

NEUROMODULATION

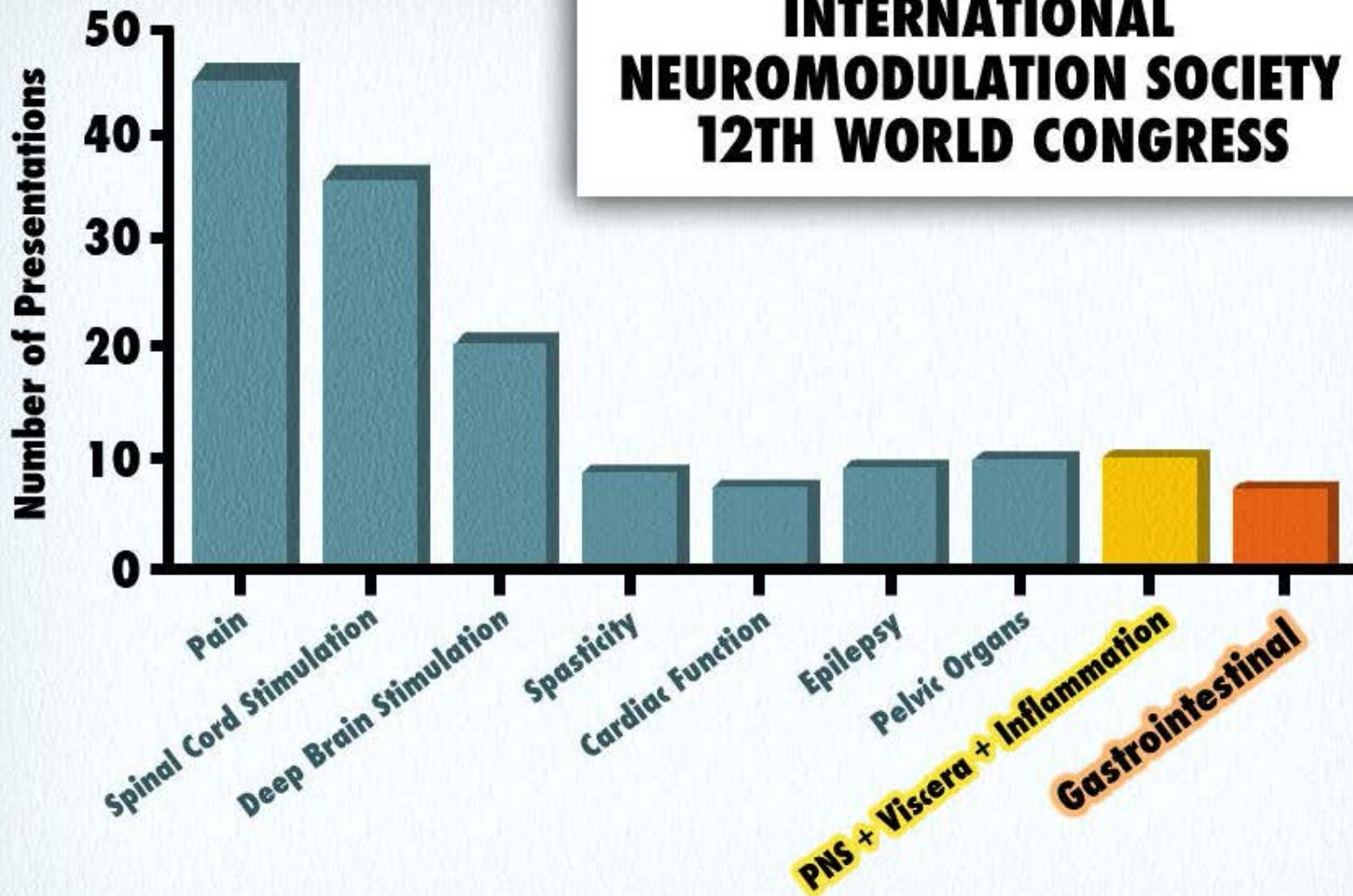
THE AUTONOMIC NERVOUS SYSTEM AND GASTROINTESTINAL TRACT DISORDERS

TERRY L. POWLEY, PH.D.

PURDUE UNIVERSITY

- **MULTIPLE REFRACTORY GI DISORDERS EXIST.**
- **VISCERAL ATLASES OF THE GI TRACT ARE AVAILABLE.**
- **REMEDICATION WITH ELECTROMODULATION MAY BE PRACTICAL.**

INTERNATIONAL NEUROMODULATION SOCIETY 12TH WORLD CONGRESS



DISORDERS TO TREAT WITH NEUROMODULATION

ACHALASIA
DYSPHAGIA
GERD
MEGA ESOPHAGUS

COLITIS
IBS
CROHN'S DISEASE
HIRSCHSPRUNG DISEASE
CHAGAS DISEASE



GASTROPARESIS

GUT DYSMOTILITY

DYSPEPSIA

VISCERAL PAIN

NAUSEA, EMESIS

OBESITY

PYLORIC STENOSIS

DUMPING

REFLUX

Gastrointestinal Tract
Autodesk® Maya®

TIME

**The Obesity
Epidemic in
America**

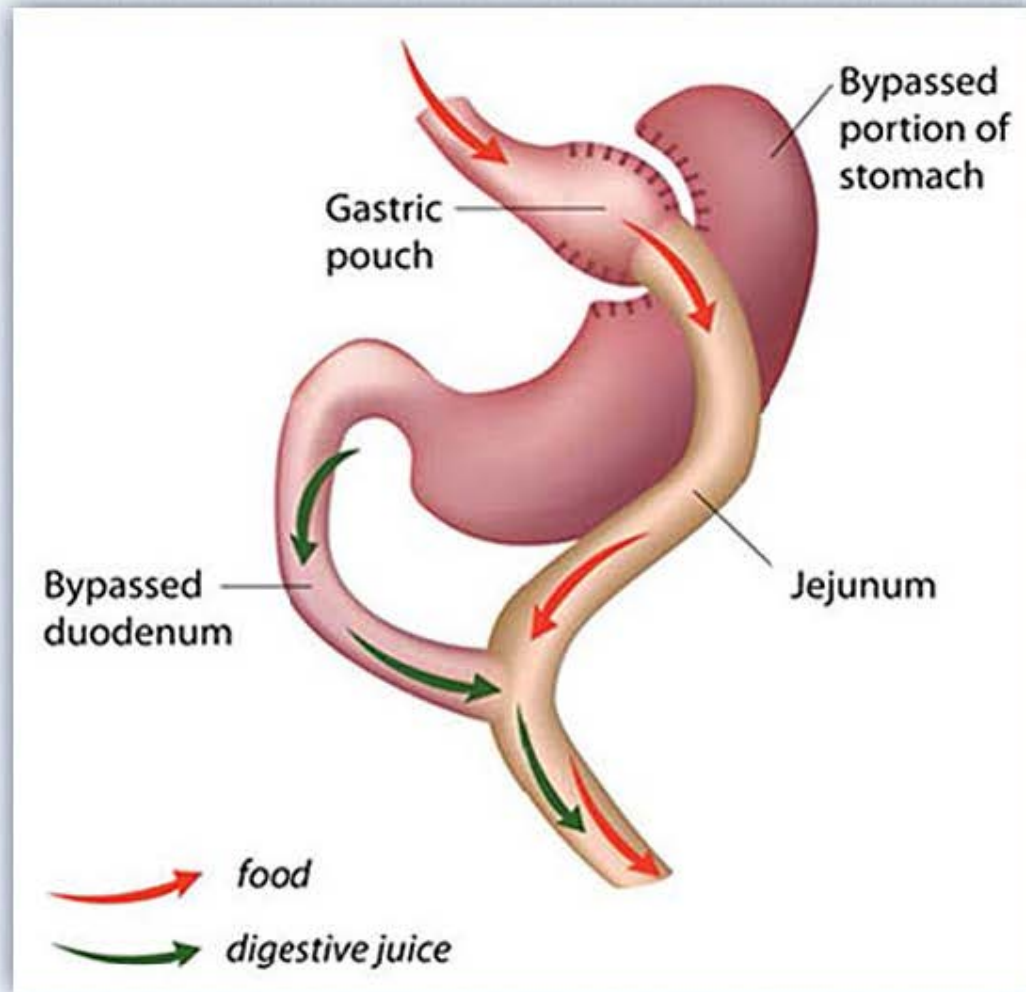


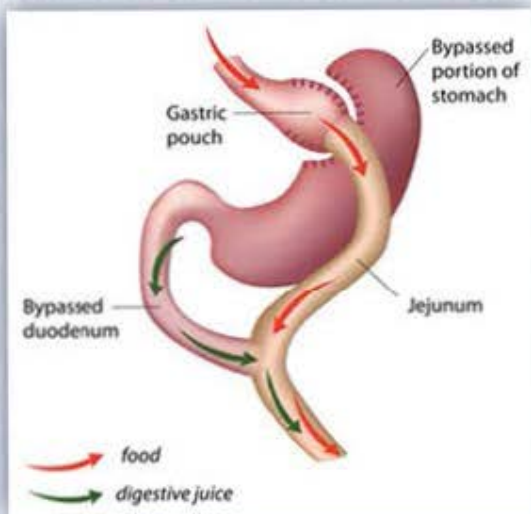
TERRY L. POWLEY, PH.D.

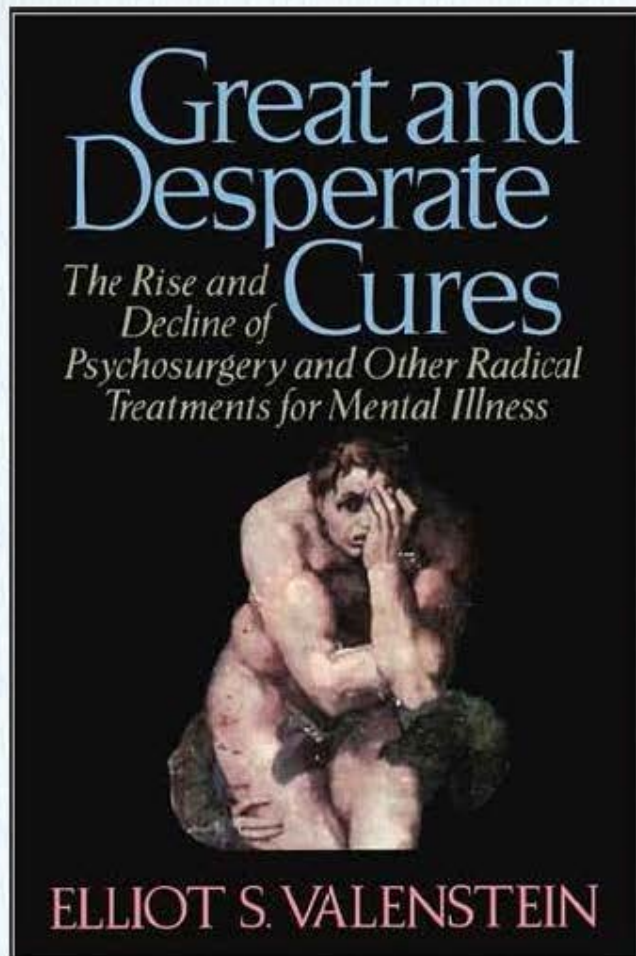
NEUROMODULATION: THE AUTONOMIC NERVOUS SYSTEM AND GASTROINTESTINAL TRACT DISORDERS

PURDUE
UNIVERSITY

ROUX-EN-Y BYPASS







- DESPERATE PATIENTS
- ABSENCE OF SATISFACTORY PHARMACOLOGICAL TREATMENTS
- POPULAR MEDIA HYPE
- ABSENCE OF A SOLID MECHANISTIC UNDERSTANDING
- UNCRITICAL ACCEPTANCE OF PROPONENT'S CLAIMS
- MYOPIA REGARDING SIDE EFFECTS

