Chemical safety requires a system, not a solution

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Safety in the ACS Vision

ACS Chemistry for Life®

Strategic Plan for 2017 and beyond

Why is this an emerging challenge today?

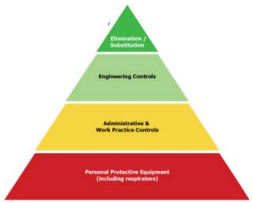
- More science
- New sciences: nano, r/sNA, big science
- Interdisciplinary sciences

Recent Lab Incidents

	Univ. of Minnesota 2014	Univ. of Hawaii 2016	Texas Tech 2016	Univ. of Bristol 2017
Event	*Unexpected compound exploded during grad research*	*Explosion of H_2 gas during oceanography research*	*Explosion of energetic compound during undergrad research*	*Inadvertent synthesis of TATP during grad research*
Physical Result	Injury, Damage to lab, loss of science	Loss of arm, damage to lab	Superficial injuries	Hazmat response; disruption of work
Other Results	Medical costs	$70,000 fine; civil lawsuit against PI and institution	Medical costs	Student reported problem immediately and response ensued
Proximate Cause	Change of Chemicals -> **Inadequate Risk Assessment**	**Inadequate Risk Assessment** -> Improper Equipment; Failure to heed warning signs	Change in Process (skipped a step) -> **Inadequate Risk Assessment**	Change in Process (change in order of chemical additions) -> **Inadequate Risk Assessment**

