

# Resilience and Vulnerability to Health Stressors: A Case Example

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## Mrs. M's Story

She is 91 years old

- Independent in caring for herself, lives alone
- Teaches Sunday school and sings in the choir, “spry”  
recently uses wheelchair for long distances
- Has 3 daughters, 1 son

“Mama is still large and in charge.”

Past medical history:

Vascular: Type II diabetes, hypertension, hyperlipidemia, obesity, remote stroke (mild L arm weakness)

Non-vascular: Arthritis, H/o Breast cancer in 1996

Went to see her primary doctor for rectal bleeding ->  
Diagnosed with colorectal cancer



# A hard decision: Surgery or no surgery?





## Course

# Underwent proctocolectomy with end colostomy

Day 1: Blood pressure dropped (78/50); Bleeding from surgical site

-Transfused 2 units of blood and received medicines to keep blood pressure normal

Day 2: **Massive Heart Attack. Emergent cardiac catheterization shows many blockages. New heart failure.** Could not immediately open the clots in her heart, in setting of surgical site bleeding. **1:1 balloon pump, intubated**

Patient remained lucid; passed “Vigilance A” test; giving “thumbs up” sign



# **“A Week of Hellish Uncertainty”**







## Questions I asked myself all week

- How much stress can this complex dynamic system take and still regain homeostasis?
- What reduced state will the system be in, when or if it regains stability?
- Is the system showing signs of critical failure? Are we past a point of no return?
- Are there tests we could do NOW (or should have done BEFORE) that would help answer the first questions?



## Course

Day 9: Undergoes cardiac revascularization w/ bare metal stents. Balloon pump removed.

Remains lucid: smiling, nodding appropriately  
Slow weaning from ventilator (a good sign)

Day 11: Ventilator requirements increase; diagnosed with **vent-associated pneumonia**. Self-extubates in early a.m., but had to be re-intubated within hours. First sign of confusion.

Day 12: **Cardiac Arrest, resuscitated**; Fluid on lungs; Team had to restart IV medications to maintain blood pressure

Holiday weekend – family wants to wait to make decisions until full team can assess her and weigh in.



# Course

Day 14: Kidney function worsens.

Day 16: Patient is confused again (alert, trying to communicate, unable to use alphabet board)

**Status Changed: Do Not Attempt Resuscitation**

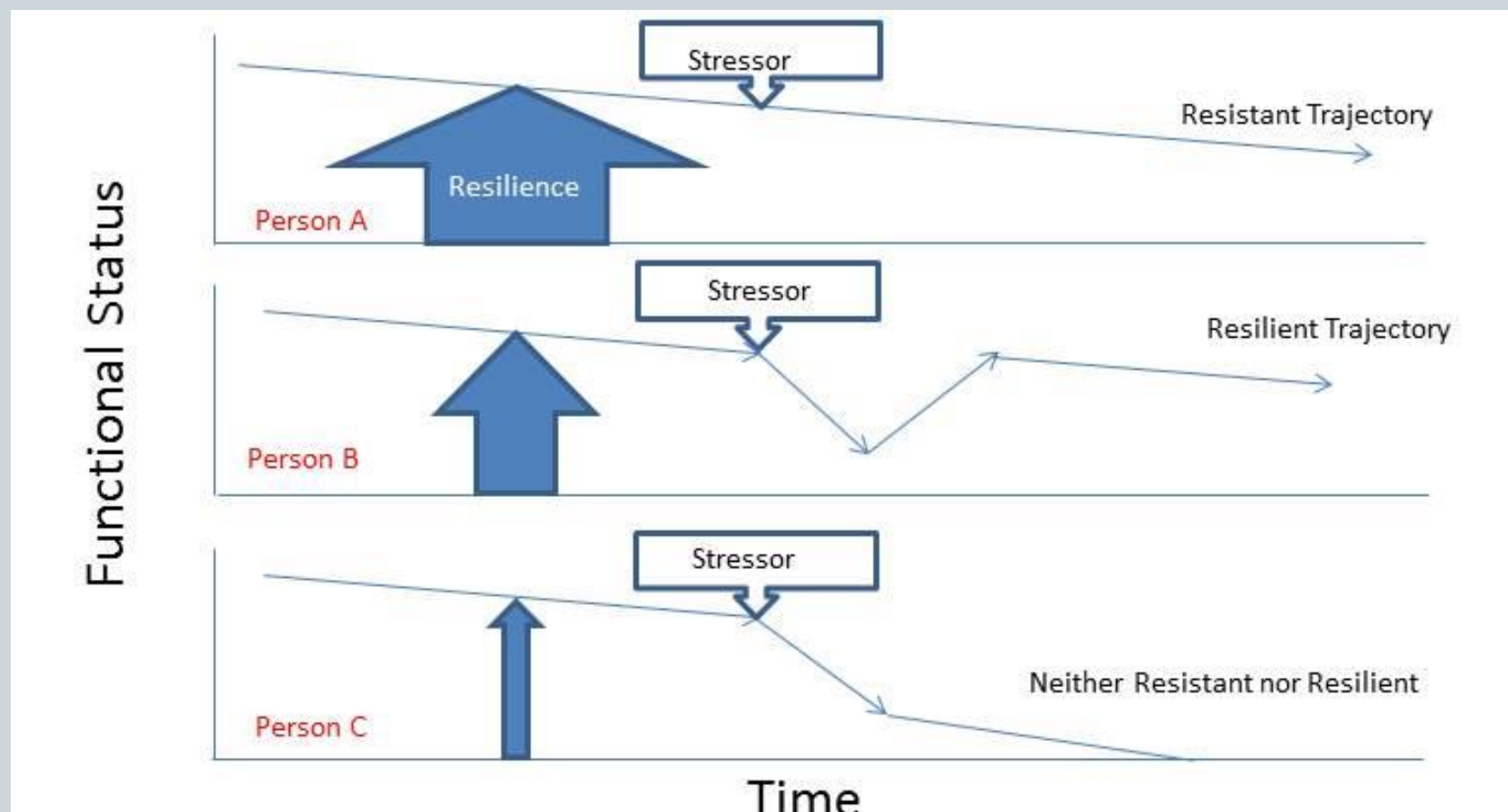
Day 17-20: Some signs of improvement – a little more lucid; kidneys are improving; blood pressure more stable; slow weaning from the ventilator

