



PSY 221

## 12. Problem Solving

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# Outline

## □ What is Problem Solving

- Weak and strong methods.
- Weak methods of problem solving

## □ Phenomena in Problem Solving

- Insight Problems
- Functional Fixedness

## □ Use of background knowledge

- Analogy
- Analogy and creativity

# There are problems all around us.

## □ Much of our life is spent solving problems.

- Getting into the cookie jar without your mother noticing.
- Stopping wars.
- Doing a crossword puzzle.

## □ What makes these problems? / Four aspects to a problem

- Goal: What is to be accomplished?
- Givens: What is known from the start of the problem?
- Means of transformation: How can the initial state be modified?
- Obstacles: Something that stands between the initial state and the goal.

## □ What would happen if one of these aspects were missing?

# Types of problems

## □ Well-defined problems

- All four aspects of the problem are specified.

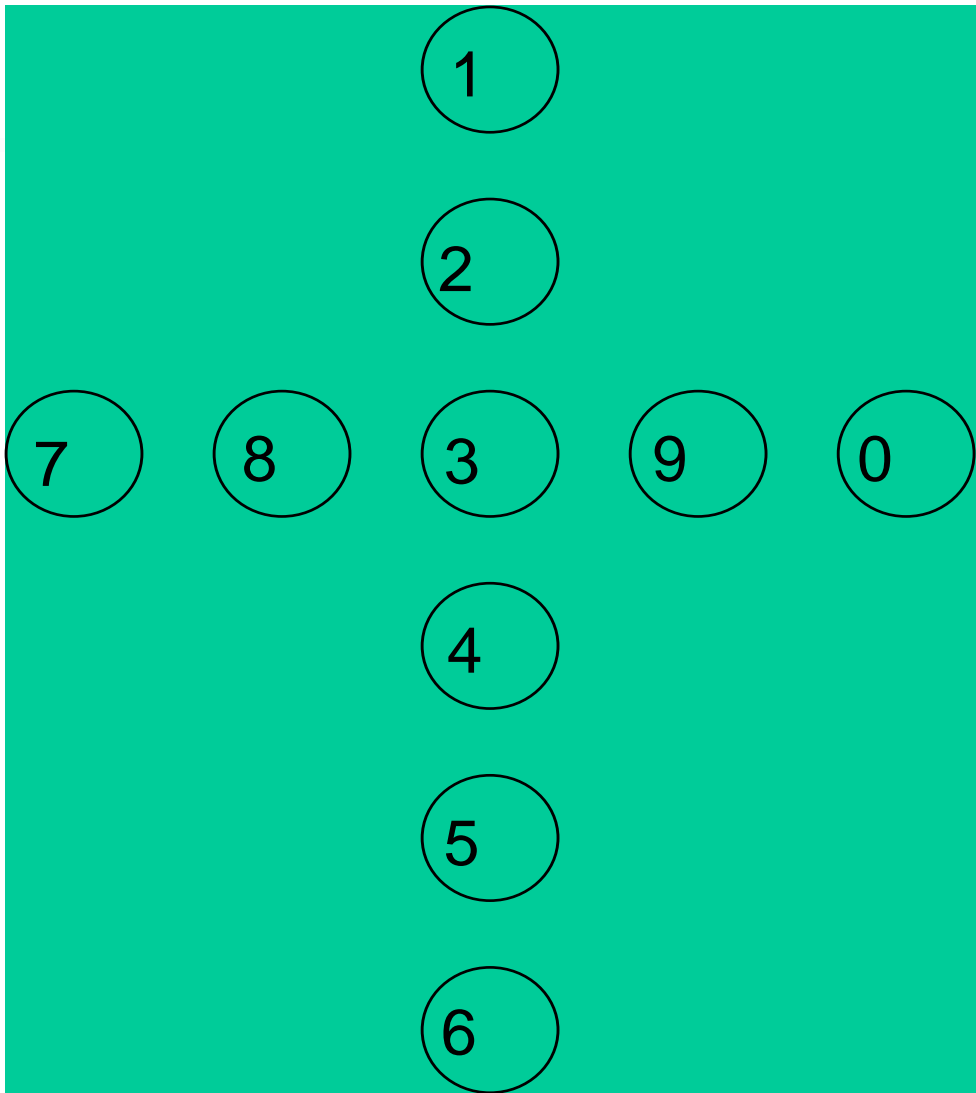
- ① Towers of Hanoi
- ② Mazes

## □ Ill-defined problems

- One or more of the aspects of the problem are not well specified.