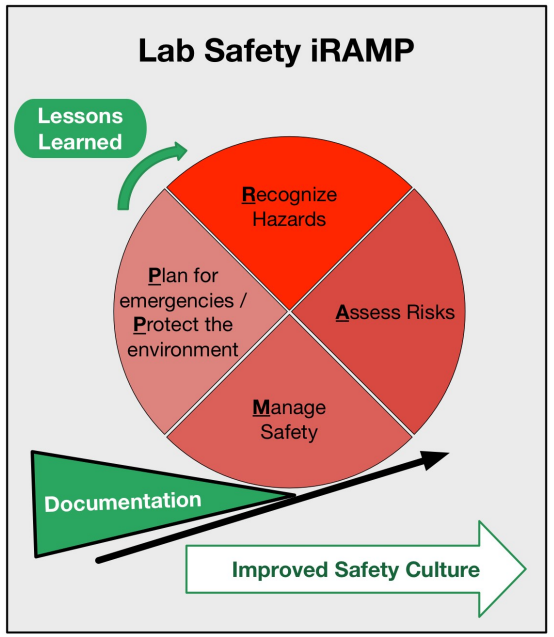
Moving Lab Safety into the 21st Century

Risk Assessment involves both Technical and Cultural Practices



Manage Hazards

Culture Change through Safety Education

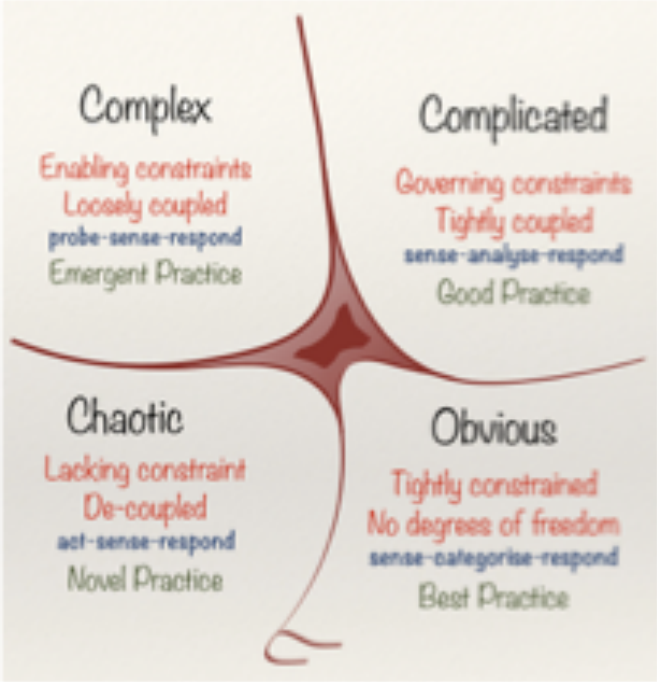


20th Century: Selecting Controls Based on Rules, guided by Chemical Intuition

21st Century: a Safety System based on documented Risk Assessment

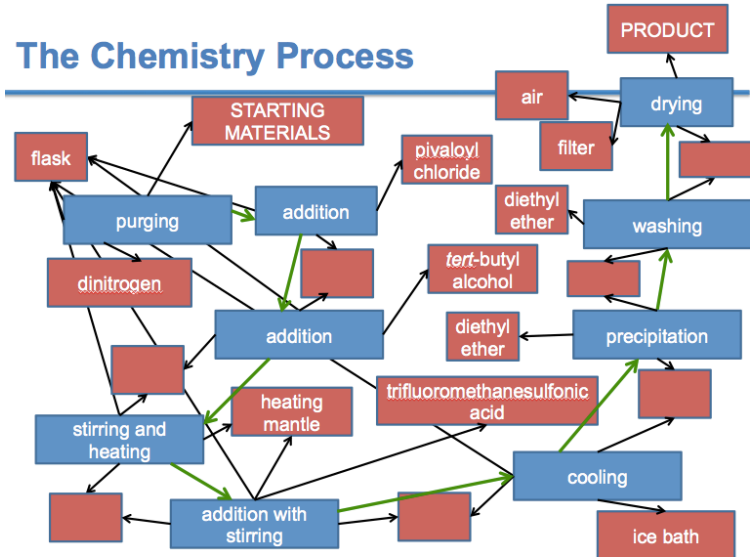
The Technical Vision

A flexibly structured **ecosystem** of *data*, *workflow tools* and *domain expertise* mapped to the **essential commonalities** of the **use case** and content, connected by **good information management practices**

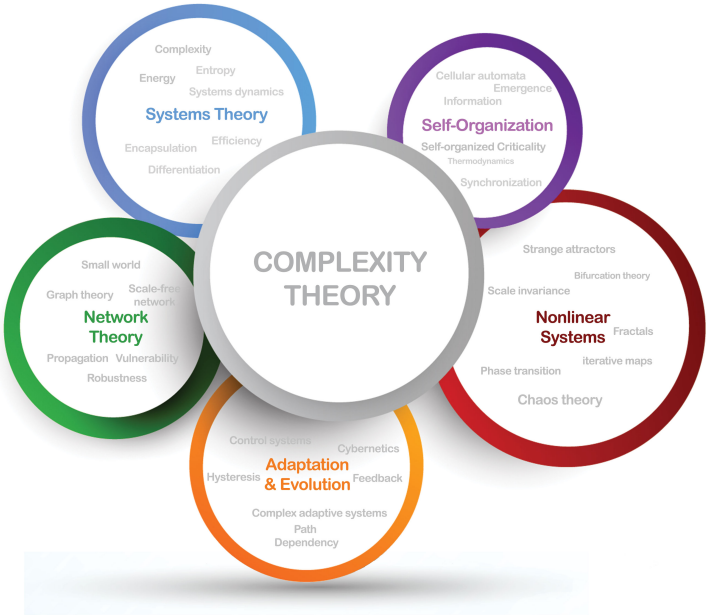


Solutions and Systems

A Solution



A System

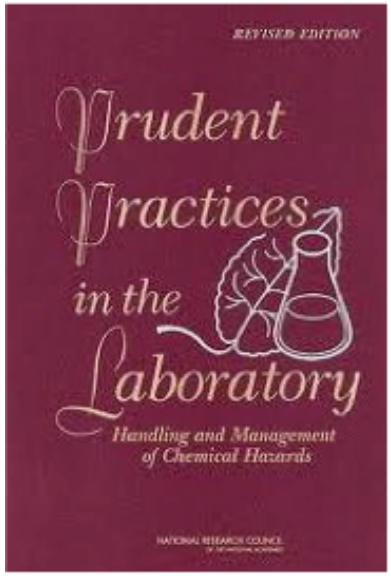


Contrasts Between Solutions and Systems

Aspect	Solutions	Systems
Predictability	*Complicated* paths lead to probabilities	*Complexity* leads to emergence
Decision tools	Formulas	Judgment based on organized literature review and experience
Boundaries	Well-defined	Diffuse
Evolution	Managed	Emerging (towards a vision?)
Mental system used	Slow thinking	Fast thinking
Safety goal	Prevention	Resilience

