

Surgical Energy: Connecting Power Electronics to Patients – Literally!



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APEC Plenary Session
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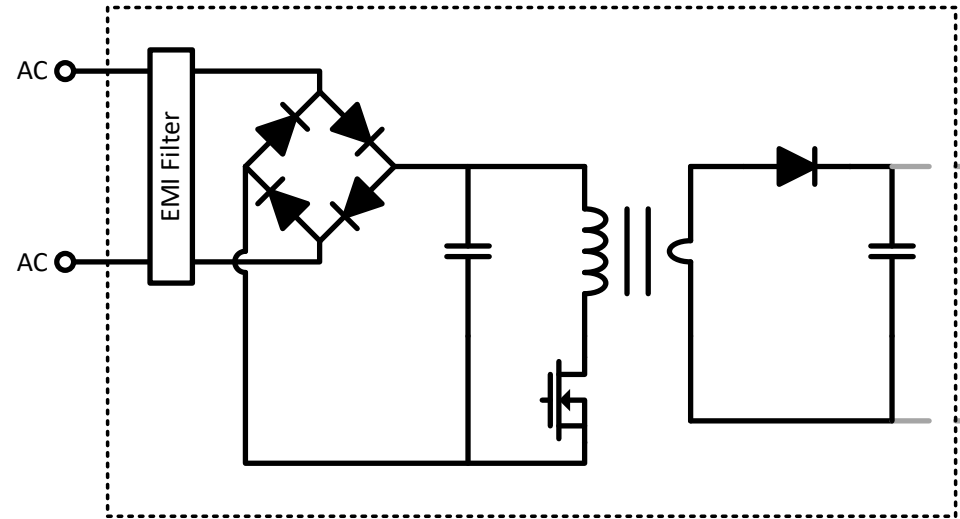



MINNETRONIXTM
MEDICAL

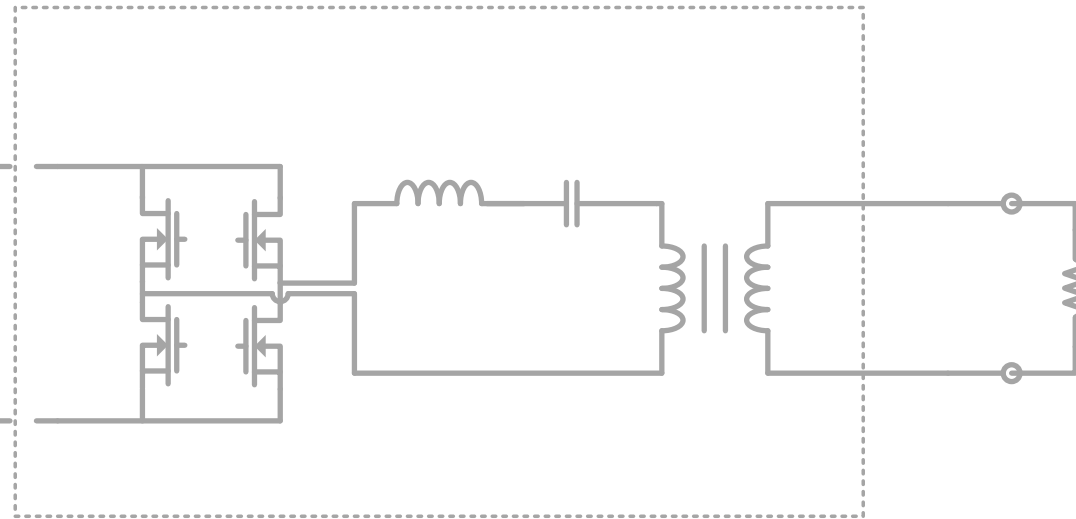
APEC[®]