- ① Stopping a war
- ② Getting cookies without your mother knowing.





Move one coin so that there are two straight lines of six coins which cross each other at the center point of each line.

What kind of problem is this?  
Ill-defined?  
Well-defined?

# How do we solve problems?

## □ Sometimes a problem is novel

- Then we use **general** problem solving strategies.
- These are called “weak” methods.

## □ Sometimes a problem is more familiar

- Then we can use our **background knowledge**.
- These are called “strong” methods.

## □ We will focus on “**weak**” methods first.

- “Strong” methods will be discussed later.

# Problem solving as search

## □ Consider a well-defined problem

- The givens are known
- The means of transformation are known
- The goal is known

## □ The obstacle is generally that there are so many possible solutions it is hard to find the right one.

- We must search for the right solution.



# The problem space

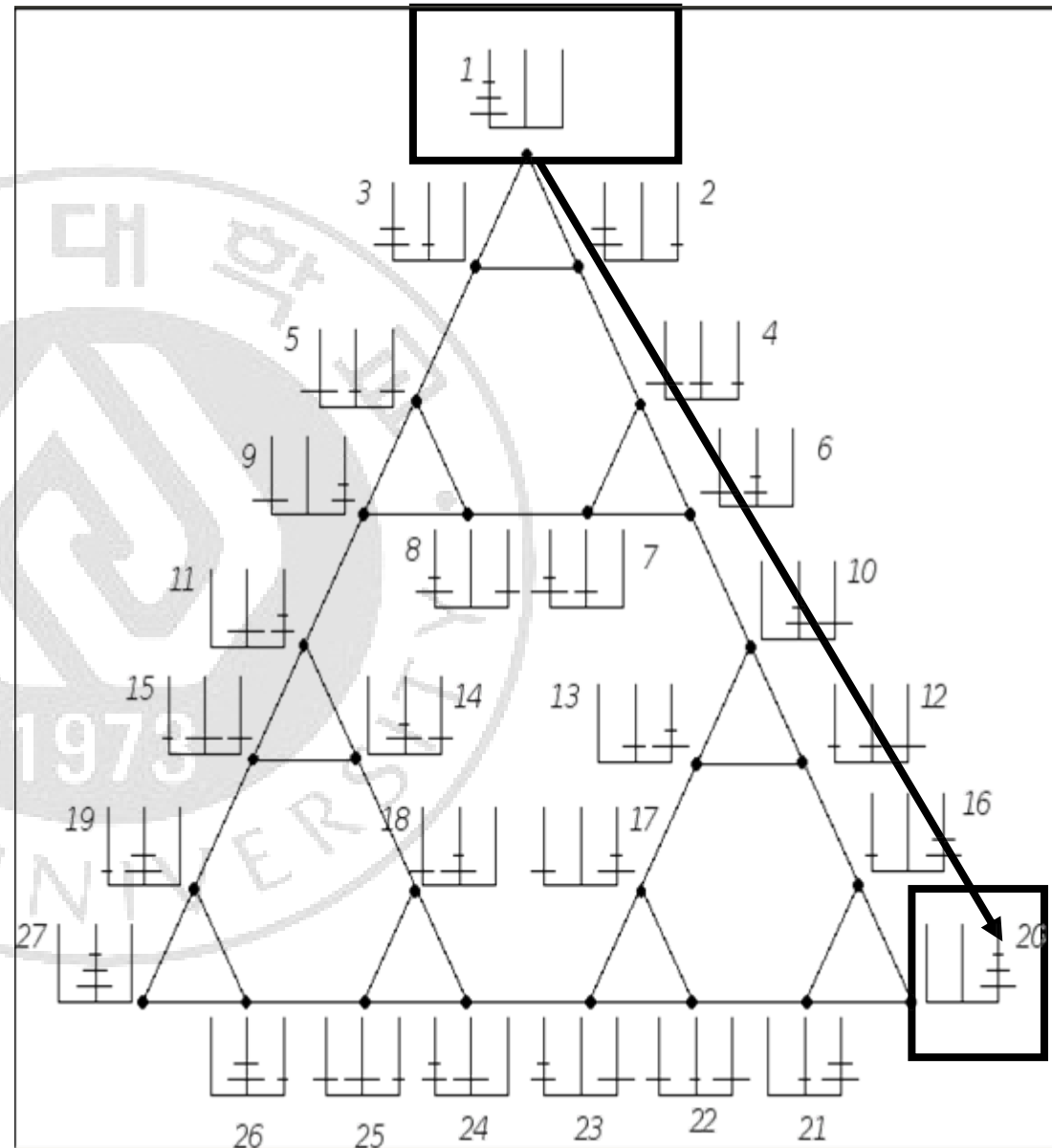
## 3 disc Towers of Hanoi problem

Initial State

Goal State

Search for a path from the initial state to the end state.

For this problem, the whole space can be enumerated.



# What if the search space is too large?

❑ **It is not possible to enumerate the entire search space for all well-defined problems.**

● Chess: After a few moves, there are too many possible moves and counter moves to consider all of them.