Lab Risk Assessment Solutions and Systems

The 20th Century Solution from the National Research Council



The 21st Century System Outline ACS, 2013 and 2016 (at the behest of the CSB)

*** Laboratory Risk Assessment Methods Described by ACS 2013**

Control Banding
Chemical Safety Levels (CSL) identifying facility requirements

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Job Hazard Analysis
Identifies best practices for a process

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What If
Identifies emergency scenarios and PPE needs

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Standard Operating Procedures
Document management choices and supports training

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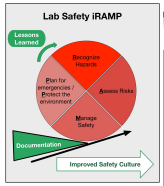
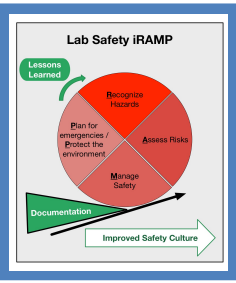
Checklist
Guides oversight requirements

Contrasting Chemical Safety Tools



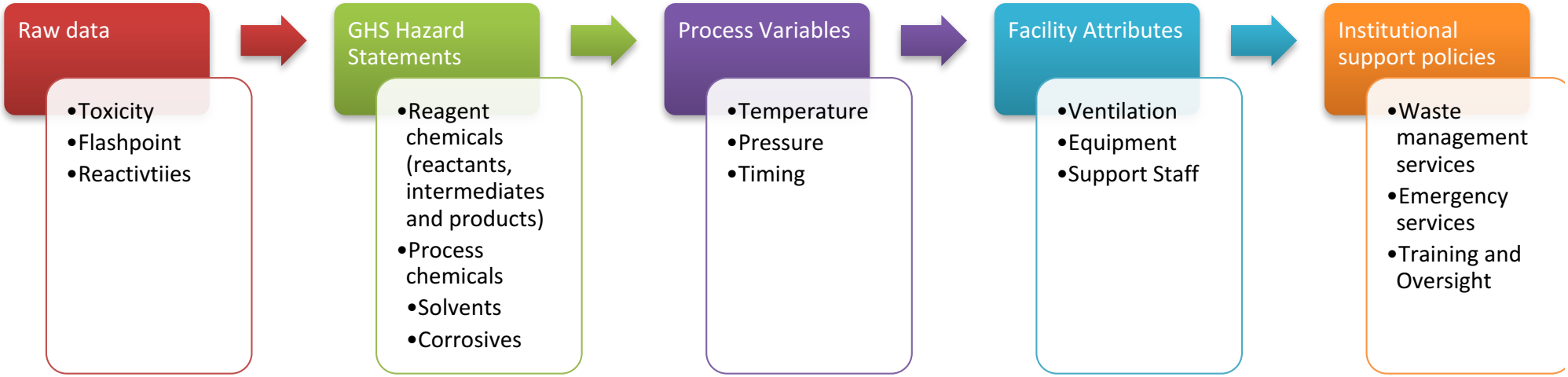
RAMP step	Solution	System
The “On RAMP”	NFPA 45 style briefing	Safety culture
Recognize	GHS H-statement	Hazards assessment as processes and chemistry evolve
Assess	Compare air concentrations to OELs	Professional Judgment
Manage	PPE selection for a specific chemical	PPE selection for a lab process
Prepare for Emergencies	Fire extinguisher training	Response to a fire
Protect the Environment	RCRA according to EPA	RCRA in labs

Mapping Lab Information Tools

	**Hazards**	**Risks**	**Manage**	**Plan / Protect**	**Feedback**
English	Nouns	Adjectives	Verb	Verb	Adverb
Chemistry	Periodic Table	Process Description	Lab notebook	Statistical Analysis	Research report
Safety tools	SDS's and LCSS's	*Assessing Hazards in Research Laboratories*	Laboratory training and oversight; facilities and safety equipment	Institutional emergency plans and waste systems	**Lessons Learned**
Electronic media	Databases, e.g. PubChem	**Assessment tools**	Excel	Web documents	Powerpoint