**ENTERIC
NERVOUS SYSTEM:**

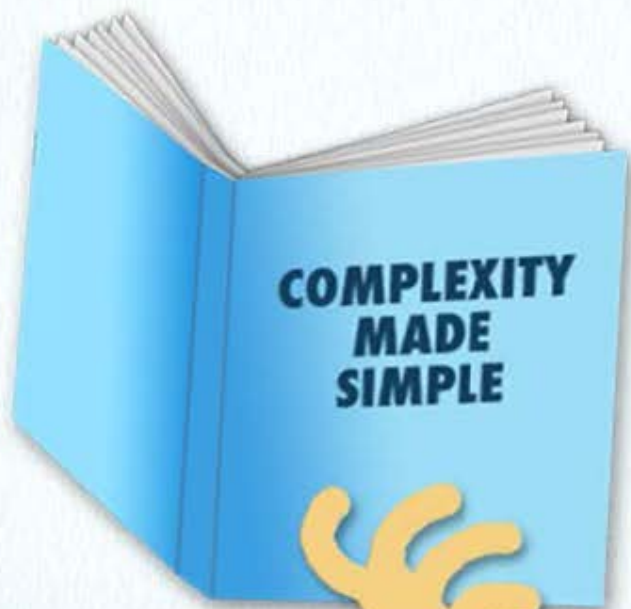
**"LITTLE BRAIN"
IN GUT**





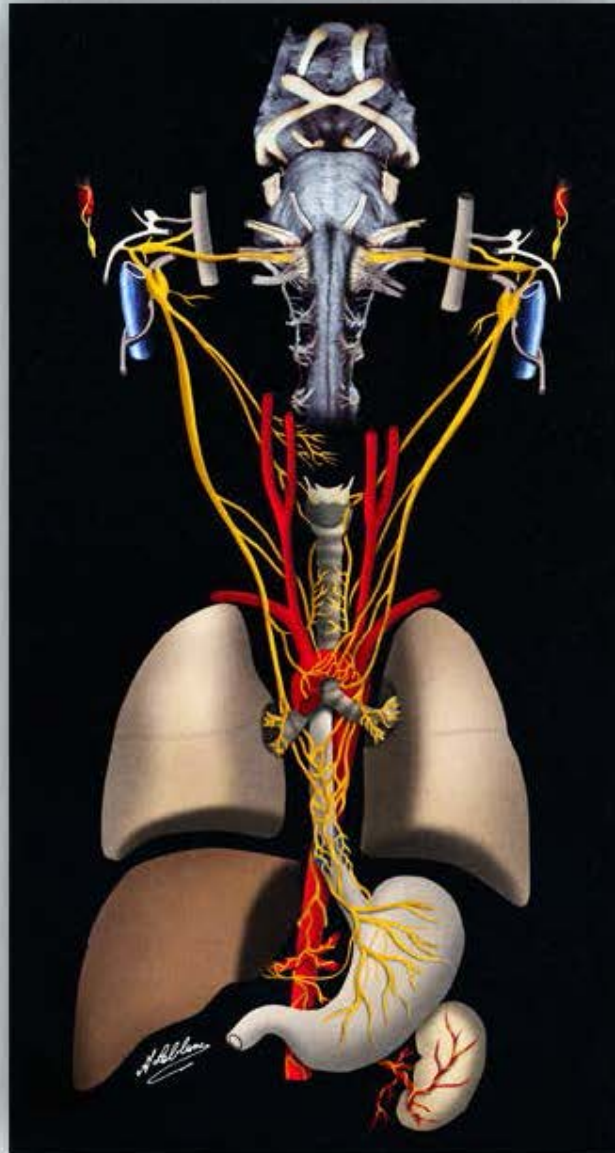
NEURO
MODULATOR

**The VAGUS may
be the answer!!**

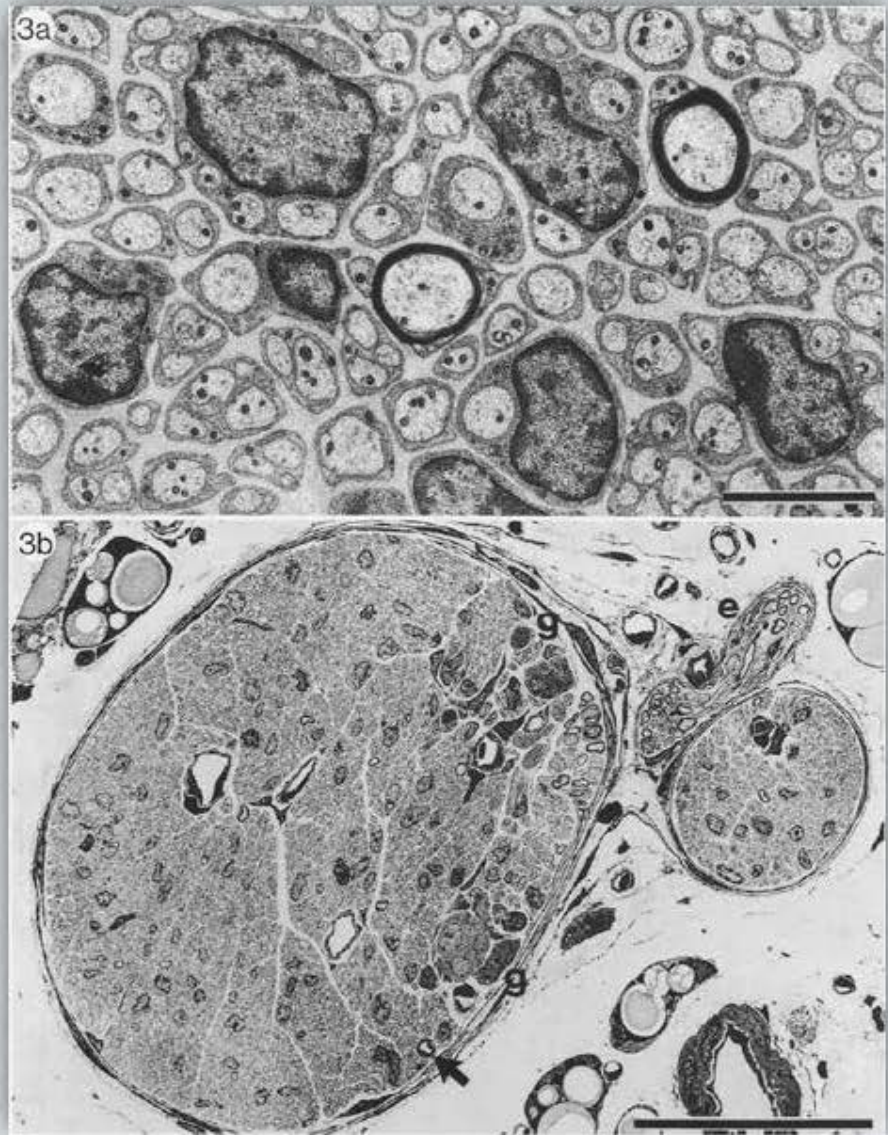
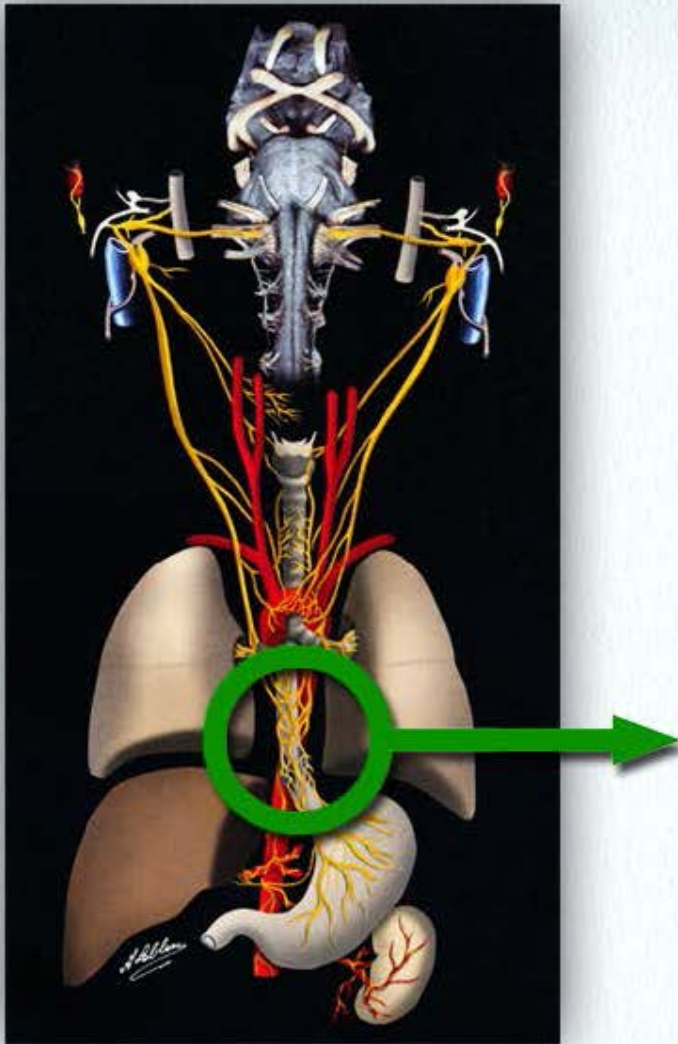


**COMPLEXITY
MADE
SIMPLE**

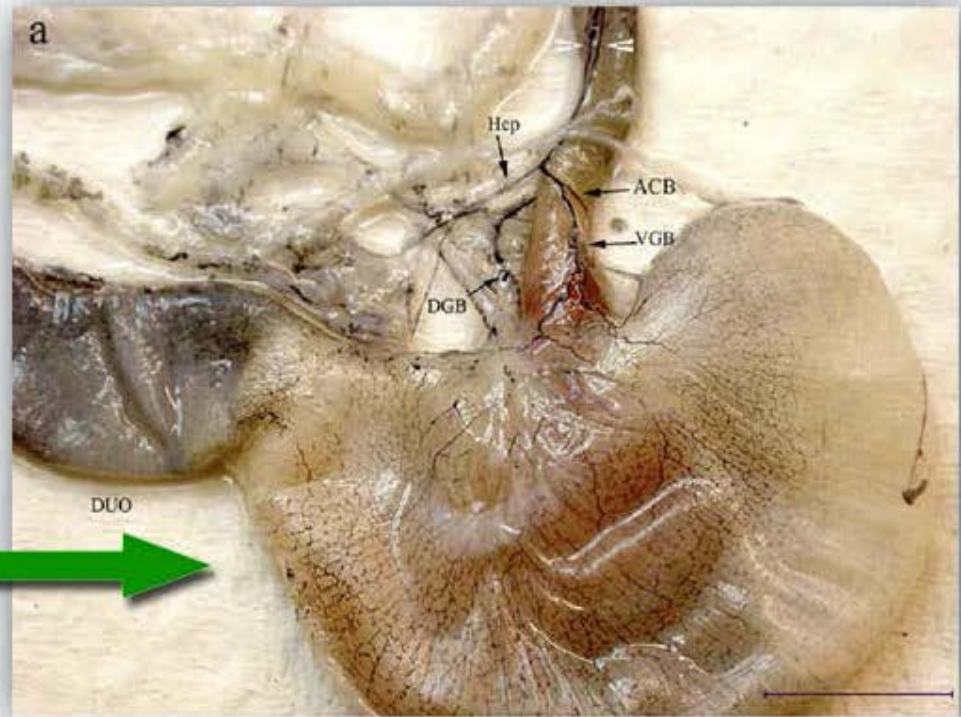
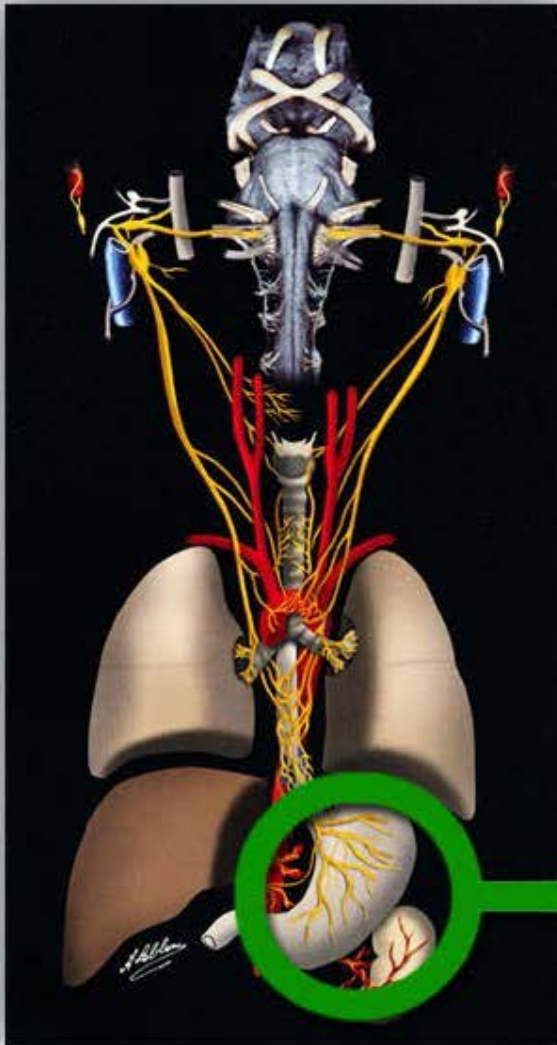
**NEURO
MODULATOR**



