

Reason for Hope: Predicting Outcome after Catastrophic Injury—Spinal Cord Injury

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MAGEE
REHABILITATION
HOSPITAL



Reason for Hope: Predicting Outcome after Spinal Cord Injury

- I. Introduction
- II. Neurological recovery
- III. Breathing & walking
- V. Residence
- VI. Future research



Introduction

- I. How to structure outcome, and hope
- II. Upper motor neuron/lower motor neuron basics
- III. Classification of SCI



How to Structure Outcome, and Hope

Dr. Staas:

WHO:

Patient:

Medical

Impairment

I can't move

Functional

Disability

I can't breathe ...

Psychosocial

Handicap

I am far from home

Introduction

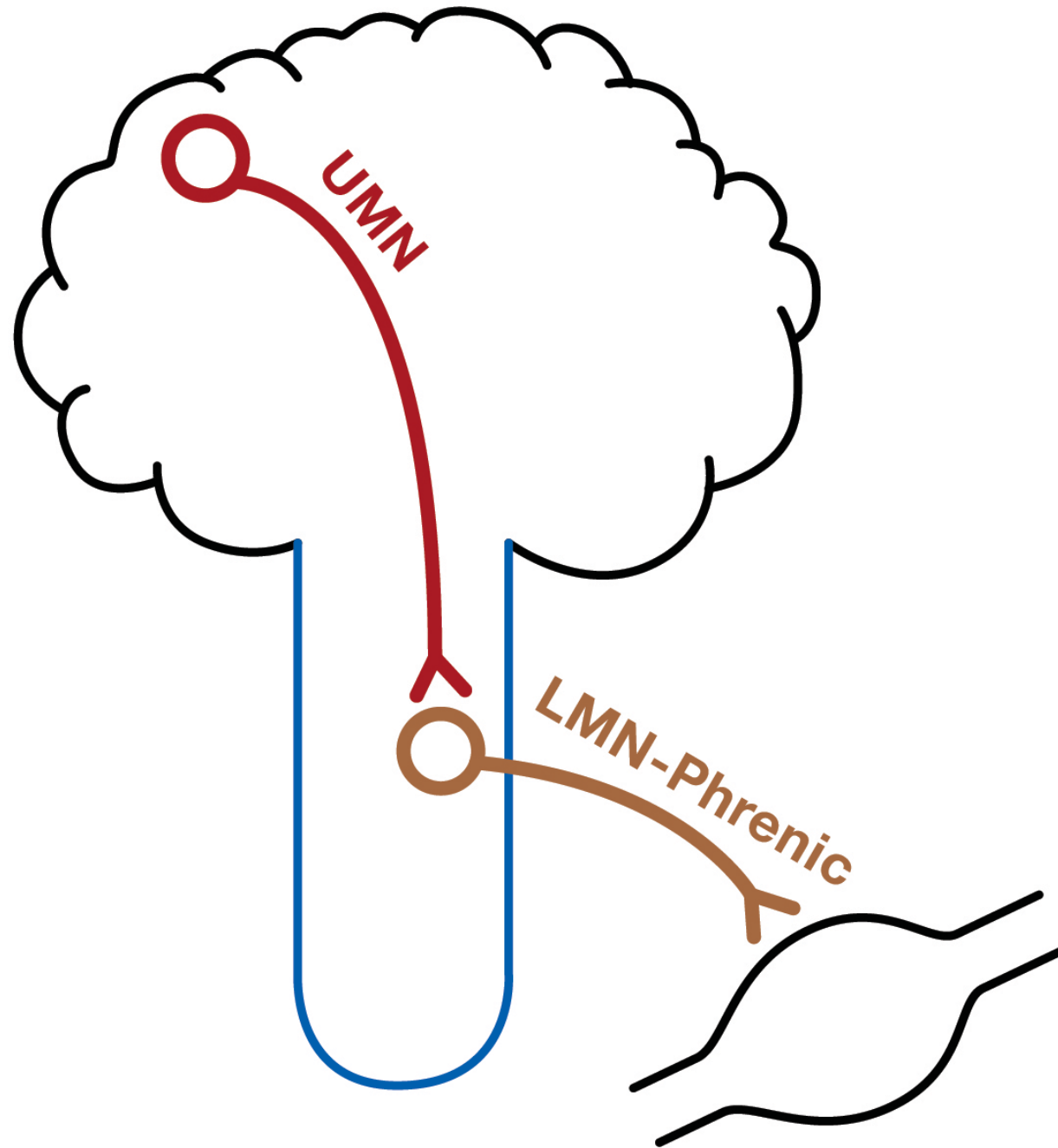
I. How to structure outcome, and hope

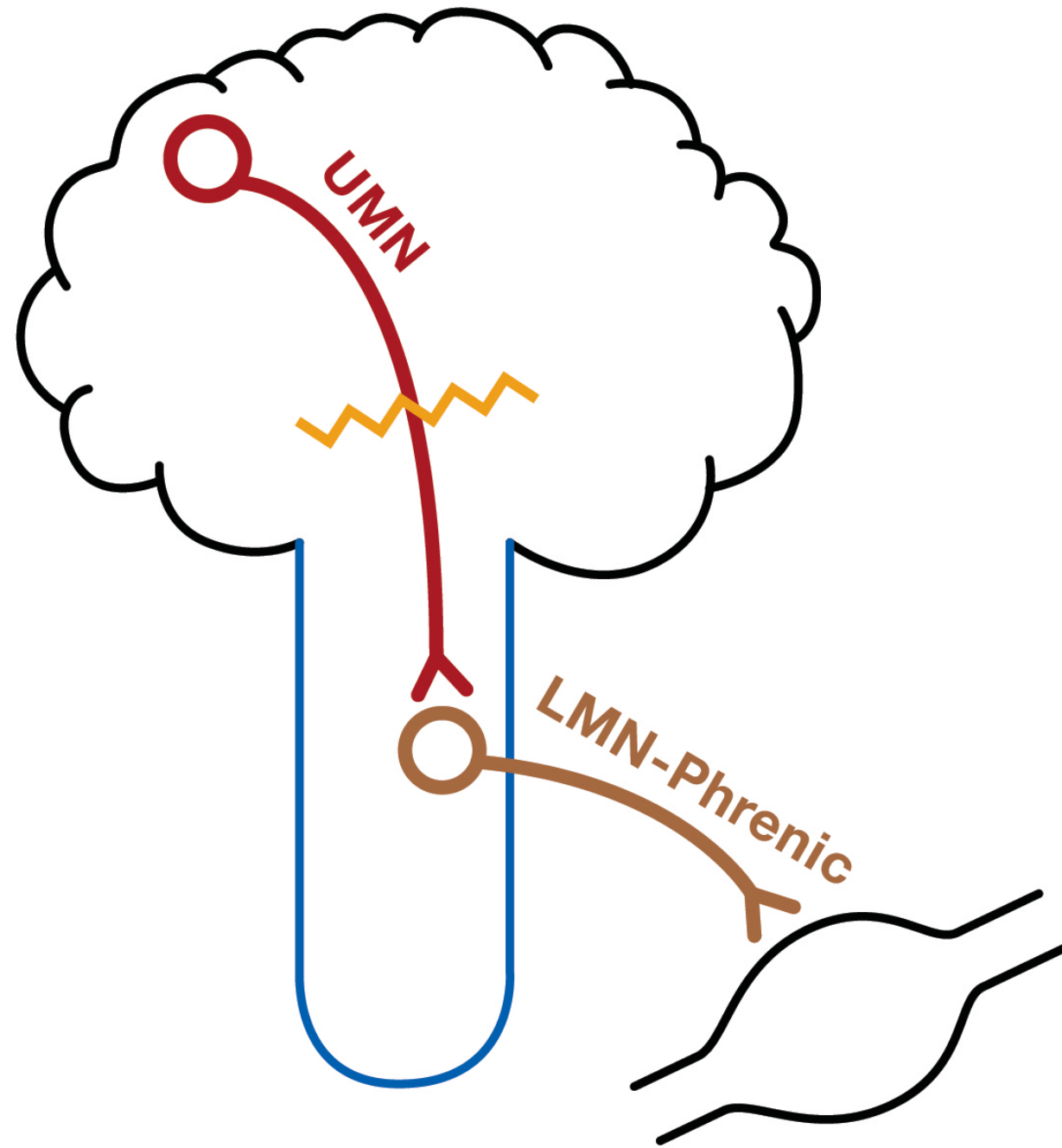
II. Upper motor neuron/lower motor neuron basics

