Concept Generation

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What you're going to learn today:

How to:

- generate 40% more ideas in a team
- identify 3x as many analogies

Agenda for Class

1. Idea Generation
2. "Rules" for Idea Generation
3. Brainstorming with Mind Maps
4. 6-3-5 (a brainwriting technique)
5. Morph Matrices
6. Checklist approaches

The Problem is Defined– Now What?

- Are you creative?

- Is it important for engineers to be innovative?

- How are concepts developed?

How to be a good idea generator (a.k.a. creative)

- Practice, practice, practice
- "Genius is 1% inspiration and 99% perspiration!"
  - Thomas Edison
- "The secret of creativity is knowing how to hide your sources"
  - Einstein
- "I use not only all the brains I have but all that I can borrow."
  - Woodrow Wilson
- <u>References your sources for this class and explain their connection to your results</u>
- "Opportunity is missed by most people because it is dressed in overalls and looks like work."
  - Thomas Edison

Starting Points for Concept Generation:
Parts of the design problem to solve

1. Individual functions
   (from a function structure)

2. Function groups (higher levels of a function tree, modules)

3. Product layout (*concept variants*)

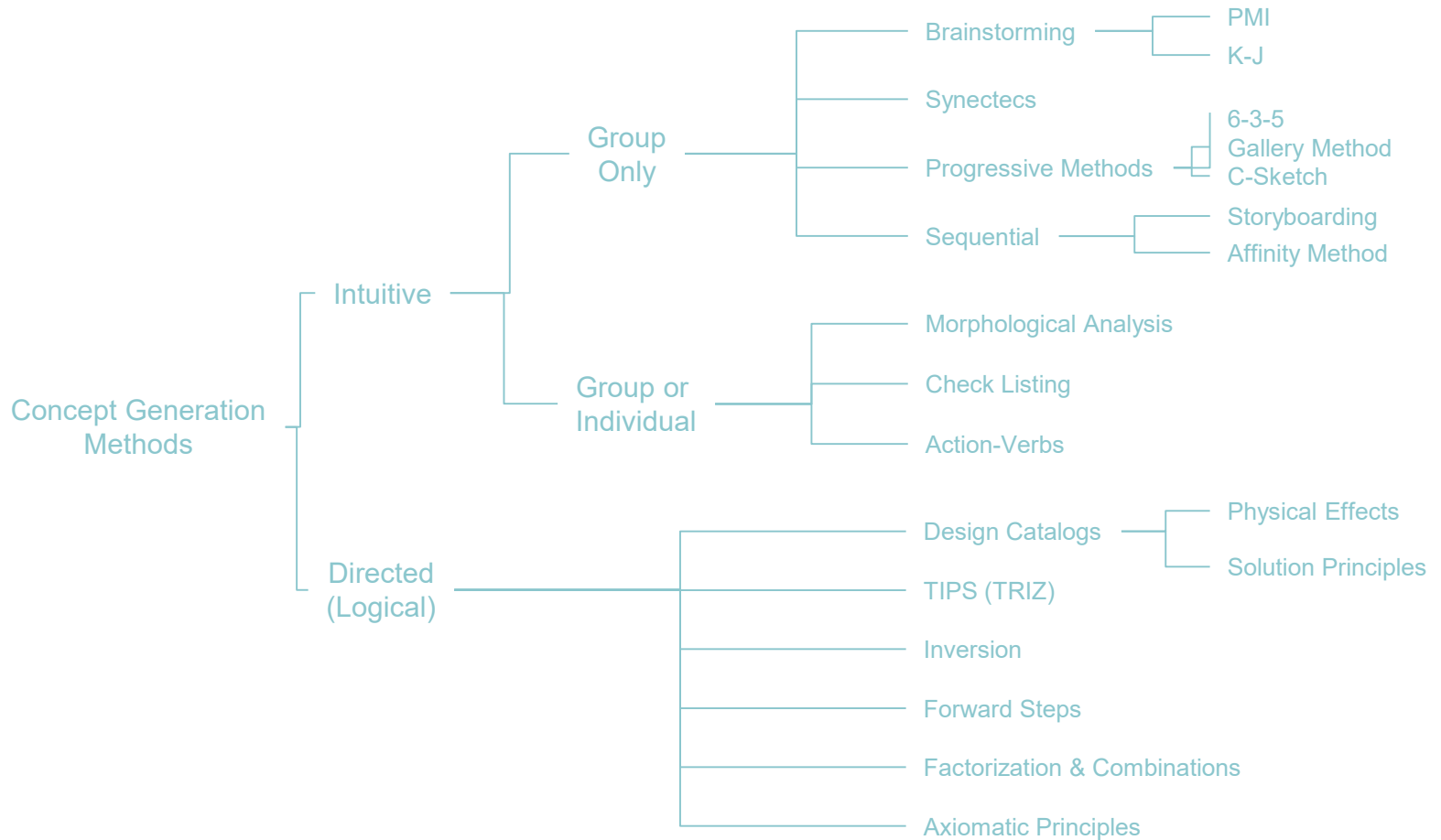# Why Use Concept Generation Methods?