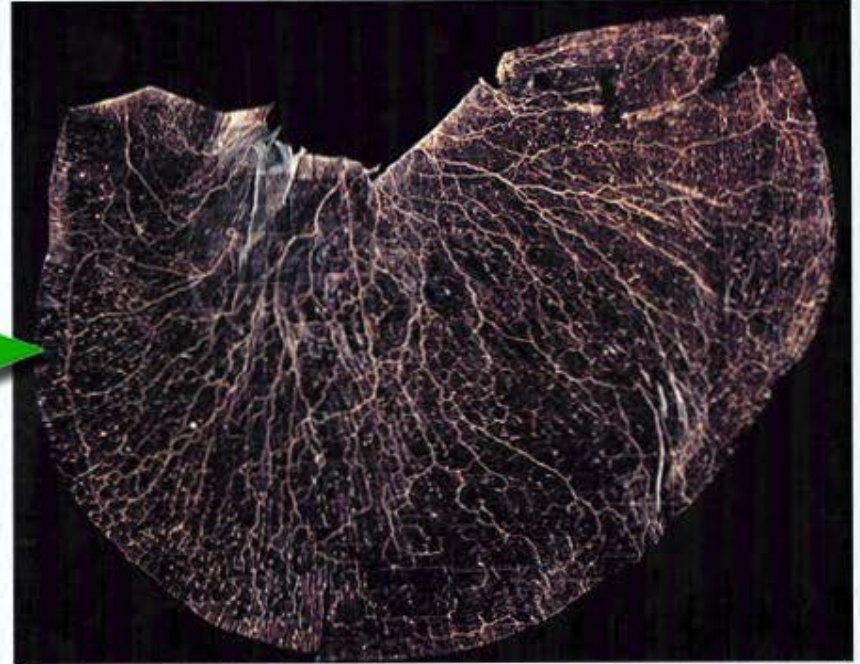
Leblanc, 2001



Precht and Powley

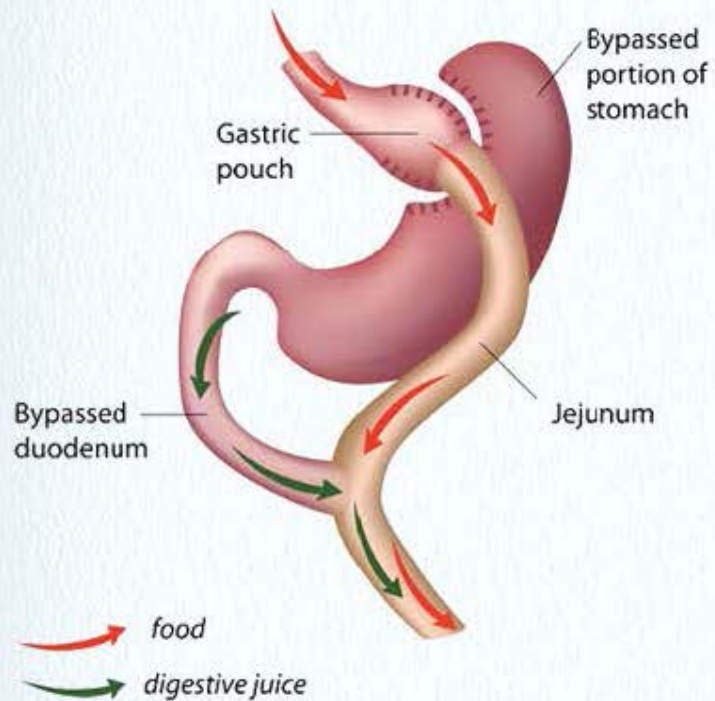


Wang & Powley, 2007

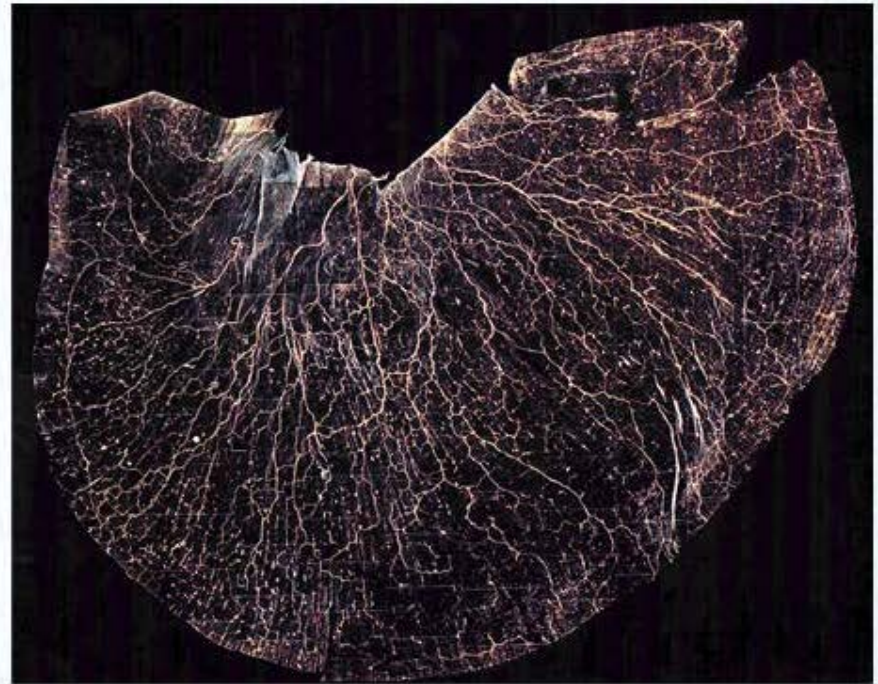


Wang & Powley, 2000

ROUX-EN-Y BYPASS

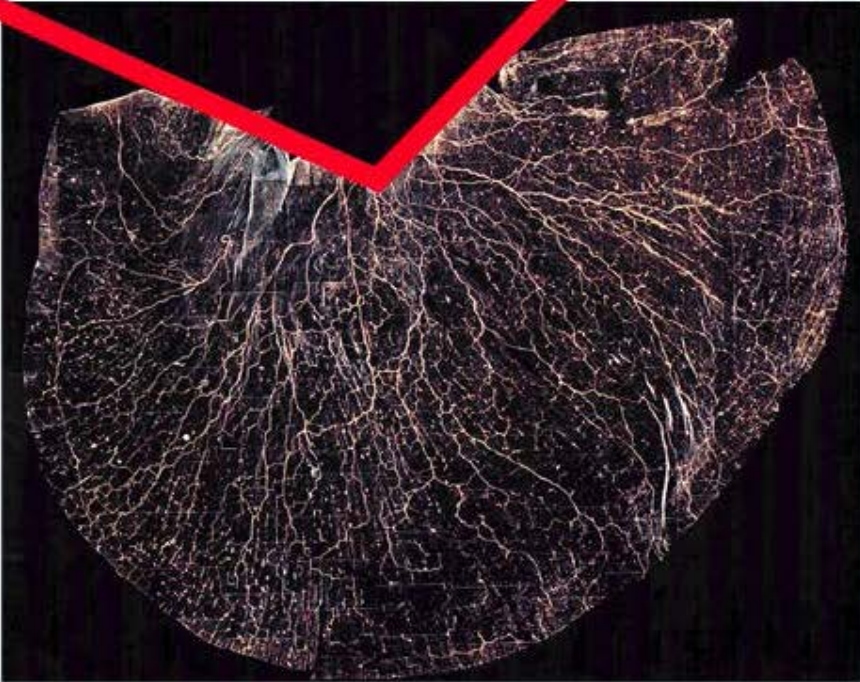
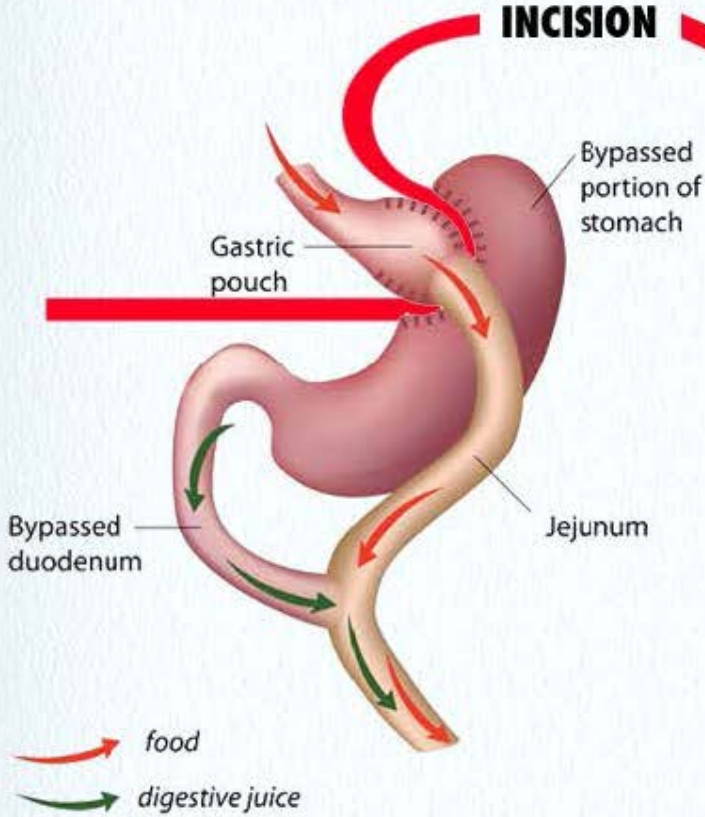


VAGAL NETWORK

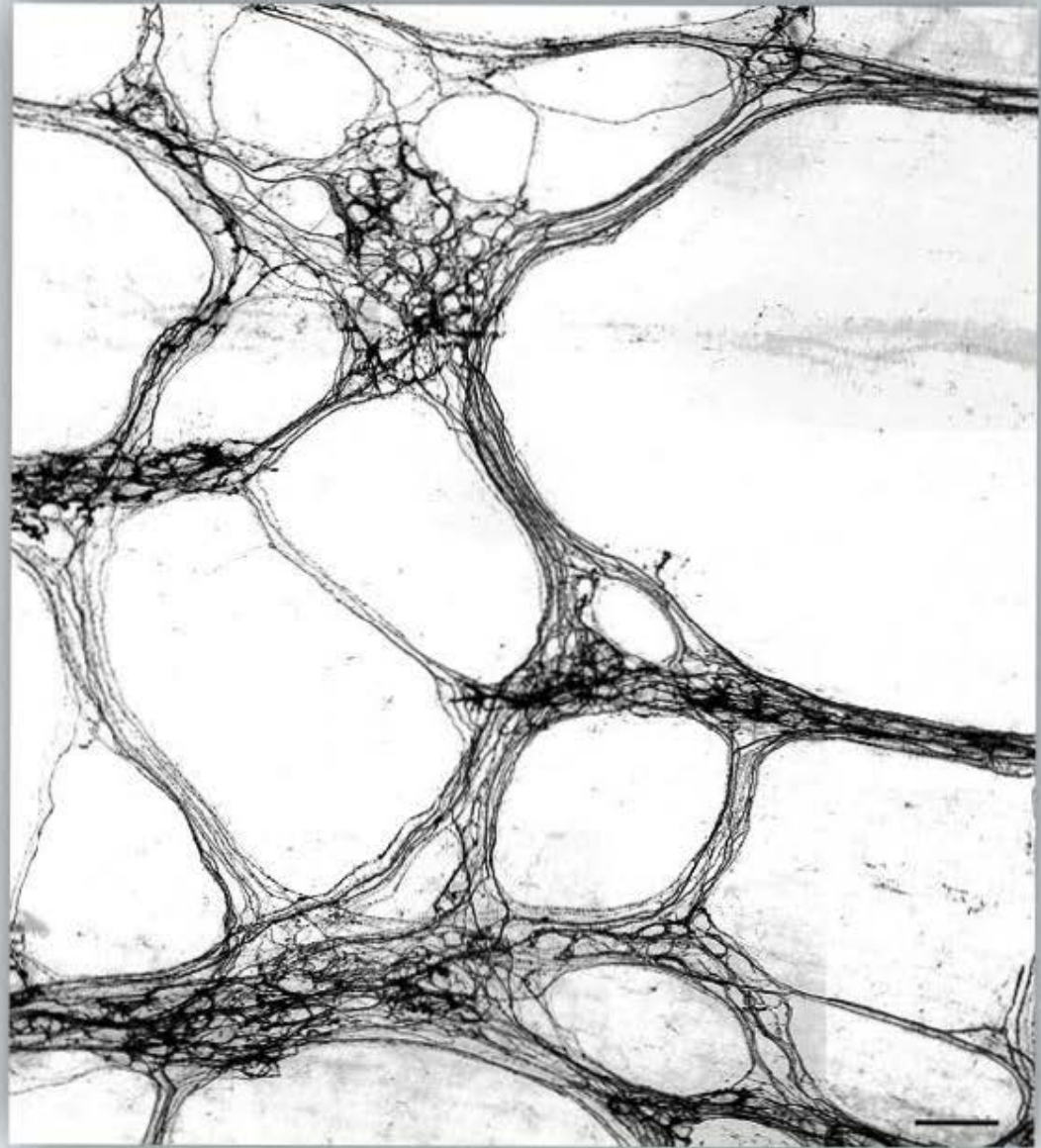


ROUX-EN-Y BYPASS

VAGAL NETWORK



VAGAL MOTOR INNERVATION OF MYENTERIC PLEXUS

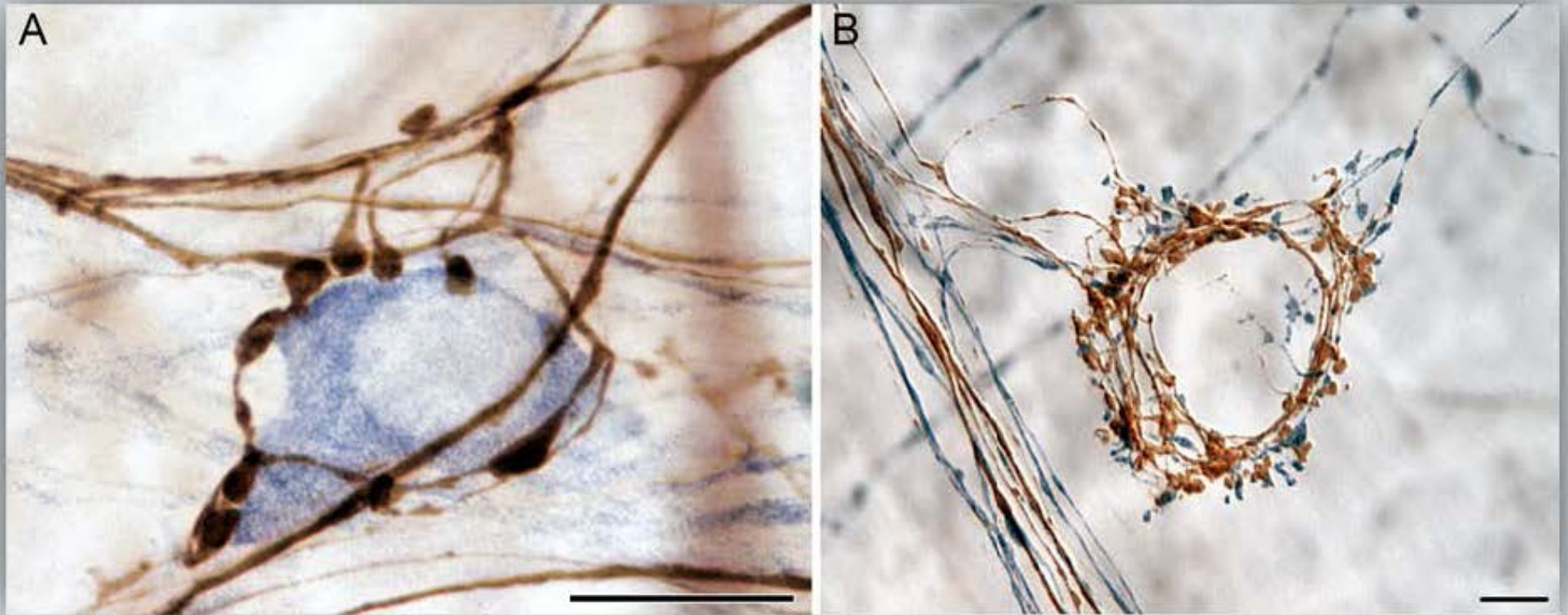


TERRY L. POWLEY, PH.D.