Day 21: Frank bleeding in endotracheal tube  
**Asystolic arrest**



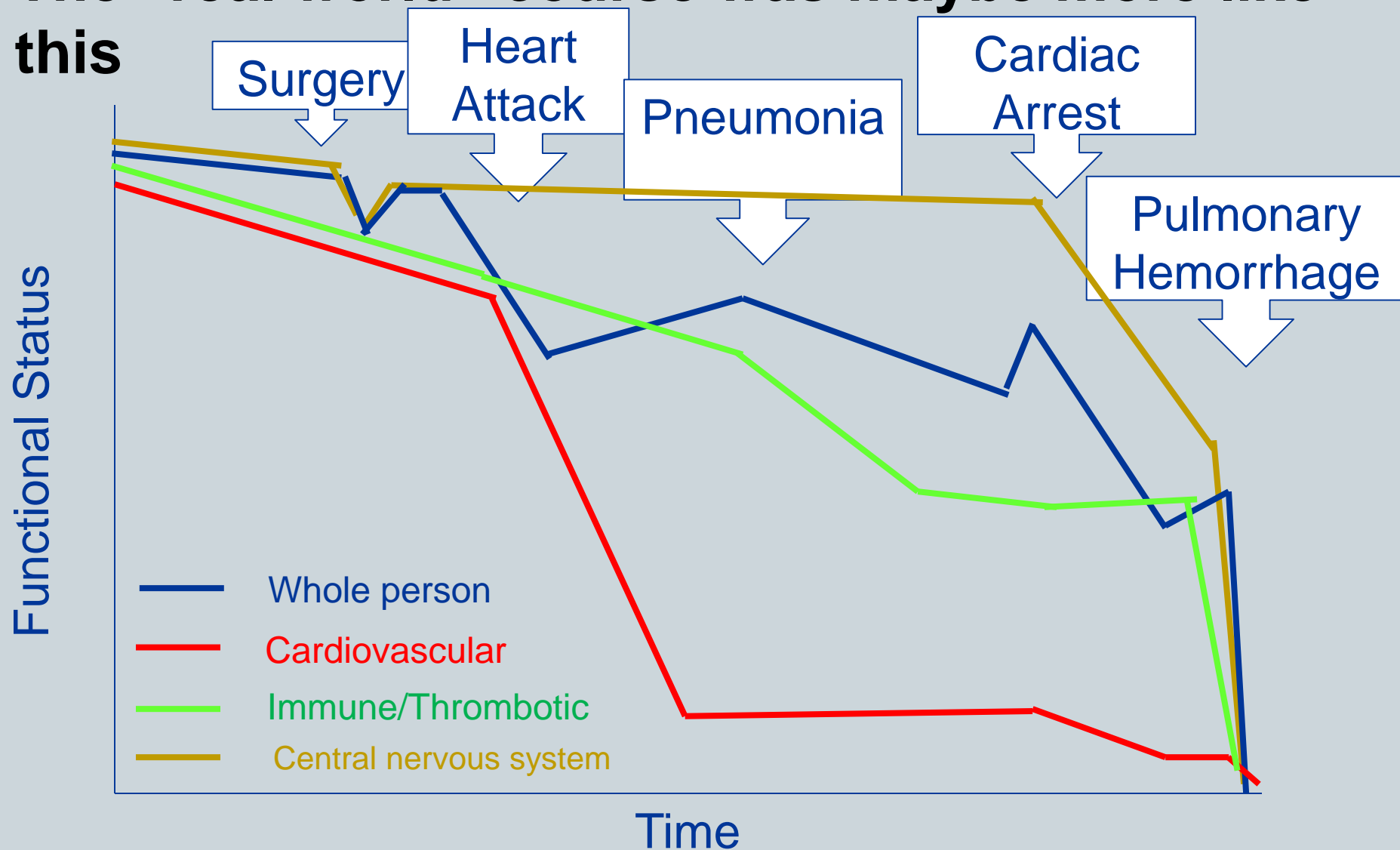


# Mrs. M's course didn't really look like any of these...





# The “real world” course was maybe more like this





# **Applying the Emerging Construct of “Physical Resilience” to Clinical Care**



## Working Definitions

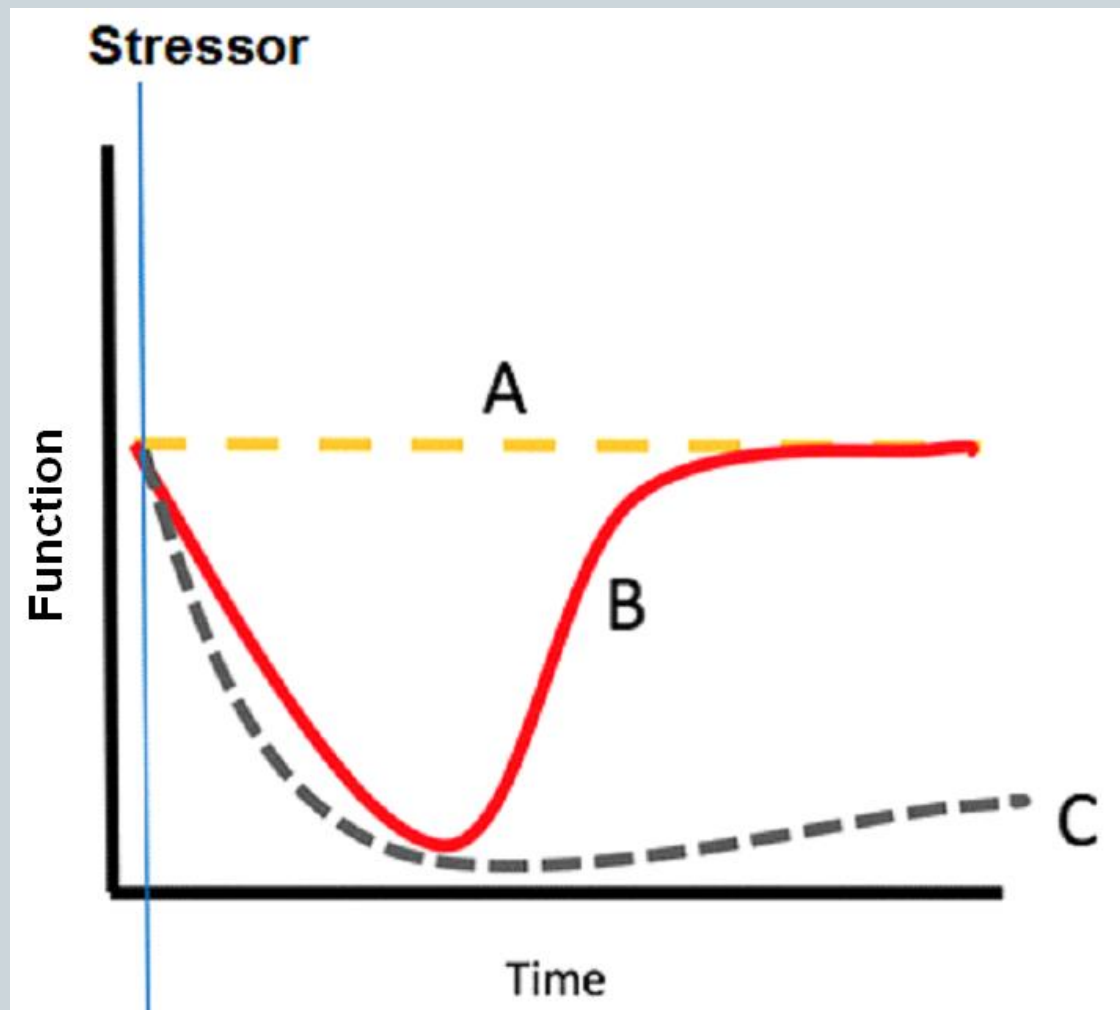
Physical Resilience = ability to avoid or recover from functional decline following acute or chronic health stressors

Resiliencies = resilience within discrete organ systems to a particular stressor

Reserve = potential capacity of a cell, tissue, or organ system to function beyond its basal level in response to demands (stressors)