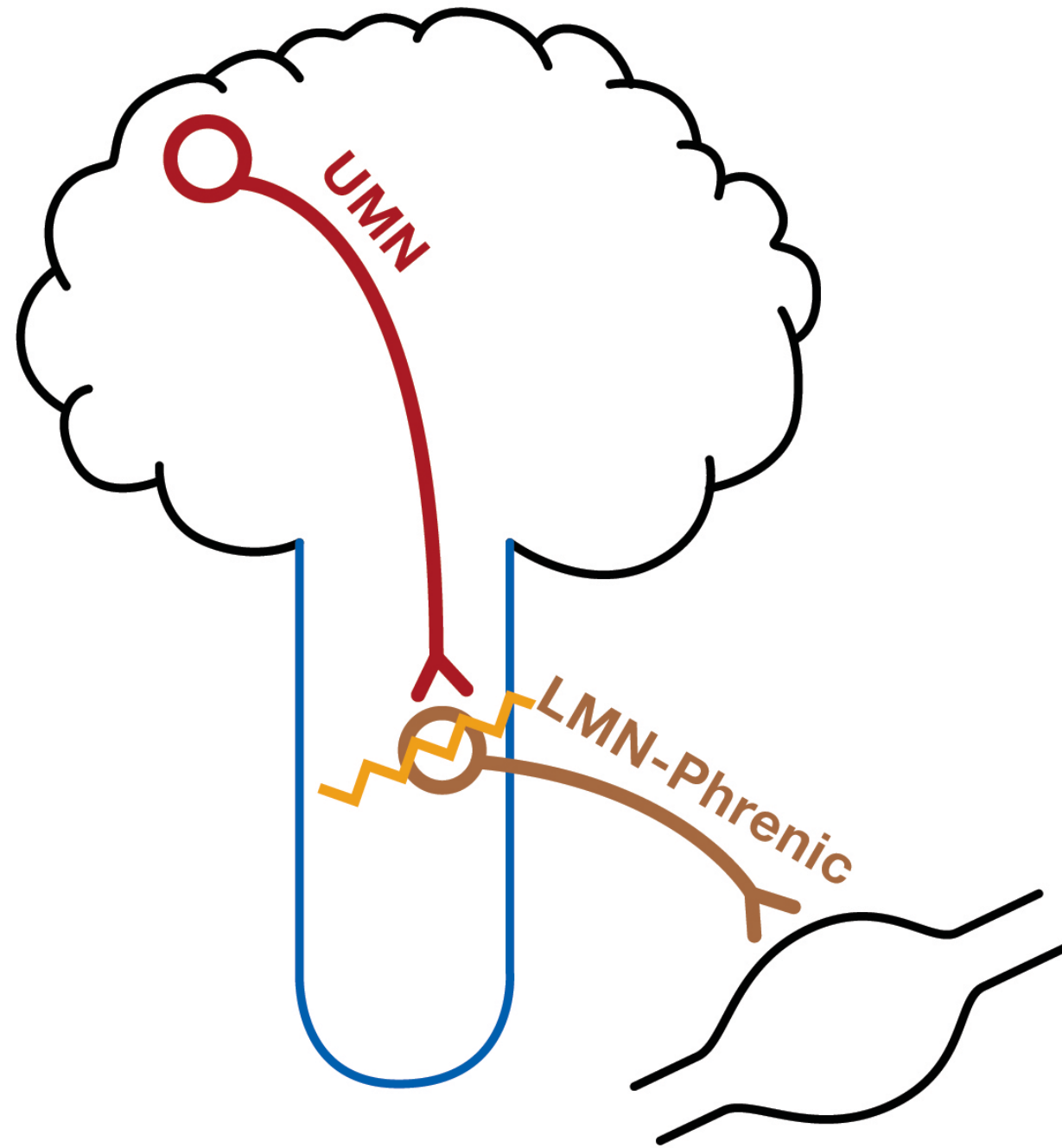
III. Classification of SCI

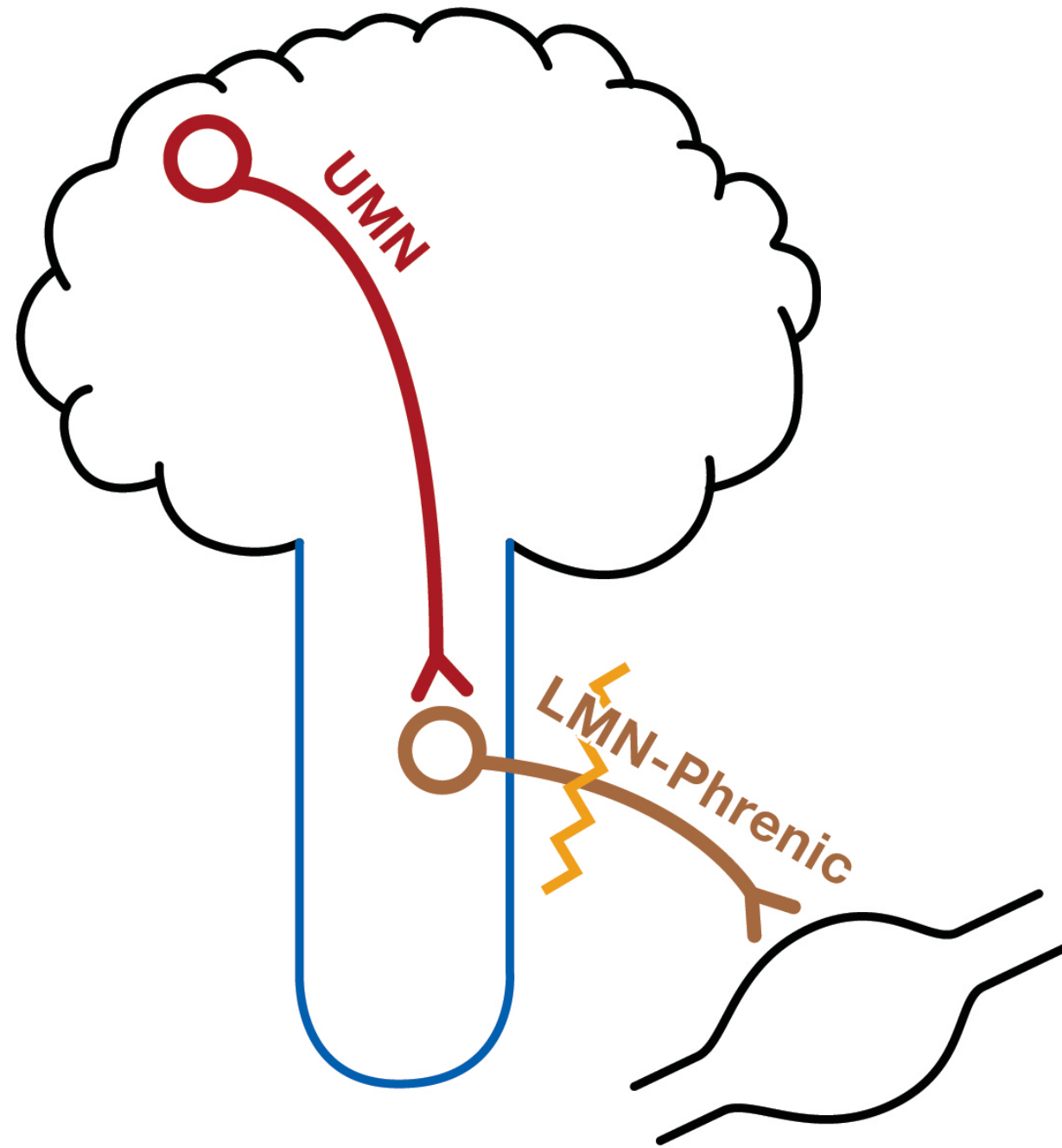
UMN/LMN Basics

- Voluntary motion originates in the brain
- Pathways cross to the other side of the body
- This crossing occurs up high
- The pathway has two neurons
- First neuron (UMN) is up in the brain—its axon crosses, and goes to the spinal cord where ...
- It synapses with the second neuron (LMN)











UMN vs LMN Injury

- They both involve weakness—
- UMN injury yields spasticity
- LMN injury yields flaccidity
- **With UMN Injury, electrical stimulation (of nerve or muscle) will cause muscle contraction**

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Description of spinal neurological deficit

- It is “simple” (no cranial nerves, etc.)
- Does not depend on imaging studies
- Two main steps—get the raw data, and then
- Put the data together to describe the injury



What is the raw data?