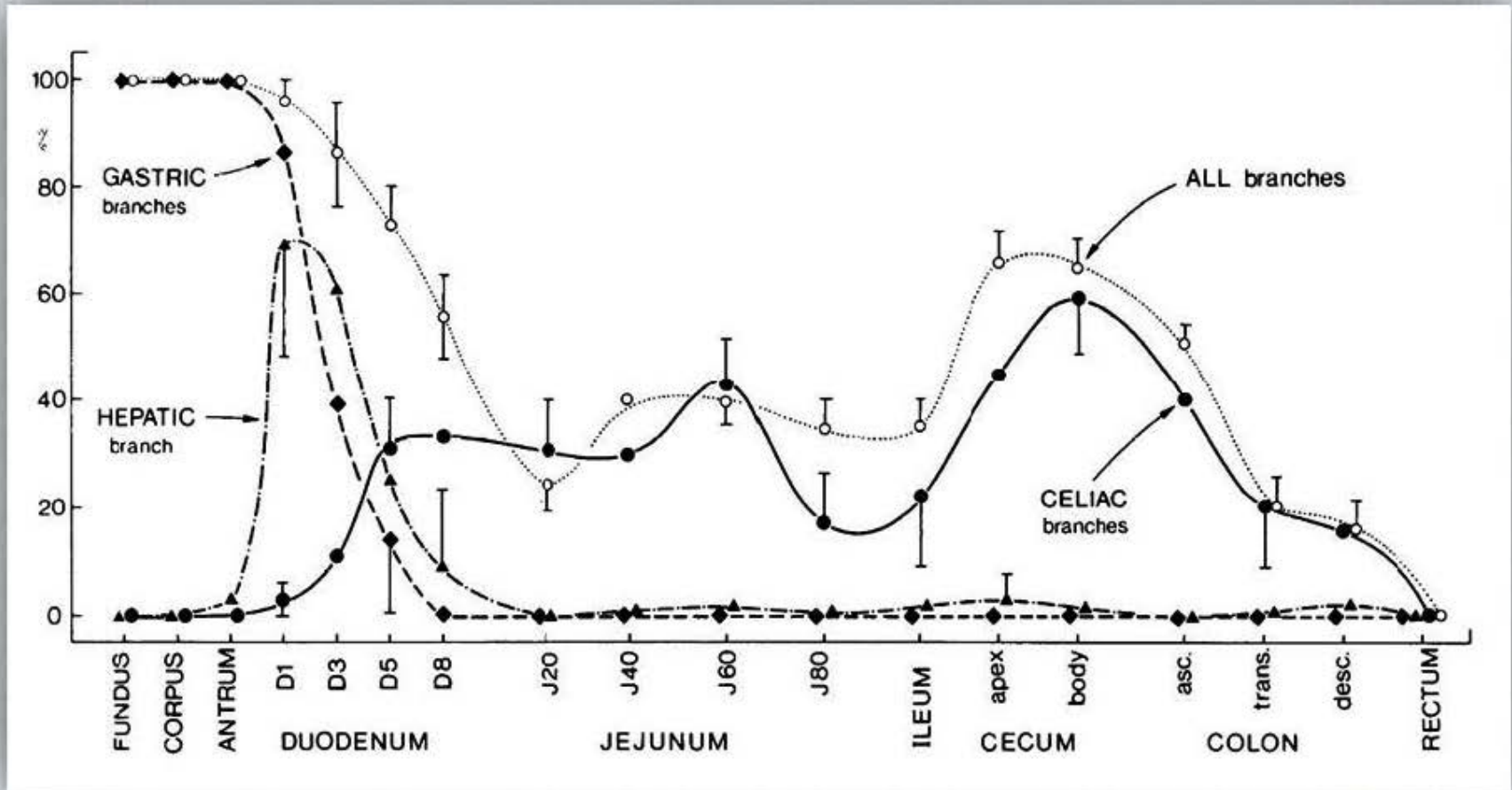
NEUROMODULATION: THE AUTONOMIC NERVOUS SYSTEM AND GASTROINTESTINAL TRACT DISORDERS