Connecting Power Electronics to Patients

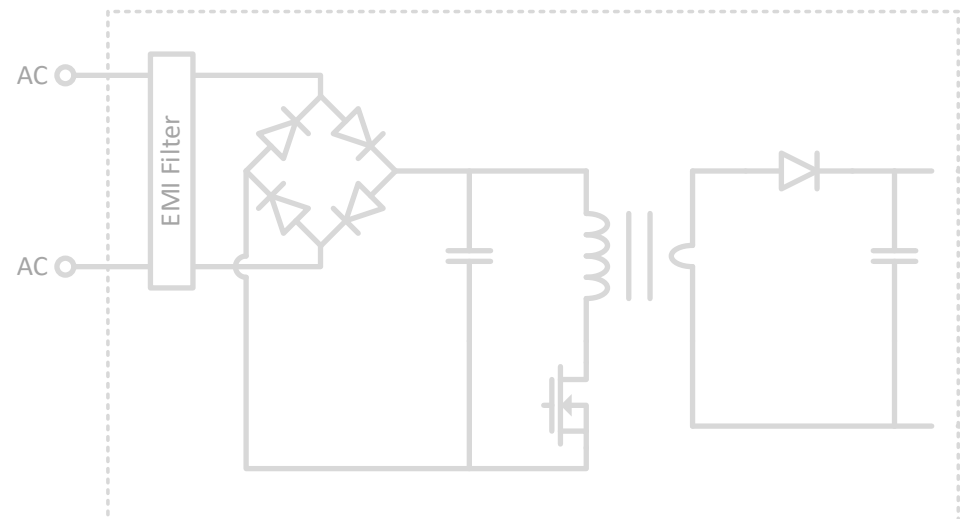
Input AC/DC



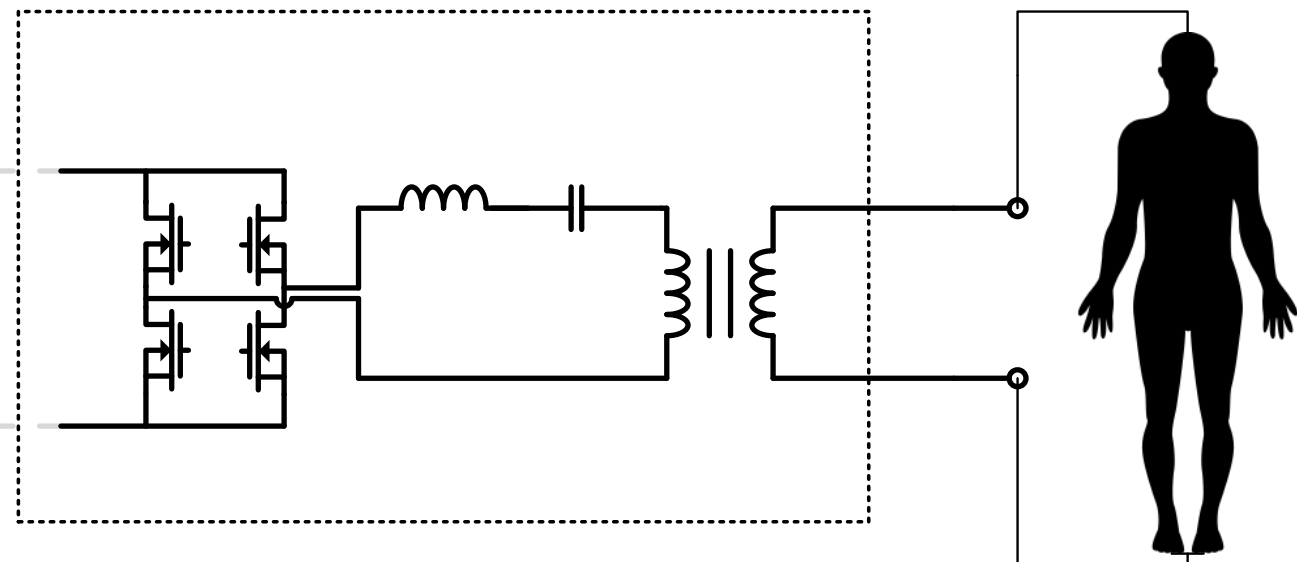
Output DC/AC



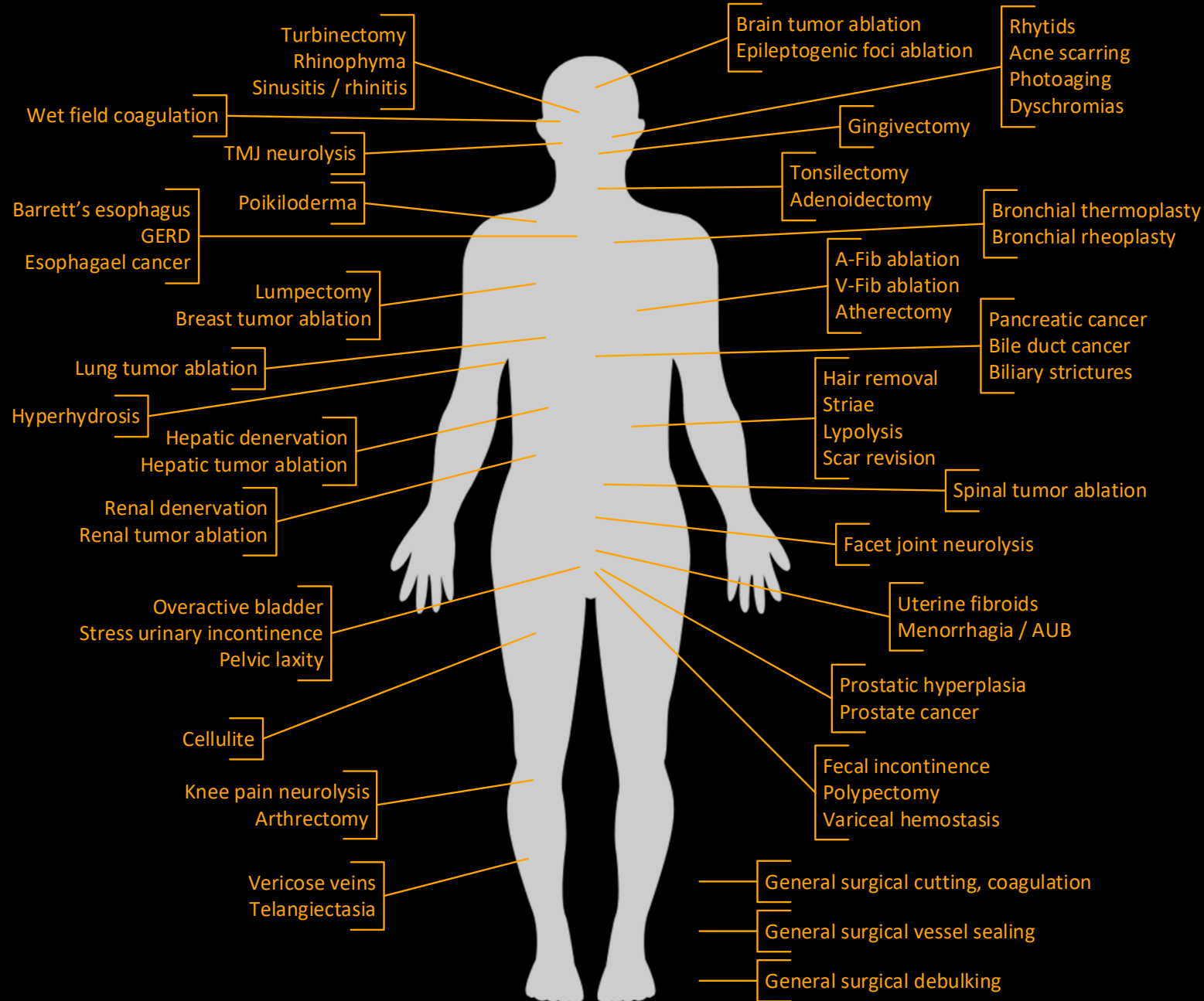
Input AC/DC



Output DC/AC



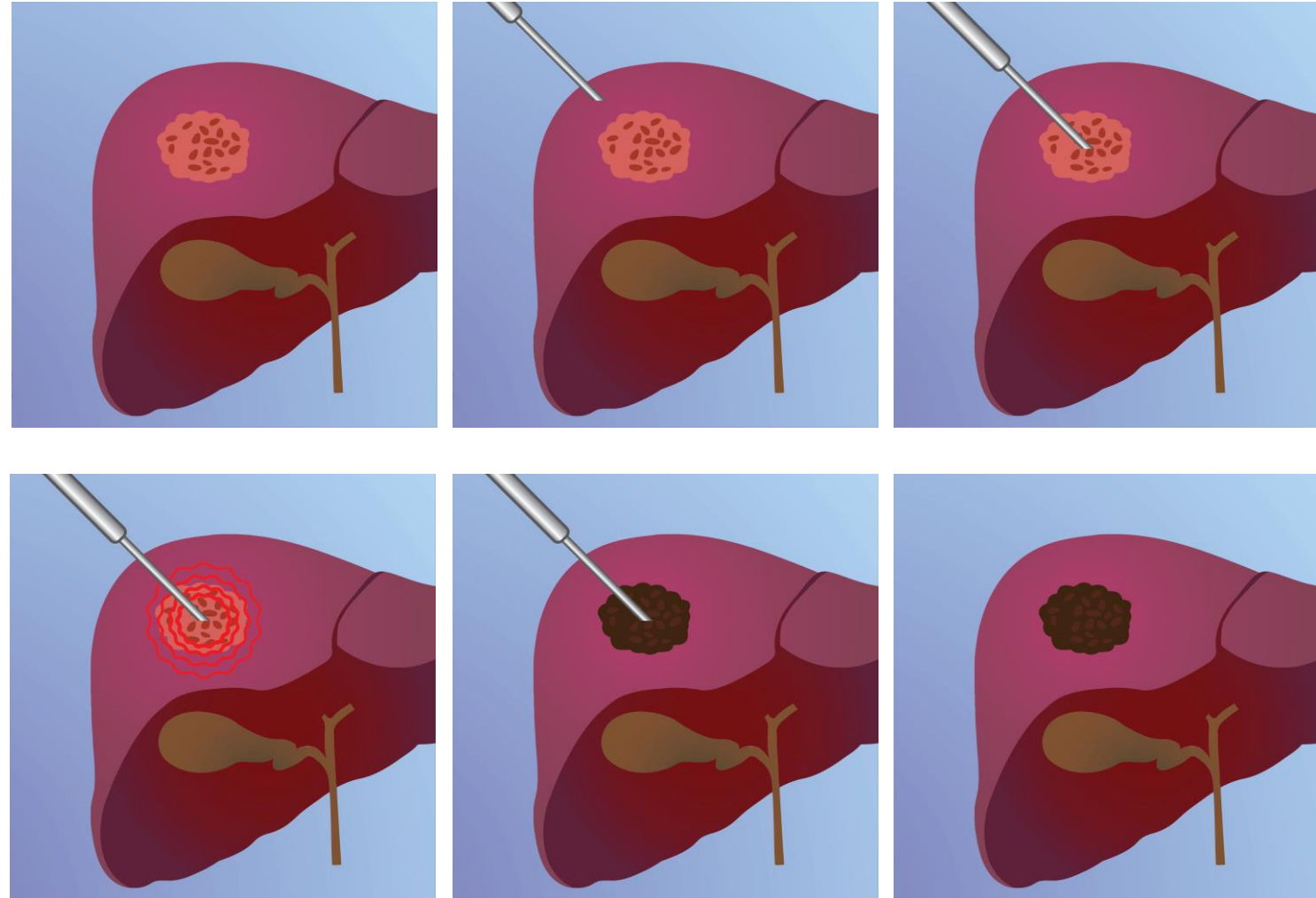