- Sensation
- Motor function
- To a lesser extent--reflexes



ASIA Classification

- **Many different systems to classify SCI**
- **ASIA --interdisciplinary**
- **10th and Locust**
- **Level—everything is normal down to (and including)—the level, thus generally the lower in the cord the better**
- **Severity (“AISG”) is the reverse of school; E is normal, while A is no sparing of function**

ASIA Impairment Scale Grade

- A: No motor or sensory function below (technically no sacral sparing)
- B: Some feeling present, but no motor function
- C: Some spared motor function, but weak
- D: Some spared motor function, not normal, but fairly strong (3/5 and better)
- E: Normal

asia-spinalinjury.org/

- Reviews anatomy and pathophysiology
- Goes over the exam
- Provides a video course on performing the exam
- Instructional tests



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What about neurological improvement after SCI? What is in the literature?

- First—people are NOT expected to decline; decline would need investigation
- What is expectation for improving from ASIA Impairment Grade A?
B? C?
- (Marino, Arch Phys Med Rehabil, 2011)

	1 year A	1 year B	1 year C	1 year D	1 year E
Admit as A					
Admit as B					
Admit as C					
Admit as D					

	1 year A %	1 year B %	1 year C %	1 year D %	1 year E %
Admit as A	78	12	6	3	0
Admit as B					
Admit as C					
Admit as D					

Prognosis for ASIA A

- Most stay “complete”
- However—22% do become incomplete within the first year, and of these a minority improve to ASIA D

	1 year A %	1 year B %	1 year C %	1 year D %	1 year E %
Admit as A	78	12	6	3	0
Admit as B	3	46	27	24	0
Admit as C					
Admit as D					

Prognosis for ASIA B

- (people should not decline)
- Over half will become motor incomplete
- A quarter will progress to ASIA D—thus functional strength in the lower limbs

	1 year A %	1 year B %	1 year C %	1 year D %	1 year E %
Admit as A	78	12	6	3	0
Admit as B	3	46	27	24	0
Admit as C	0	1	22	77	0
Admit as D					

Prognosis for AIS C

- (should not decline)
- Over half will improve to ASIA D, thus functional strength in the lower extremities

	1 year A %	1 year B %	1 year C %	1 year D %	1 year E %
Admit as A	78	12	6	3	0
Admit as B	3	46	27	24	0
Admit as C	0	1	22	77	0
Admit as D	0	1	1	84	14

Effect of time from injury ...

- Clearly a person with ASIA B injury of one day's duration has a greater likelihood of improving to C or D than a person with ASIA B injury of one year's duration
- BUT we don't know much about this quantitatively; we don't have a chart to use



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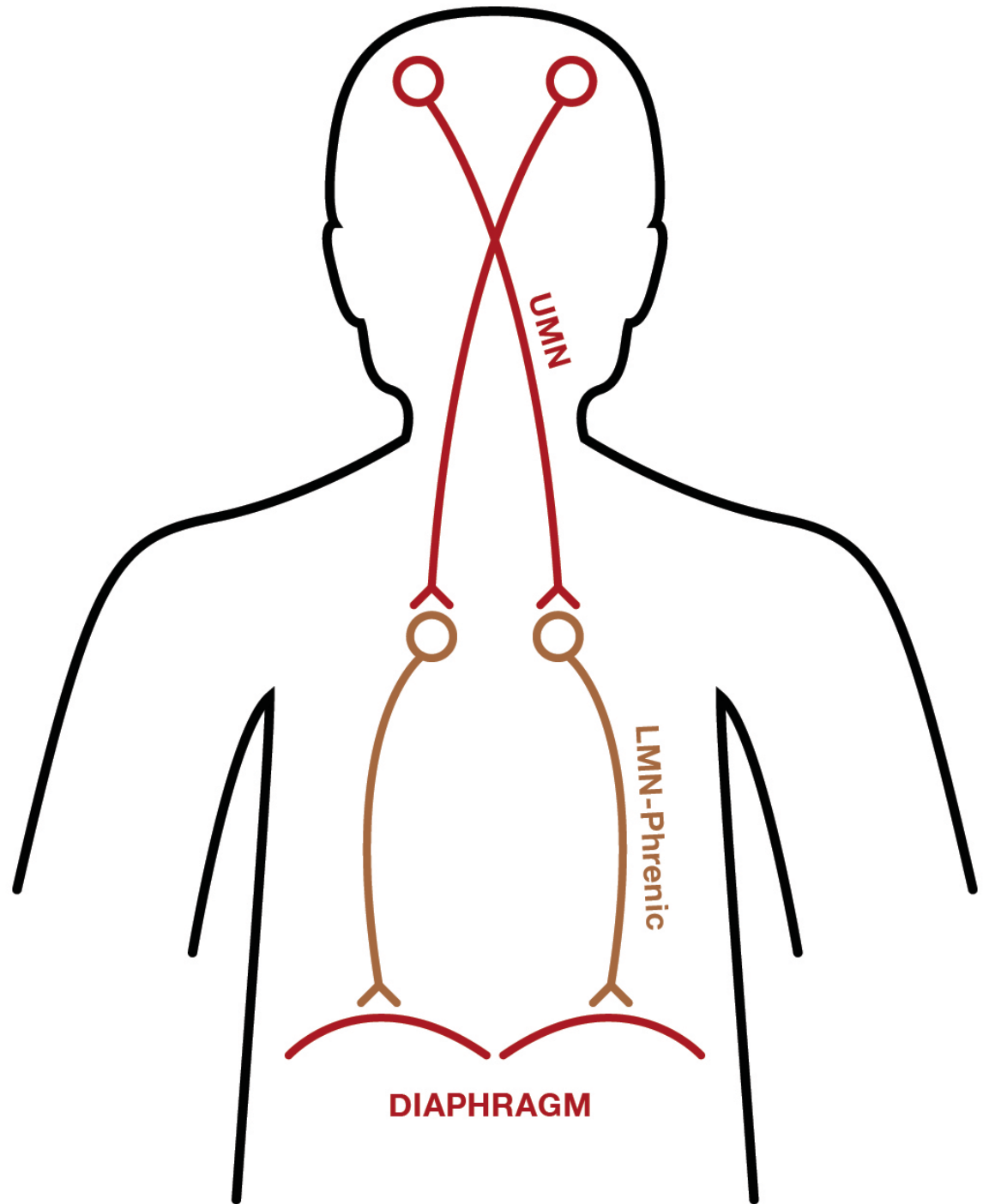
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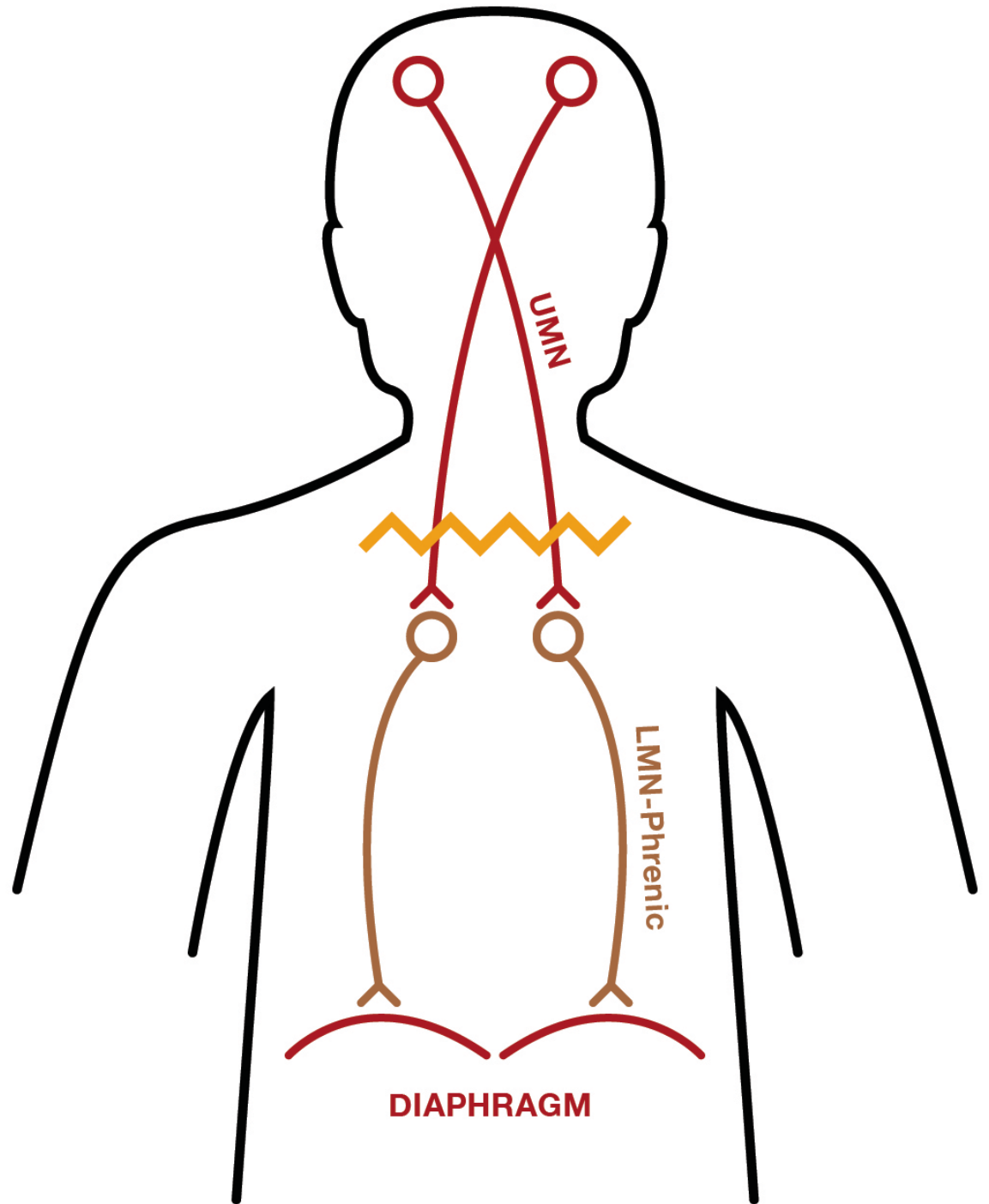
Breathing