PURDUE
UNIVERSITY

VAGAL & SYMPATHETIC MOTOR - MYENTERIC PLEXUS

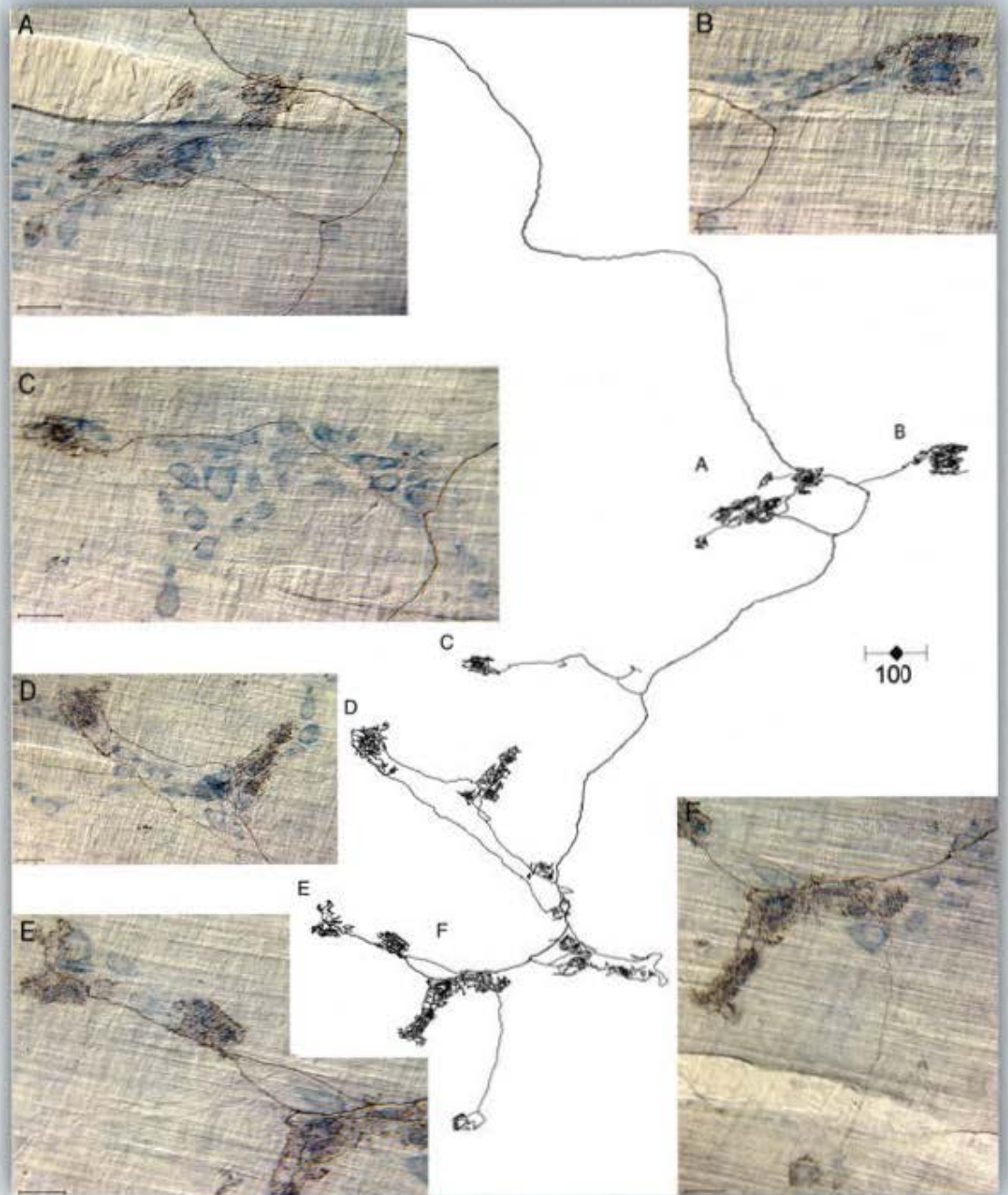


PERCENT MYENTERIC GANGLIA INNERVATED BY VAGUS

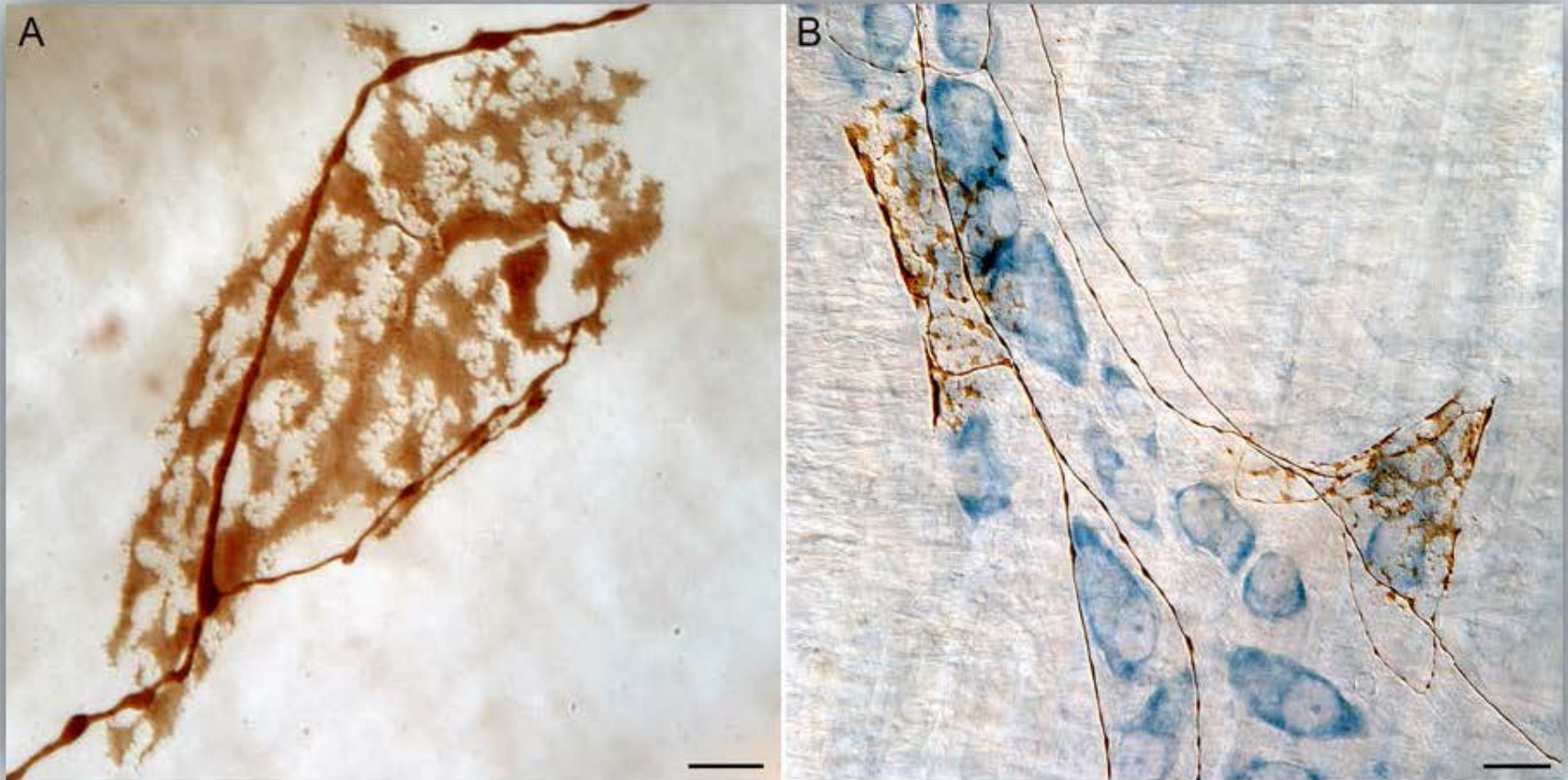


Berthoud, Carlson, and Powley

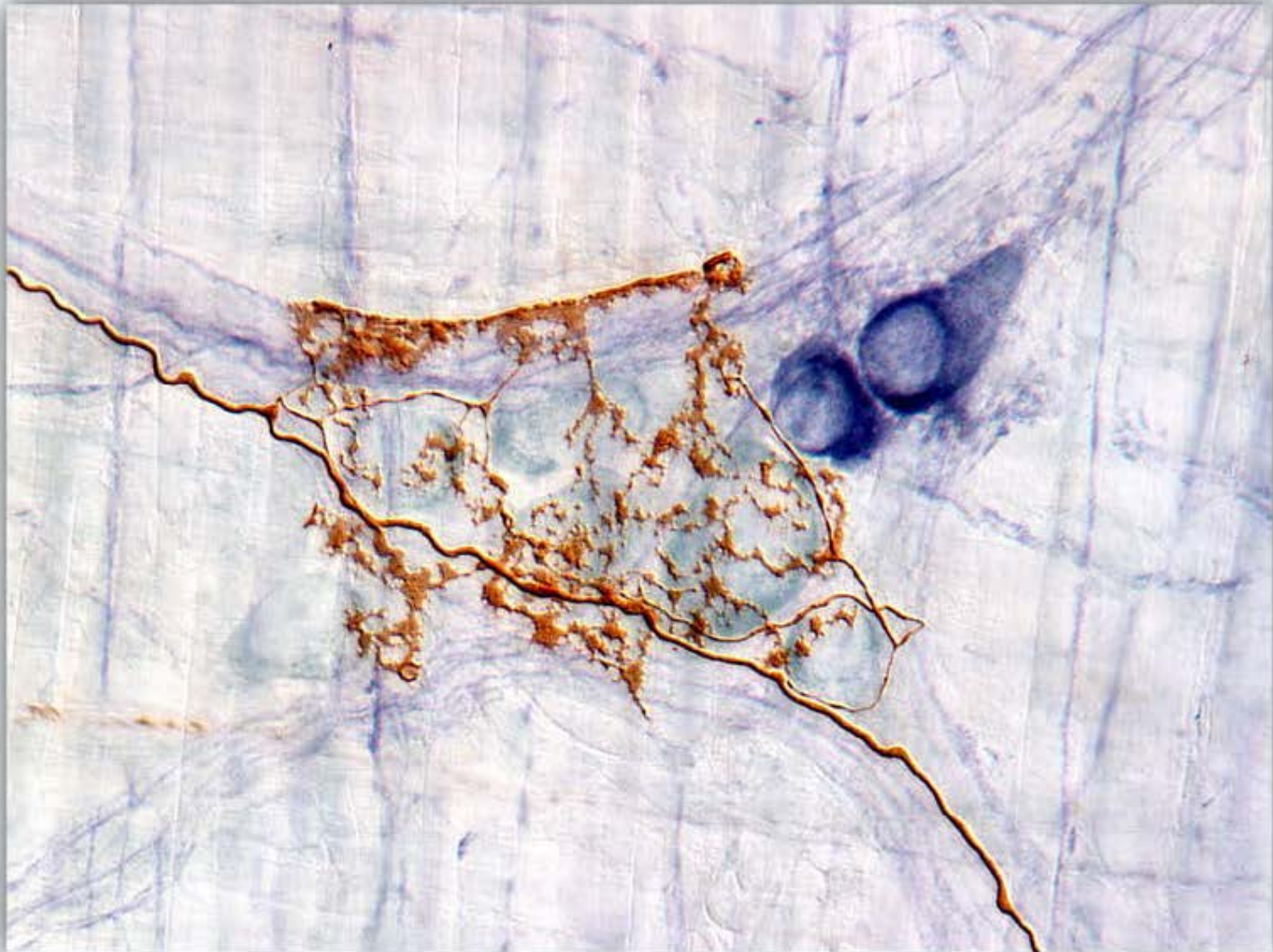
**VAGAL SENSORY
INNERVATION:
INTRAGANGLIONIC
LAMINAR
ENDING (IGLE)**



VAGAL SENSORY - IGL_s - PLATES ON MYENTERIC GANGLIA



**VAGAL SENSORY FIBER INNERVATES CHOLINERGIC NEURONS
& IGNORES NITRERGIC NEURONS IN MYENTERIC GANGLION**



VAGAL SENSORY INNERVATION: INTRAMUSCULAR ARRAY (IMA)

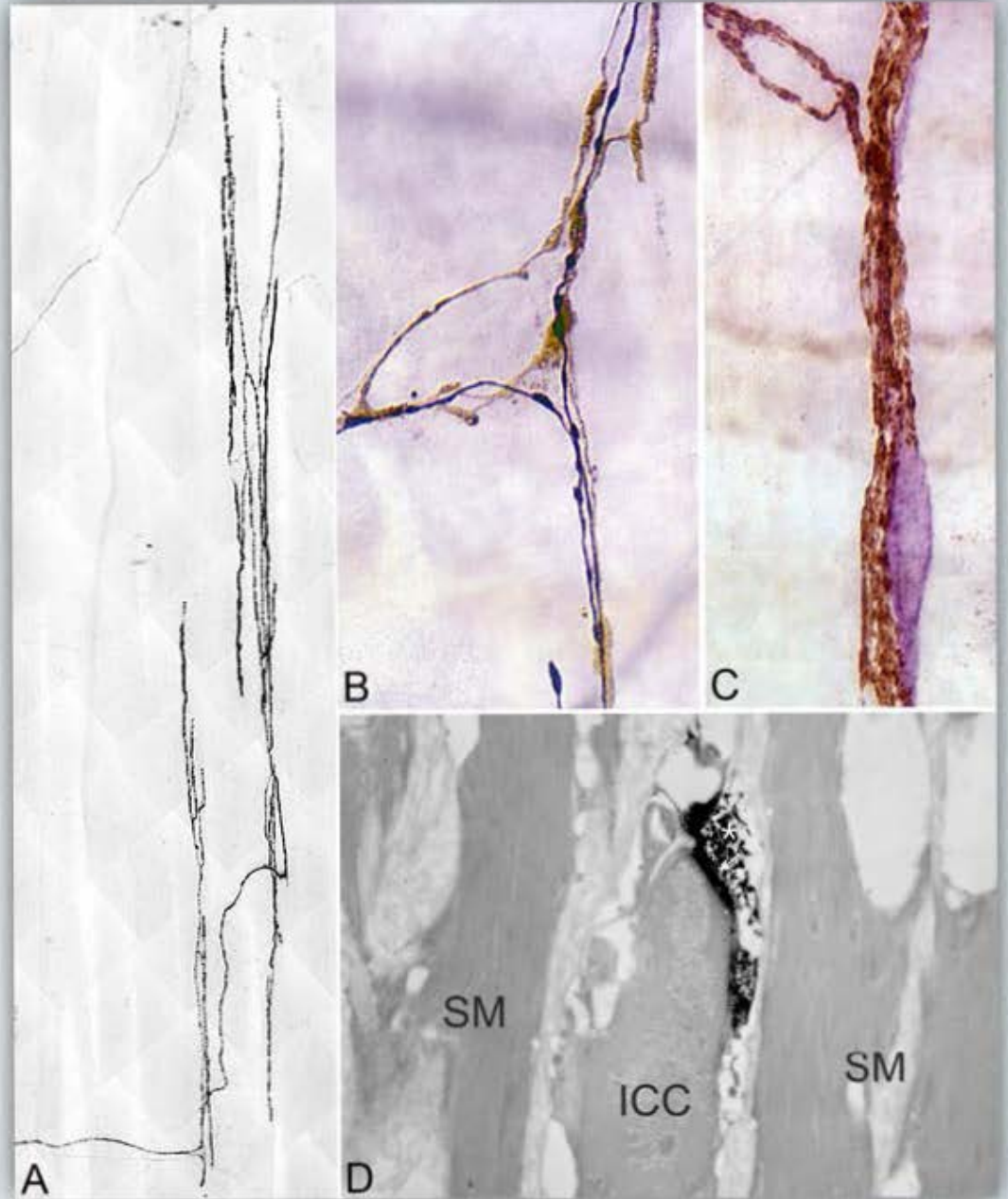


**VAGAL SENSORY
IMAs:**

STRETCH RECEPTORS?

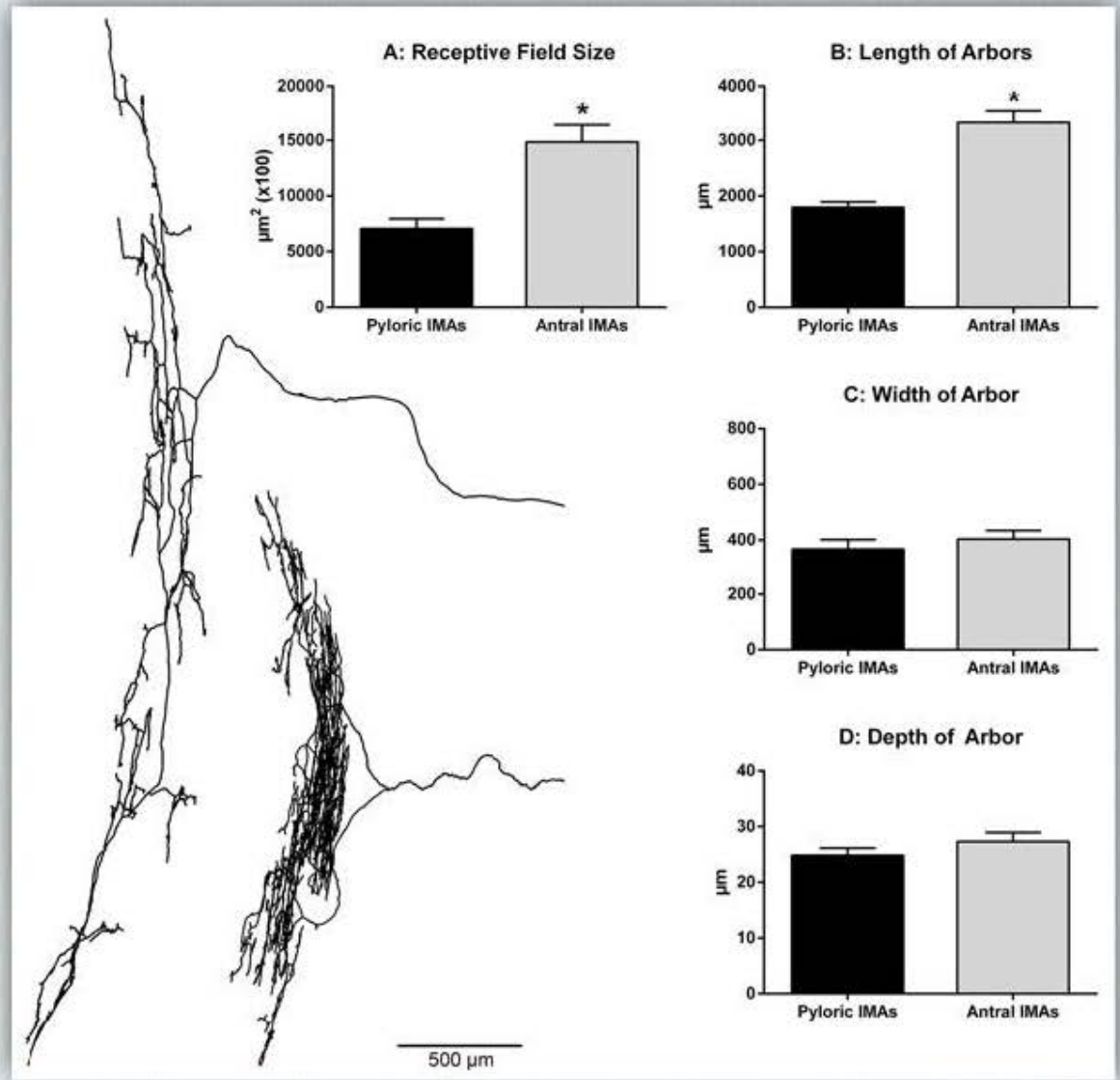
**MUSCLE SPINDLE
ORGAN ANALOGUES?**

AXON REFLEXES?