Applications of *Surgical Energy* Across the Human Body



Clinical Application #1: RadioFrequency Ablation of Tumor

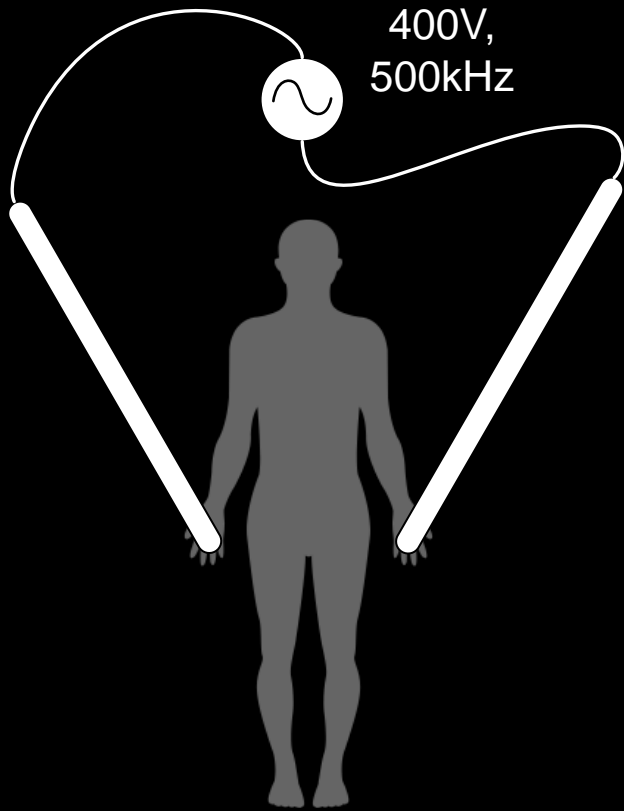
1. Needle electrode introduced
2. Navigated to center of tumor
3. Electric current causes I^2R heating
4. Heat causes cell death
5. Remove needle electrode