- Usually the lungs are healthy
- If presented with air, the lungs will function properly—taking in oxygen and getting rid of carbon dioxide
- Problem is getting the air there—ventilation; a motor problem

Ventilation

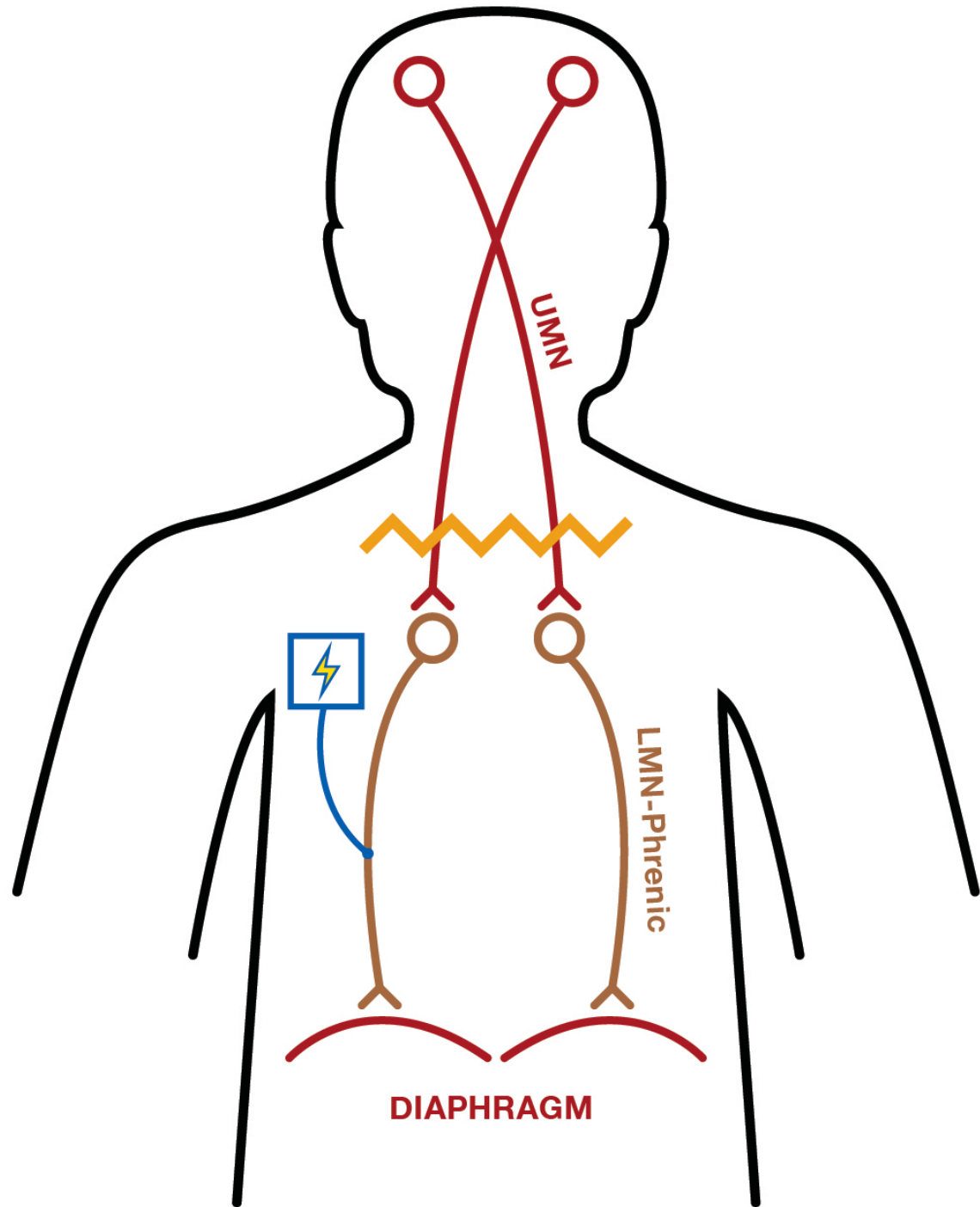
- Moving the air in—**inhalation**—**diaphragm**
- Moving air out—**exhalation**-especially **coughing**—**lower muscles**
- One can get along well with just ability to inhale—thus, if **phrenic nerve** is working





