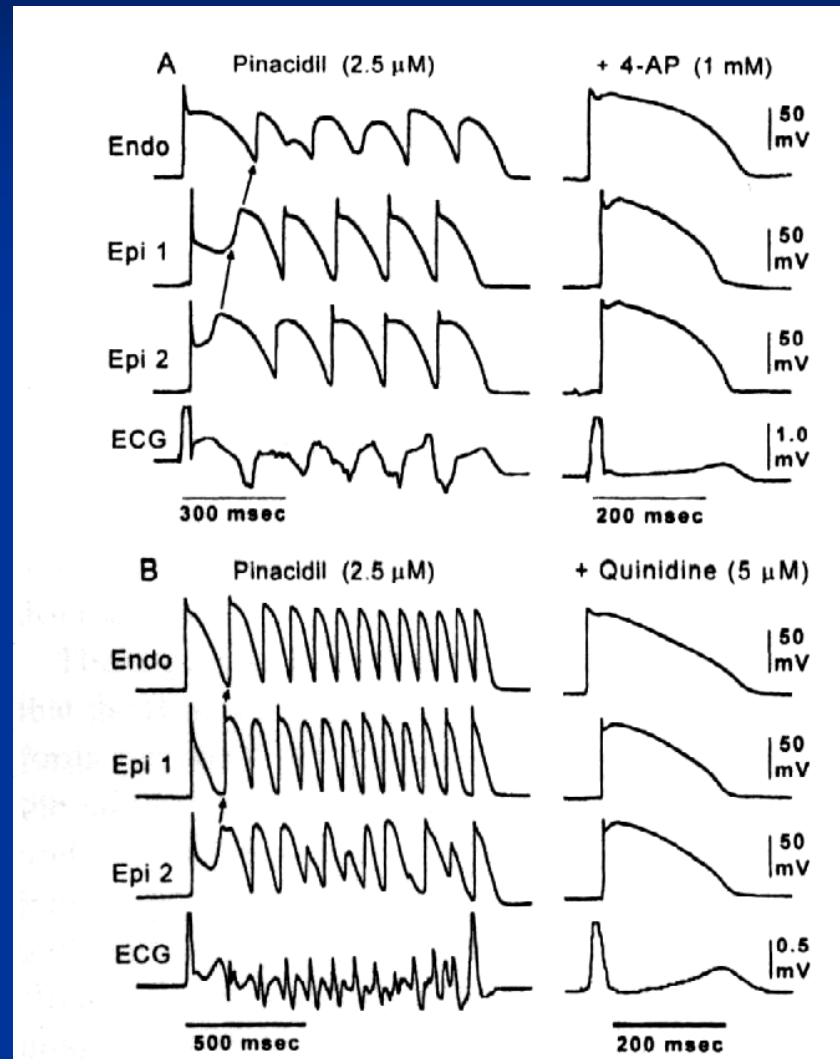


Viskin, Prog Cardiovasc Dis 1998;41:17

Phase II Reentry



Phase II Reentry



Clinical Reentry Tachyarrhythmias

Definite

SANRT

AVNRT

AVRT

A Flutter

Post MI VT

BBR VT