❑ **We must use constraints.**

● Often called *heuristics*

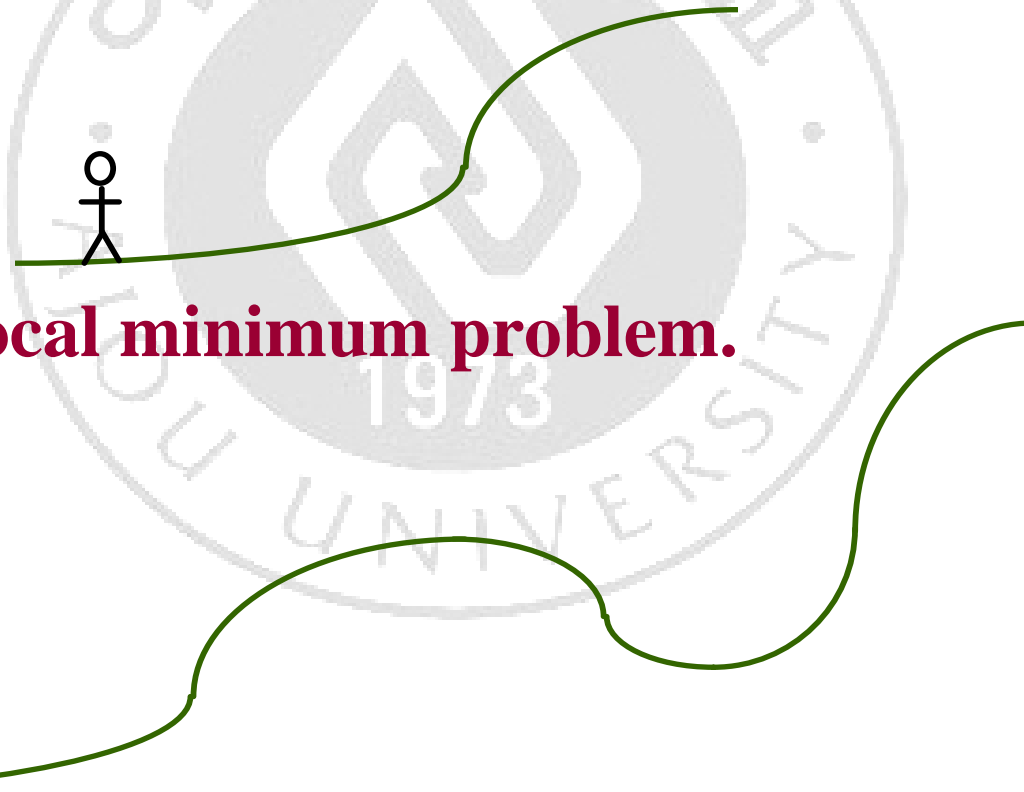
● A heuristic is a general guideline

① It is likely to lead to a good solution

② Not guaranteed to work

# Hill climbing

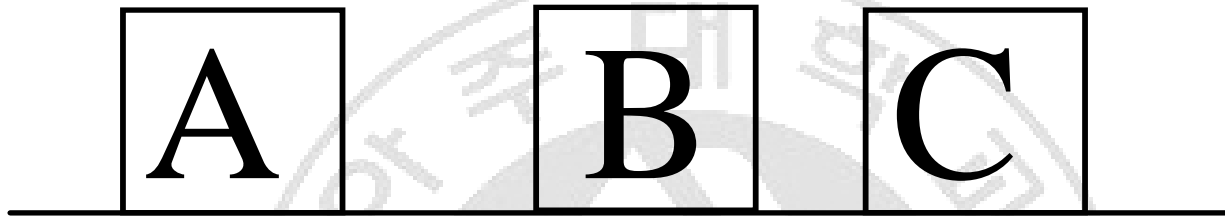
- ❑ Find some measure of the distance between your present state and the end state.
  - Take a step in the direction that most reduces that distance.



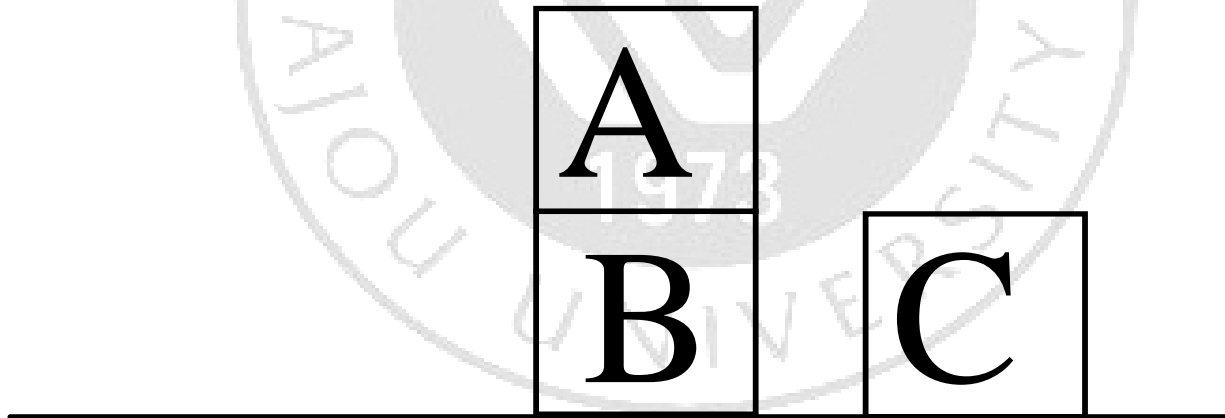
- ❑ A potential local minimum problem.

# An example

## □ Stacking blocks



*Create a stack with A on top, the B, then C.*