Lab Risk Assessment Process

Recognize | Assess | Manage | Plan / Protect



SDS and LCSS from PubChem

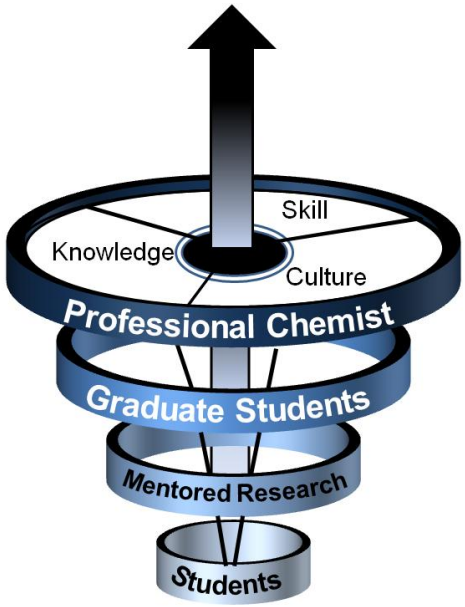
Procedure from Chemists

Institutional Sources

Risk Assessment Tool Values

- **Sustainability**
  - In terms of the effort needed to use them
- **Scalability**
  - Varying Quantities (within the OSHA lab definition)
  - Various levels of detail
- **Transferability**
  - To support spiral learning
  - Understandable by a variety of stakeholders
- **Traceability**
  - For follow up questions

Cultural Education: Spiral Learning Model for Lab Safety Competencies



Educational competencies include:

- **K**nowledge / Science
- **S**kill / Group performance
- **A**ttitude / Culture

Developmental Stage	Science	Group Performance	Culture
Professional chemist	Identify and estimate significance of emerging risks	Make risk decisions and teach risk assessment	Accountable for group safety performance
Graduate researcher	Develop procedures with risks in mind	Use Risk Assessment tools to propose risk levels for review	Oversee others' safety practices
Mentored researcher (CURE, REU, etc.)	Review procedure and locate information to identify hazards	Learn to use Risk Assessment tools	Raise questions and concerns related to risk
Student	Based on prerequisite requirements	Identify applicable rules	Respect Rules

Tools We'll Hear About Today

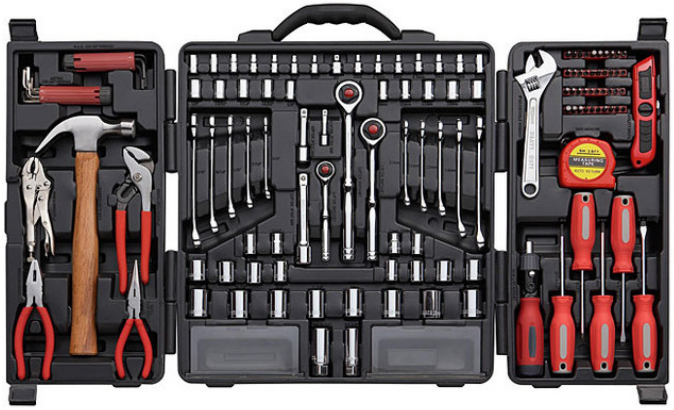
- Lab Ventilation Control Bands
- Catalog of Unexpected Reactivities

- Chemical Inventory Information
- GHS Hazard Statements
- Chemical Safety Terminologies

- Safety Data Sheets
- Hazard Assessment in the Research Lab
- Web Resources Discovery