- Initial solutions are rarely the best

- Helps prevent design fixation

- Increase skills in concept generation

- <u>Amplifies</u> concept generation ability

Basic "Rules" of Idea Generation:
Applies to all Idea Generation Methods

- Suspended judgment of ideas

- Present all ideas, including the bad or silly ones

- Wild and Crazy Ideas are good

- Build from others' ideas

- Strive for quality and quantity

- Review the problem at the beginning of the session

Overview of Methods

Concept Generation Methods
- Intuitive
  - Group Only
    - Brainstorming
      - PMI
      - K-J
    - Synectecs
    - Progressive Methods
      - 6-3-5
      - Gallery Method
      - C-Sketch
    - Sequential
      - Storyboarding
      - Affinity Method
  - Group or Individual
    - Morphological Analysis
    - Check Listing
    - Action-Verbs
- Directed (Logical)
  - Design Catalogs
    - Physical Effects
    - Solution Principles
  - TIPS (TRIZ)
  - Inversion
  - Forward Steps
  - Factorization & Combinations
  - Axiomatic Principles

Redrawn from figure 10.3, Product Design

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Brainstorming Procedure

1. Select a <u>facilitator</u>

2. <u>Review the problem</u> ~10 minutes - (task clarification, CN's, specifications, etc.)

3. Rapid <u>idea generation</u>

4. When ideas <u>trickle</u>, either stop or use idea generators (analogies, physical principles, etc.)

Recording a Brainstorm: Mind Maps

- Step 1: Write Problem in the center
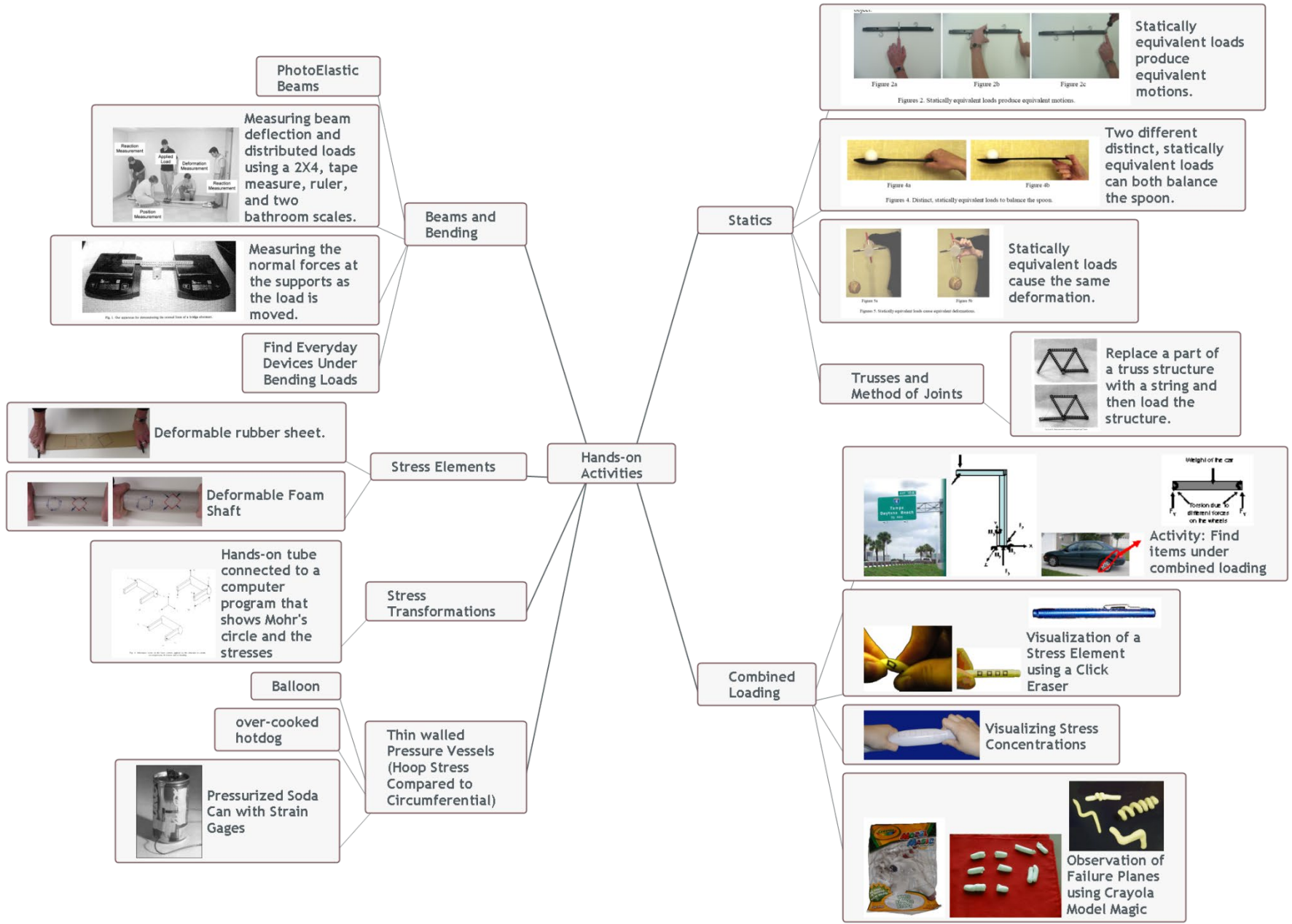- Step 2: Add ideas: cluster into hierarchical groupings