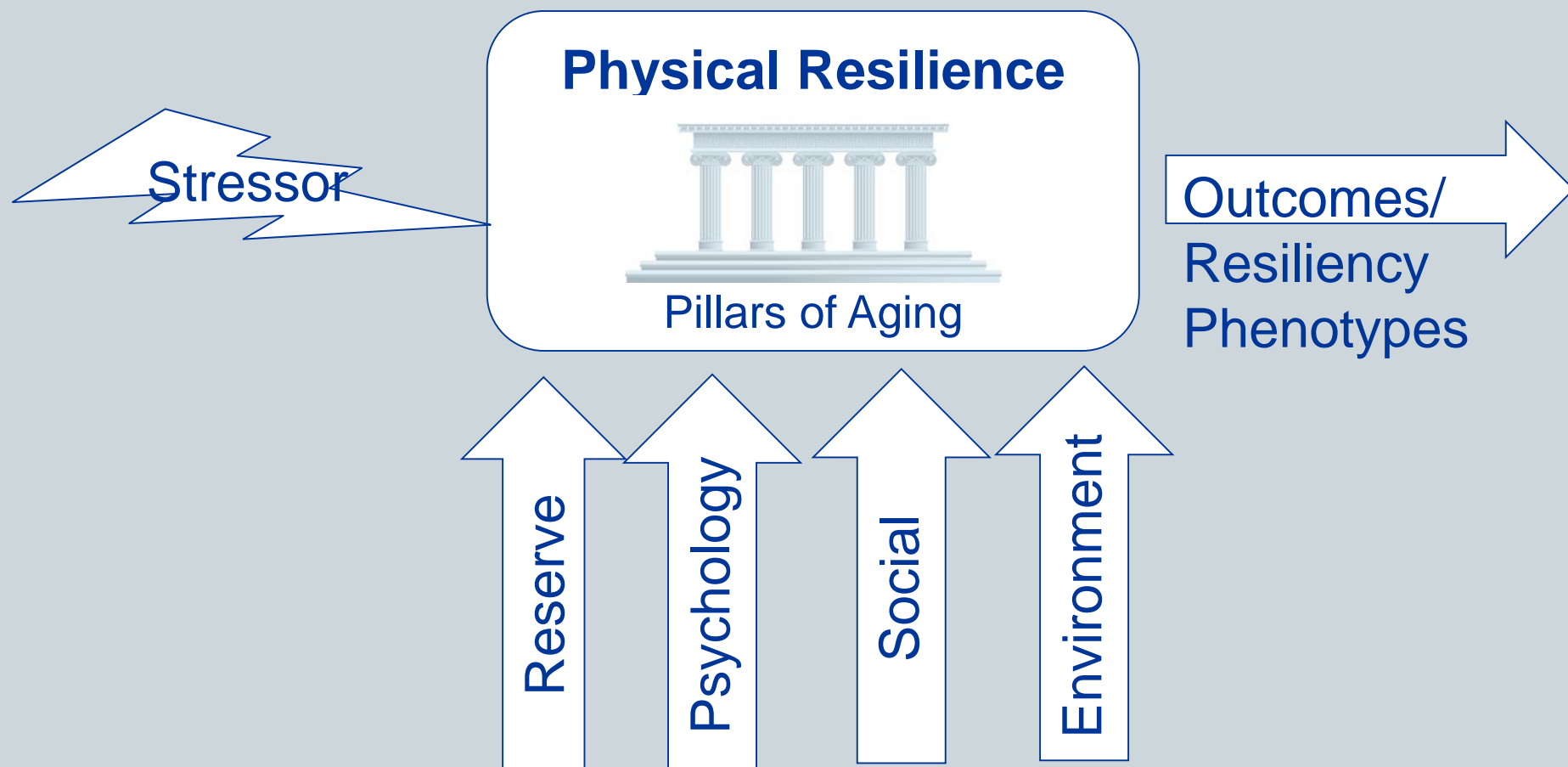


# Phenotyping Resilient Outcomes after a Stressor

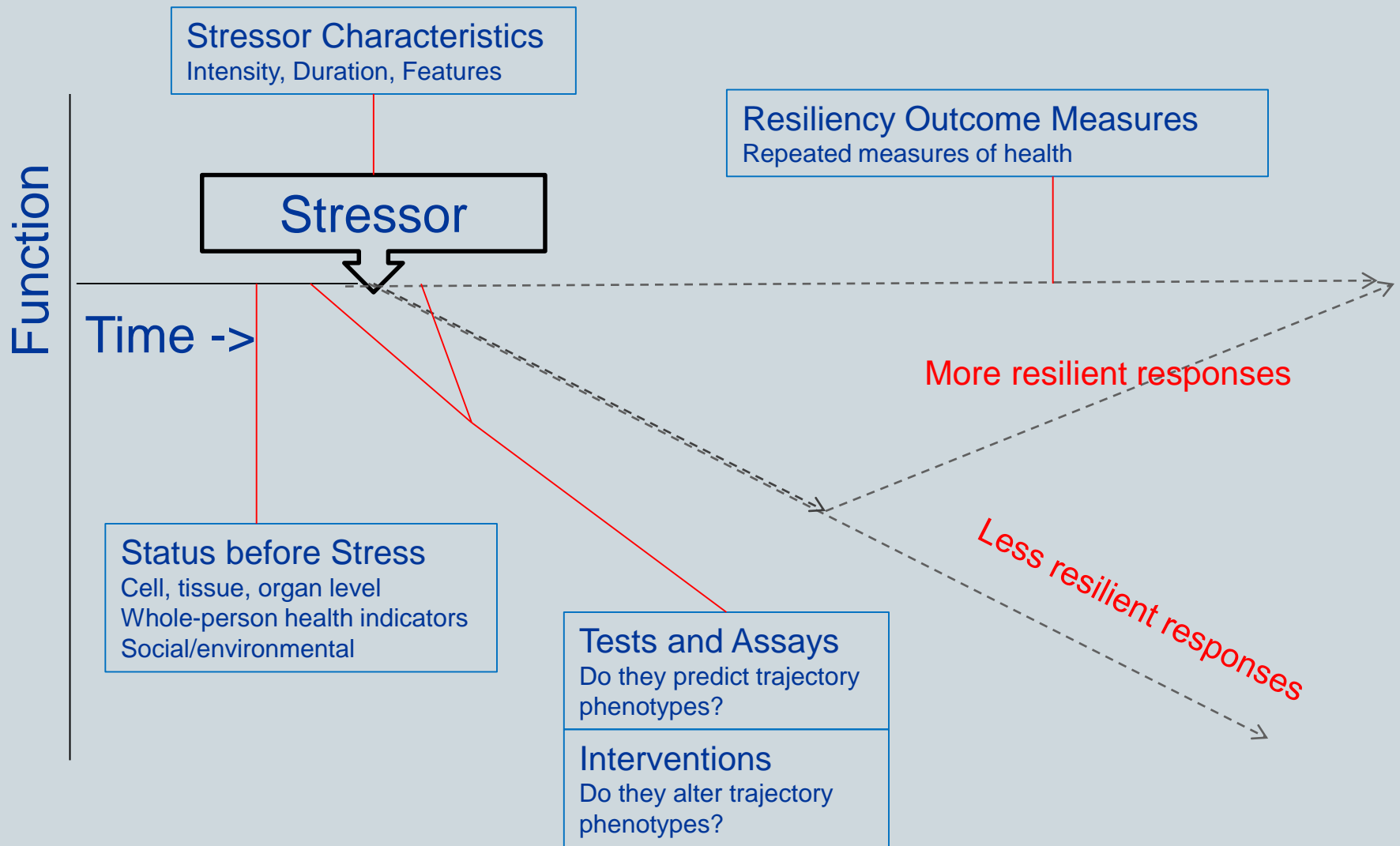




# Working Conceptual Model







# Approach for Clinical Research on Physical Resilience