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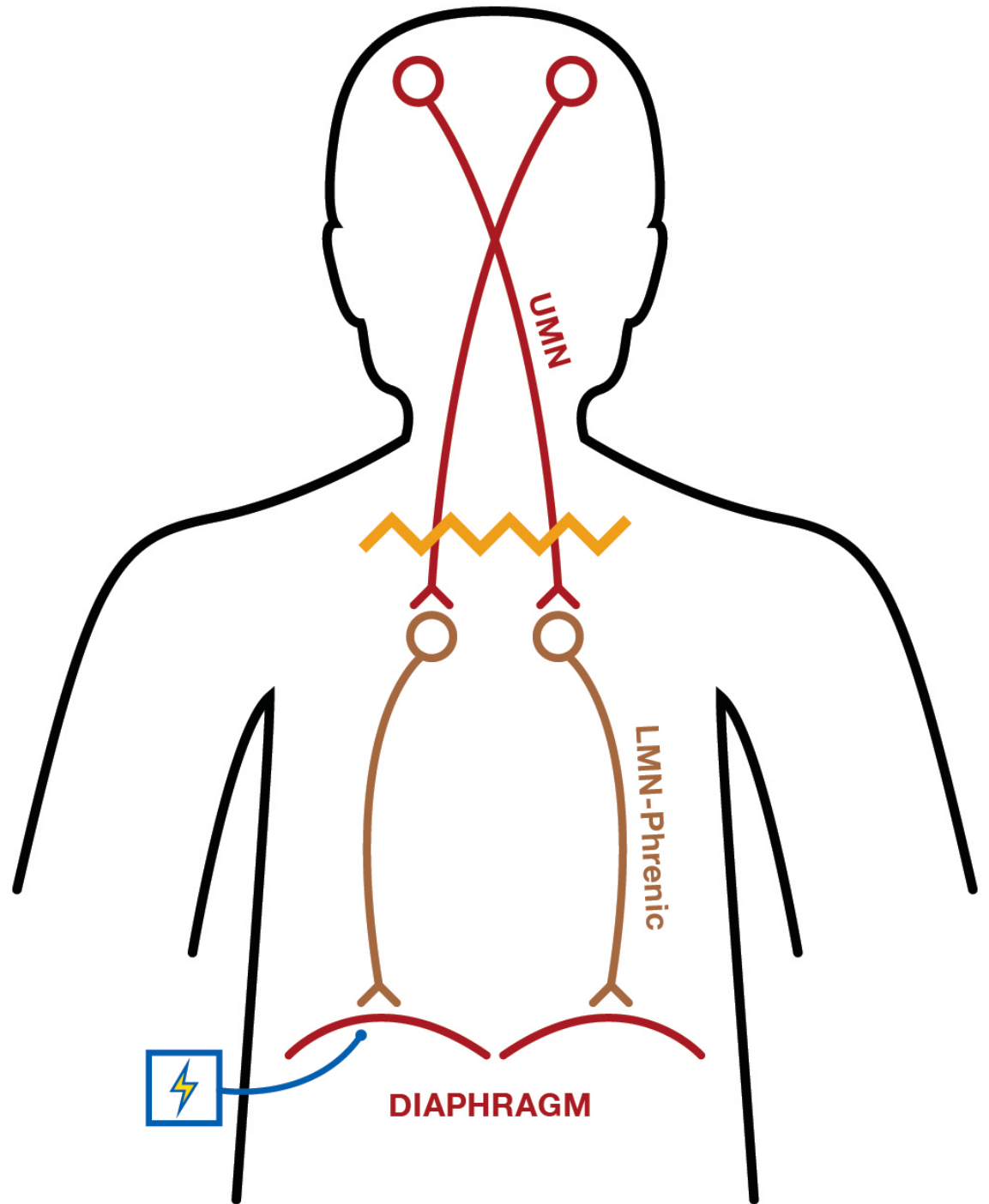
Phrenic nerve pacing

Implanted system;
nothing through the skin

Challenging surgery

Diaphragm must be
conditioned





Diaphragm Pacing System



“DPS”

- Relatively easy to place ...
- Diaphragm must be conditioned
- A bridge, or a destination
- Parameters are managed externally
- “Percutaneous”