- Look for categories!!
- Groupings help lead to more ideas
- Documents brainstorming
- Power of technique – utilizes fact that ideas in memory are linked by association

Mind Maps

- Step 1: Write Problem in the center
- Step 2: Add ideas: cluster into hierarchical groupings
- Look for categories!!

Mind Maps- Detect & display the location of a golf ball

- Step 1: Write Problem in the center
- Step 2: Add ideas: cluster into hierarchical groupings
- Look for categories!!

Software

- Mindmanager
- <u>others</u>

Include Pictures in Mind Maps

Hands-on Activities

Beams and Bending

PhotoElastic Beams

Measuring beam deflection and distributed loads using a 2X4, tape measure, ruler, and two bathroom scales.

Measuring the normal forces at the supports as the load is moved.

Find Everyday Devices Under Bending Loads

Stress Elements

Deformable rubber sheet.

Deformable Foam Shaft

Stress Transformations

Hands-on tube connected to a computer program that shows Mohr's circle and the stresses

Thin walled Pressure Vessels (Hoop Stress Compared to Circumferential)

Balloon

over-cooked hotdog

Pressurized Soda Can with Strain Gages

Statics

Statically equivalent loads produce equivalent motions.

Two different distinct, statically equivalent loads can both balance the spoon.

Statically equivalent loads cause the same deformation.

Trusses and Method of Joints

Replace a part of a truss structure with a string and then load the structure.

Combined Loading

Activity: Find items under combined loading

Visualization of a Stress Element using a Click Eraser

Visualizing Stress Concentrations

Observation of Failure Planes using Crayola Model Magic

A Sticky Note Mind Map

Generate 40% More Ideas!!!!

6-3-5 (brainwriting)

- Procedure

    6 – group members

    3 – ideas (sketches & keywords) per paper

    5 – exchanging papers

Guidelines
- Each rotation allows adding to and synthesizing (combining) ideas
- Avoid negative comments
- No talking! (Emphasizes sketching)
- Sketches with brief keywords