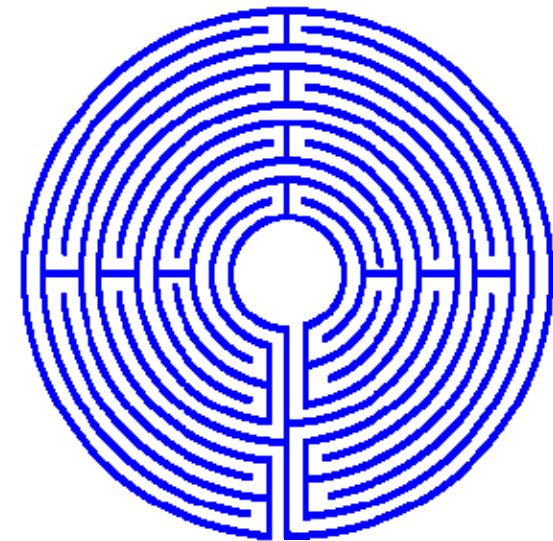
*Sometimes you have to move away from your solution to reach it.*

# Means-end analysis

- ❑ Try to reduce the largest difference between the initial state and the goal state first.
- ❑ How should you get from Ajou campus to the Empire State Building?
  - Fly from Incheon to New York
    - ① That takes care of the biggest difference.
  - That creates new sub-problems
    - ① Getting from Ajou campus to the airport
    - ② Getting from a New York airport to the Empire State Building
  - Each of these new sub-problems needs to be solved.