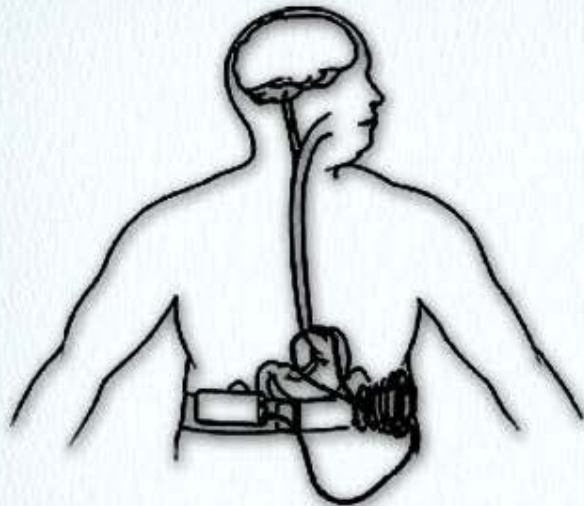


**IMAs ARE REGIONALLY
SPECIALIZED AND
CONCENTRATED:**

**SPHINCTERS,
FORESTOMACH, ETC.**



OBESITY: VBLOC THERAPY



NEUROREGULATOR

CONTROLLER



ELECTRODES



TRANSMIT COIL

Sarr et al., 2012

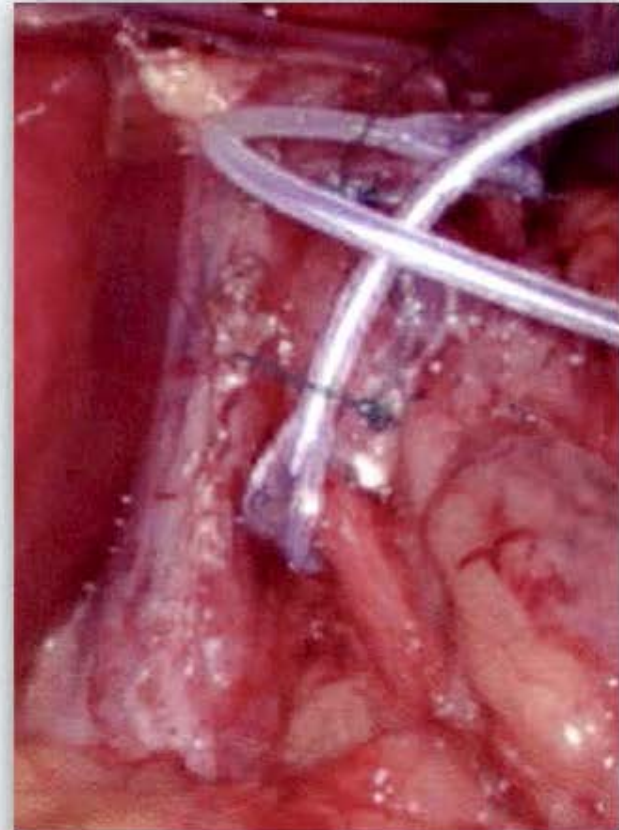


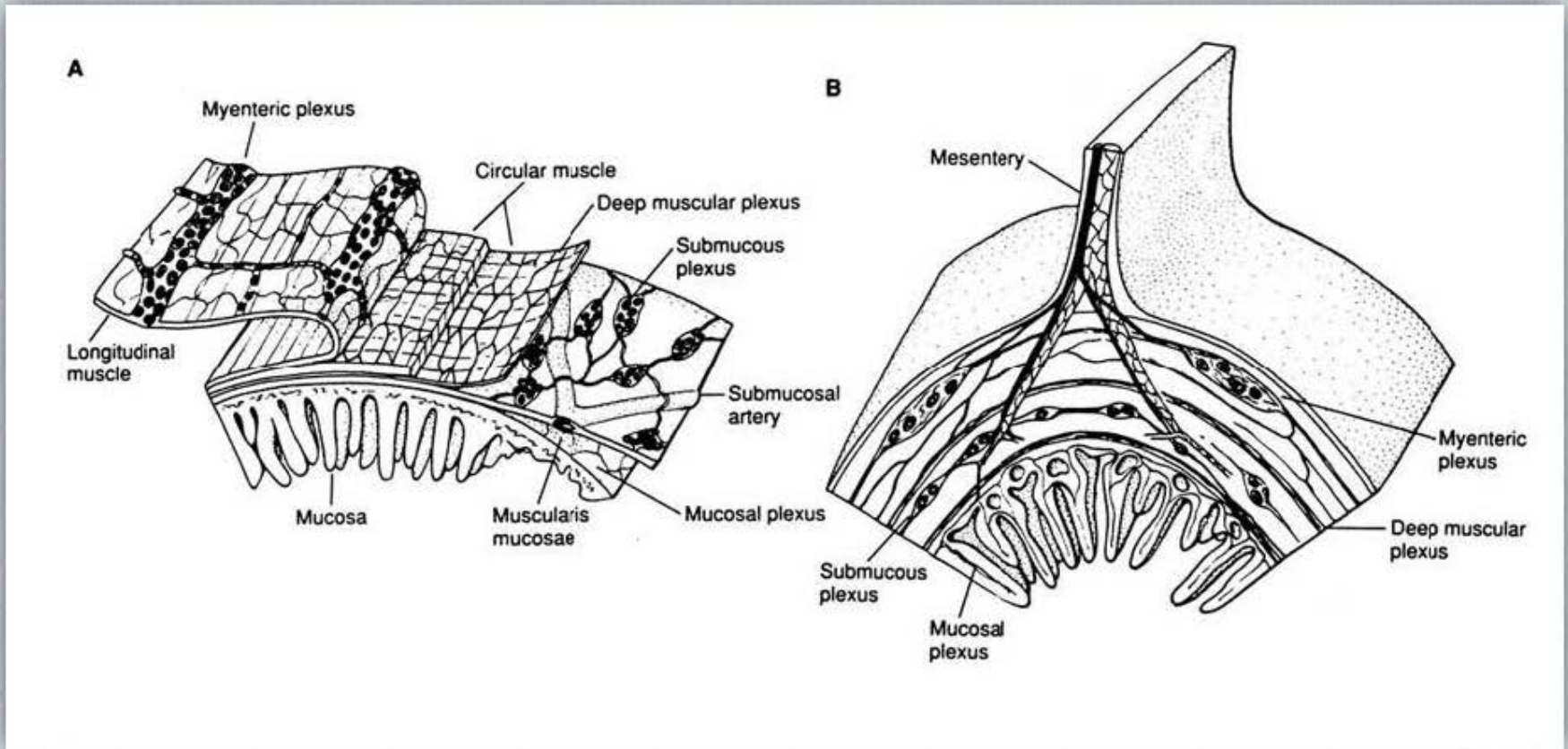
Fig 1. Electrodes implanted on anterior and posterior vagal trunks (original magnification, $\times 4$).

Camilleri et al., 2008

**VAGAL MOTOR
INNERVATION:
ESOPHAGUS**

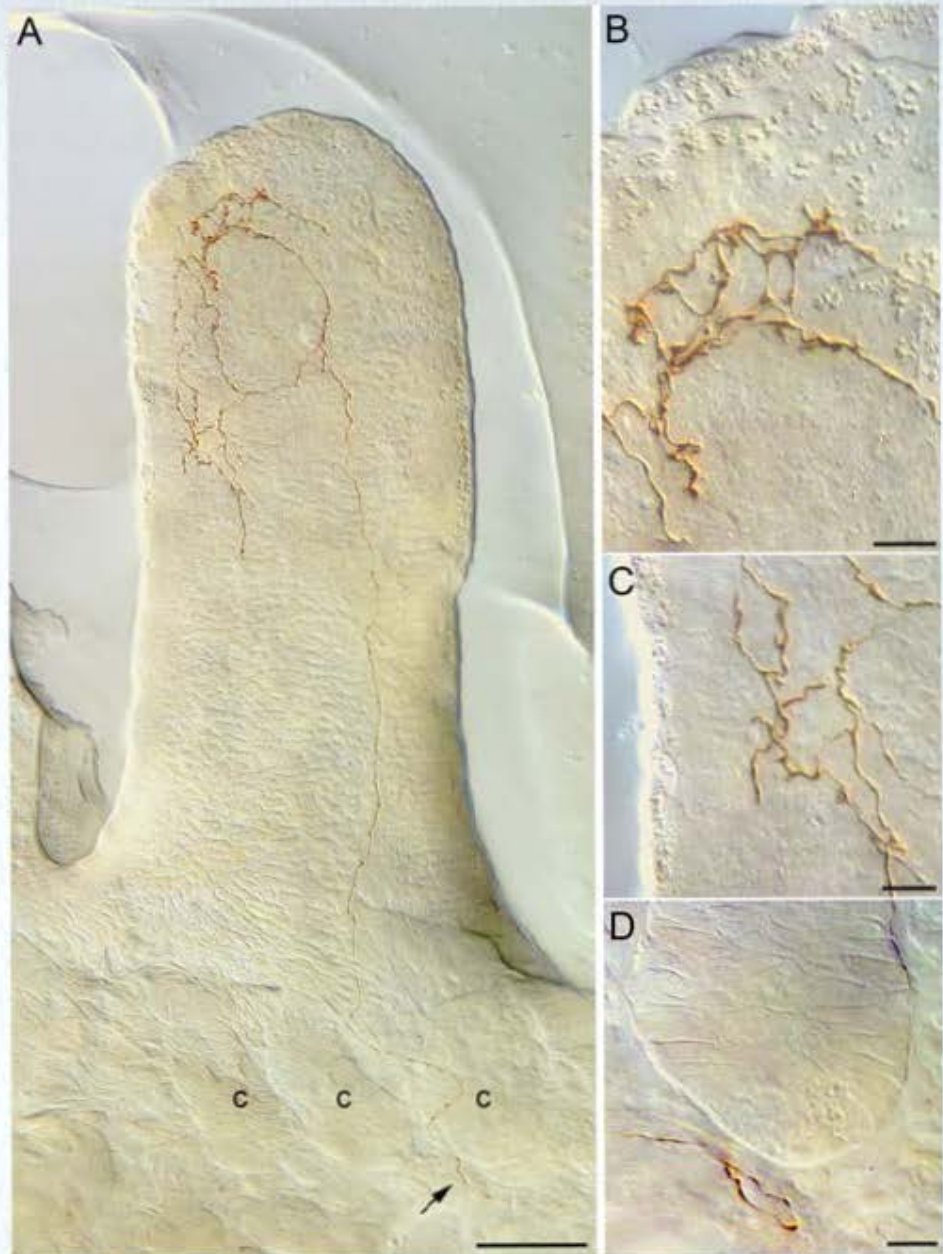


ENTERIC NERVOUS SYSTEM: "LITTLE BRAIN" IN GI TRACT

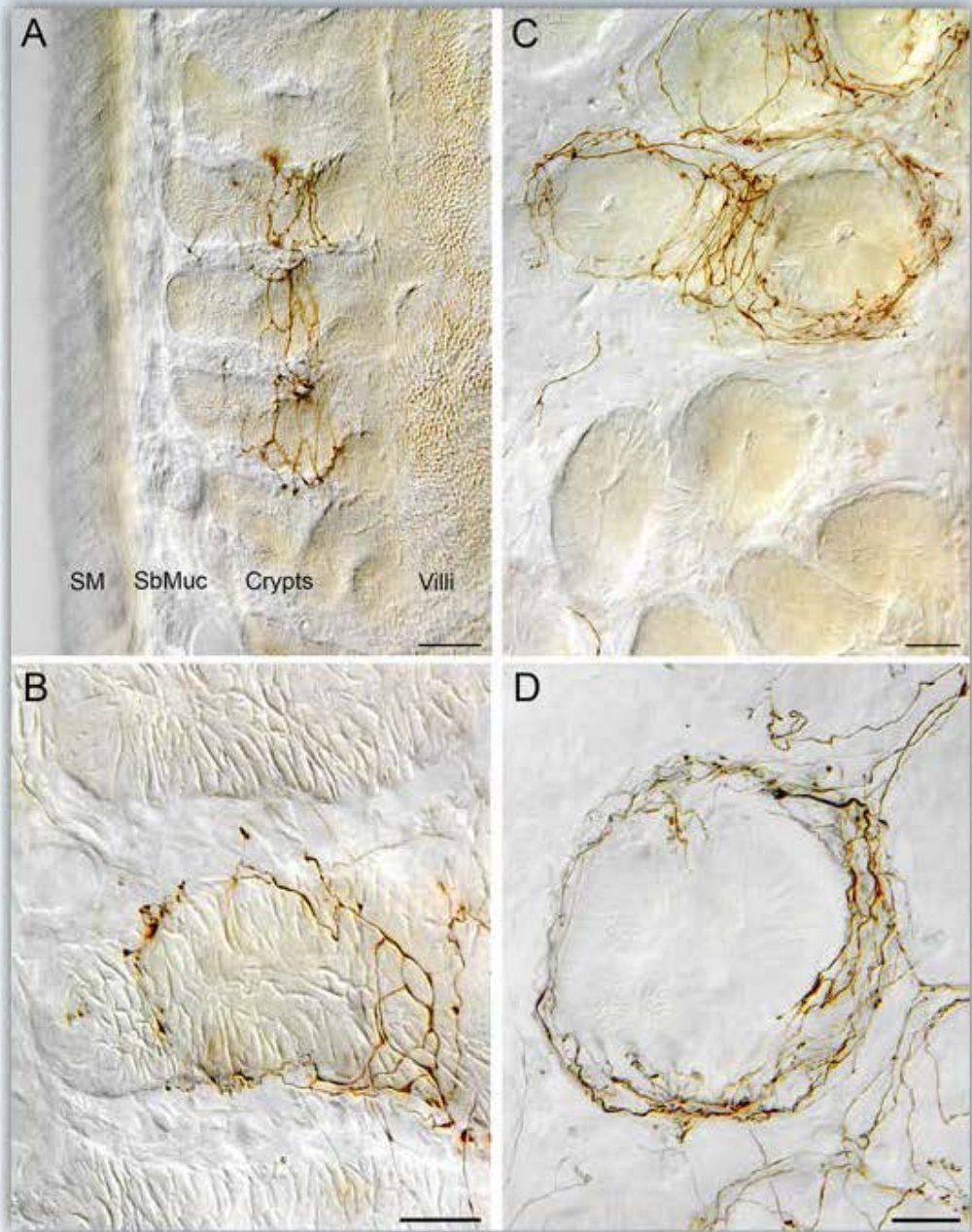


Furness & Costa

**VAGAL SENSORY
AXONS INNERVATE
GI MUCOSAL
VILLI WITH
CHEMORECEPTORS**



**VAGAL SENSORY
AXONS ALSO
INNERVATE
CRYPTS**



- **MULTIPLE REFRACTORY GI DISORDERS EXIST.**
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GI NEUROMODULATION PRIORITIES