NeuRx CLINICAL STATION

MODE

RESET STIMULUS SETTINGS

SEND STIMULUS SETTINGS

RETRIEVE STIMULUS SETTINGS

RESET SURGICAL MAPPING

DISPLAY CONTRAST

LINE FEED

START/ NEXT SEQUENCE

PAUSE/ RESUME SEQUENCE

PRINT STIMULUS SETTINGS

ENABLE AUTO PRINT

STIMULUS SETTINGS

CHANNEL

SELECT ON OFF AMP PW

BPM INSP FREQ RAMP

STIMULUS ACTIVATE

1 2 3 4

LEFT ALL RIGHT

PULSE INSP BPM


MAPPING

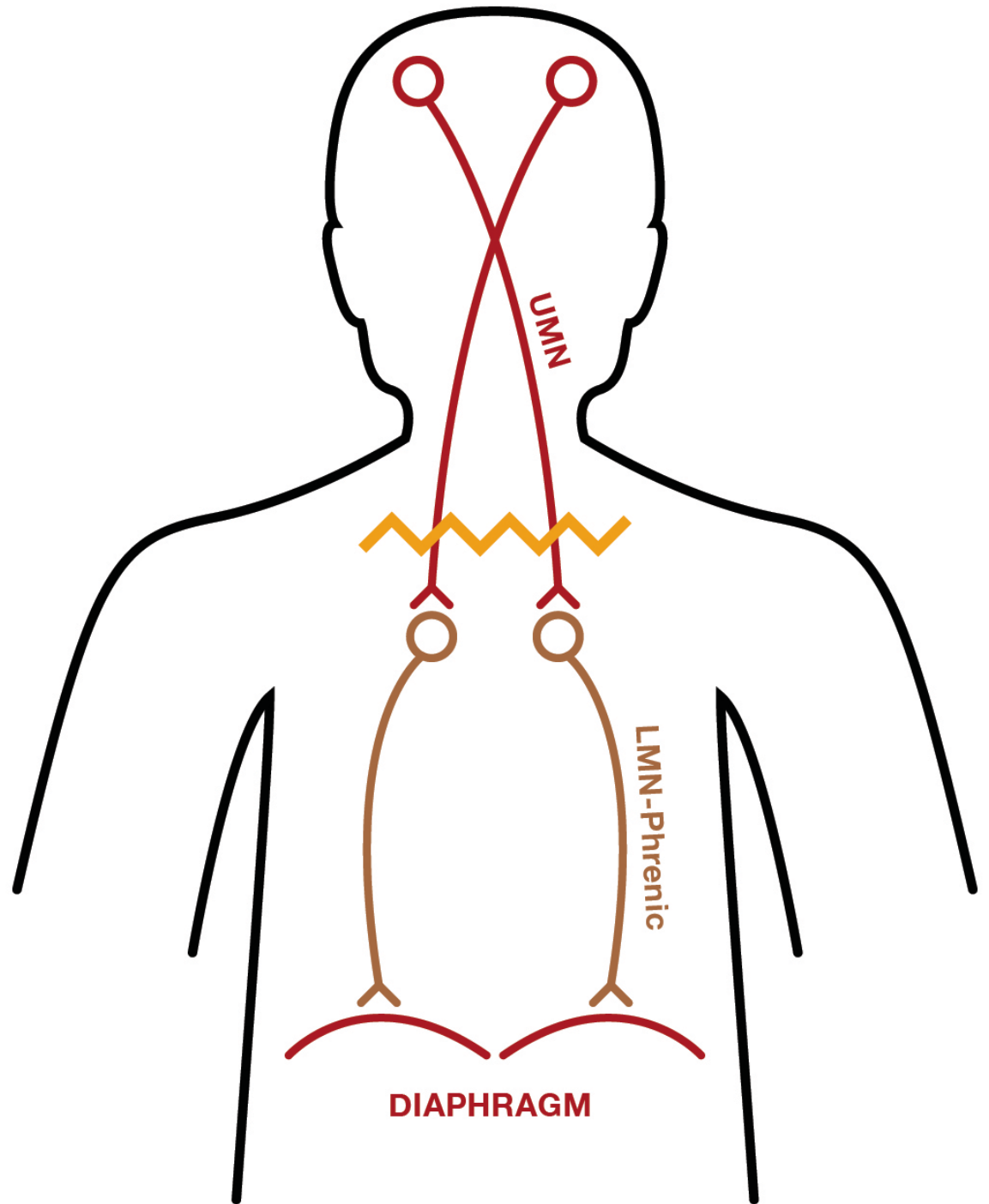
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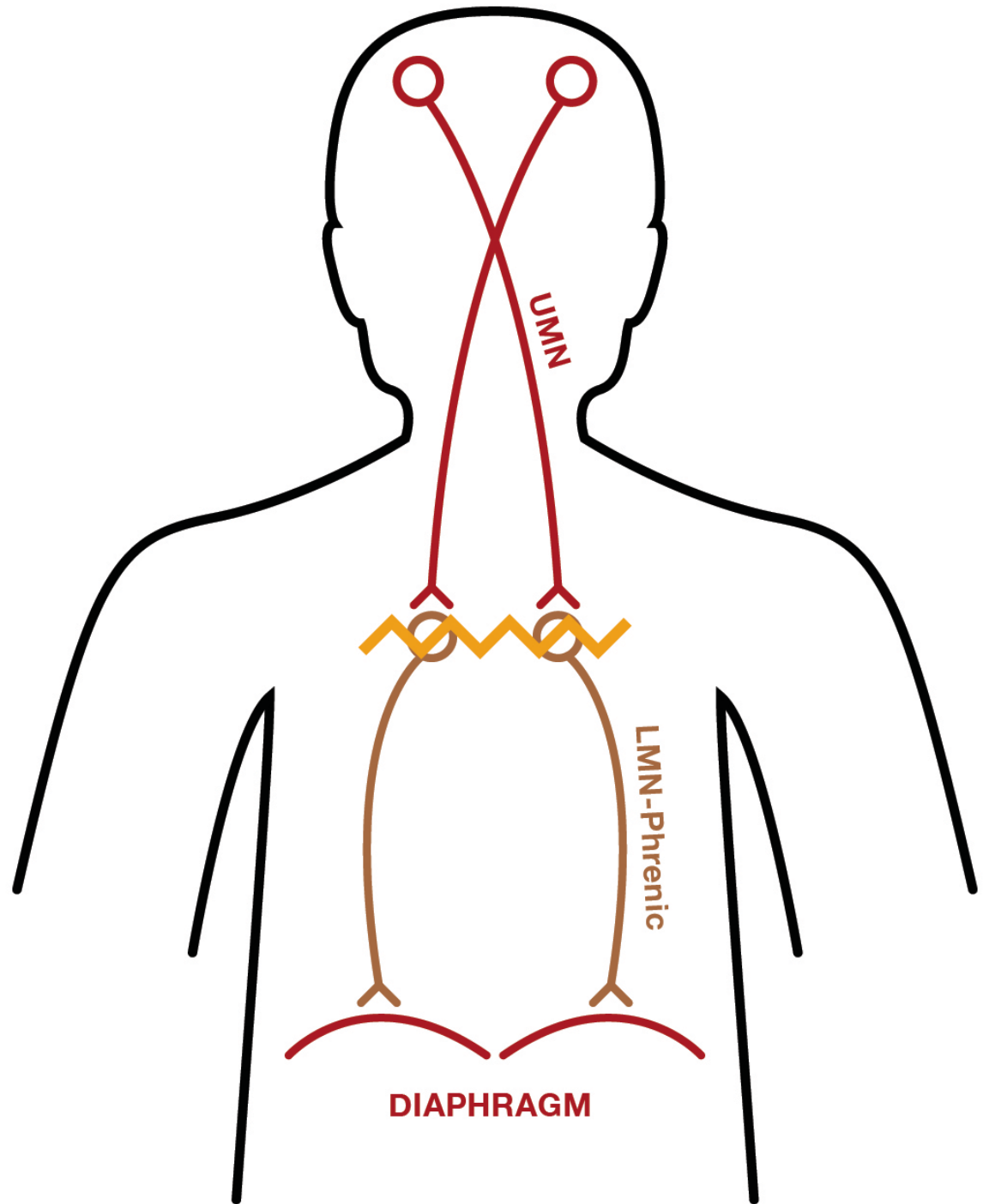
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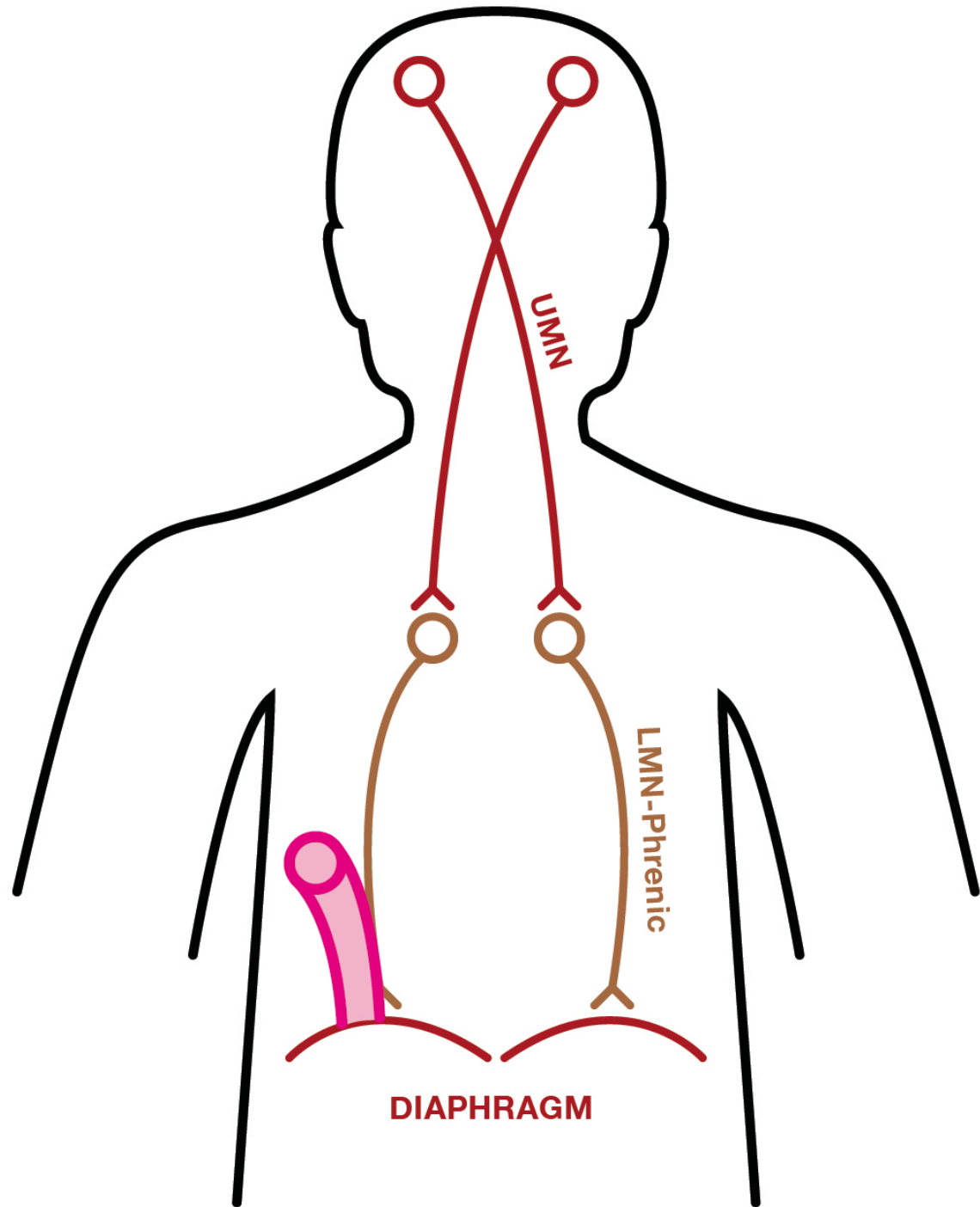
POWER CHARGING

SYNAPSE









DIAPHRAGM

UMN

LMN-Phrenic



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Early prognosticators:

Crozier Arch Phys Med Rehabil 91

- Sparing of pin sensation predicts better prognosis for gait than touch sparing only.
- Why ...