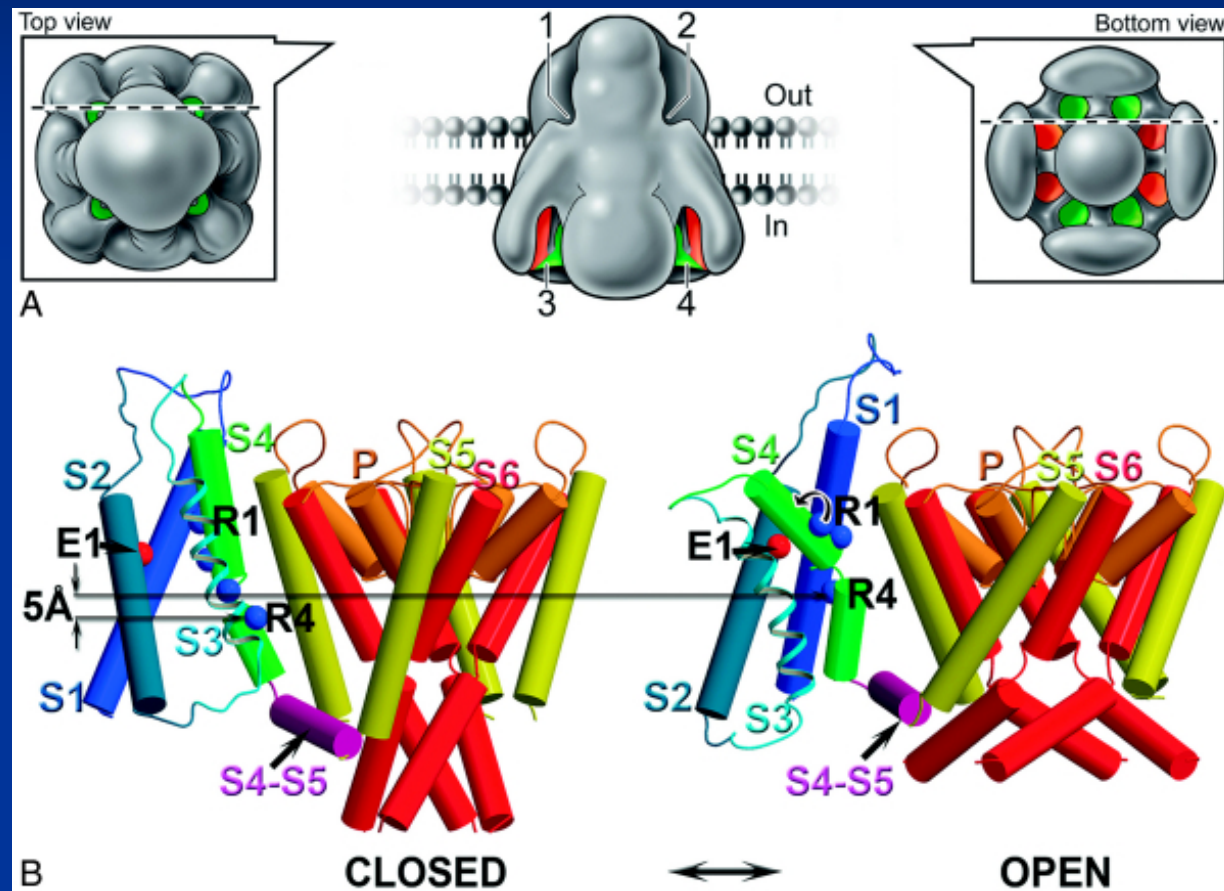
Probable

A Fibrillation

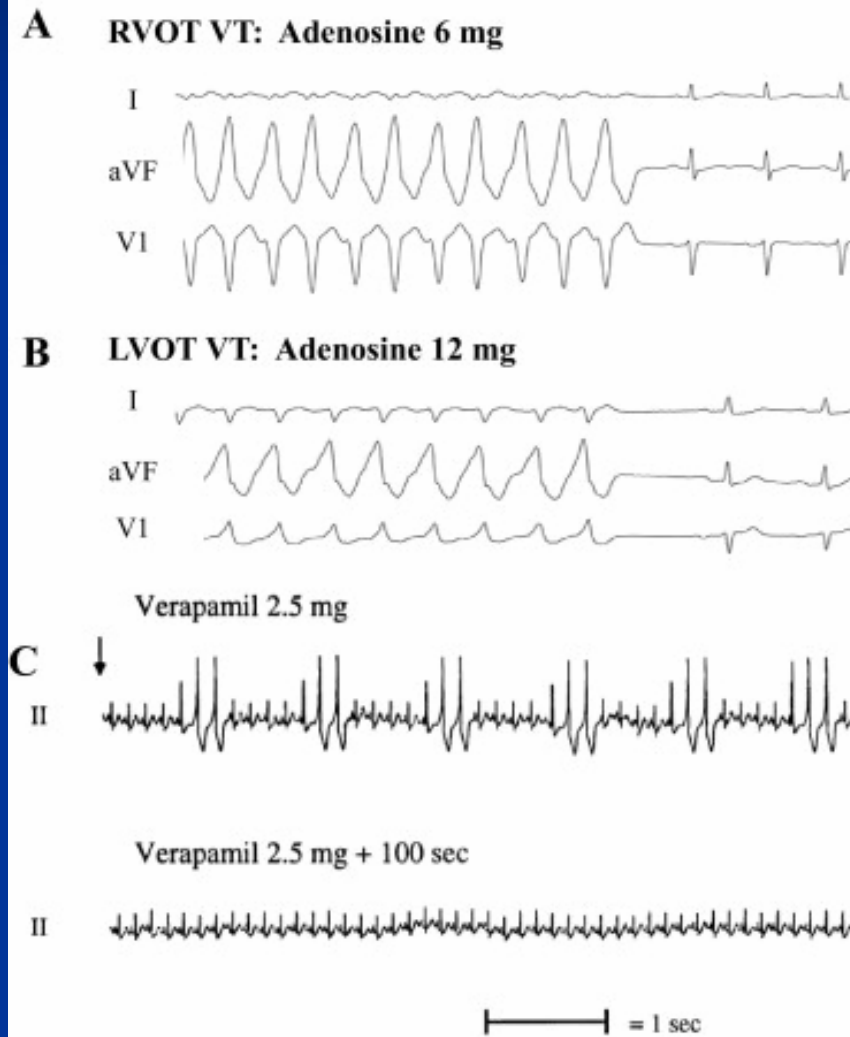
PVT

VF

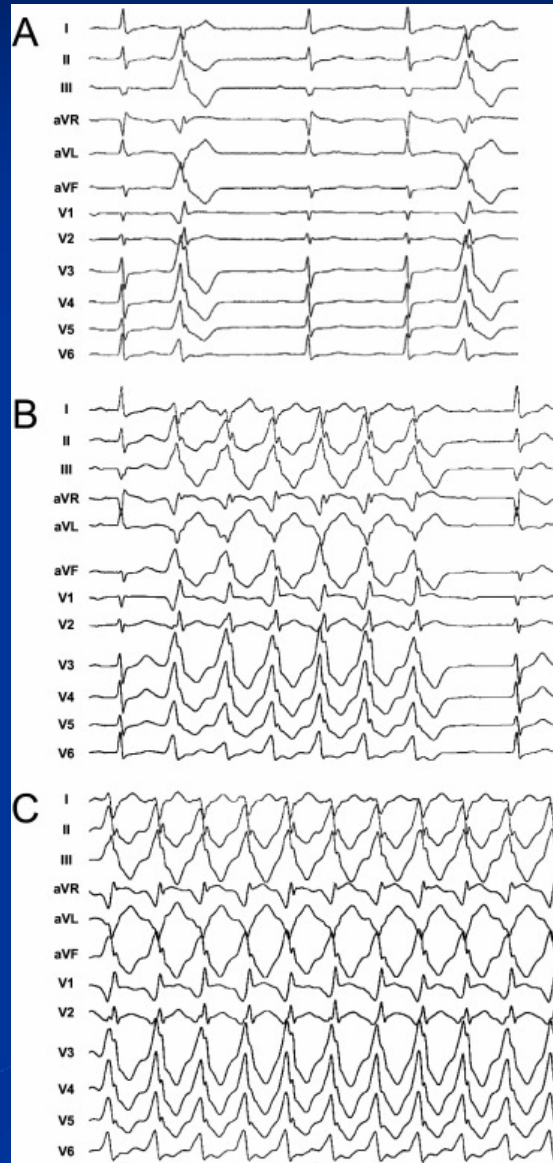
Na Channel

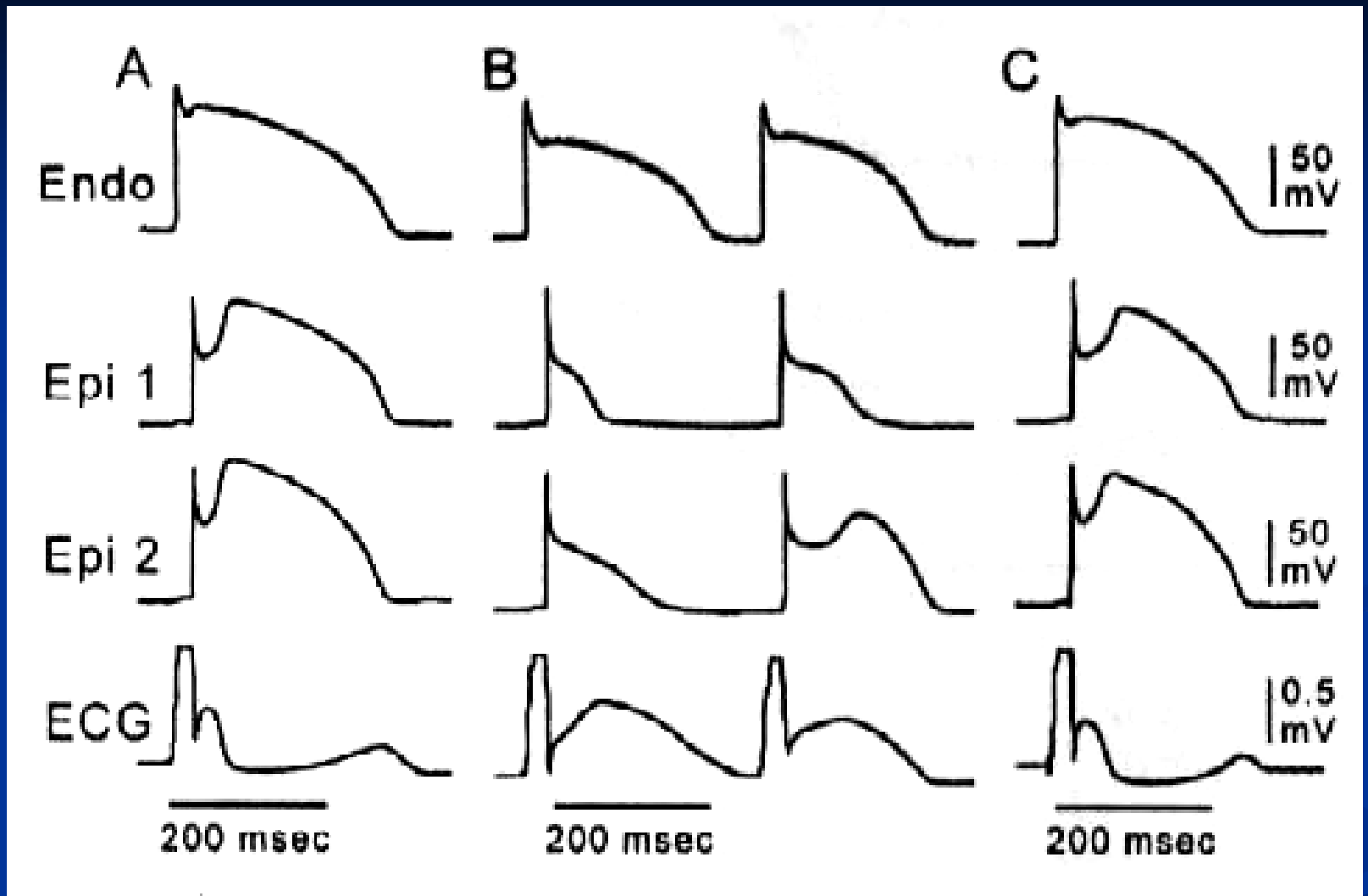