6-3-5 Illustration

10 Minutes
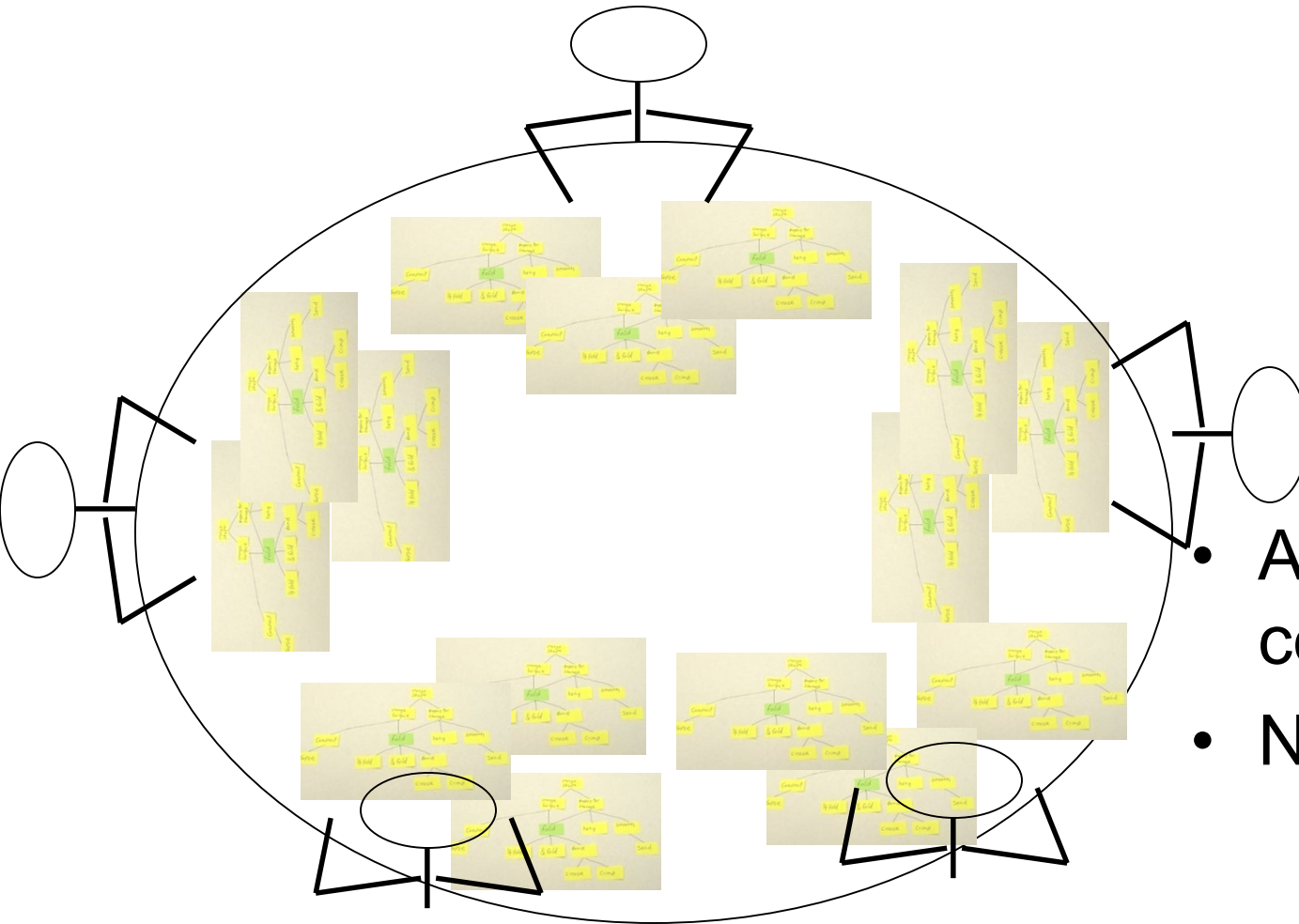
- Avoid negative comments
- No talking!

6-3-5 :
Rotate sets of concepts, spend 7 minutes adding ideas and combining
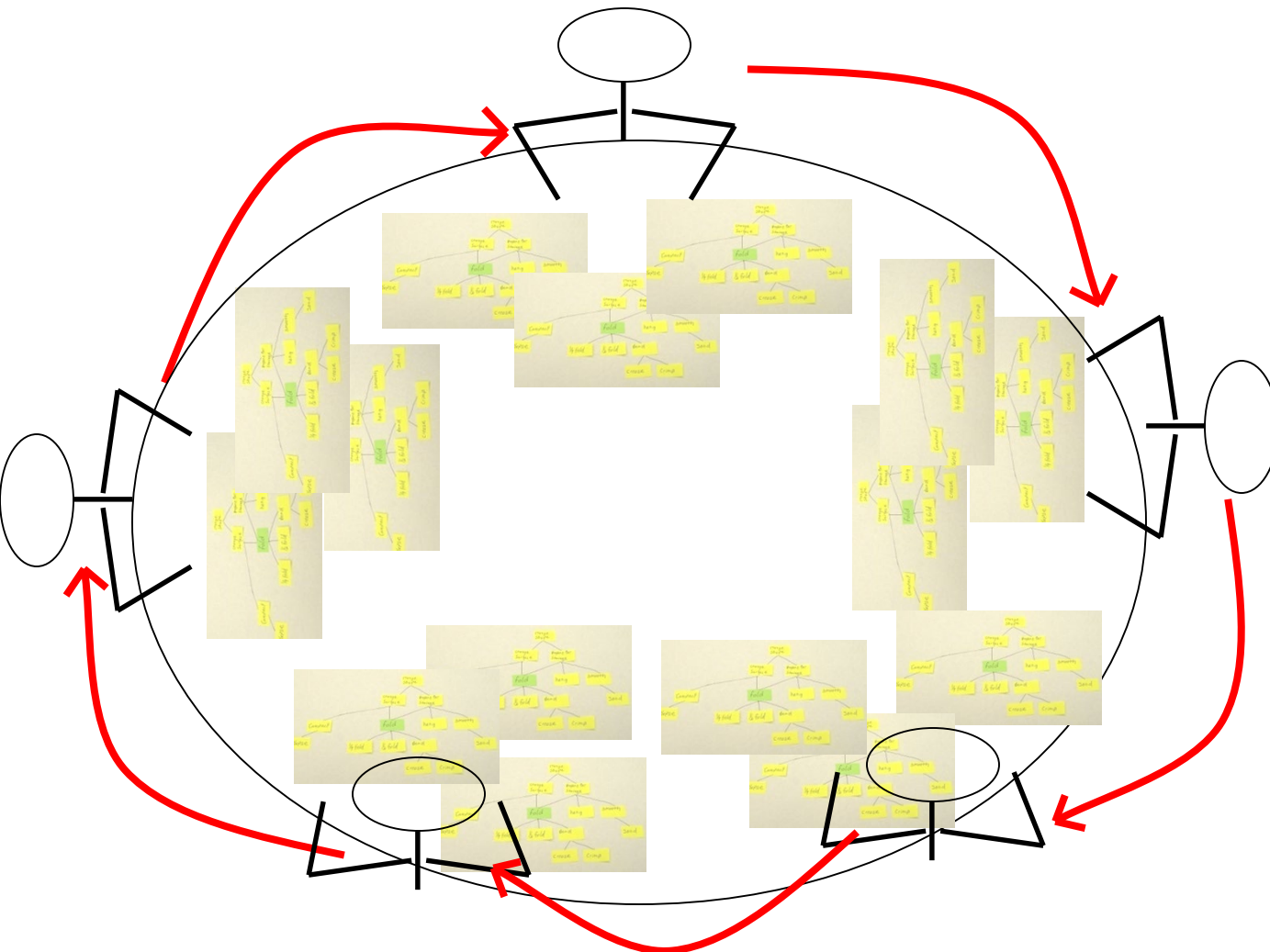
7 Minutes More per exchange

