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Sandia National Laboratories

The Art of Research: Opportunities for a Science-Based Approach

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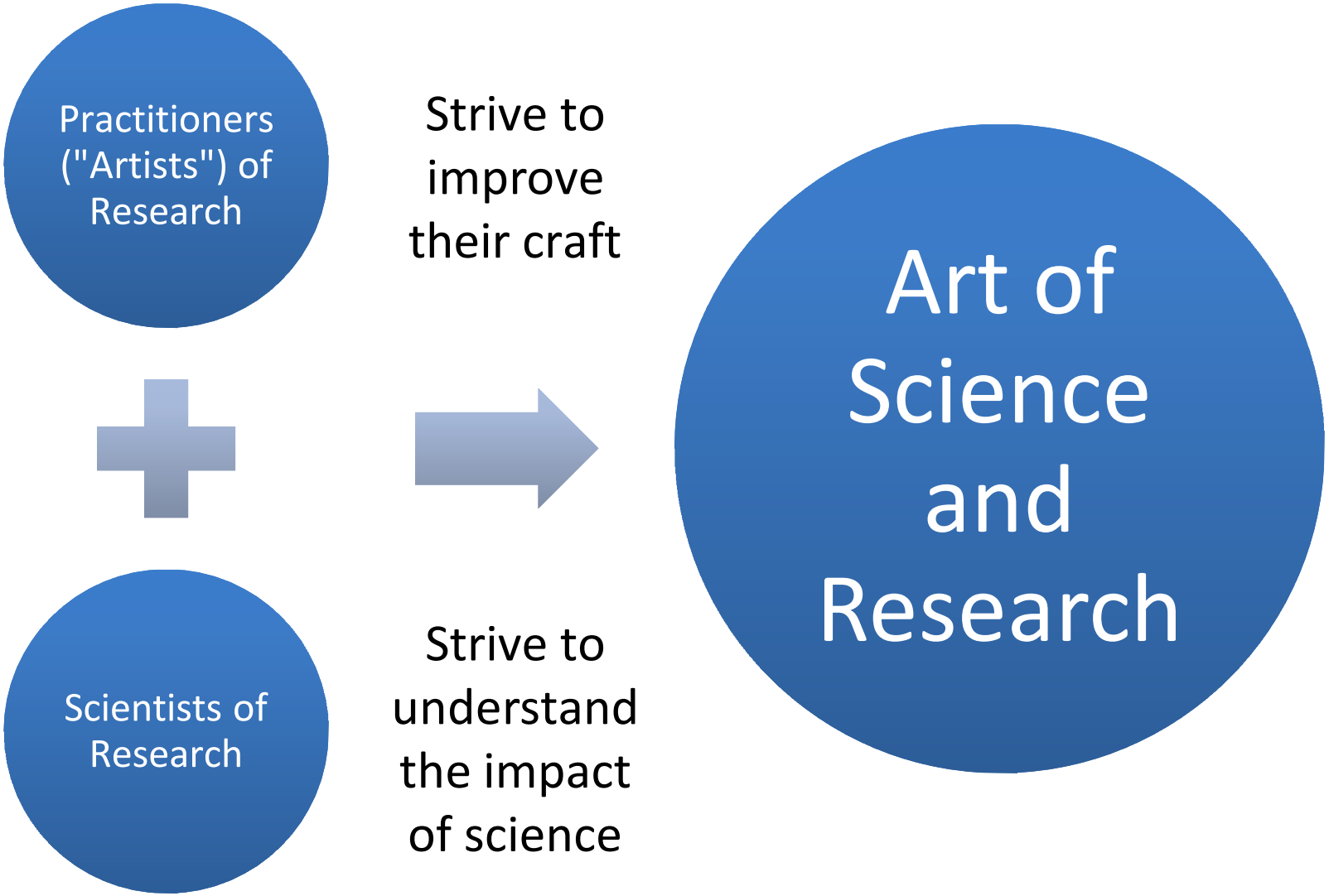
Introduction

- The Art of Science
- Convergent/Divergent Thinking
- Three Level Research Ecosystem:
  - The Scientist
  - The Team
  - The Institution
- A Vision of the Future

