

*Exceptional service in the national interest*



# Towards an Applied Science of Research

## *Thinking More Deeply about the Nature and Nurture of Research*

- 1 Framework
- 2 Nature of Research
- 3 Nurturing Research

**Jeff Tsao (Sandia National Laboratories)**

**Acknowledgements**

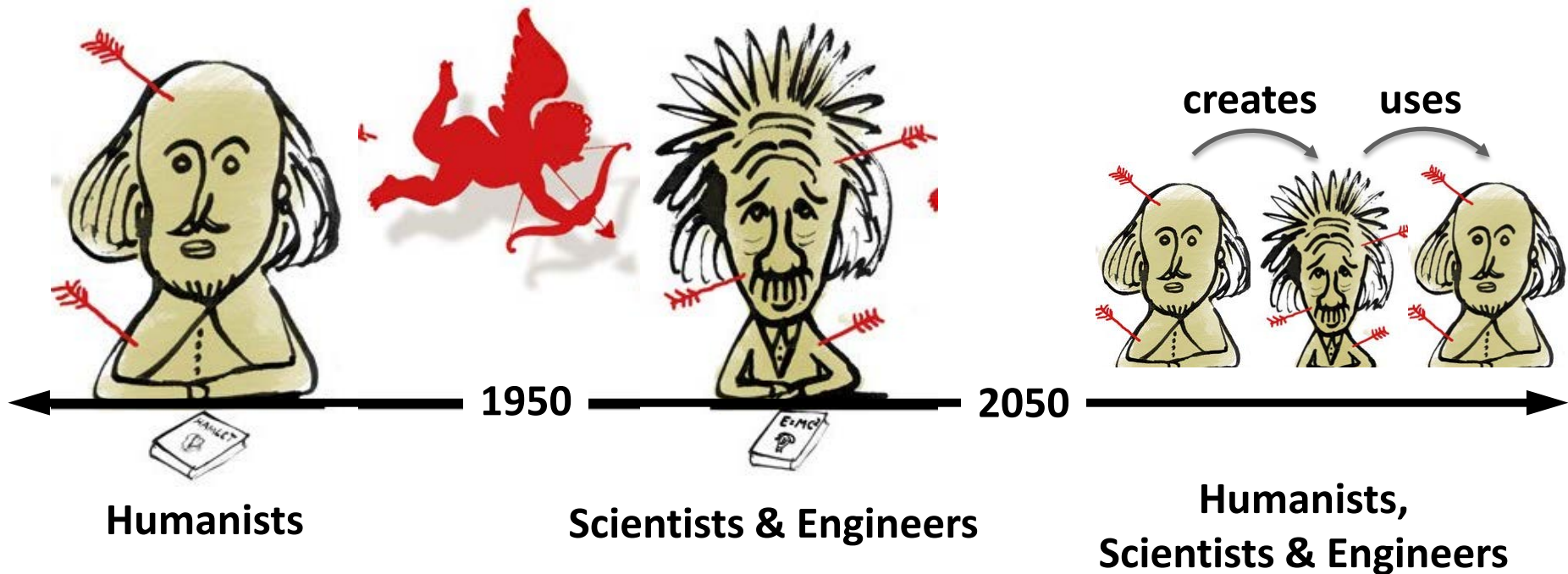
***Venky Narayanamurti***

***Curtis Johnson, Christina Ting***

***Dean Simonton, Mike Coltrin, Kevin Boyack, Jessica Turnley, Tim Trucano***

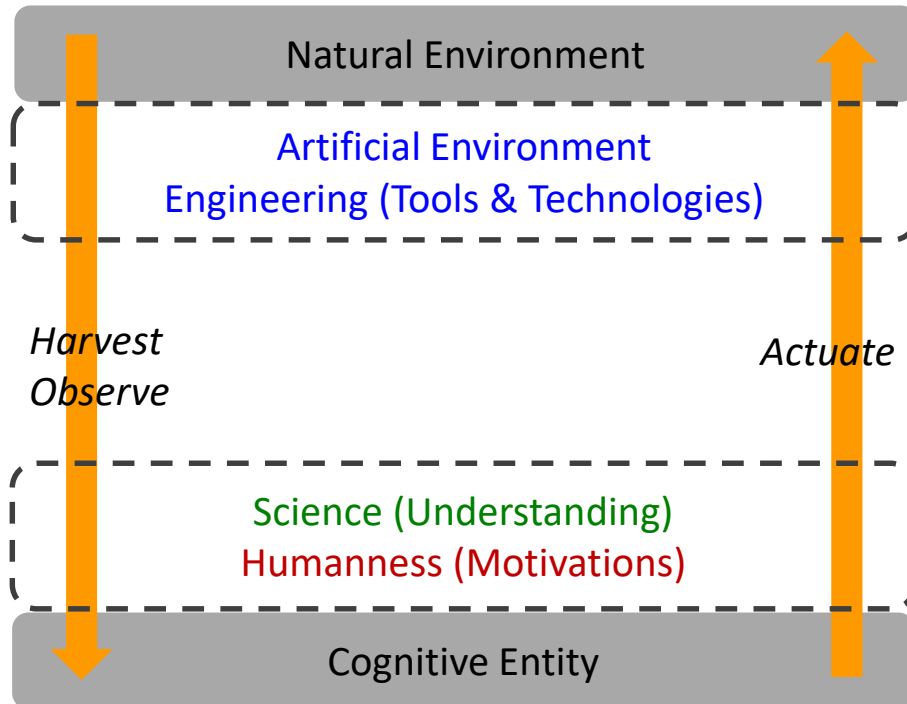
***Steve Rottler, Rob Leland, Jerry Simmons, Julie Philips***