6-3-5 Case Study: Power Driver

electricity, human force →		torque, heat, noise →
hand, bit →	**loosen/tighten screws**	hand, bit →
direction, on/off ⇢		looseness (or tightness) ⇢

→ Energy flow   → Material flow   ⇢ Signal flow

F10.7:
6-3-5

Top-left illustration labels: Bit Storage, Actuator Switch, Spring Chuck, Hand Grip, Battery Cavity/Latch, Battery

Top-right illustration labels: Spring Chuck, Bit, Actuator Switch, Battery, Hand, Grip, Bit Storage, Motor, Epicyclic

Bottom illustration labels: Screw Chuck, Bit, Worm Drive, Motor, Actuator Switch, Hand Grip, Battery

Figure 10.8: 6-3-5, Second Rotation

Bit Storage

Actuator Switch

Handle Profile

Battery

Battery Cavity/Latch

Hand Grip

Spring Chuck

Power Level Display

Actuator Switch

Battery

Spring Chuck

Bit

Hand

Grip

Bit Storage

Motor

Epicyclic

Rotary Joint

Screw Chuck

Bit

Worm Drive

Motor

Actuator Switch

Hand Grip

Battery

Actuator Switch

Battery

Handles

Carry Strap

Hand Grip

Battery
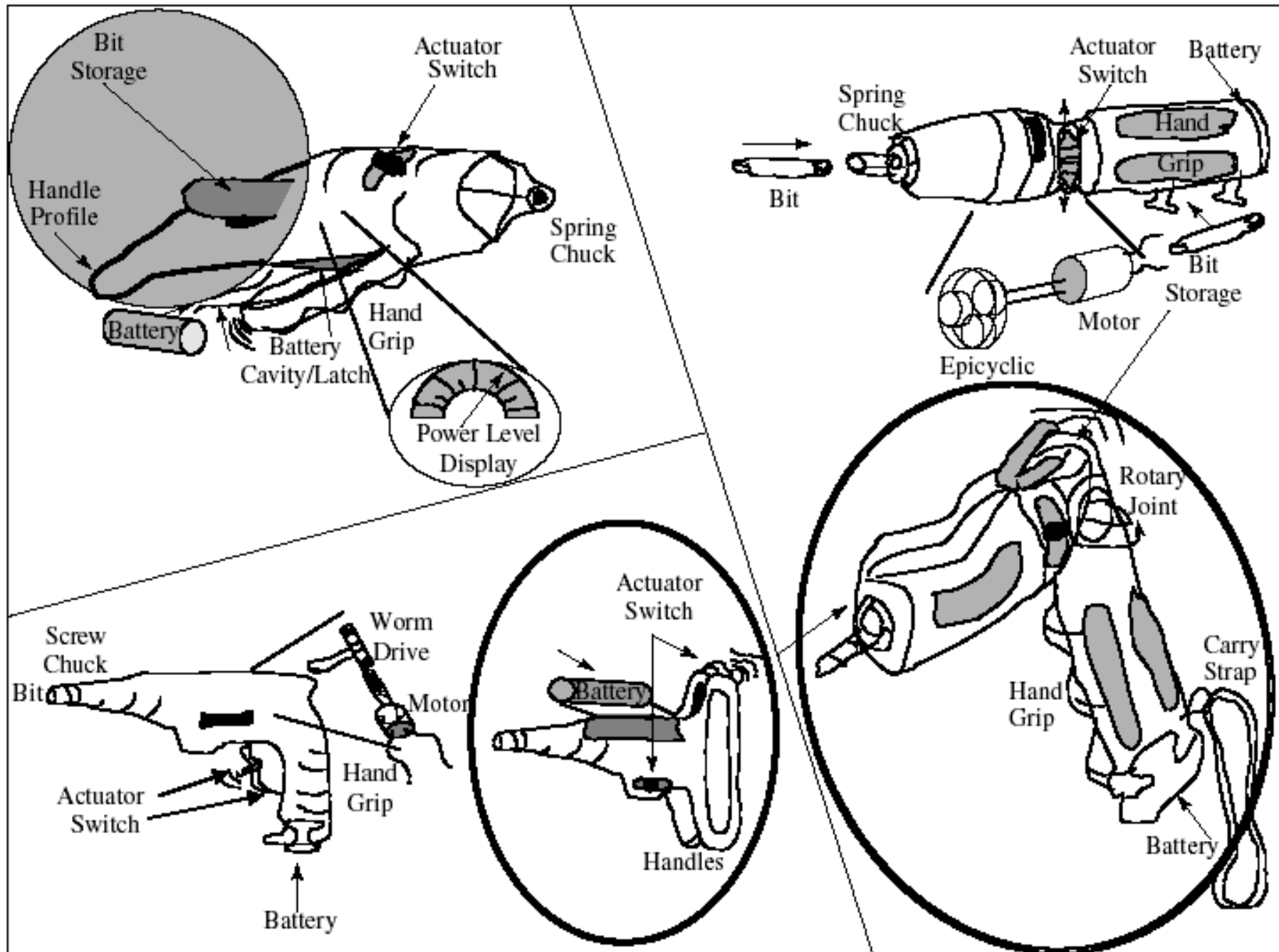
6-3-5 Method: Geographically or Time Distributed Version