The Art of Science

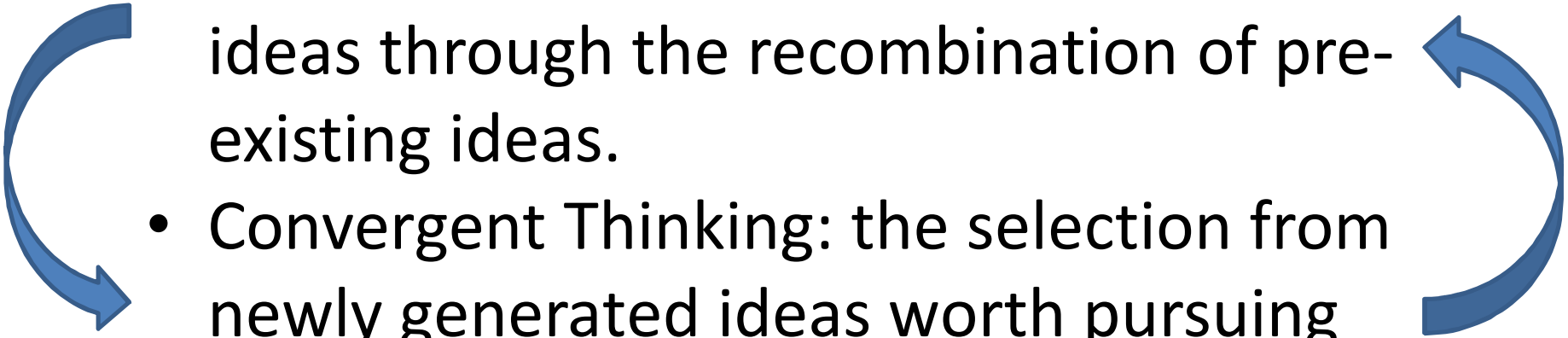
- Research is an estimated $1.6T/year enterprise
- Over 11 million researchers world-wide
- Yet, it is often practiced as art and passed down generation to generation.

The Art of Science



Divergent & Convergent Thinking

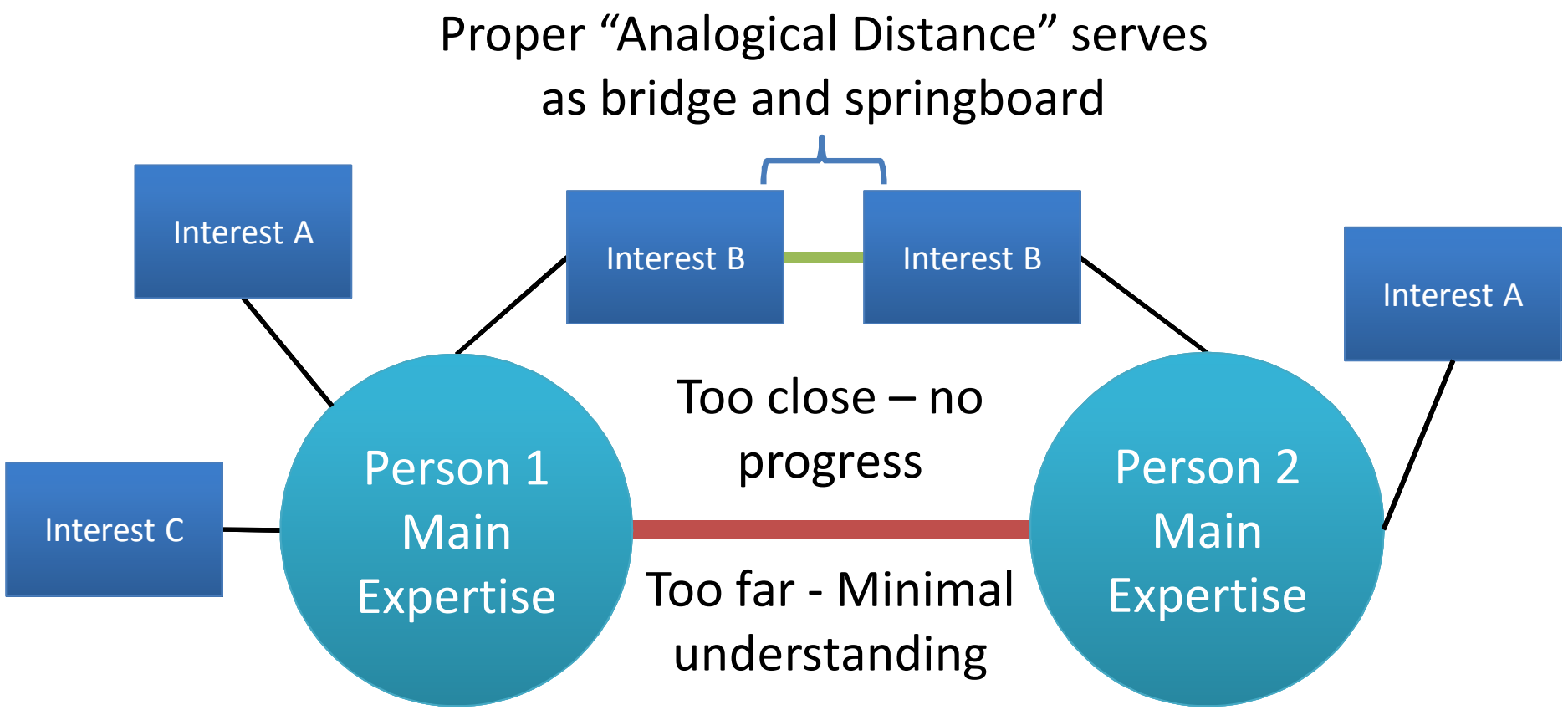
- Divergent Thinking: the creation of new ideas through the recombination of pre-existing ideas.
- Convergent Thinking: the selection from newly generated ideas worth pursuing through logic and analysis.