# Working backward

- ❑ **Sometimes it is hard to solve a problem by starting at the initial state**
  - Many puzzles are intentionally designed to be hard to solve from the givens.
- ❑ **It can be useful to start at the end state and work backward.**



# Summary

- ❑ **Problems involve overcoming obstacles**
- ❑ **Weak methods of problem solving**
  - Domain-general heuristics for solving problems
  - Best for well-defined problems
    - ① No real mechanisms for dealing with ill-defined problems
    - ② Domain knowledge needed for this.

# Phenomena in Problem Solving

- ❑ **Insight Problems**
- ❑ **Functional Fixedness**



# What do we know about insight?

## Many studies of insight problems (Duncker)

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. It is impossible to operate on the patient, but unless the tumor is destroyed the patient will die. There is a kind of ray that can be used to destroy the tumor. If the rays reach the tumor all at once at a sufficiently high intensity, the tumor will be destroyed. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue, but they will not affect the tumor either. What type of procedure might be used to destroy the tumor with the rays, and at the same time avoid destroying the healthy tissue?

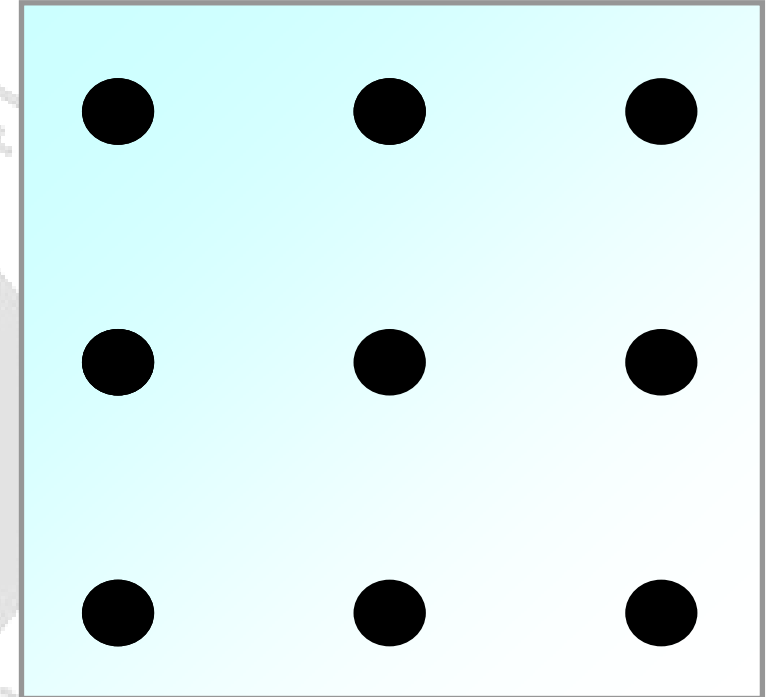
# Characteristics of insight problems

- ❑ **People initially have no idea how to solve the problem.**
- ❑ **There is no linear “feeling of warmth”**
  - There is no sense that one is getting closer to solving the problem.
- ❑ **Often, there is a period of “incubation”**
  - Perhaps you walk away from the problem for a while.
- ❑ **The solution comes in a flash**
  - Often, it feels as though the solution is fully formed.