# Clinical Tests that may indicate level of resilience to some future stressor



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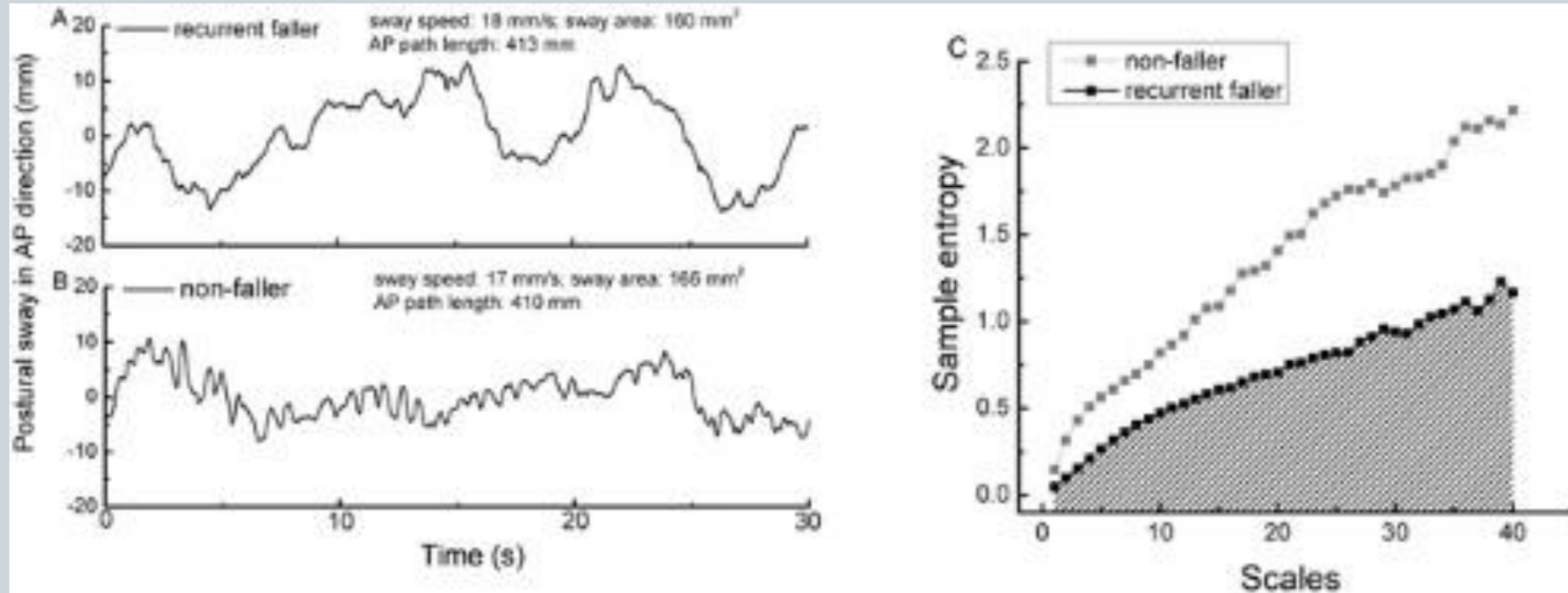
# Predicting Resilience – Provocative Tests