OT VT

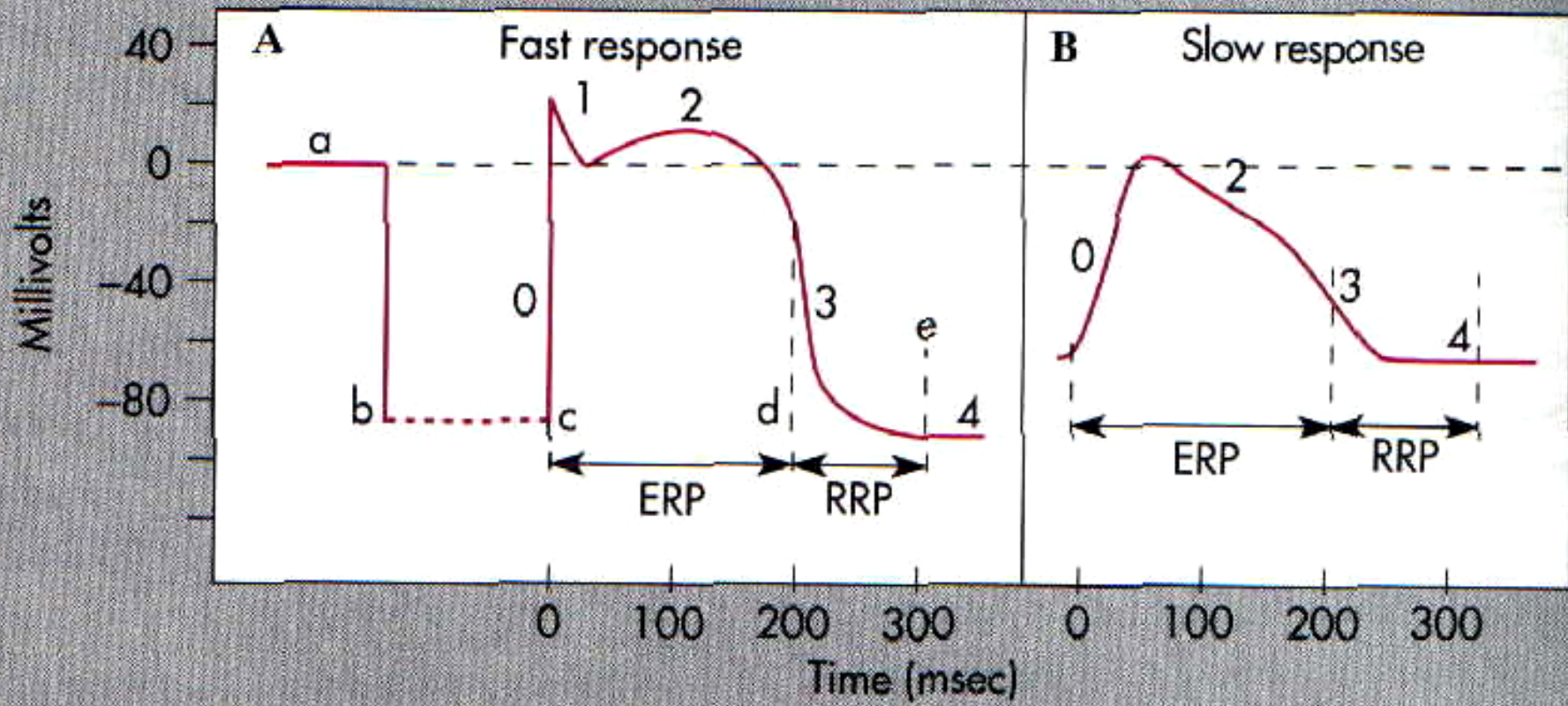


LVOT VT





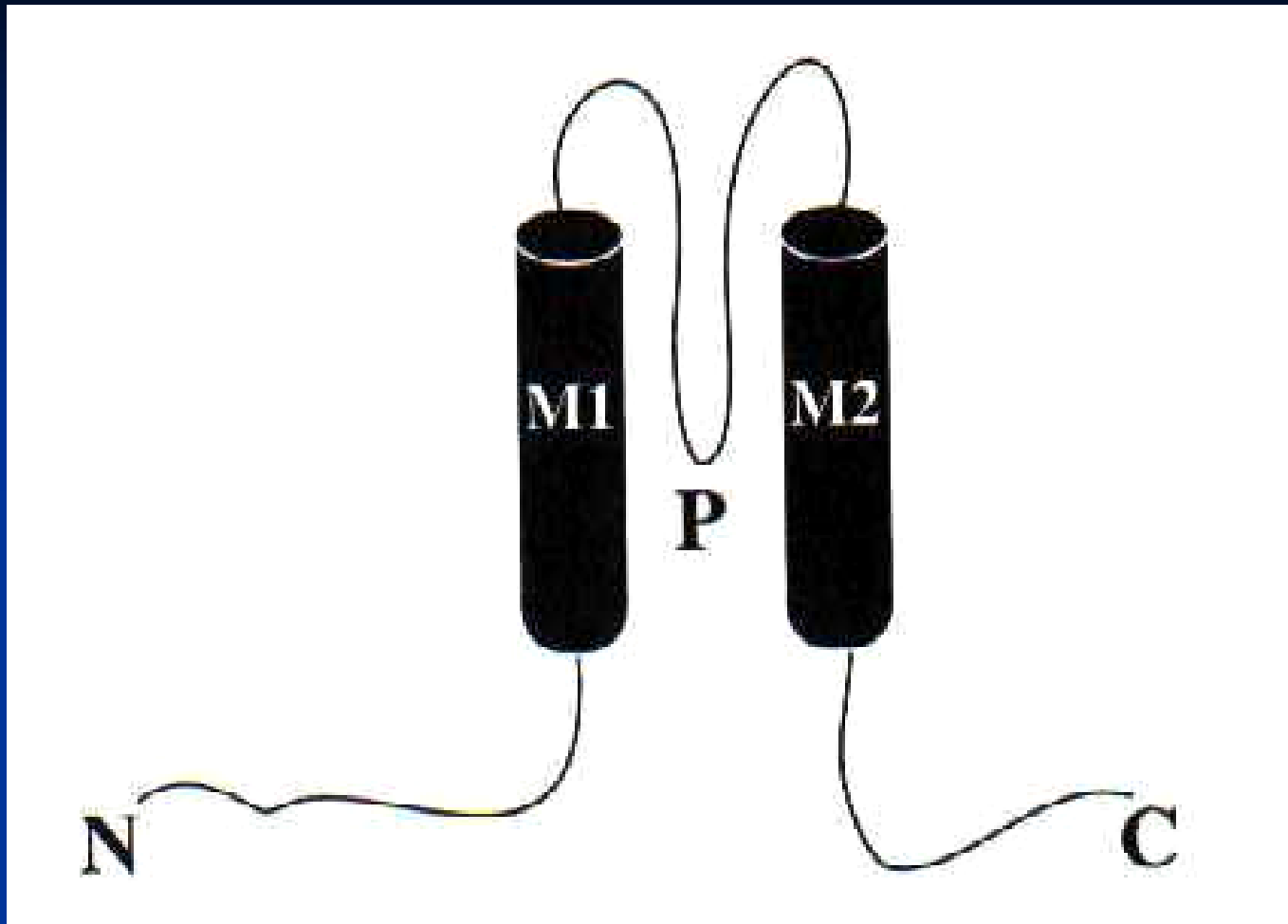
Yan Gan-Xin, Circulation 1999;100:1660



2. מי מהתעלות הבאות האחראית העיקרית לשלב II של פוטנציאל הפעולה החדרי?