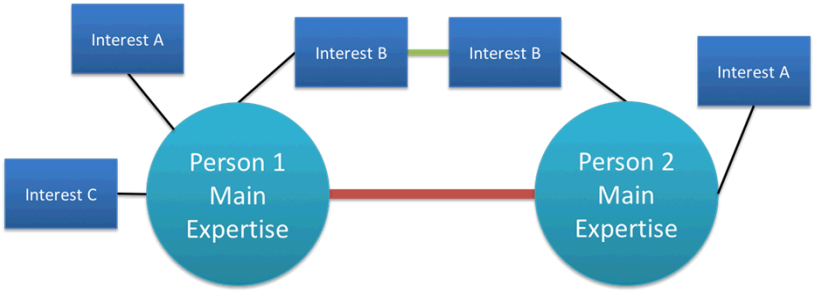
Arising Issues

- Individuals must overcome issues along the innovation process:
  - Cognitive Biases
  - Idea Fixation
  - Sloppy Thinking
- Teams and groups of researchers also must overcome:
  - Strong Links (knowledge and social networks)
  - Groupthink
  - Social Pressures (conflict avoidance, social cohesion)

Optimizing Analogical Distance



Quantifying Analogical Distance



Opportunities to quantify:

- Clutter analysis of publications
- Lexical clustering of syntactic/semantic regularities
- Word-order-based discovery of latent topic areas

This could lead to more powerful search and recommendation system to help feed researchers ideas outside their comfort zones and get connected with individuals for collaborations.