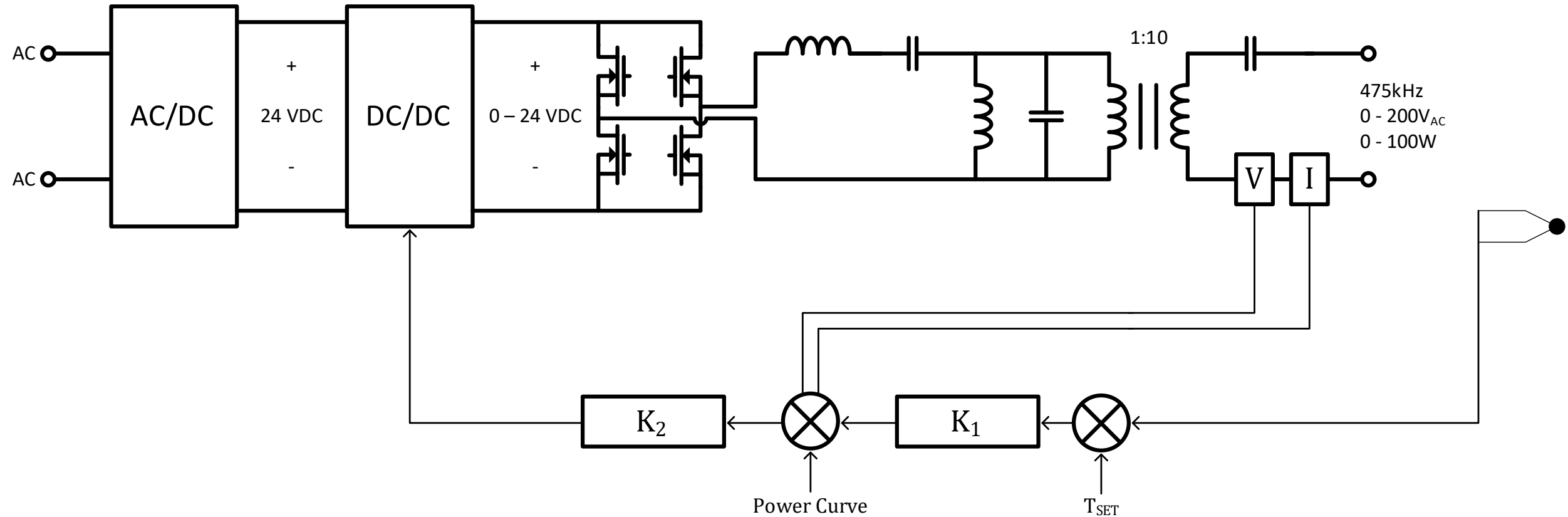
***Minimally-invasive,
curative procedure***



Is This Safe?

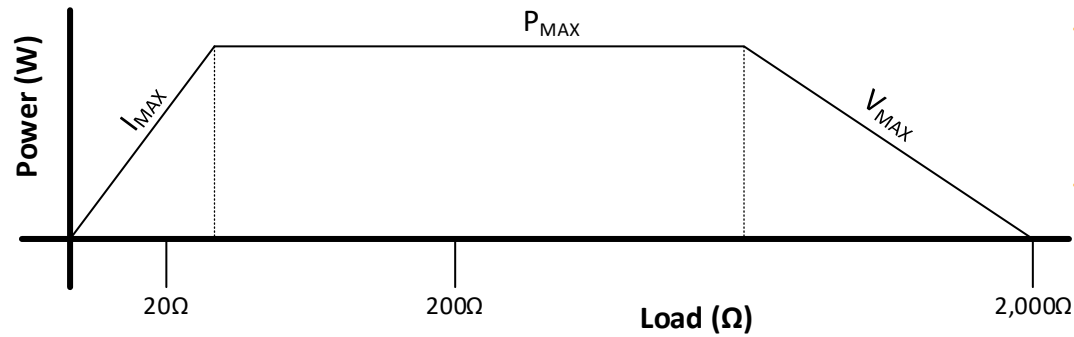
Yes! Currents above $\sim 100\text{kHz}$ can pass through tissue without stimulating muscle





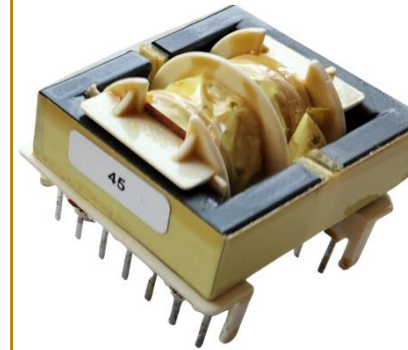
- + Resonant converters
- + Temperature controlled to $<100^{\circ}\text{C}$
- + Secondary control loop limiting V_{MAX} , I_{MAX} , P_{MAX}