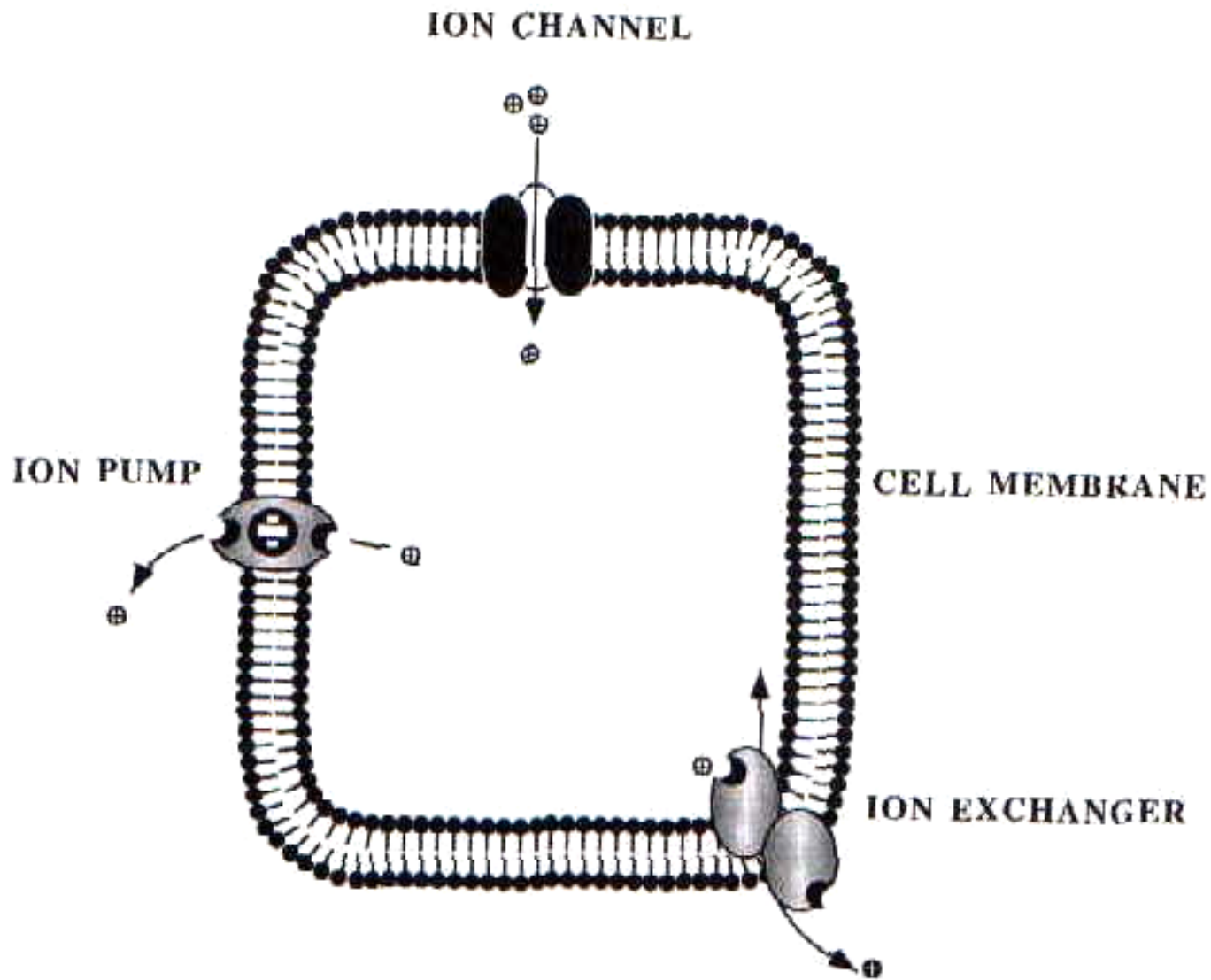
$I_{Ca,L}$	א-
I_{Na}	ב-
I_K	ג-
I_{K1}	ד-
$I_{K,ach}$	ה-

התשובה – א'



Inward Rectifier— I_{k_1}

Jalife et al. Basic Cardiac Electrophysiology for the Clinician, 1998:69



Jalife et al. Basic Cardiac Electrophysiology for the Clinician, 1998:40

1. מי מהבאים יוצא דופן?

I_{ca} -א

I_k -ב

Ryanodin receptor -ג

Na/K ATPase pump -ד

Ca/Na exchanger -ה

התשובה – ג'

4. המשפטים הבאים מתייחסים ל-Triggered Activity. אחד אינו נכון, מהו?

- א- DAD גדלים עקב טכיקרדיה
- ב- LQT3 נגרם בשל מוטציה בתעלת אשלגן
- ג- TdP מתרופות נגרם מחסימת תעלת אשלגן
- ד- מחויב להיגרם ע"י פוטנציאל פעולה קודם
- ה- עודף יונים חיוביים בתא גורם להארכת QT

התשובה הנכונה – ב'

3. אחת מהפרעות הקצב להלן נגרמת עקב . Abnormal automaticity. איזו היא?

א- PAT עקב הרעלת דיגוקסין

ב- TdP מקינידין

ג- RVOT VT במאמץ

ד- AVNRT

ה- AIVR

התשובה הנכונה – ה'

5. המשפטים הבאים מתייחסים ל REENTRY. אחד

אינו נכון,
מהו?

א- המנגנון השכיח ביותר לאריתמיות באדם

ב- אחראי לאריתמיה בתסמונת ברוגדה

ג- אחראי עיקרי ל VT לאחר אוטם ישן

ד- חסם חד כיווני אינו תנאי הכרחי להתחלתו

ה- בטכיקרדיה, אורך הגל קצר מאורך המסלול

התשובה הנכונה – ד'

EAD

Pathophysiology

- AP prolongation

↓ I_k , I_{k1} , I_{to}

↑ I_{NA} , I_{ca} , electrogenic Na–Ca exchanger

AP Plateau - ↓Currents → ↑sensitivity

- Net depolarizing current

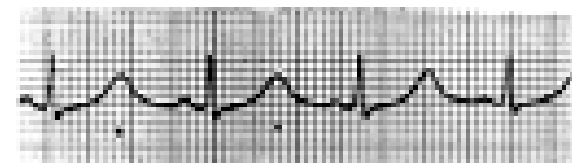
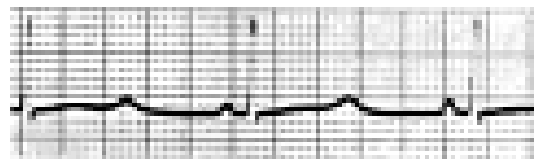
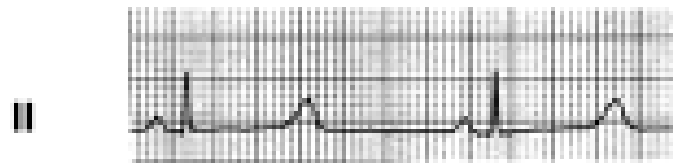
- $I_{ca,L}$ (window) -