# CP Snow's Two Cultures: Research is a human *and* intellectual enterprise

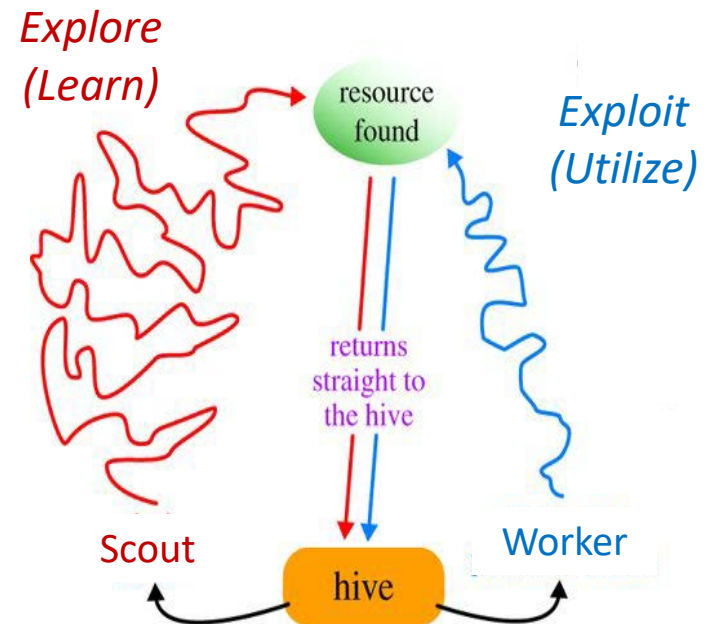


# Human Knowledge and Knowledge Processes

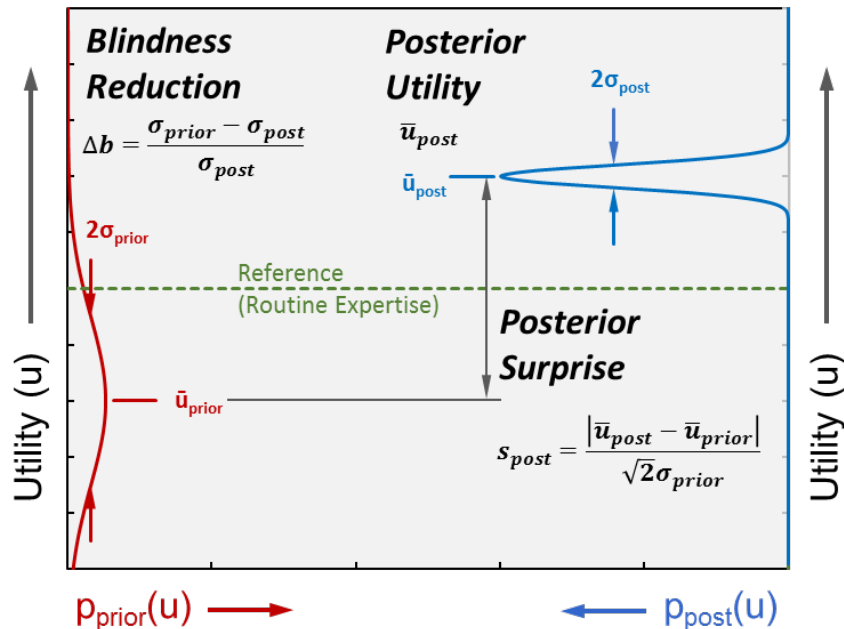
## Science, Engineering and Humanness



## Research vs Development



# Nature of Successful Research: *Implausible Usefulness*



	Non-Learning	Learning