PHASE ONE

Spend 10 minutes in silent individual idea generation. All individuals submit by a deadline

It is key to:

*   Draw and annotate

*   Avoid negative comments

*   Not talk during activity
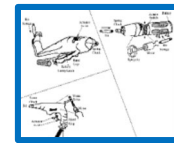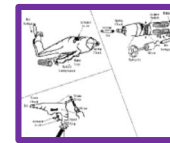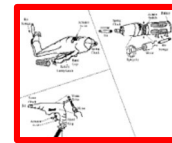
Team Repository
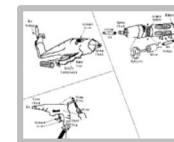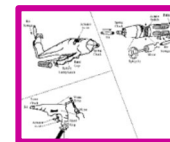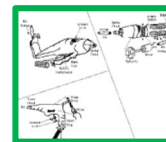
6-3-5 Method:
Geographically or Time Distributed Version

PHASE TWO

Rotate concepts and spend 5-7 minutes adding and combining ideas
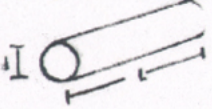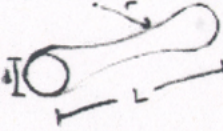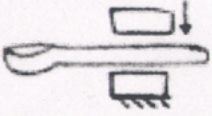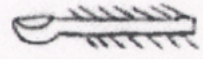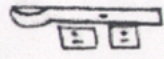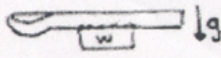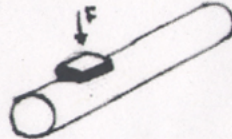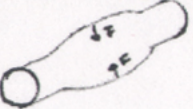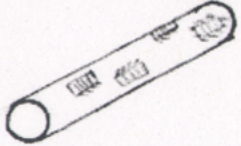
Team Repository
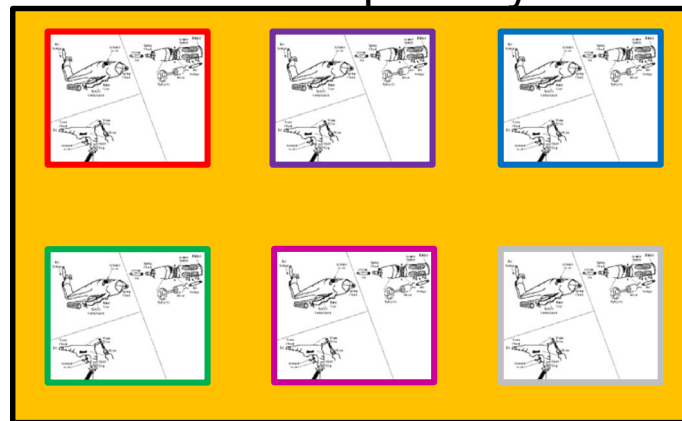
Repeat for a total of 5 exchanges