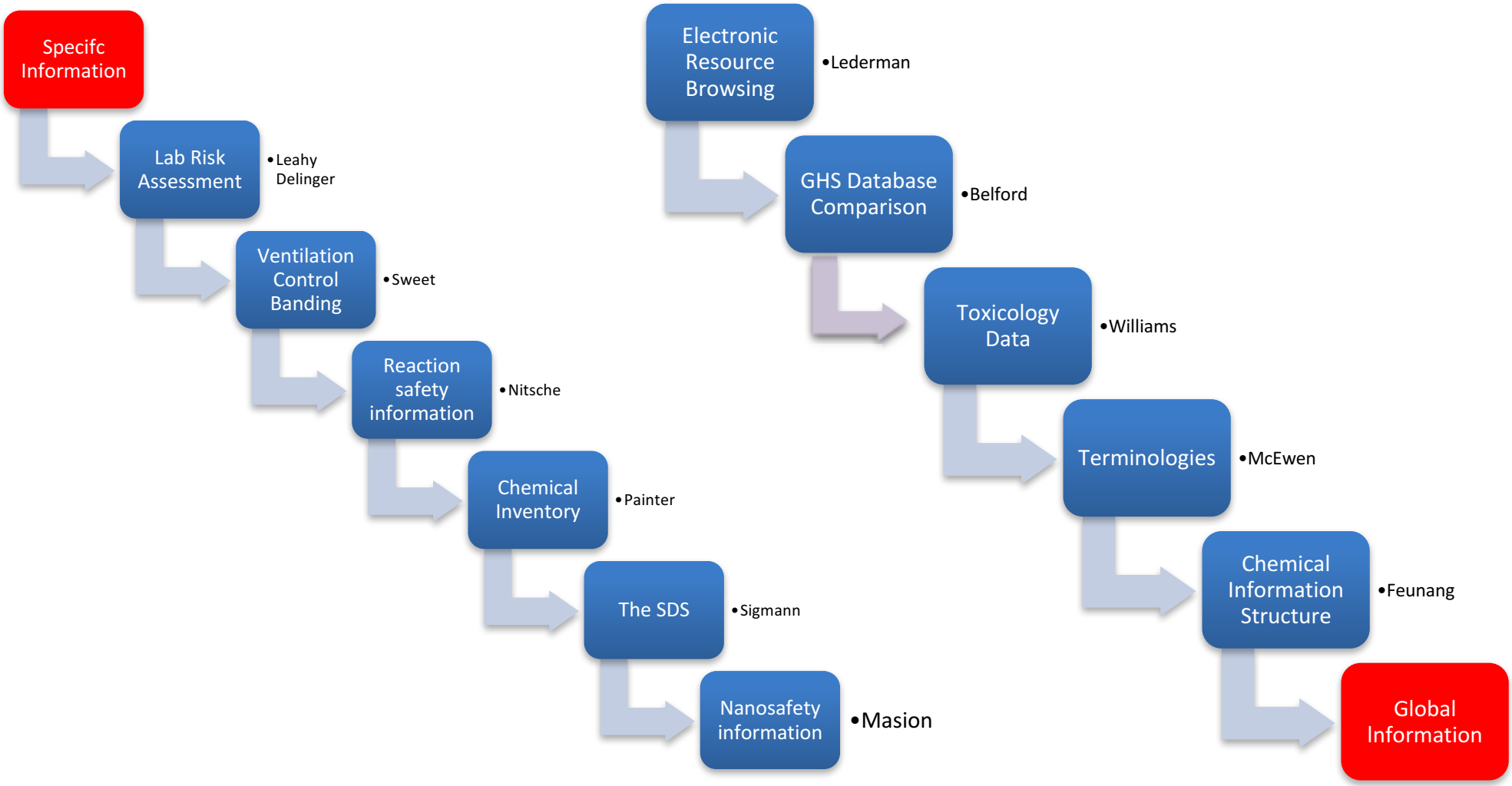
- Toxicology Data Work
- Nanosafety
- Applying Cheminformatics Techniques

Tool collection



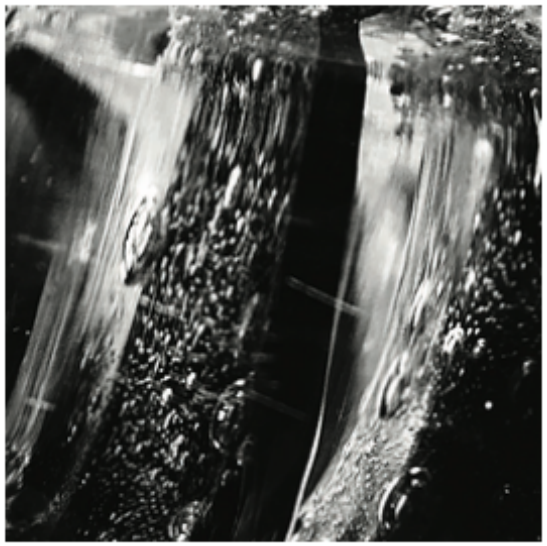
Tool set

Today's Universe of Tools



Questions?

Divergent ideas
Coexisting in harmony
Resilient Progress



Resilience through innovation depends on a divergent co-existence of ideas. Responsive and resilient solutions to societal challenges and opportunities – and solutions that can be adapted or substituted within a rapidly changing and uncertain world – require a rich feedstock of divergent, novel ideas that can be combined in creative ways. How can such a rich diversity of ideas best be nurtured?