Power curves



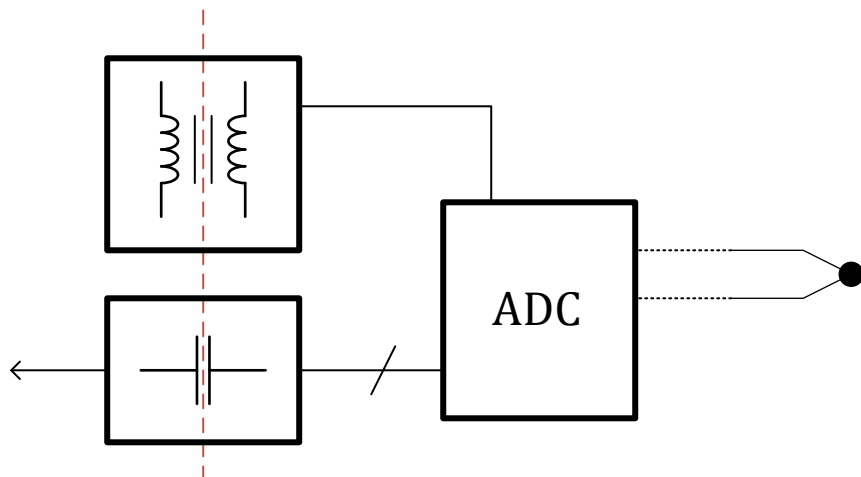
- + Wide range of load impedance
- + Each “power curve” specific to a therapy

Output transformers



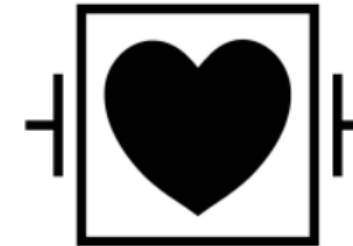
- + **Galvanic isolation**
 - Split bobbin
 - Large creepage and clearance
- + **Litz wire**
- + **Gapped to incorporate**
 $L_{leakage}$