- Stimulus-Response
- Examples in use:
  - Response to vaccine
  - Glucose tolerance test
  - Gait lab challenge
  - Dual tasking tests





# Predicting Resilience – Dynamic output



Force Platform

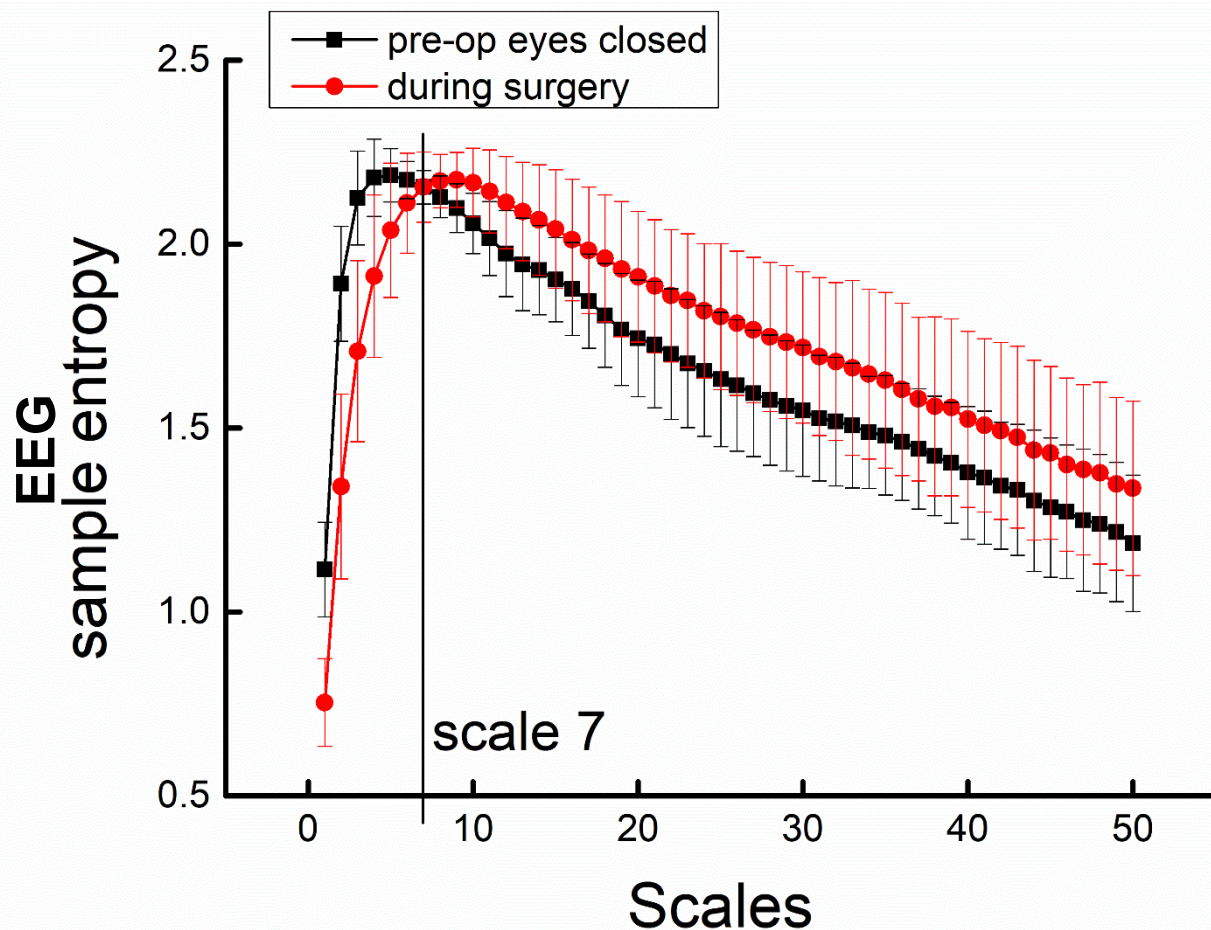
Multiple, interconnected inputs =  
complex output