# How to study insight?

## □ Insight problems are hard to study.

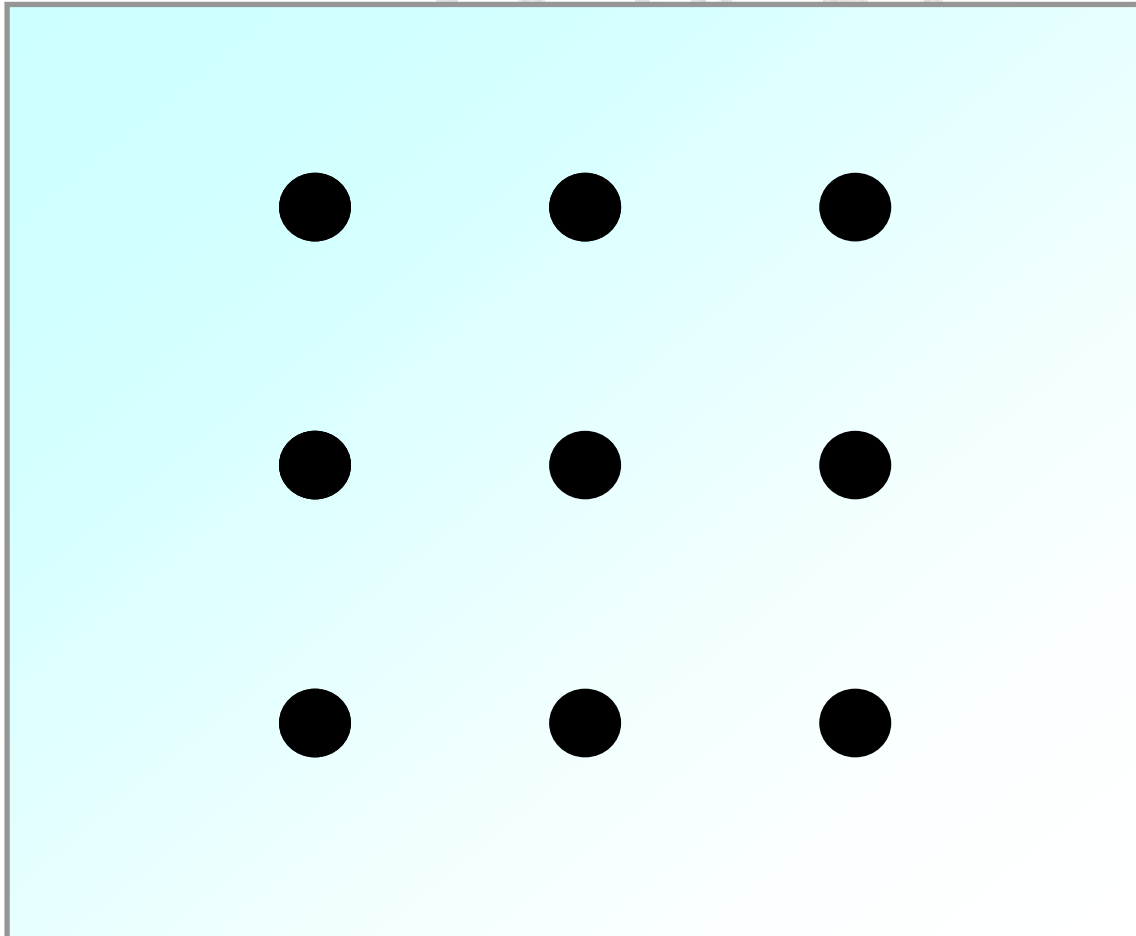
- Cannot ask people for their intuitions
- There is no feeling of warmth
  - ① People have an “aha” experience
  - ② What we want to know is what causes the “aha”.
- Insight problems are rare
  - ① There are only a few laboratory examples that work
  - ② There are also rare in real life.



*“Connect all 9 dots with four lines without lifting your pen from the page.”*

# A solution

*The problem only seems well-defined (as in the previous slides)*  
*Most people do not think of going outside the lines.*



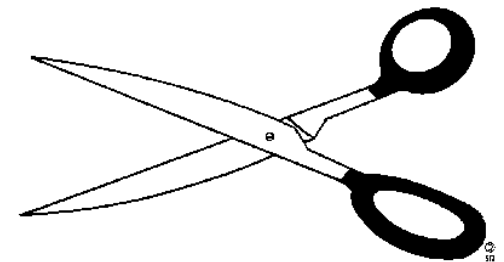
# Functional Fixedness

## □ Why does incubation help?

- We may get locked into a way of thinking about the objects in a problem.