Useful	<p>Society thinks it's here</p> <p>It's here</p>	<p>Society doesn't think it's here</p> <p>It's here</p>
Not Useful	<p>Society doesn't think it's here</p> <p>It's not here</p>	<p>Society thinks it's here</p> <p>It's not here</p>

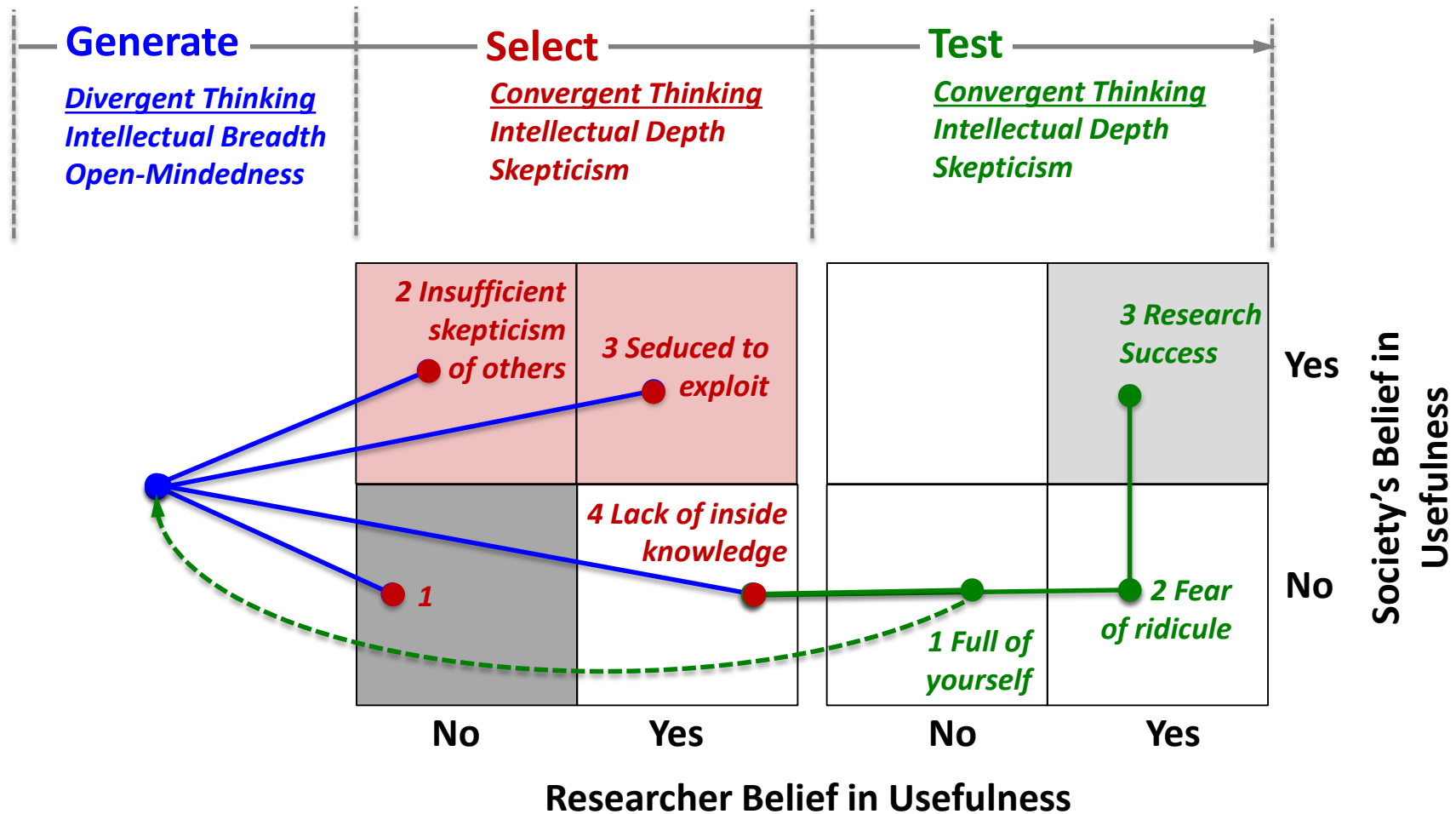
**Successful Research = Useful Learning =  $u \cdot I$  (Kullback-Leibler divergence)**