Peripheral Isolation



- + **Isolated power and data**
- + **pF's matter!**

Safety Standards



- + **Defib proof**
- + **Leakage currents**

From Thermal Energy to Electric Field Energy

2,000 BCE



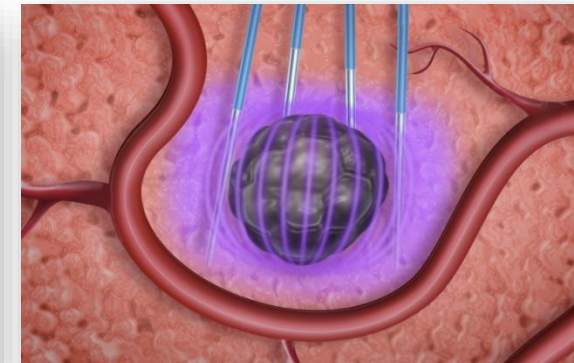
Thermal Cautery

1920's

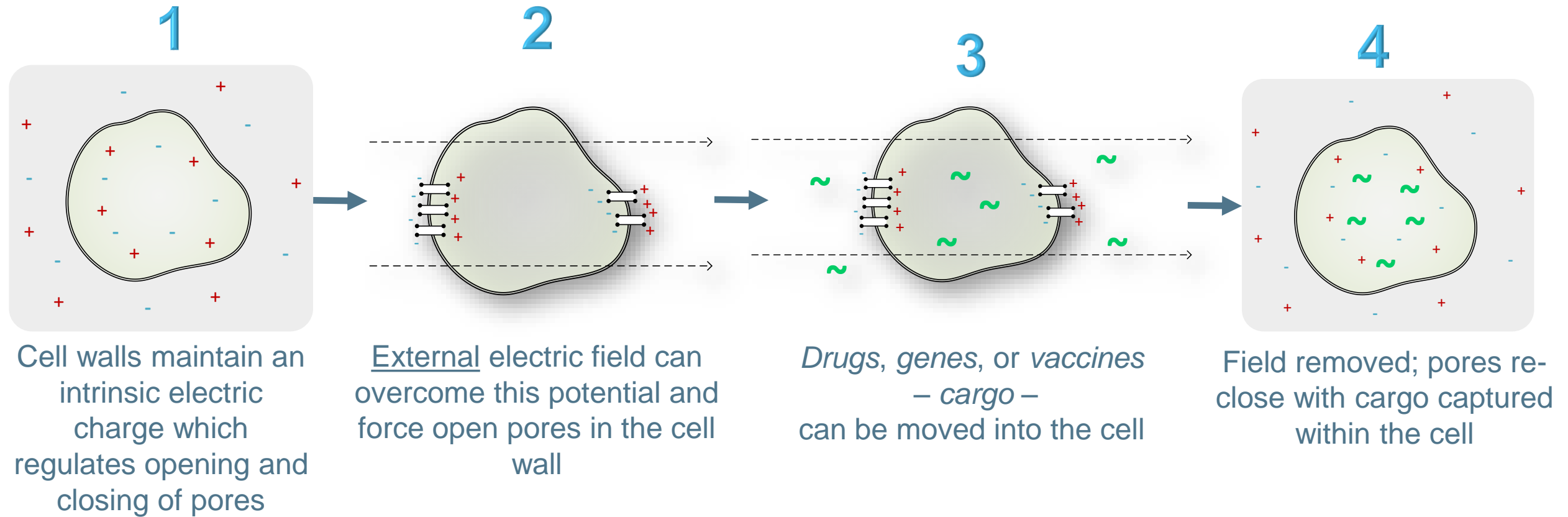


First
RadioFrequency
Surgical Energy
Devices

2000's

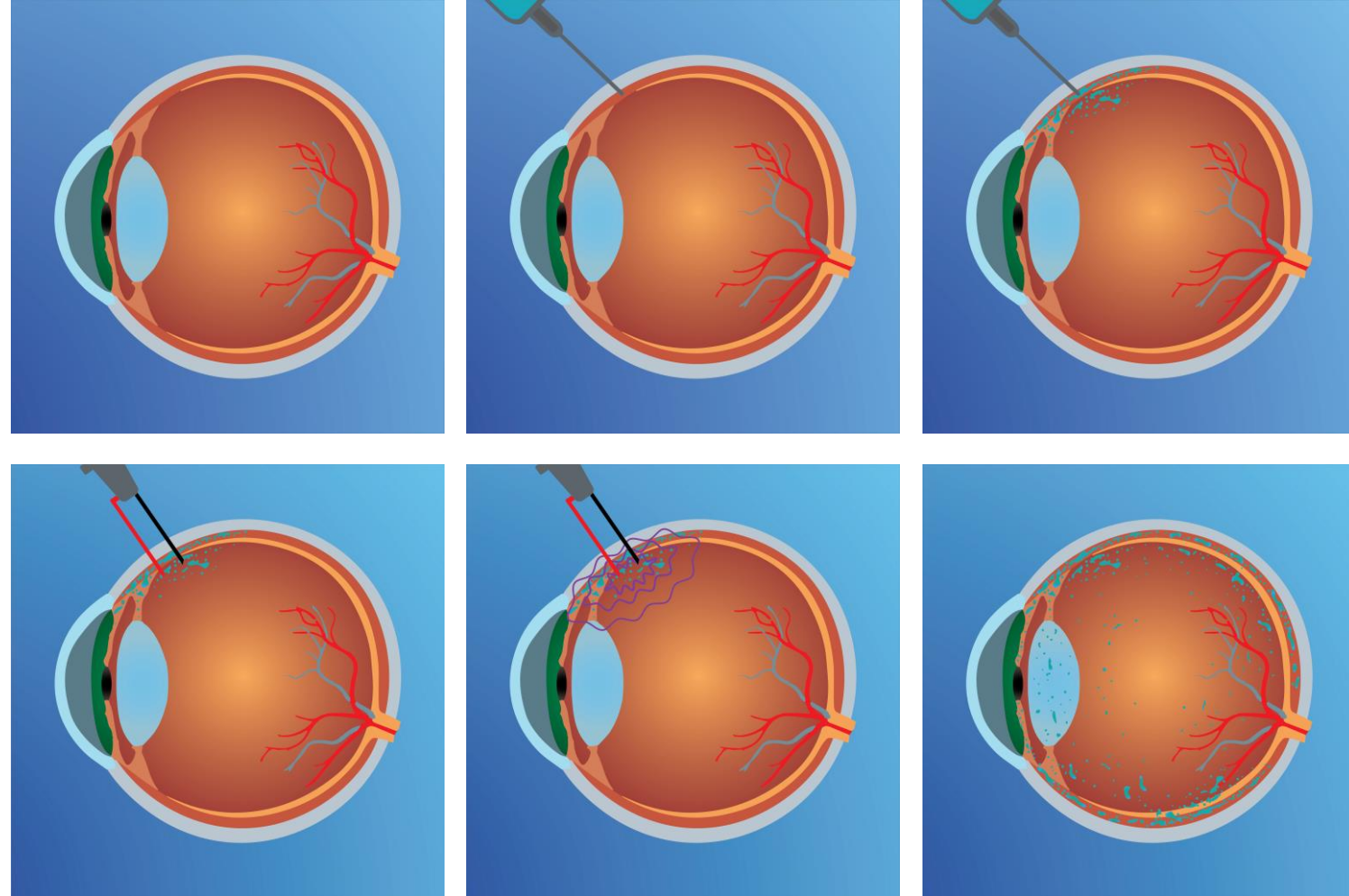


Electric Field
Therapies



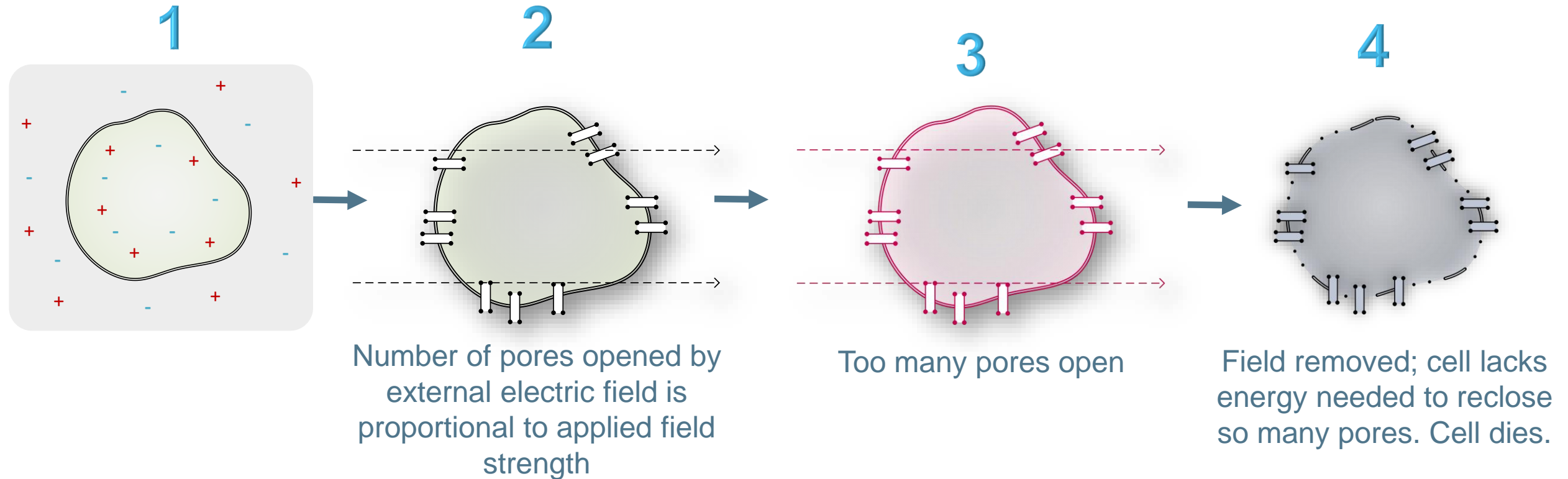
Clinical Application #2: Treating Macular Degeneration