Zhou et al. Sci Reports 2017



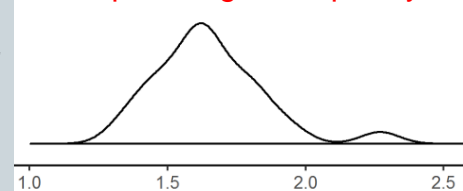


# Ongoing Study in Elective Surgery Cohort

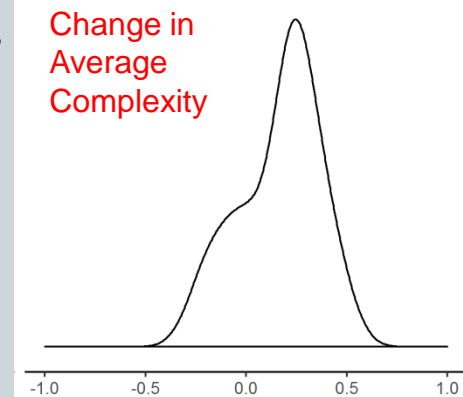


Density (n=25)

Pre-op Average Complexity



Change in Average Complexity





## Points for Discussion

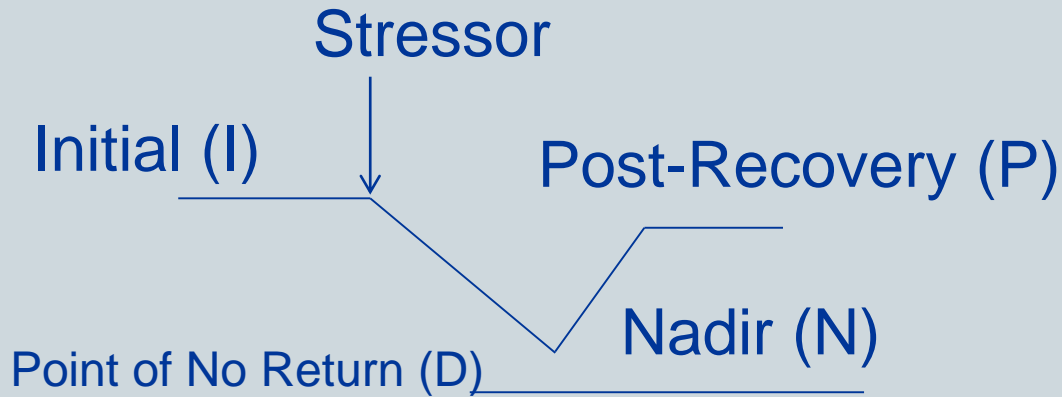
- Conceptualizing resilience in discrete organ systems versus one complex dynamical system
  - Helpful or overly simplistic?
  - Role of psychological, social, and spiritual domains
- What tests or markers BEFORE surgery, or along the way, may have predicted course?
  - Stimulus-response (stress) tests? Biomarkers?
- What interventions may enhance resilience?
- Elective procedures as an opportunity to address knowledge gaps about human physical resilience