$$= u \cdot \left[ \ln(1 + \Delta b) - \frac{1}{2} + \frac{1}{2(1 + \Delta b)^2} + s_{\text{post}}^2 \right]$$

**= Implausible Usefulness**

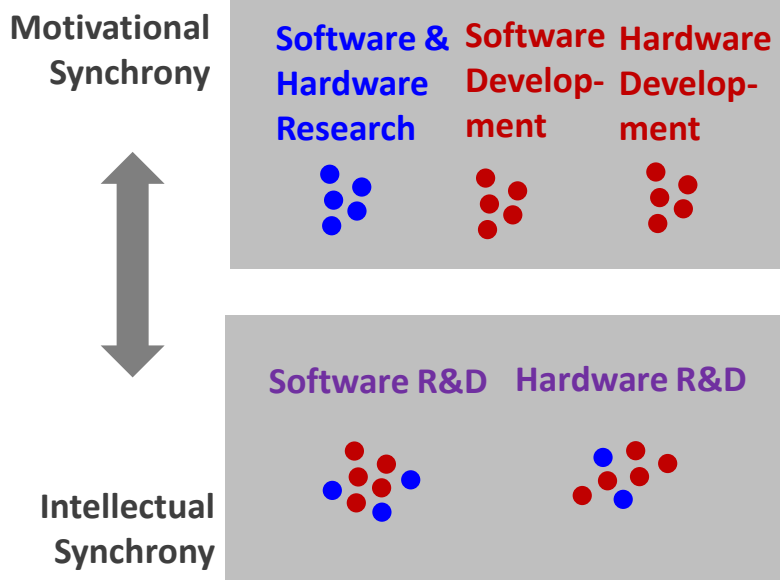
**= Creativity**

# Nature of a Successful Research Process: *Birth-Death of Research Ideas*

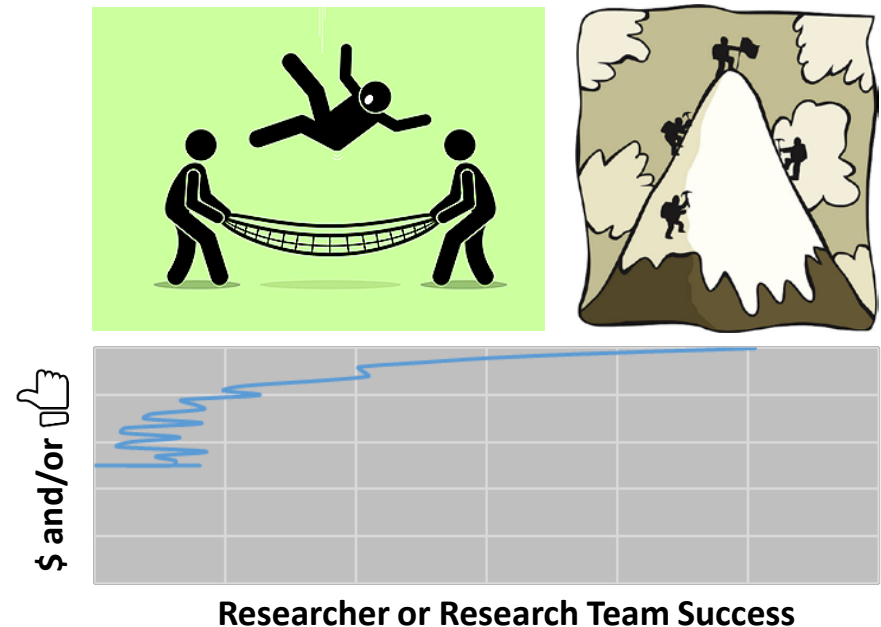


# Researchers are Humans 1<sup>st</sup>, Intellects 2<sup>nd</sup>: *nurturing