Crozier Arch Phys Med Rehabil 91

- Better than 3/5 quad at three months predicts gait
- Why ...

Early prognosticators

Penrod, Arch Phys Med Rehabil 90

- Age below 50 is a good prognosticator for persons with a similar SCI syndrome
- Why ...

Middendorp, Lancet 2011

- Confirmed age, quads
- Also, plantar flexors—why?
- Also touch sense L3 and S1

Problems ...

- Varying definition of ambulation (note WISCI scale)
- What “we” need is information about prognosis for people based on findings sometime after injury

Data for persons at 1 month ...

- For 13 persons with SCI, ASIA B tetraplegia at 1 month—
- None were community ambulators at 1 year
- Some did regain some LE motors—these were people with preservation of pin sensation

(Waters, Arch Phys Med Rehabil, 1994)

BUT ...

- People with ASIA C injuries often did well
- Most of those with a “summed LE motor score” of 10 or better, as 30 days, were able to walk in the community at 1 year
- Perspective: 10 lower limb muscles; having trace function in all of them would give a LE score of 10
- Waters et al, Arch Phys Med Rehabil 1994



A Memorable Case ...

- 15yo boy was hurt wrestling—with tetraplegia.
- Presented for rehabilitation at day 16, with C6 level, sensory incomplete tetraplegia, no motor function in lower limbs. (“ASIA B”)
- Began to regain lower limb strength at day 51.
- Five months after injury, walking/running without assistance or device.

Body weight supported training

- Stegosauruses and babies
- Cats
- Hess's Law
- Body weight supported training
 - upright
 - sensory input
 - upper limbs free

Traditional Body Weight Support

Arms free/input through
feet/upright

Therapist input to help
facilitate response

Labor intensive in
numbers of personnel
and in exertion

Physically vigorous

Robotic Suspended Training

Arms free/input
through
feet/upright
Less labor
intensive
“Smooth”

Overland Suspended Gait Training

Arms free/input
through feet/upright

Allows overland
training with obstacles

Allows some lateral
motion

Three modalities ...

- Unusual to have all of them in one setting
- No paradigms for how to utilize with different persons
- Benefits extend well beyond ambulation
- Appropriate for training with persons with other impairments