Genotype and ECG

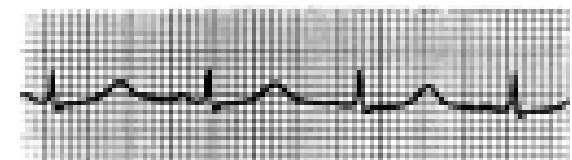
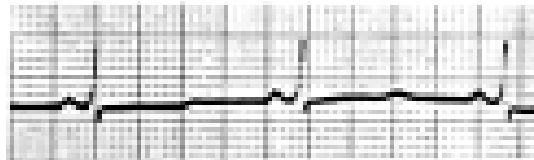
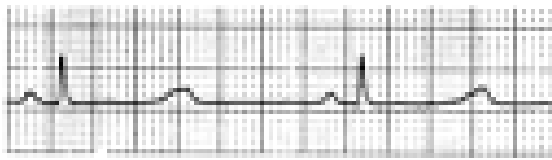
Chromosome 3

Chromosome 7

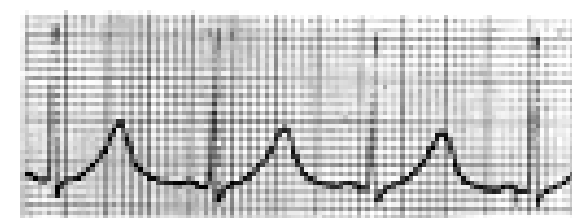
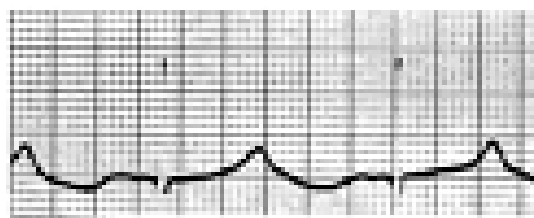
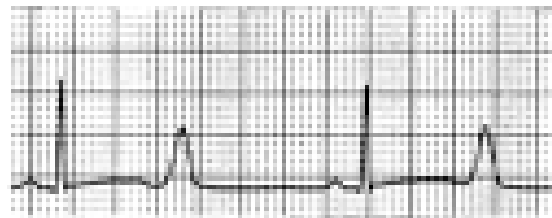
Chromosome 11



aVF



V6

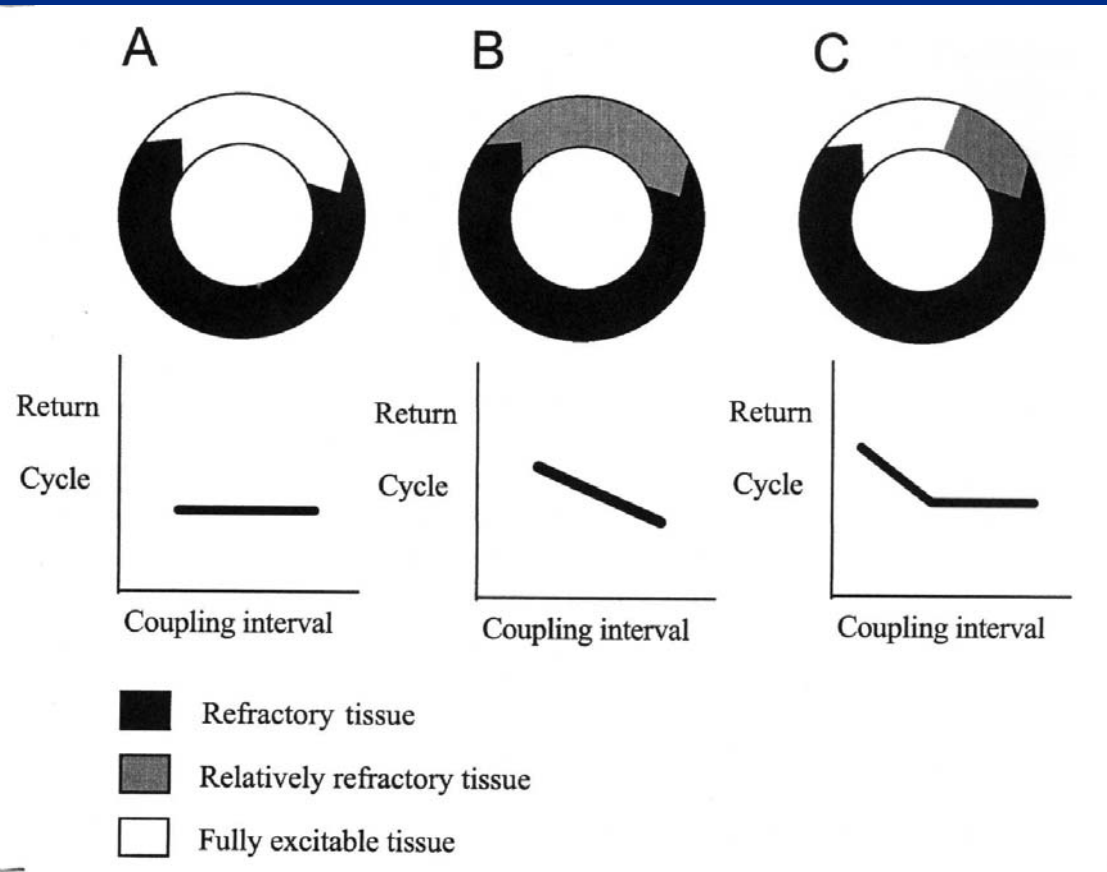


Reentry

Unidirectional block

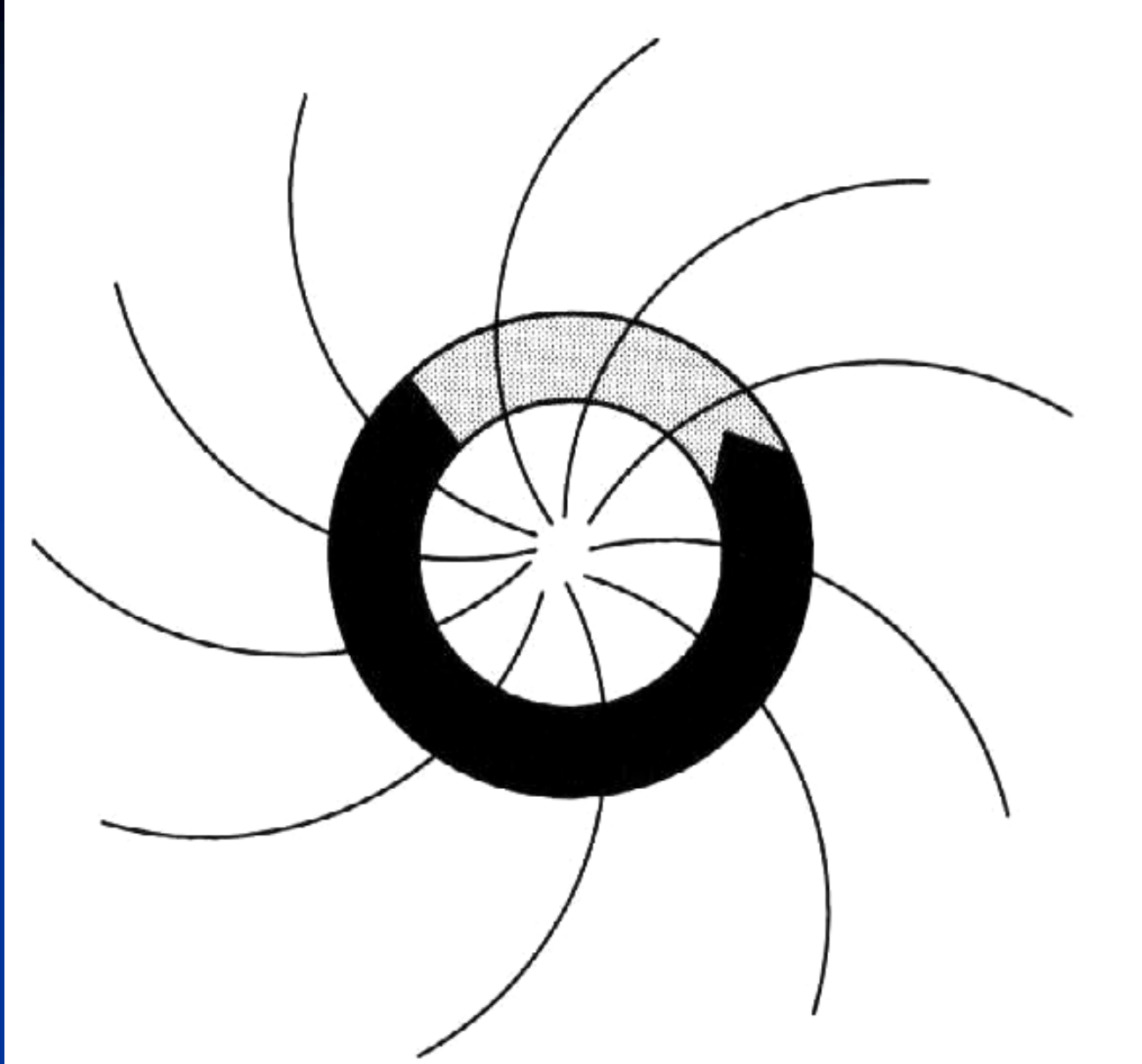
1. Increase in sinus rate
2. Rapid or premature atrial pacing
3. Retrograde activation from VPC
4. Autonomic influence
5. AAD
6. Ischemia