Morph Matrix Example

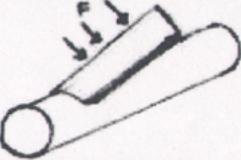|	Cylindrical	Toroidial	Prism	Outer Handle	Deformable
Accept User (shape)					
	Dycem	**Ridges**	**Santoprene**		
(surface)					
	Clamping	**Permanent Attach**	**Slot**	**Magnets**	
Accept Utensil				(metal spoon)	
	Eccentric Weight	**Lever**	**Button**	**Squeeze Tube**	**Photocells**
Accept Energy	(No user energy)				

Morph Matrix Example: Ways to Store Energy

Type of Energy / Principle	Mechanical	Hydraulic	Electrical	Thermal
1				
2				
3				
4				

Checklists & Idea Generators for Concept Generation

- Use when the group "runs" out of ideas

- Jump starts new ideas

- Have the list ready during a Concept Generation Session

TABLE 10.3. IDEA GENERATORS FOR INTUITIVE CONCEPT GENERATION METHODS

Idea generator	Questions or application
Make analogies	What analogies exist in nature? What analogous products exist in any product domain? How do these products solve the same product functions?
Wish and wonder	What if . . . ?
Sketch/use physical models (e.g., Tinkertoys or LEGOs)	What would an idea look like? How does this model satisfy the function? What can we change?
Eliminate or minimize?	If we remove a feature, how does the device perform? What can we use to replace the feature? What if a feature were smaller? What should I omit? Should I divide it? Split it up? Separate it into different parts? Understate? Streamline? Make miniature? Condense? Compact? Subtract? Delete? Can the rules be eliminated?
Substitute	What can be substituted? Who else? What else? Can the rules be changed? Other ingredient? Other material? Other process or procedure? Other power? Other place? Other approach? What else instead?
Combine	Can we combine purposes? How about an assortment? How about a blend? An alloy? Combine units? What other article or device could be merged with this?
Adapt	What else is like this? What other idea does this suggest? Does the past offer a parallel? What could I copy? Whom could I emulate? What idea could I incorporate? What other process could be adapted?
Modify or magnify	What can be magnified, made larger, or extended? What can be exaggerated? Overstated? What can be added? More time? Stronger? Higher? How about greater frequency? Extra features? What can add extra value? What can be duplicated? How could I carry it to a dramatic extreme? Convert a round action to straight? How can this be altered for the better? What can be modified? Is there a new twist? Change meaning, color, motion, sound, odor, form, or shape? Change name? What changes can be made in the plans? In the process? In the marketing?
Put to other uses (repackage an old idea)	What else can this be used for? Are there new ways to use as is? Other uses if modified? What else could be made from this? Other extensions? Other markets?
Reverse or rearrange	What other arrangements might be better? Interchange components? Other pattern? Other

SCAMPER

- Substitute
- Combine
- Adapt
- Magnify or minify
- Put to other uses
- Eliminate or elaborate
- Rearrange or reverse