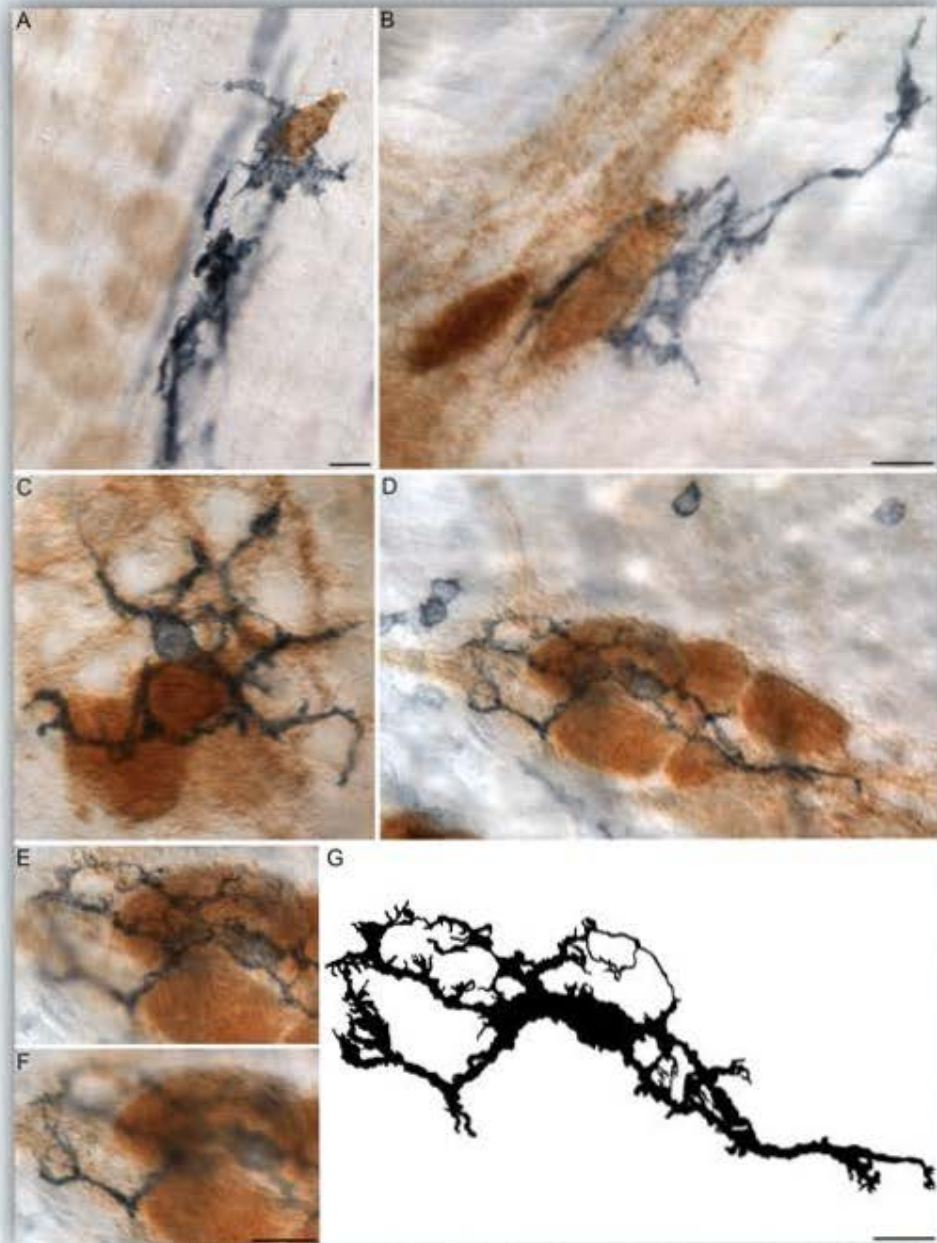
- **HIGH-PRIORITY OPPORTUNITIES:**

- OBESITY
- GASTROPARESIS

- **TECHNOLOGICAL NEEDS:**

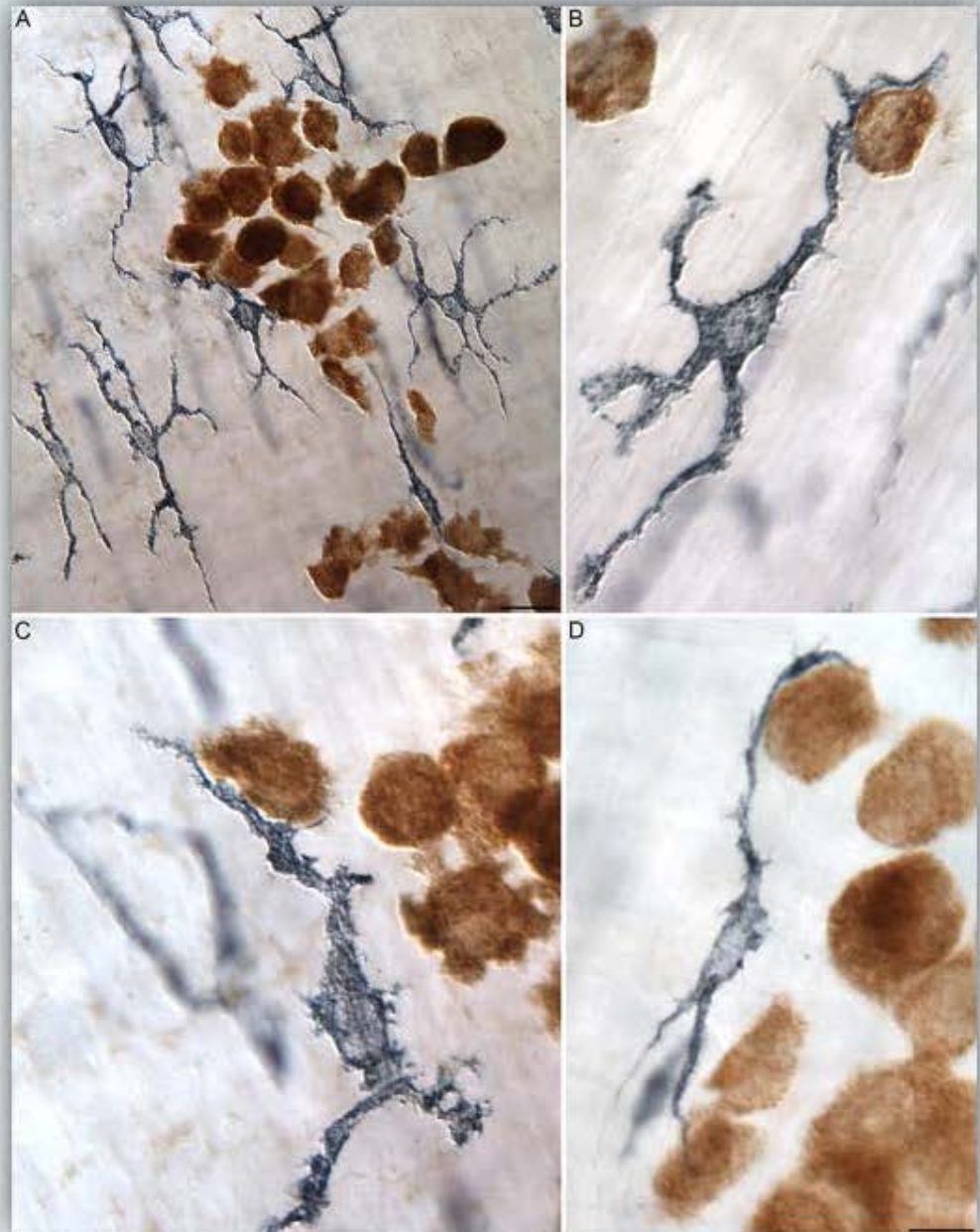
- NEXT-GENERATION STIMULATORS
 - Fiber-caliber tuned
 - Closed Loop
 - Self-programming, real time
- DATA ON VAGAL INTEGRATIVE ARCHITECTURE

**MACROPHAGES
INTERACT WITH:
MYENTERIC GANGLIA
(AND EXTRINSIC
NERVE AXONS)**

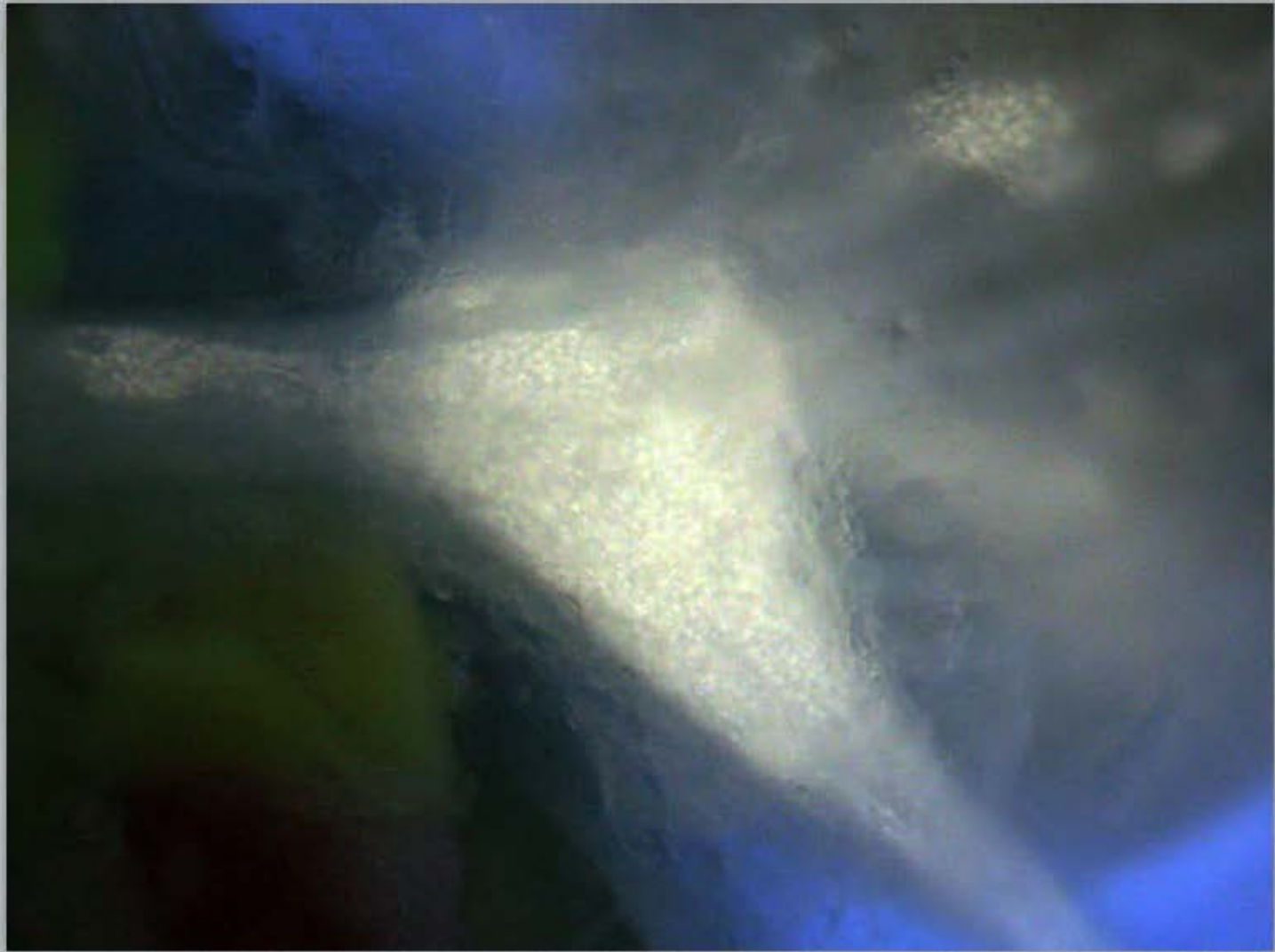


**MACROPHAGES
INTERACT WITH:**

**MYENTERIC GANGLIA
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NERVE AXONS)**

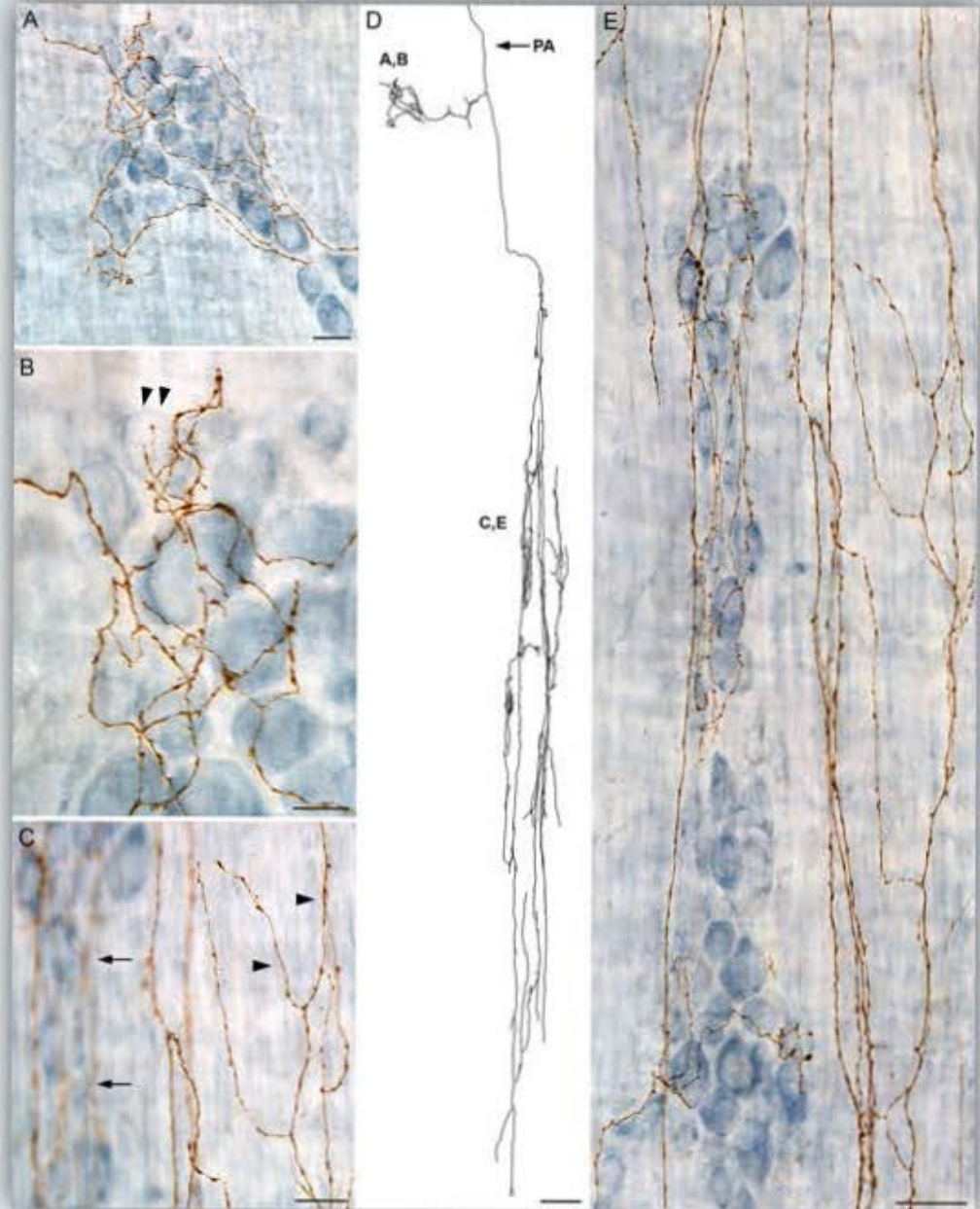


SYMPATHETIC GANGLION (CELIAC) EXPOSED FOR SURGERY

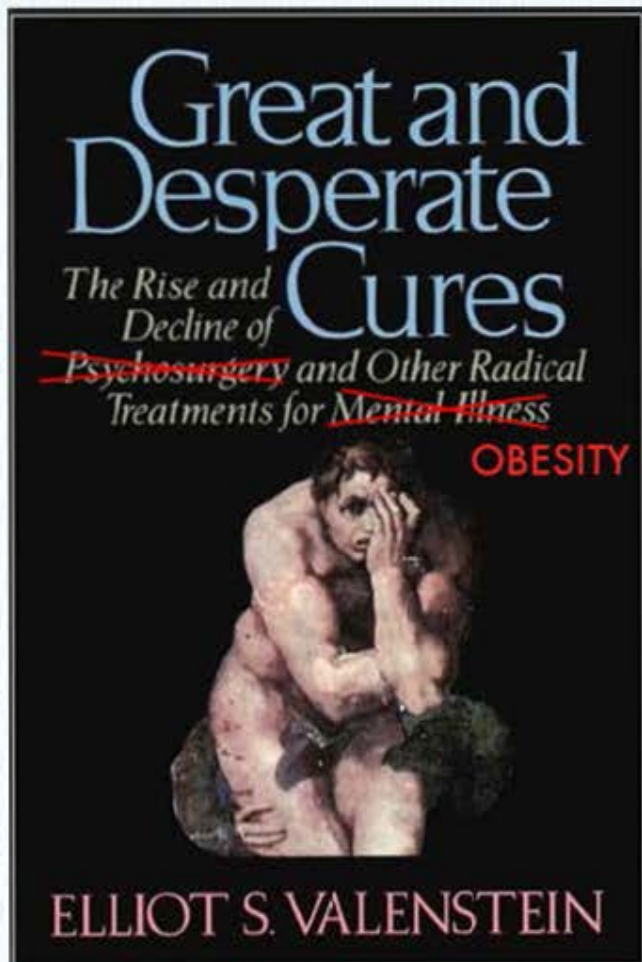


Phillips et al.