Resetting



Leading Circus Reentry

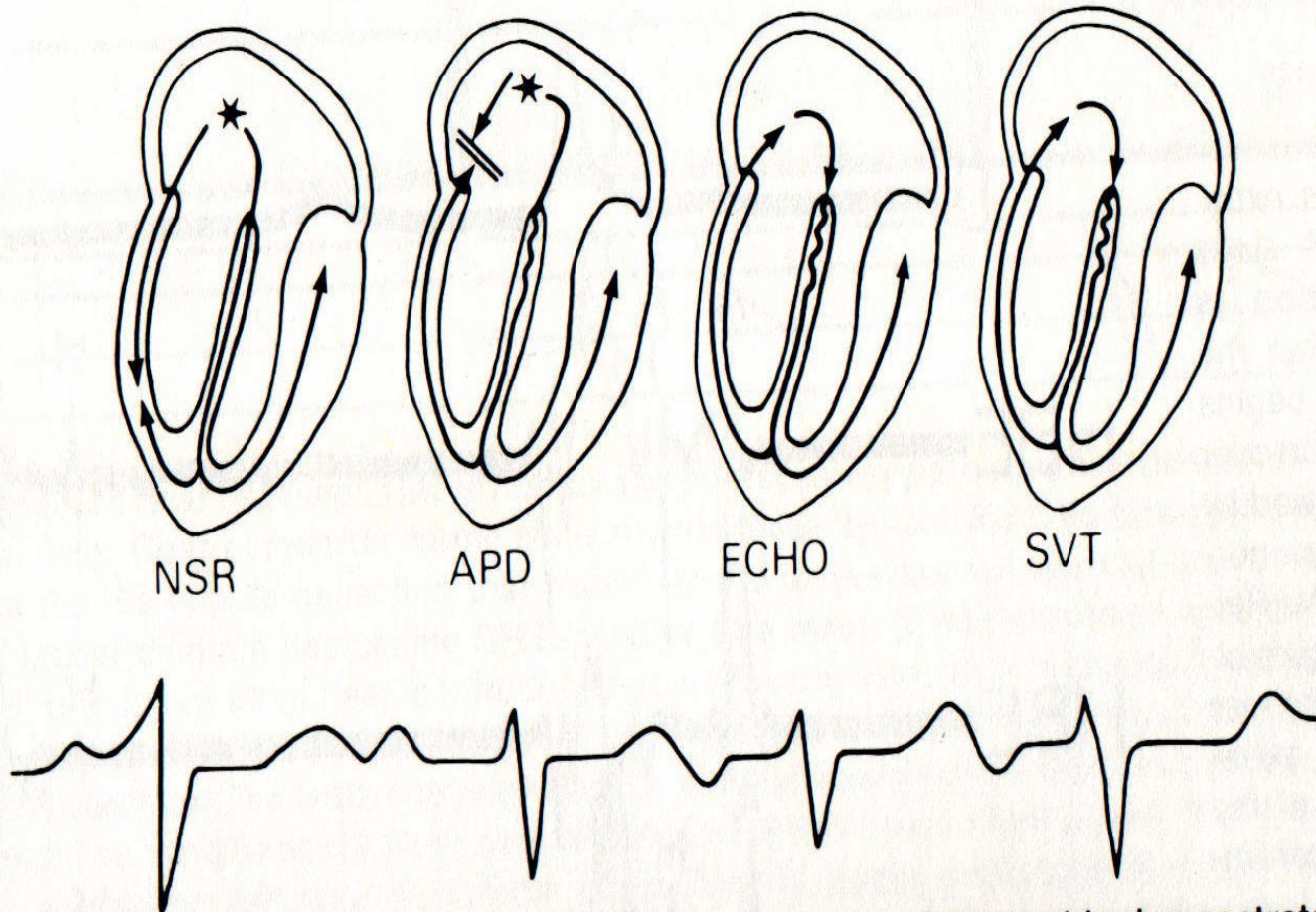
1. Cannot be interrupted by disrupting the circuit
2. No fully excitable gap
 - unstable
 - insensitive to electrical stimulation
3. Short cycle length