1. Needle injects DNA strand
2. Bipolar electrode introduced
3. Connection to external voltage source electroporates DNA into target cells
4. Treated cells are re-programmed to act as a perpetual “bio-factory” for therapeutic proteins



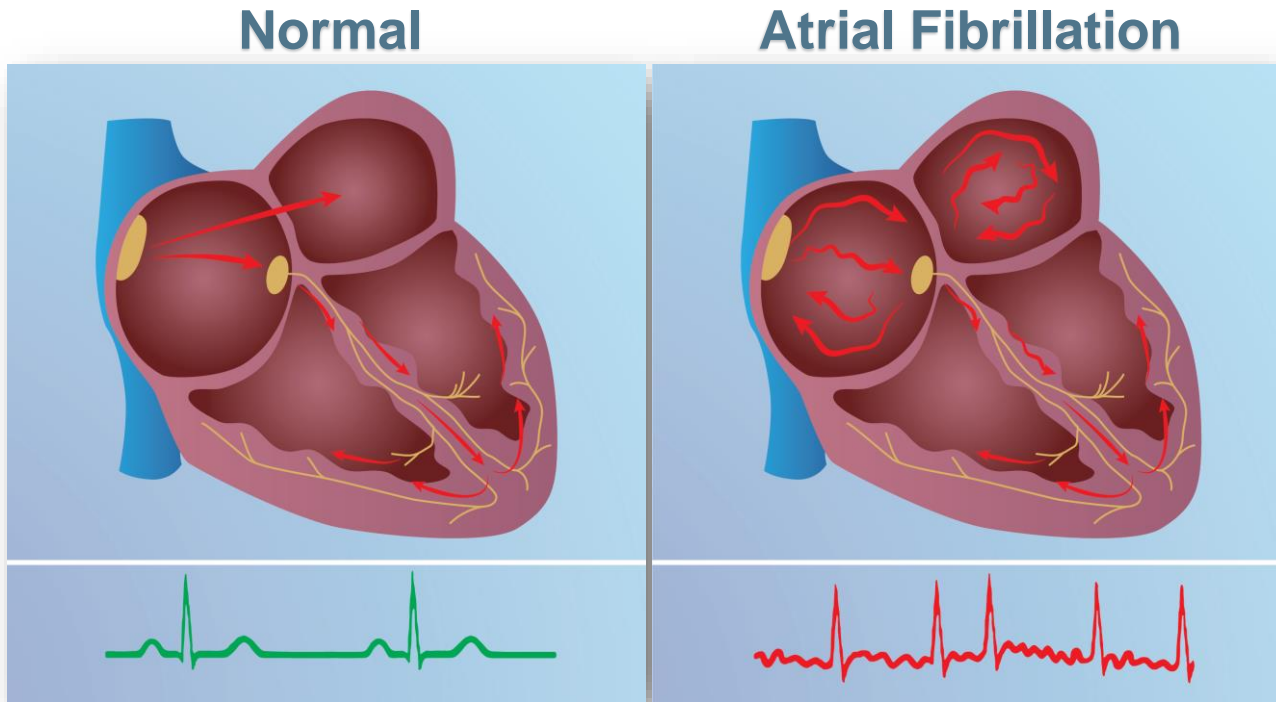
*One-time treatment
replaces recurring
injection therapy*

Cellular-Level Mechanics of Pulsed Field Ablation (PFA)