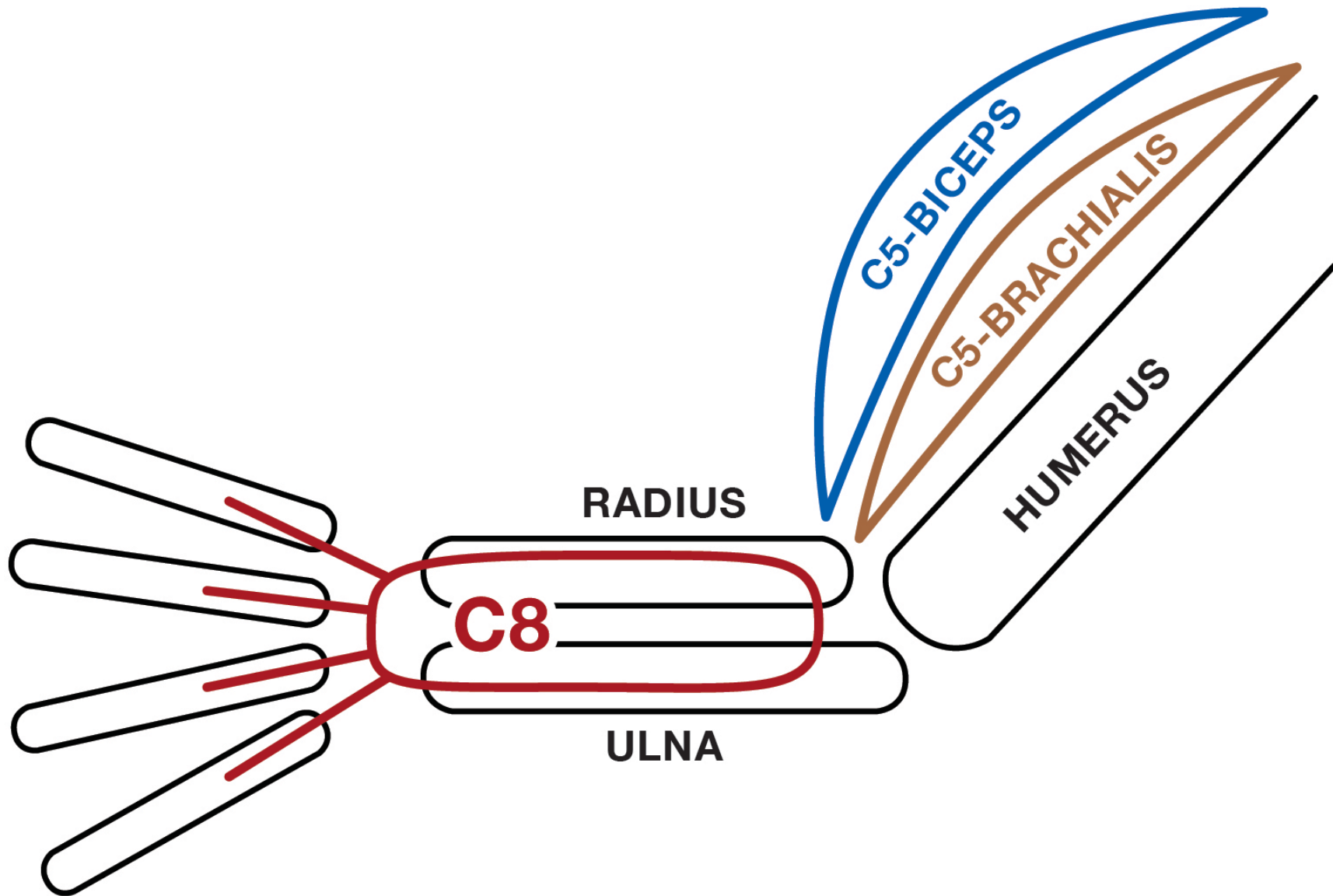
External Powered Skeletal Support

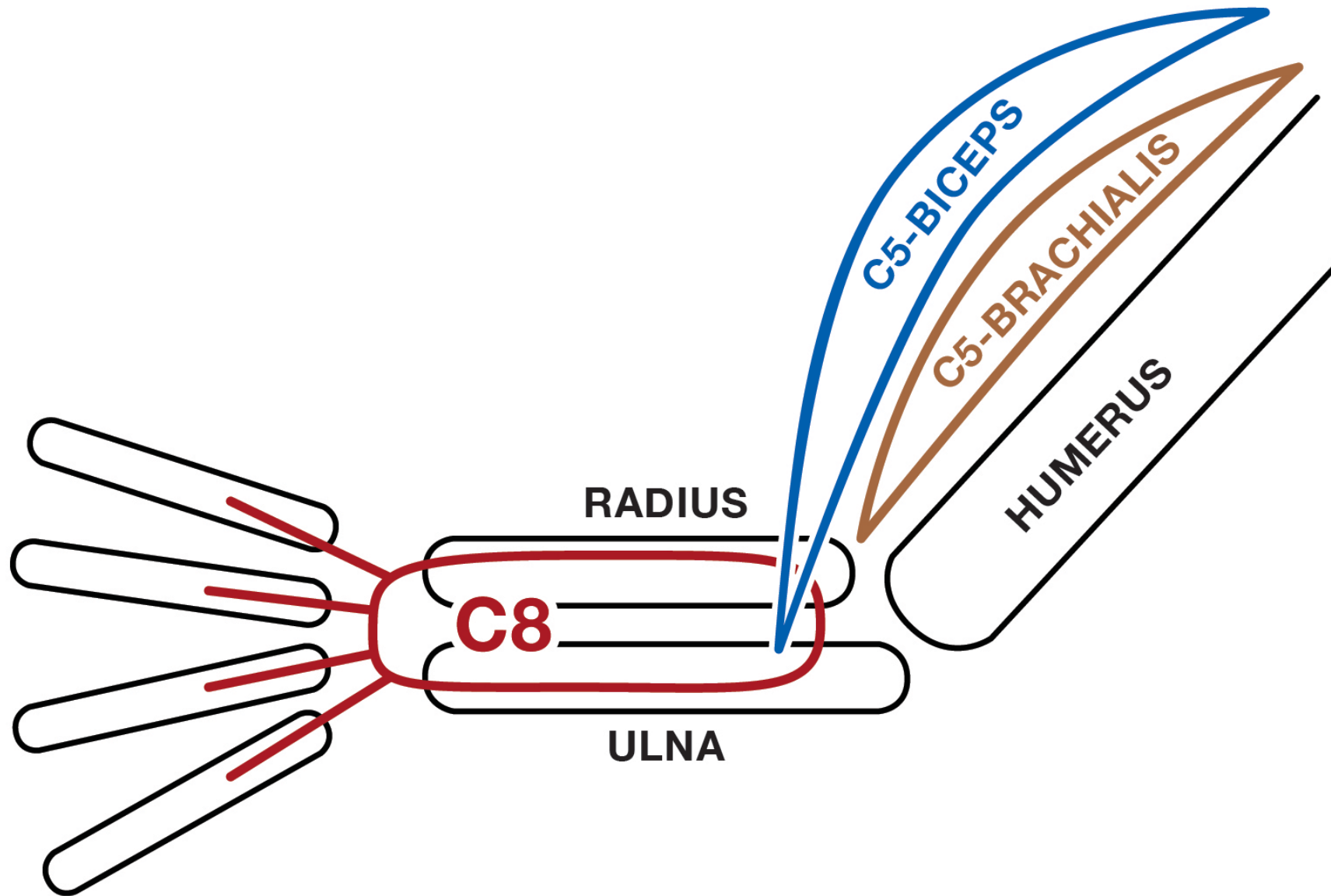
Can substitute for A to B
mobility; can replace, for
certain situations, a
wheelchair

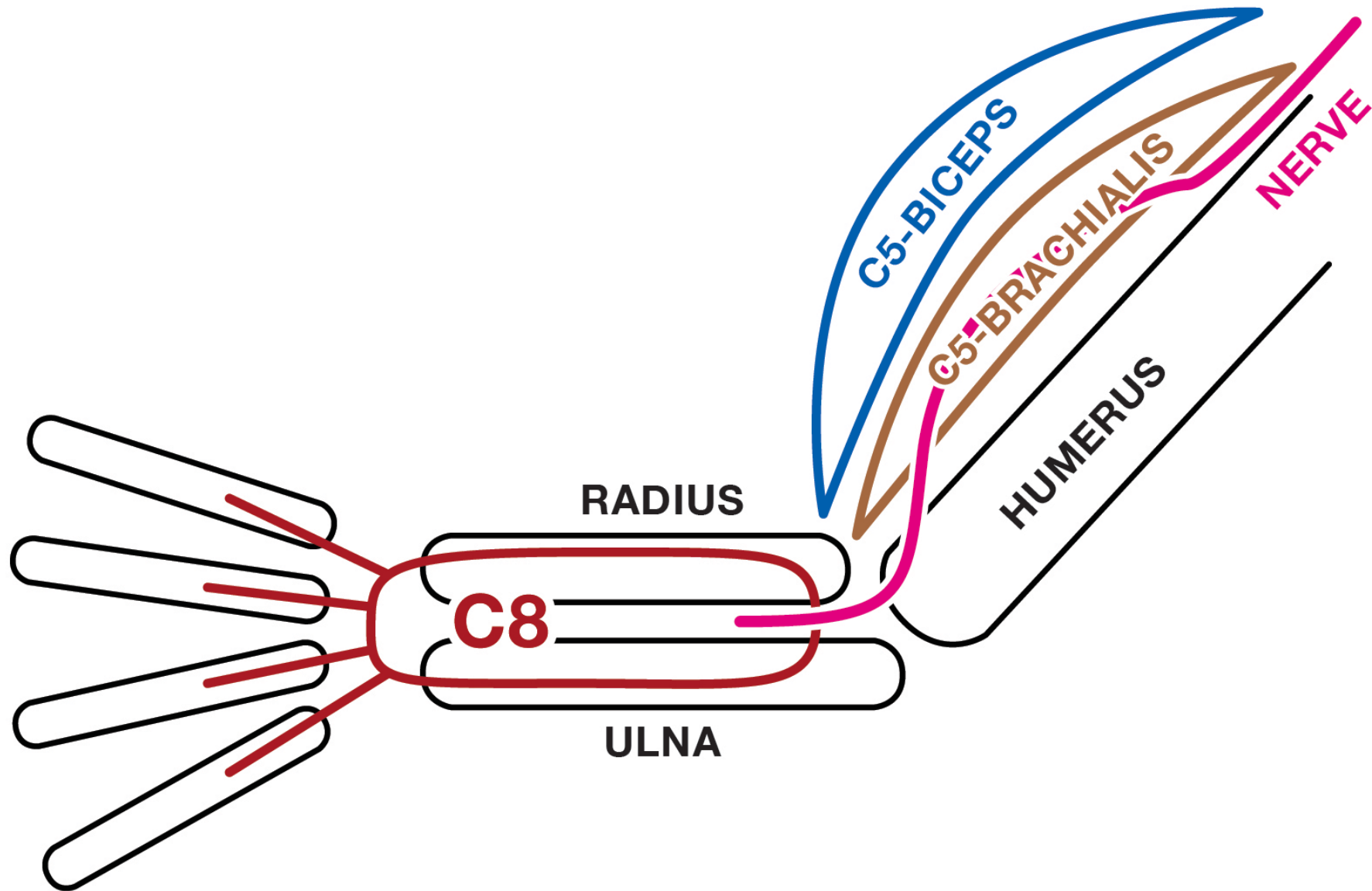
Not truly suspended,
arms are **not** free

More than a substitute;
has been broadened to
use as a training device

Upper Limb Systems









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Residence and Life Satisfaction

- 87% of persons with acute SCI are discharged to a private residence in the community (Model Systems Data, University of Alabama/Birmingham)
- Why is that important?

Which most affects Life Satisfaction?

Possibilities here--

- Impairment—paraplegia, say vs tetraplegia
- Disability—ambulatory, vs using a wheelchair
- Handicap/level of societal role—in an accessible vs inaccessible environment

Answer: Societal role

- Greater life satisfaction of a person with tetraplegia, using a wheelchair, in an accessible environment, than for a less impaired person in an inaccessible environment
- Cross cultural/cross generational (Dijkers, Spinal Cord, 1997)

Importance of societal role/handicap

- “If they develop a cure for my spinal cord injury, I will take advantage of it, when I can fit it into my schedule.”
- A good outcome (per the patient) can occur without neurological recovery.



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Future research—stem cells

- I. Framework for thinking of stem cells
- II. Why would such a cell help?
- III. Asterias
- IV. Jefferson & Magee

Basics

- A stem cell can branch out to make different, more specialized cells neurons
- Where does one get a neural stem cell?
- A goal: “Induced, pluripotent stem cell”
(no embryonic concerns, no immunosuppression)

Why would a stem cell help?

Three patients

- Chronic central cord syndrome with loss C8/T1 hand muscles
- A person with chronic incomplete paraplegia
- A person spinal cord injured two weeks ago, with “swelling”

Three cell types

- Neurons
- Myelin-producing cells
- Support cells

“Asterias”

- “OPC”
- Help for early on
- Collaborative with TJUH; Dr. Fried here as Principal Investigator; Mary Schmidt now in Atlanta meeting.
- A long-term view—15 years of follow-up

15 year follow up



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