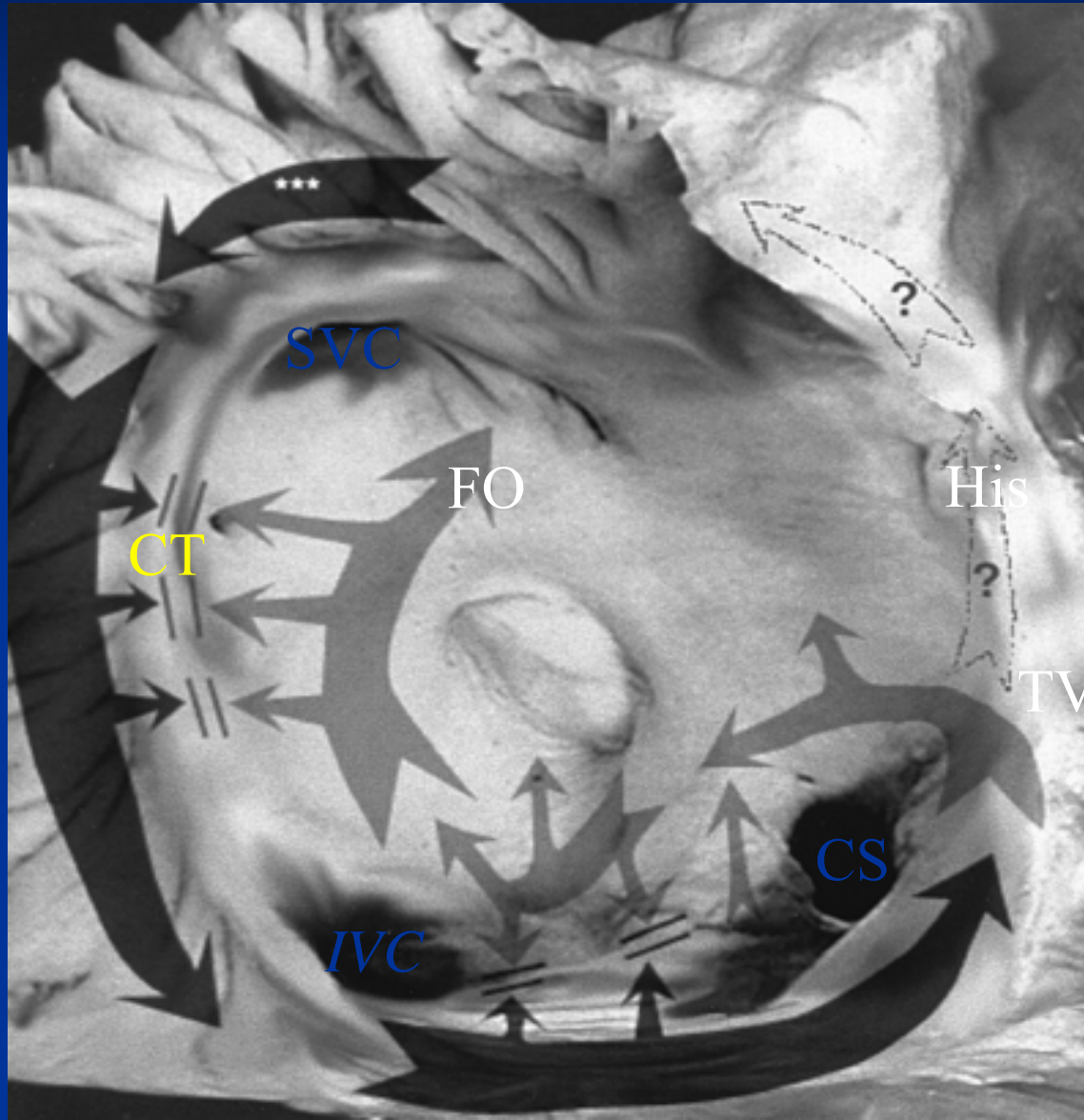
Leading Circle

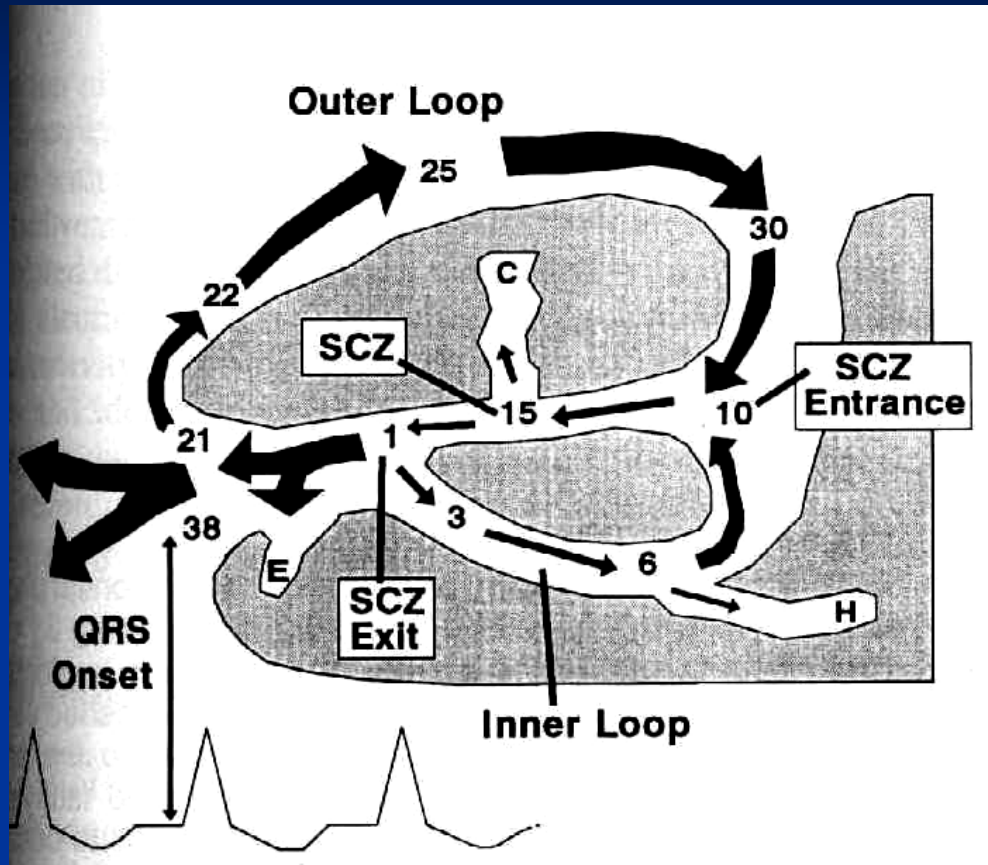
Jalife et al. Basic Cardiac Electrophysiology for the Clinician, 1998:237