human motivations*

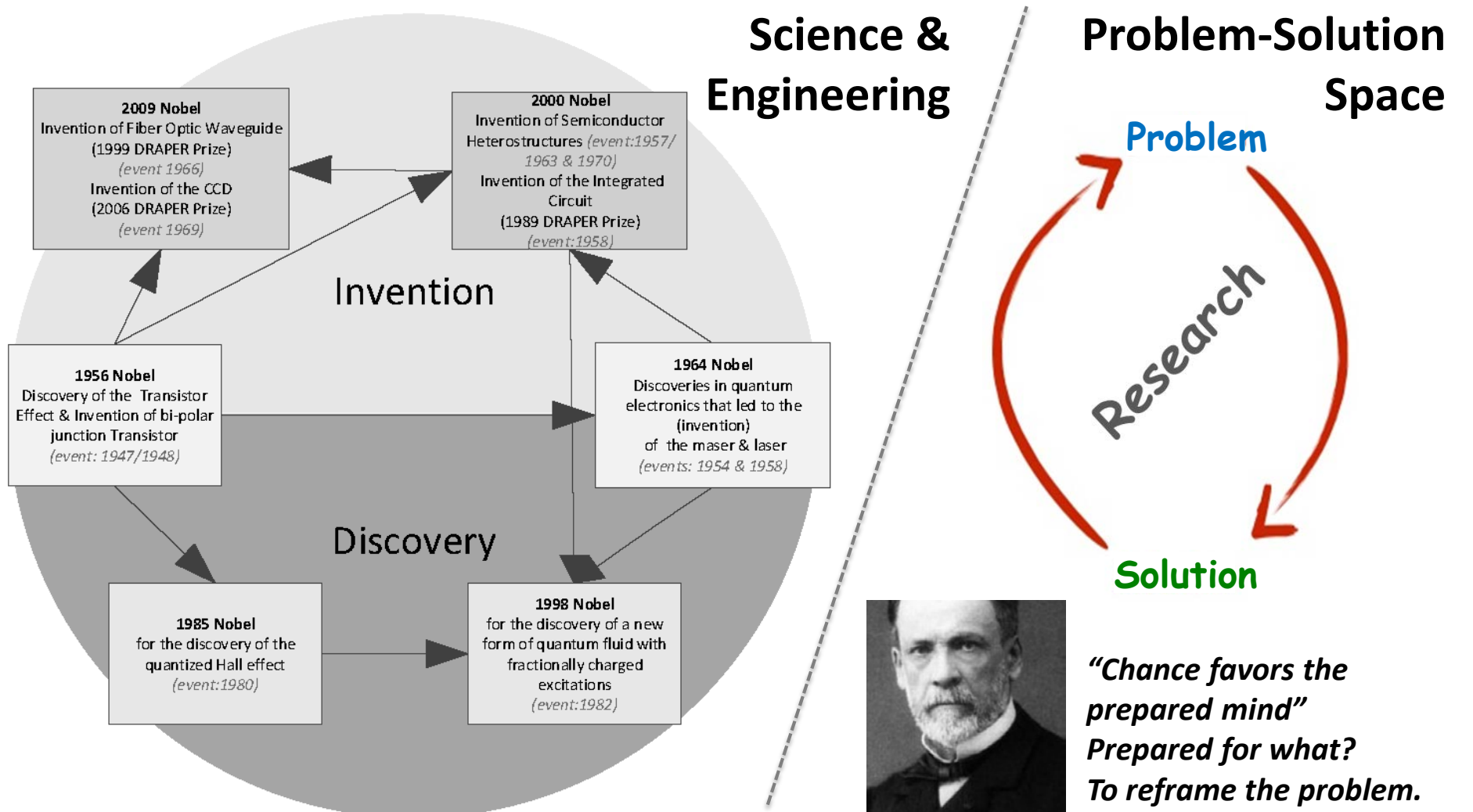
**Strengthen our Motivation  
to Explore**



**Defuse our Motivation to be Safe  
Harness our Motivation to be Respected**



# But Researchers are also Intellectuals: *nurturing intellectual freedom*



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*Thinking More Deeply about the Nature of Research,  
so as to Nurture It Better*