**SYMPATHETIC
MOTOR AXONS
CO-INNERVATE
SMOOTH MUSCLE
AND
MYENTERIC GANGLIA**

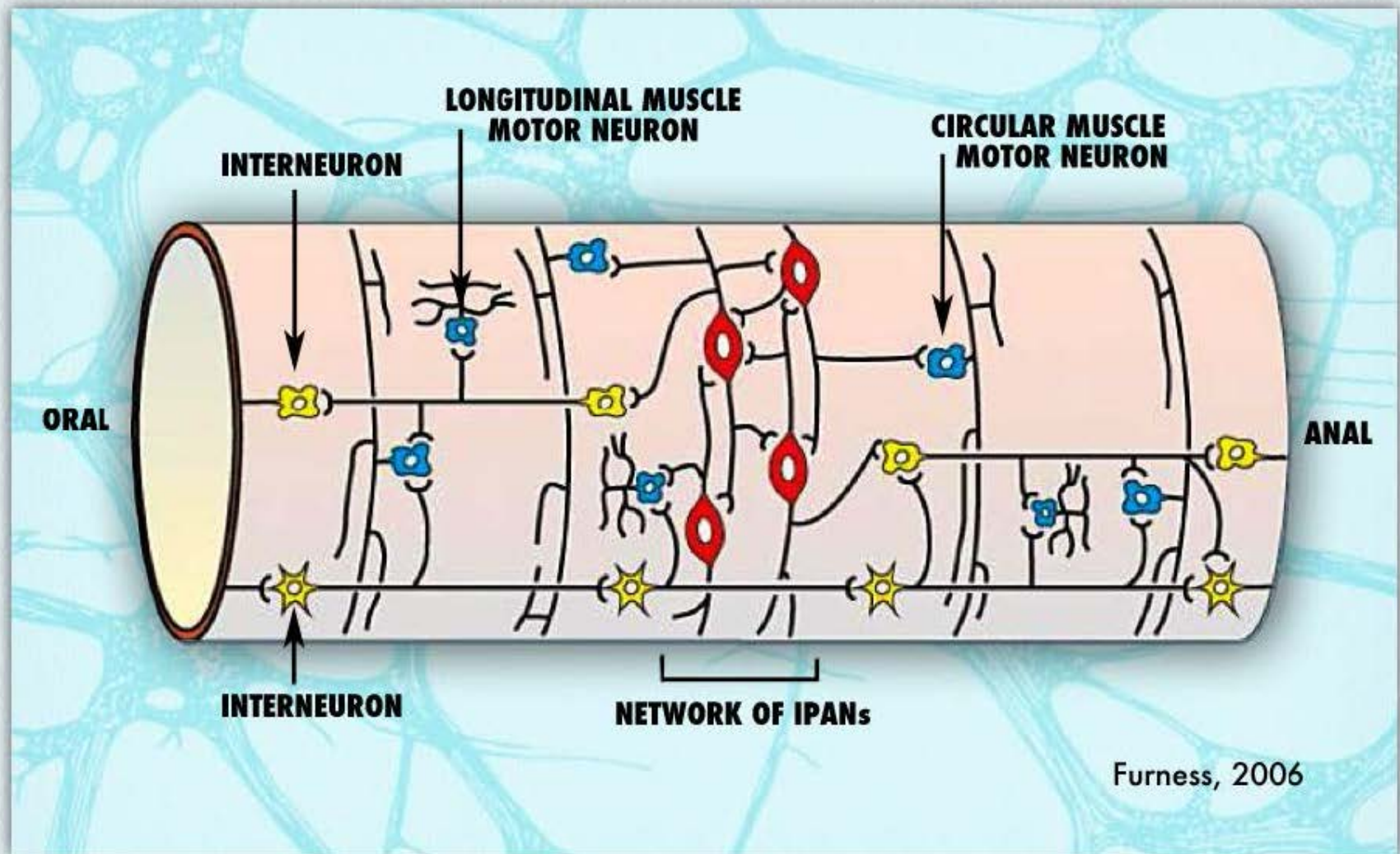


GASTRIC
BYPASS

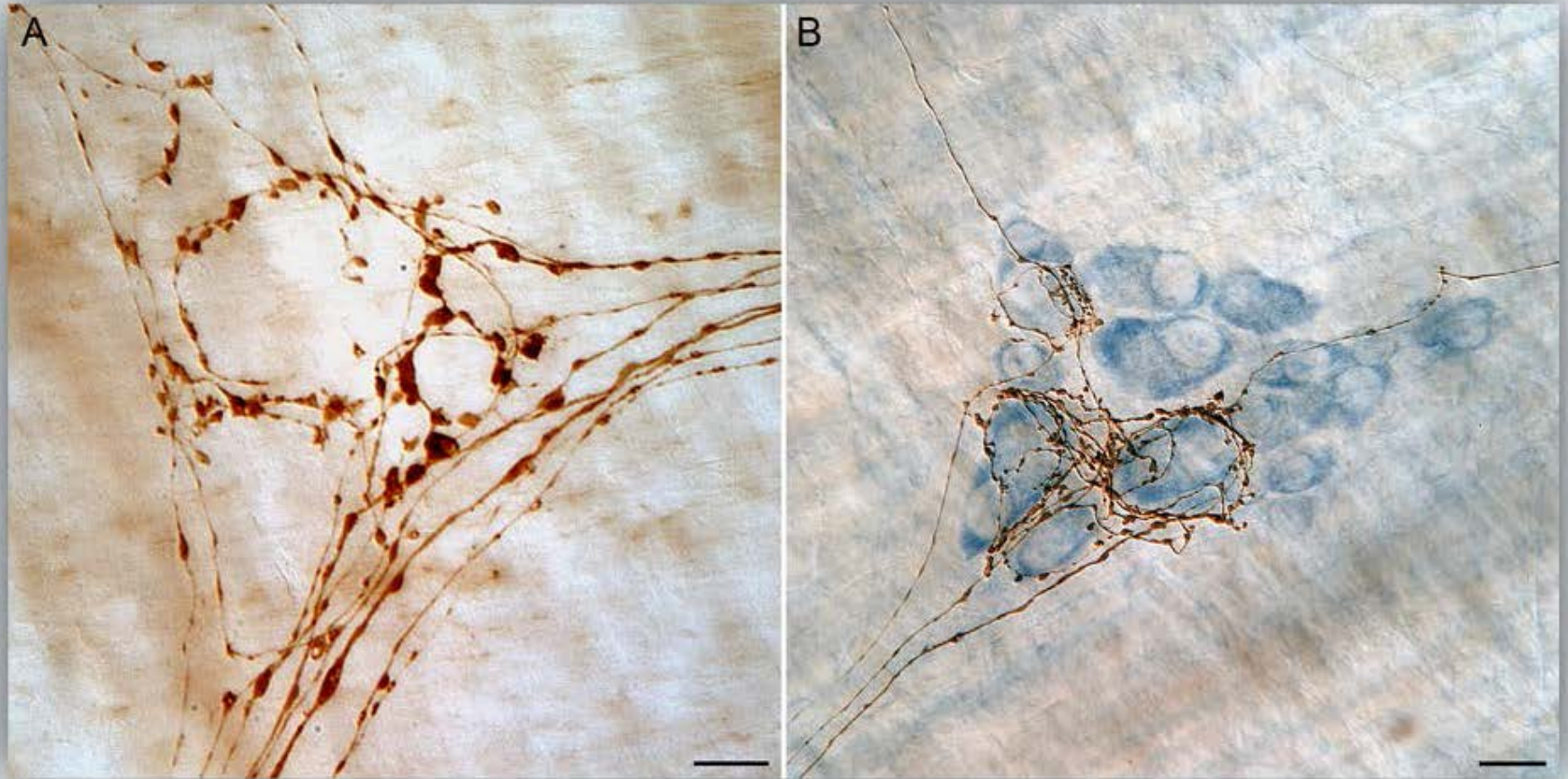


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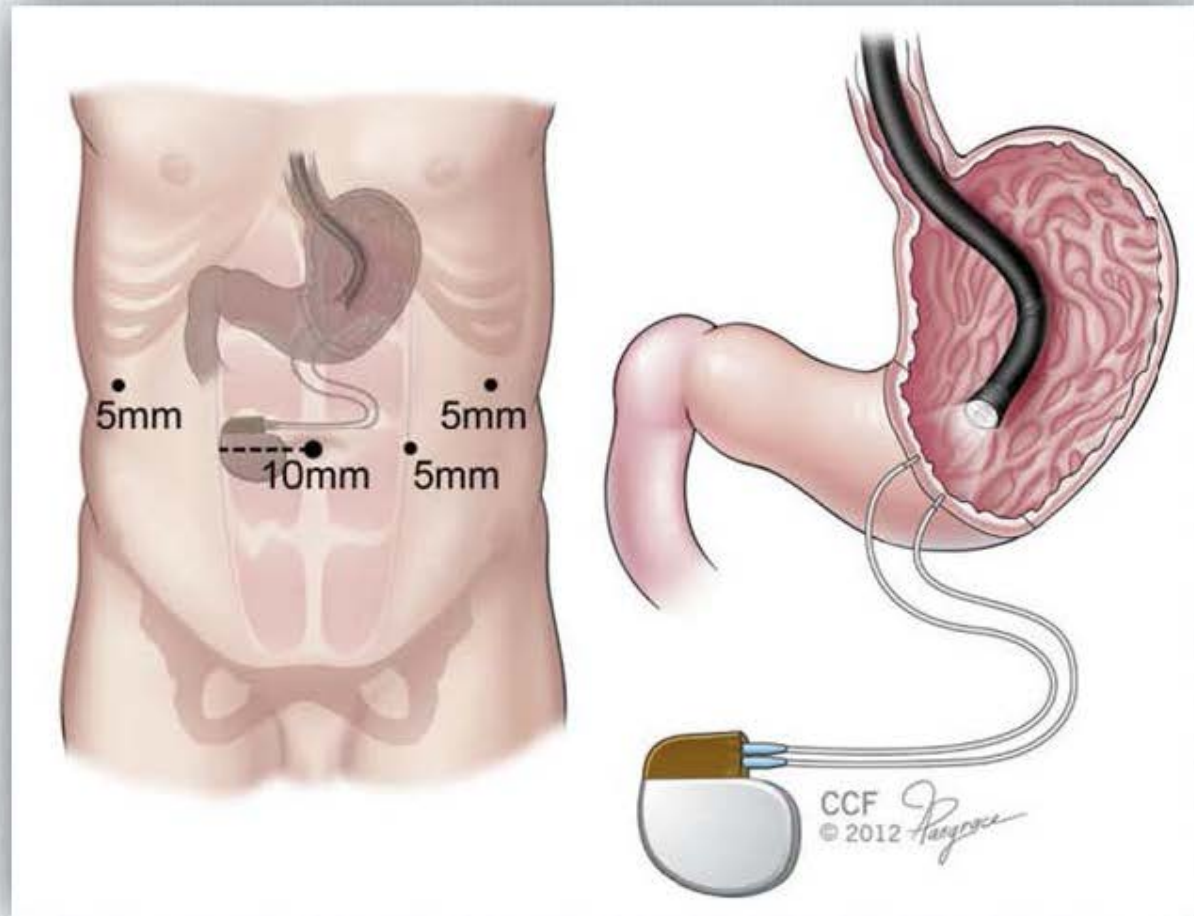


VAGAL MOTOR - MYENTERIC PLEXUS



GASTROPARESIS: GASTRIC STIMULATION

Fig. 2 Depiction of laparoscopic gastric electrical stimulation placement with trocar placement and intraoperative endoscopy



**VAGAL MOTOR
INNERVATION OF
ESOPHAGUS:
CO-INNERVATION
OF MUSCLE FIBERS
AND GANGLIA**