Crafting Research Narratives

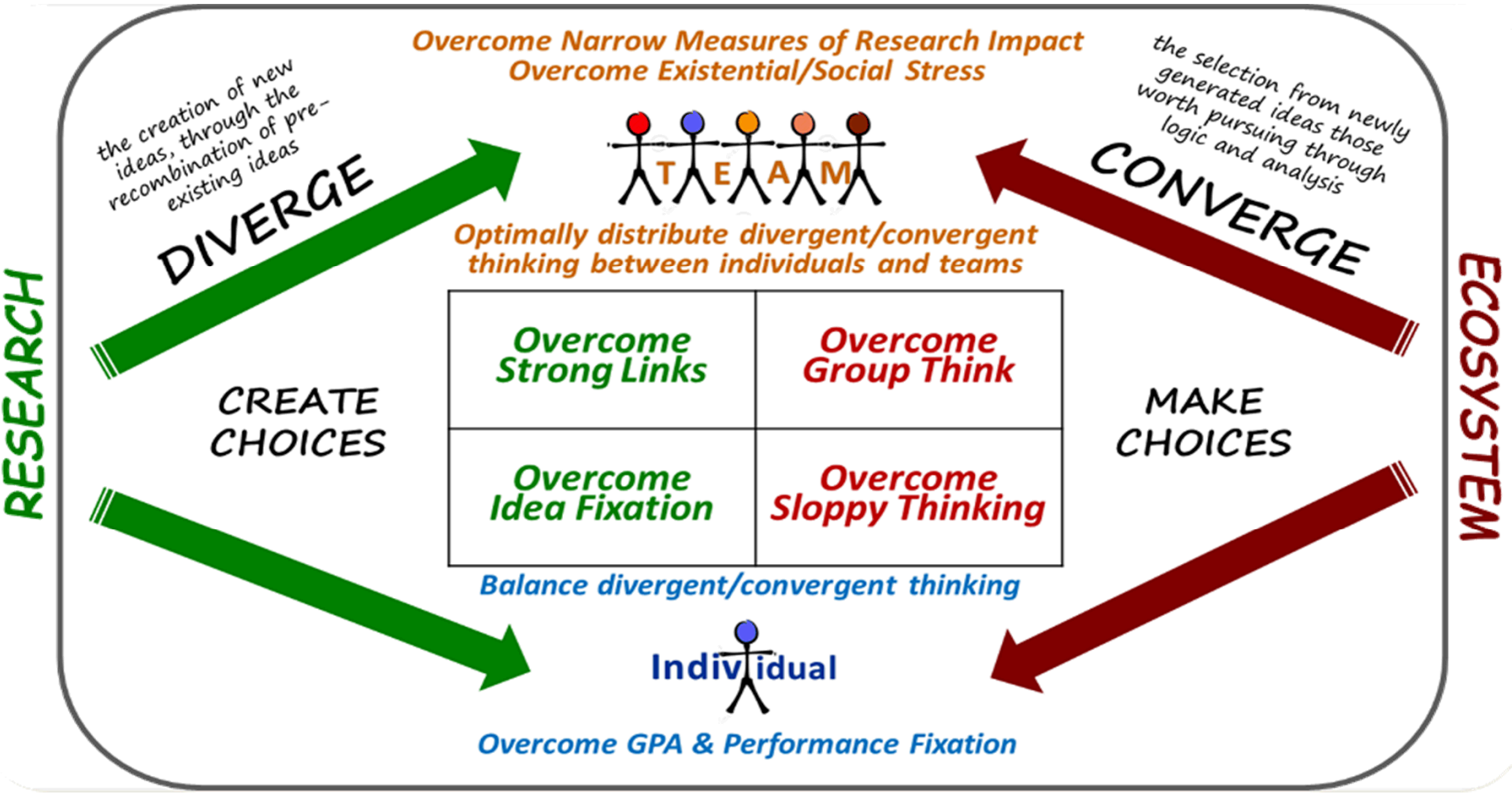
Another strategy to help the researcher in the innovation cycle is the *Research Narrative*, which knit together the background, hypothesis, methodology, analysis, findings, and implications.

Future opportunities for text analysis include constructing ways to evaluate research narratives as the the beginning of a project as well as understand effective narratives.

Distributing Thinking

- Distribution of divergent and convergent thinking can exist at both the individual and team level.
- Innovation is best accomplished in a cyclical pattern:
  - Individual vs Team
  - Divergent vs Convergent
- Data analytics can be used to:
  - Understand the lifecycle of the project
  - Determine which thinking type is needed
  - Adjust team composition and vector

Building a Research Ecosystem



Vision for the future

- Institutions wish to understand more about their own research ecosystem and become open to scientific inquiry
- Teams are valued as much as individuals in the innovation cycle
- More broad measures of impact are developed and applied to research outcomes
- Computational tools and techniques are further developed to understand the “science of the craft” and how to positively influence it

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