APC in WPW



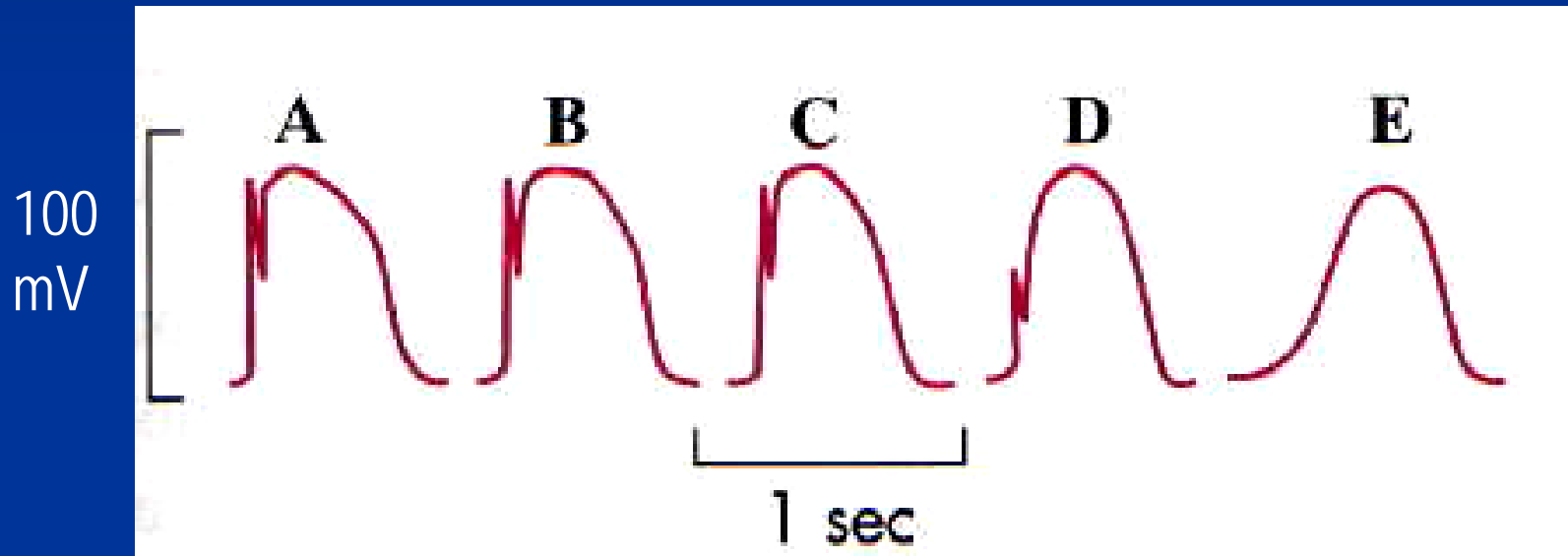
Atrial flutter circuit



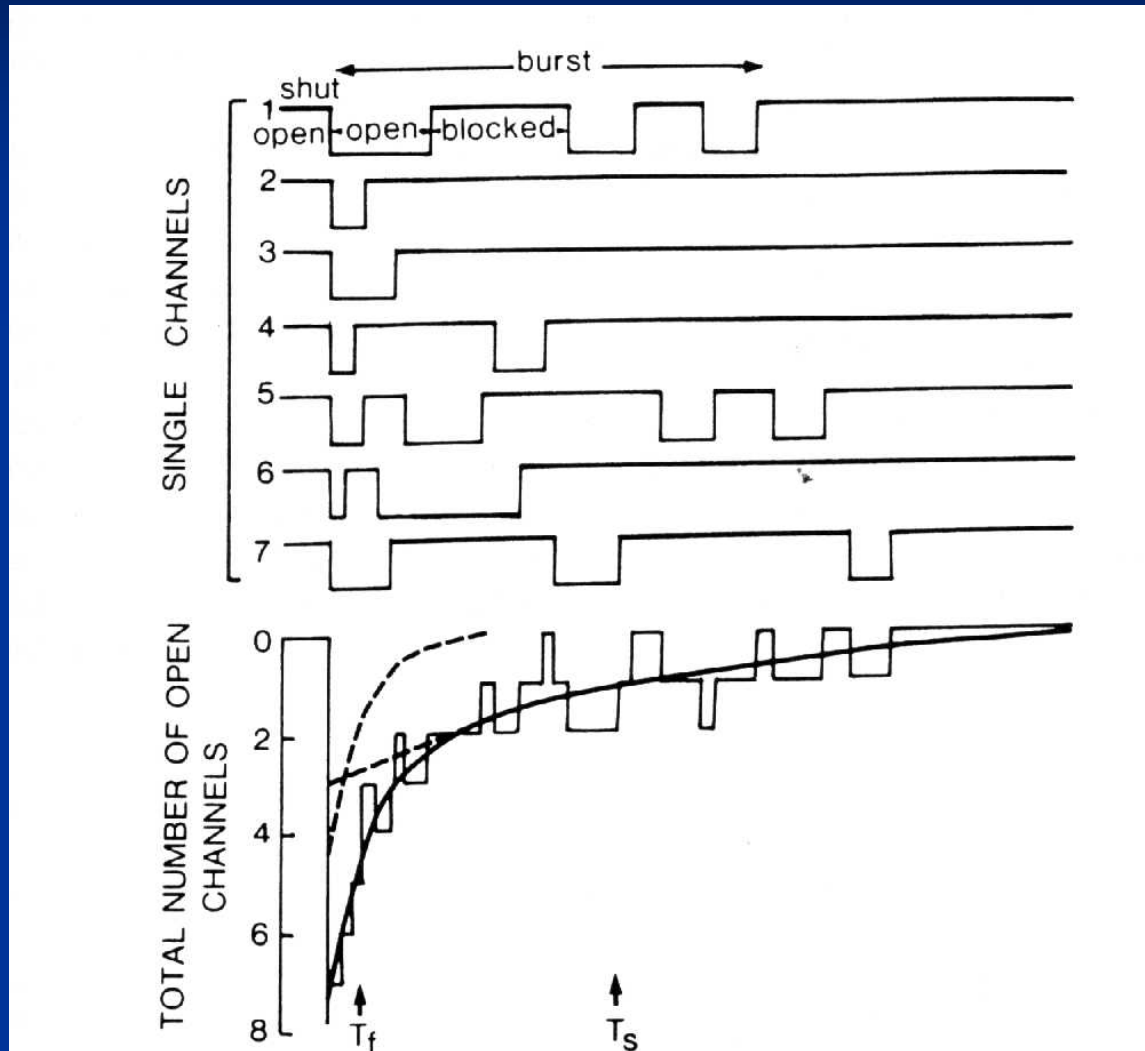


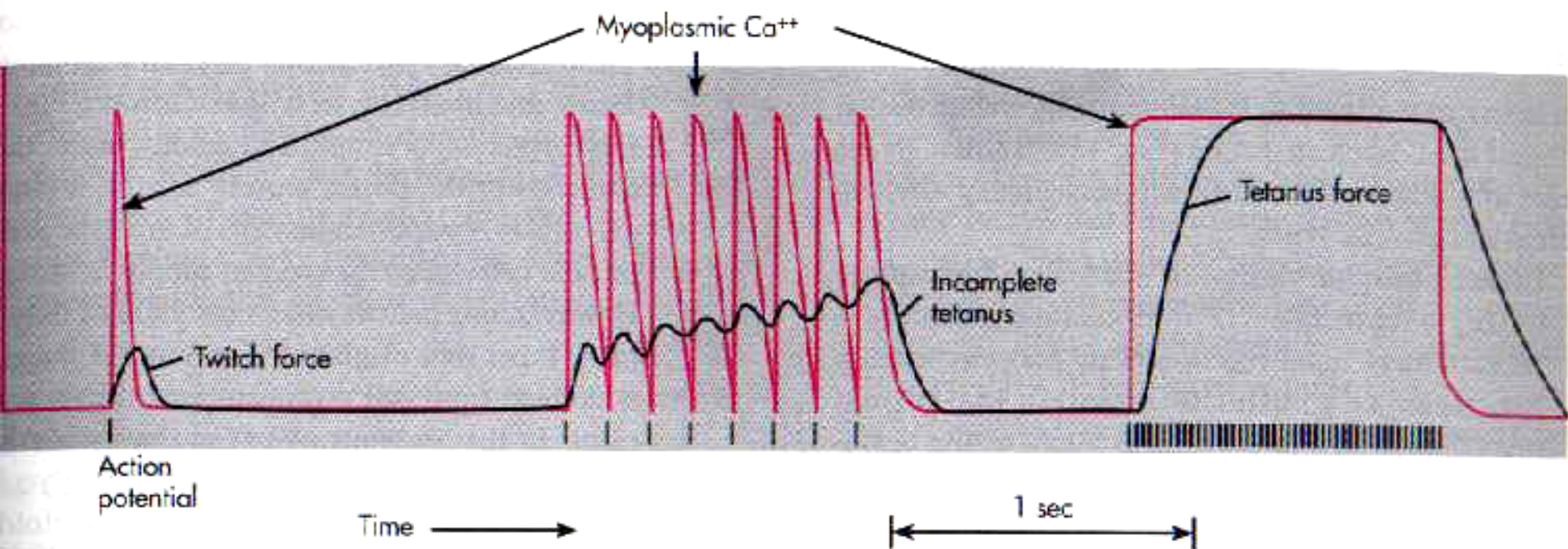
Reentry circuit

Tetrodotoxin effect on Action Potential



Channels Open in Bursts





DAD

Characteristics

- Induction
 - fast train
 - 1 ES
- ↓ CI / CL of initiating stimulus/li
 - ↓
 - ↓ CI of triggered response
- Termination
 - 1 ES
 - ODP