SCAMPER: Substitute, Combine, Adapt, Magnify or minify, Put to other uses, Eliminate or elaborate, Rearrange or reverse
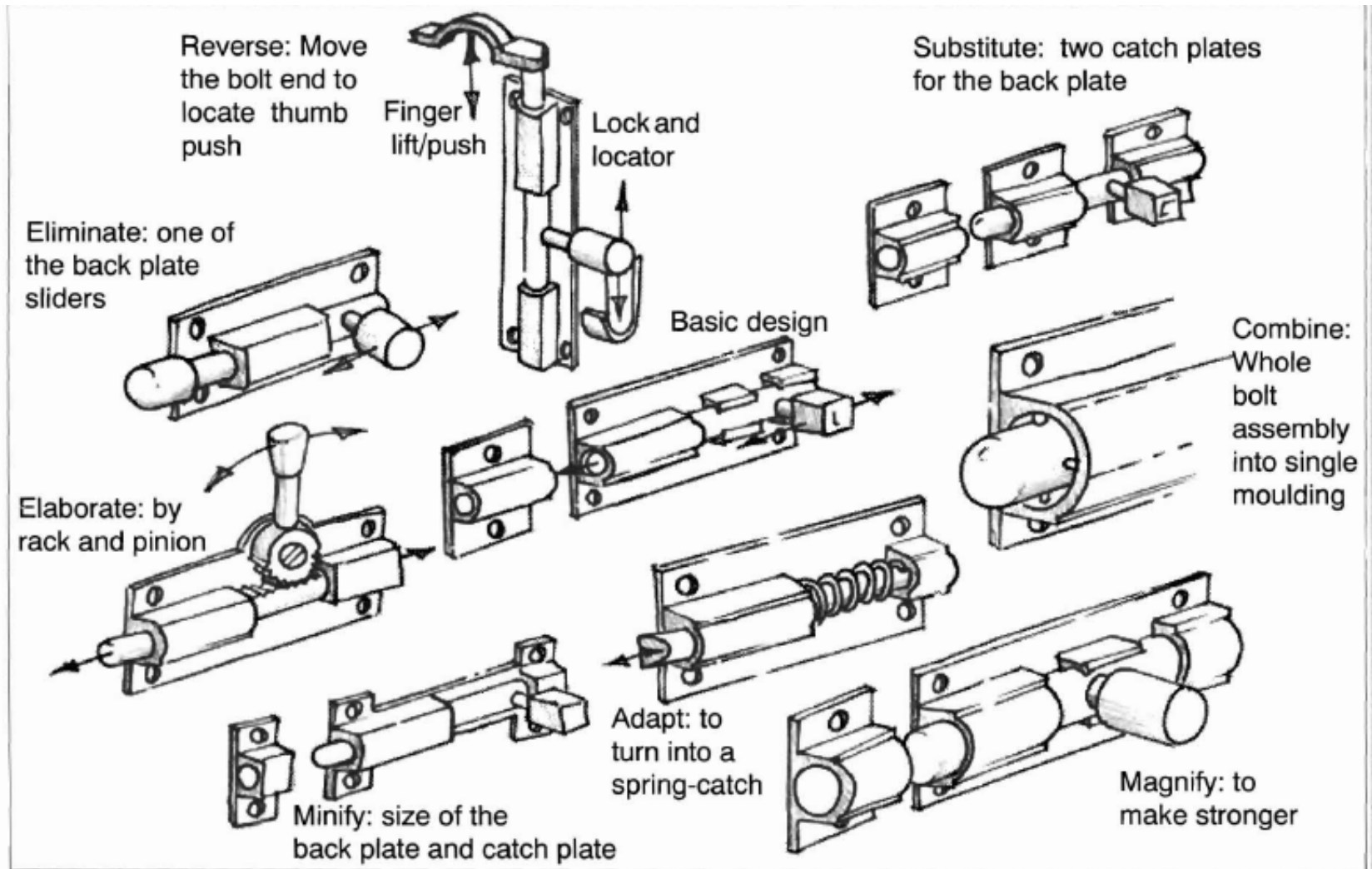
CREATIVITITY

- Combine
- Reverse
- Enlarge
- Adapt
- Tinier
- Instead of
- Viewpoint change
- In other ways
- To other uses
- Yes!

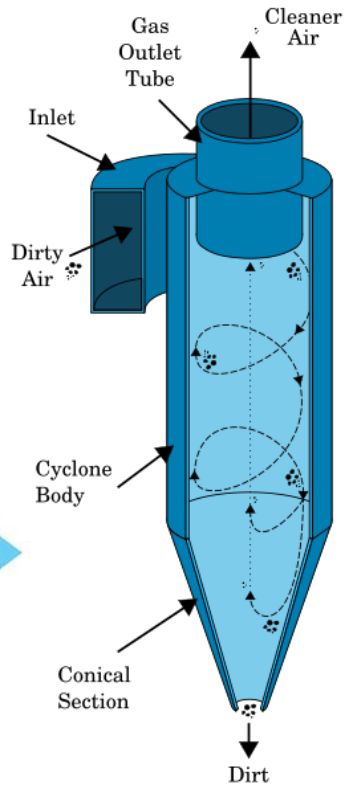# Innovation through Design-by-Analogy

Analogy to Existing Products

Bioinspired Design

Dyson vacuum based on a saw mill dust collector

Gas Outlet Tube

Cleaner Air

Inlet

Dirty Air

Cyclone Body
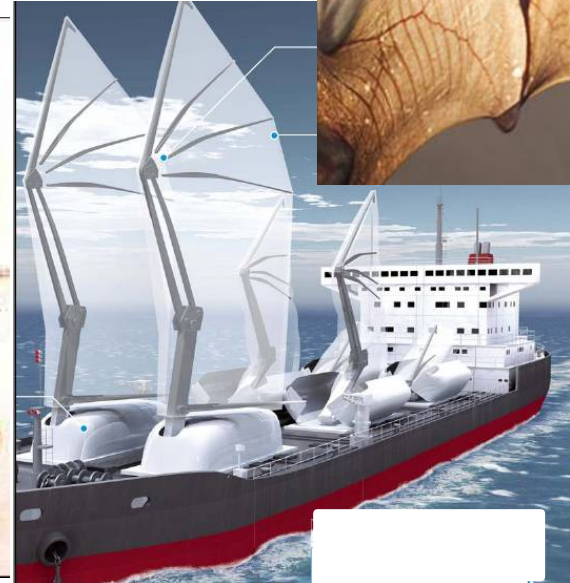
Conical Section

Dirt

Dyson vacuum

Dust Collector

Environmentally friendly, collapsible sail for cargo ships

Questions? There are many more techniques and tools for idea generation

- Asknature.org
- WordTree Method for Analogy
- patents
- TRIZ/TIPS