# RESERVE SLIDES

# Quantifying Phenotypes of Resilience

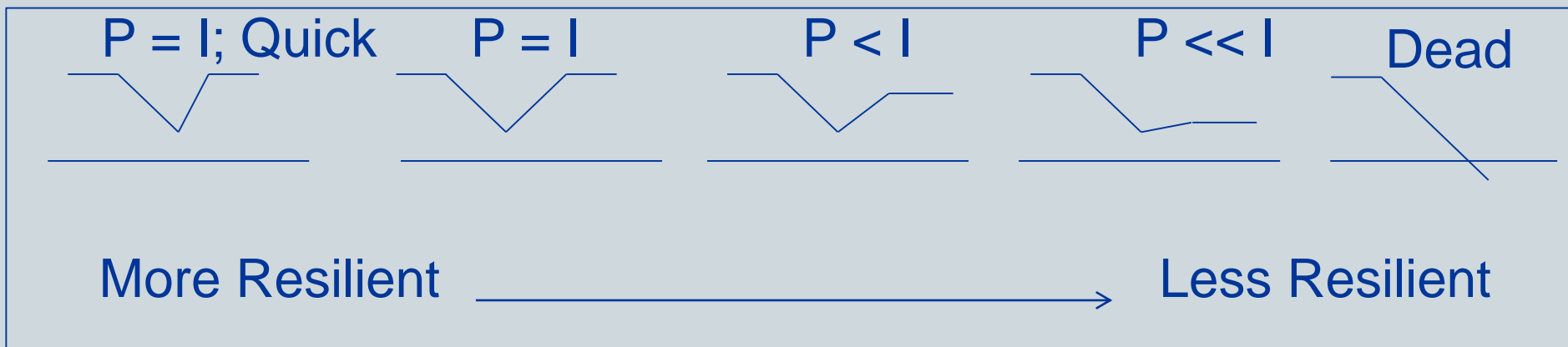


## Resilience Parameters

1.  $P$  minus  $I$  at a given  $t$
2.  $P$  minus  $N$
3.  $(P \text{ minus } N)\Delta t$  (rate of recovery)

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$$\text{Reserve} = (I - D)$$



Is resilience related to distance between the initial state and point of no return?

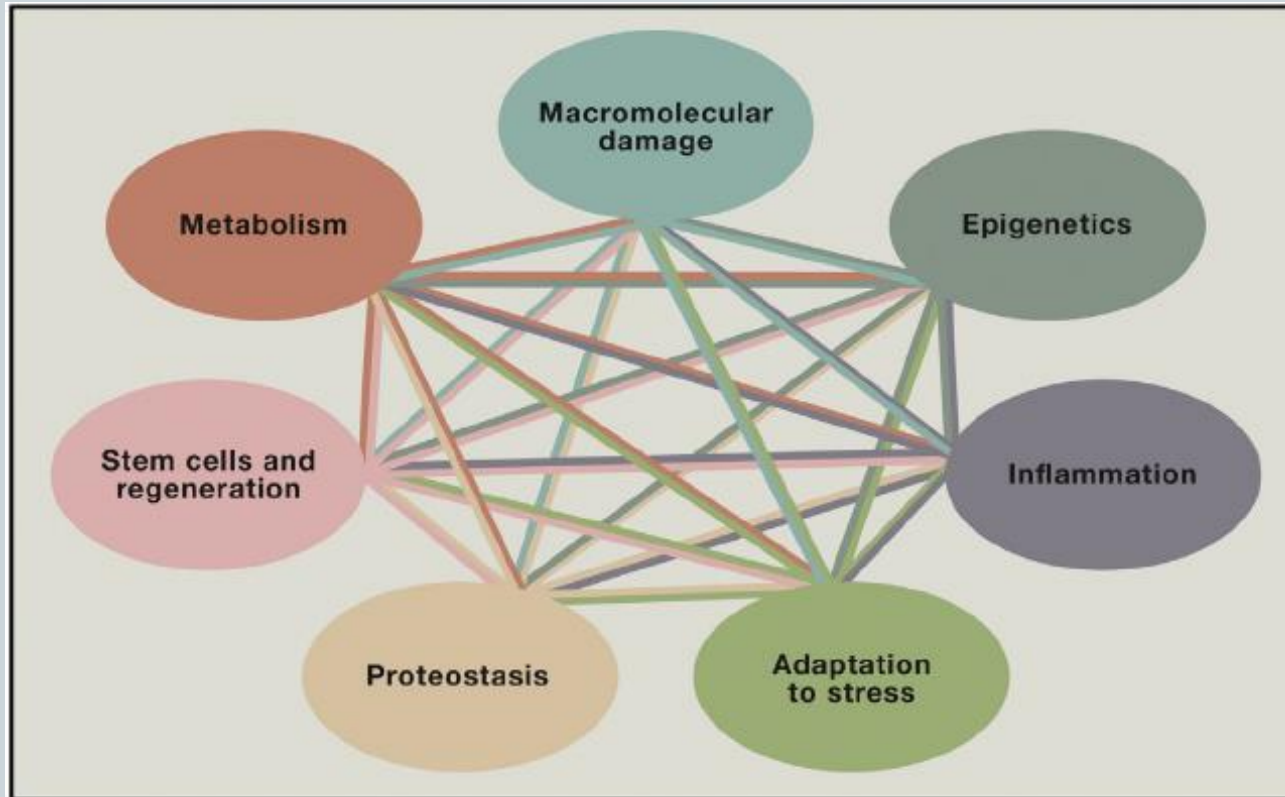
Is resilience related to the distance between nadir and the point of no return?

What degree of recovery is sufficient to be considered resilient?



# Geroscience Initiative – The Pillars of Aging

7 intertwined and potentially modifiable pathways affected by age



**Hypothesis:**  
Favorable biology in these pathways may cut across organ systems to support resilience at the whole-person level.

From Kennedy et al. *Cell* 159; 2014



# Resilience is About What Happens After the Stressor

The spectrum from **robust** to **frail** may reflect an individual's degree of physical reserve (potential capacity)