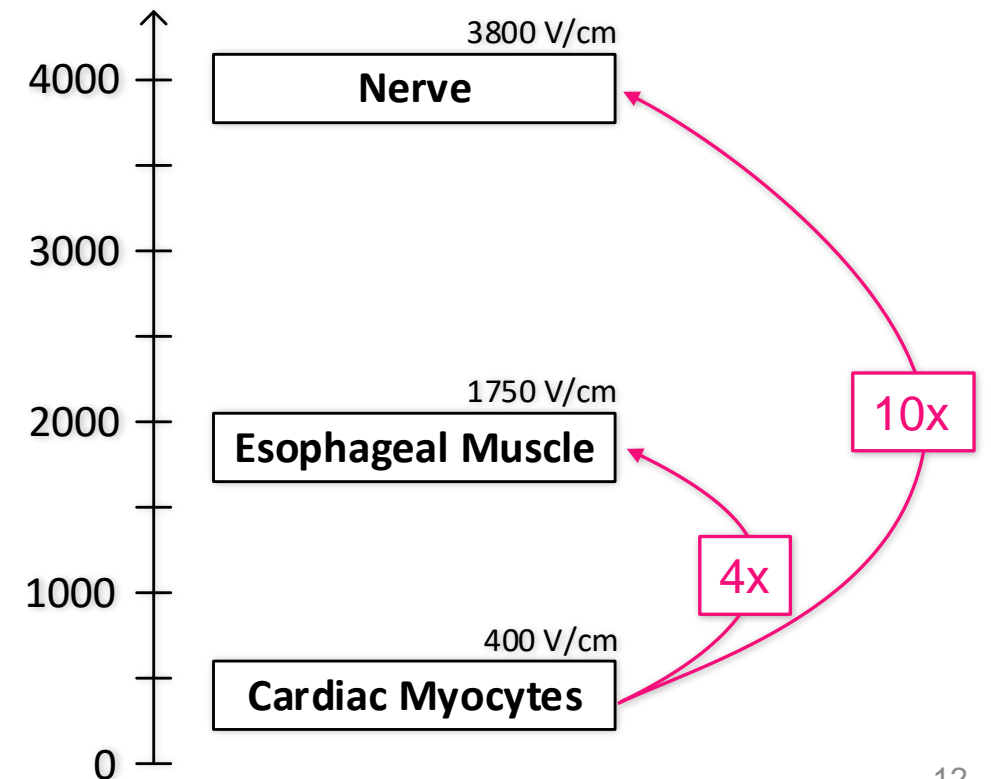


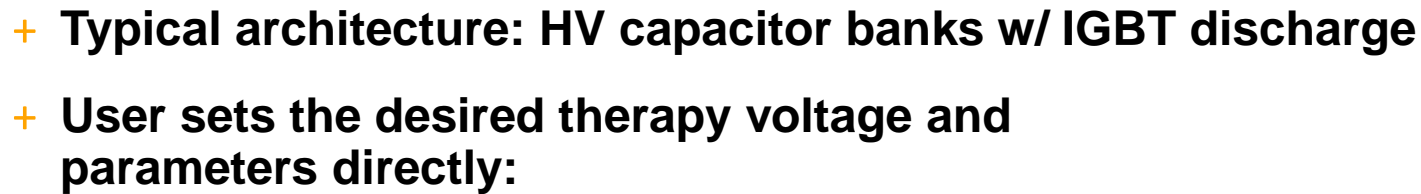
Clinical Application #3: Treating Atrial Fibrillation

- + Atrial fibrillation is a heart arrhythmia affecting 10% of >65-year-olds, and can lead to stroke
- + Thermal (RF) ablation is standard of care, but risks injury to phrenic nerve or esophagus



PFA Threshold (V/cm)





-

- 13

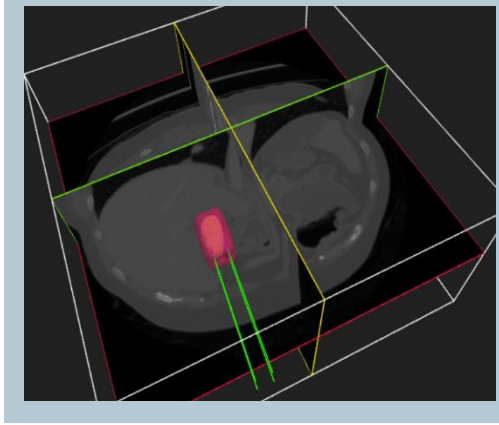
- + **#1 Need: Replicability**
- + **Research: Flexible, robust experimental equipment**
- + **Commerical: Expedite product development**
 - Modularity
 - Support for lower-volume, higher-cost designs

Surgical Energy Therapy of the Future

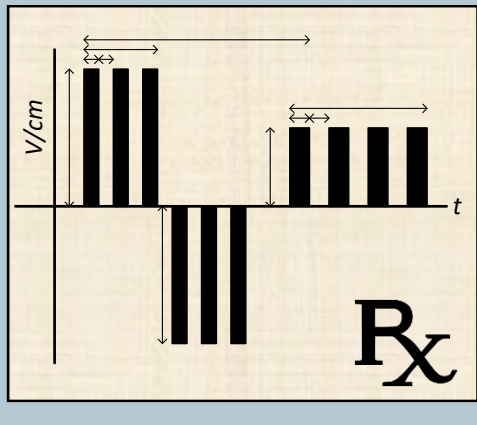
Pre-Procedural Imaging



Treatment Modeling



Custom Energy Prescription



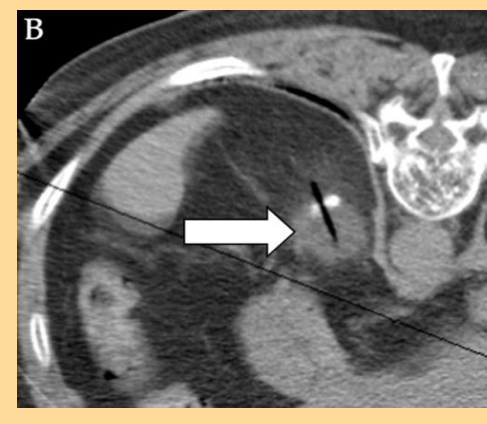
Custom Fixtures / Electrodes



Surgical Robotics



Intraprocedural Imaging



Data Logging

Procedure 1234			
10C	25C	35C	40C
Power Accuracy	Power Accuracy	Power Accuracy	Power Accuracy
8.55%	7.44%	5.18%	5.05%
5.82%	4.49%	4.00%	2.68%
6.22%	4.67%	4.03%	2.79%
5.84%	4.68%	4.10%	2.72%
5.82%	4.55%	3.89%	2.72%
8.00%	7.32%	5.28%	4.29%
5.50%	5.01%	3.84%	2.68%
5.93%	4.72%	4.15%	2.82%
5.75%	4.95%	4.08%	2.68%
	4.67%	3.85%	2.62%
7.37%	5.91%	5.74%	4.90%
6.45%	4.98%	4.84%	3.32%
6.51%	5.30%	4.65%	3.28%
6.25%		4.34%	3.24%

Confirmatory Modeling





Thank you!

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