Tie the two ropes together. They are too far apart to grasp them both.



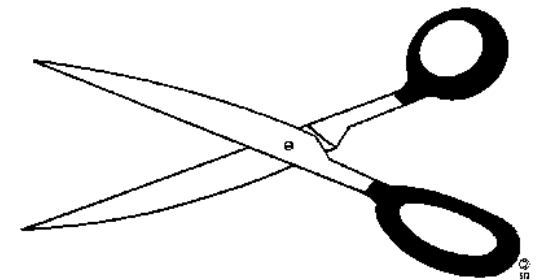
# Time away from the problem

- We may eventually be able to see objects in a new way.



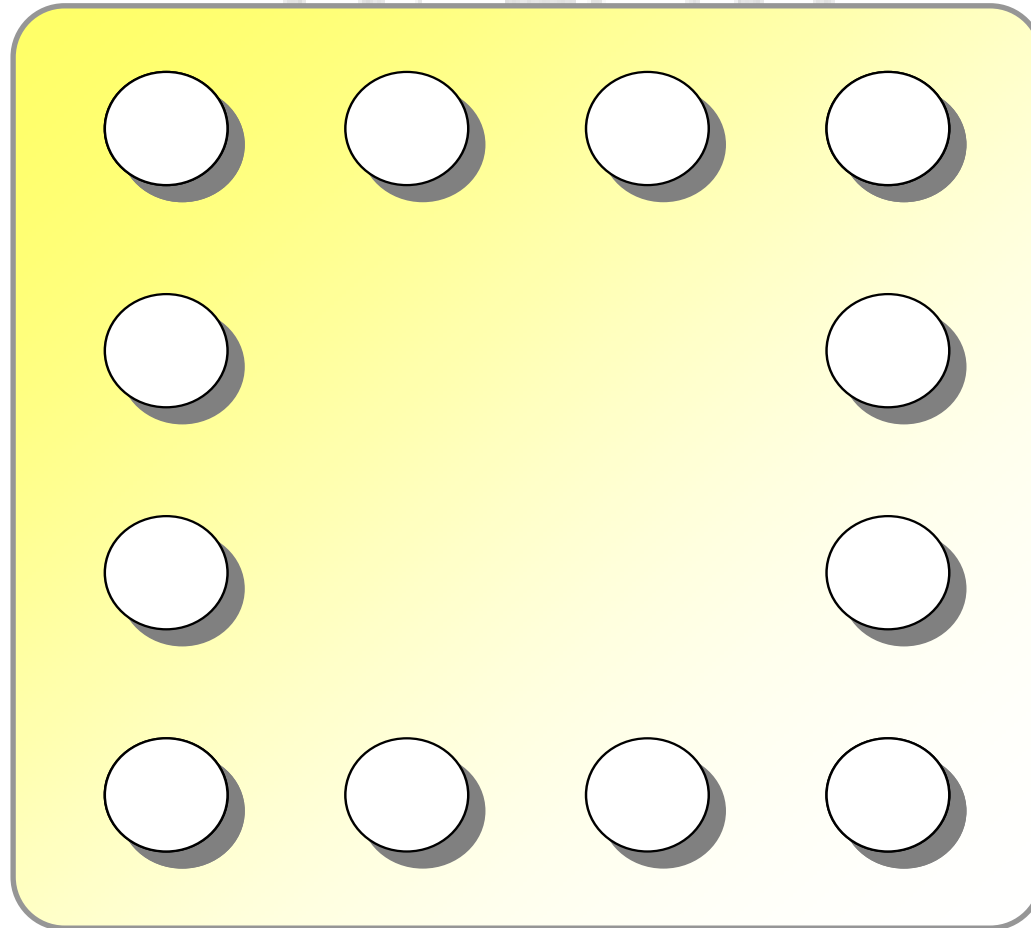
*Scissors are heavy.*

*Tie them to one rope and swing it.*



# What drives insight?

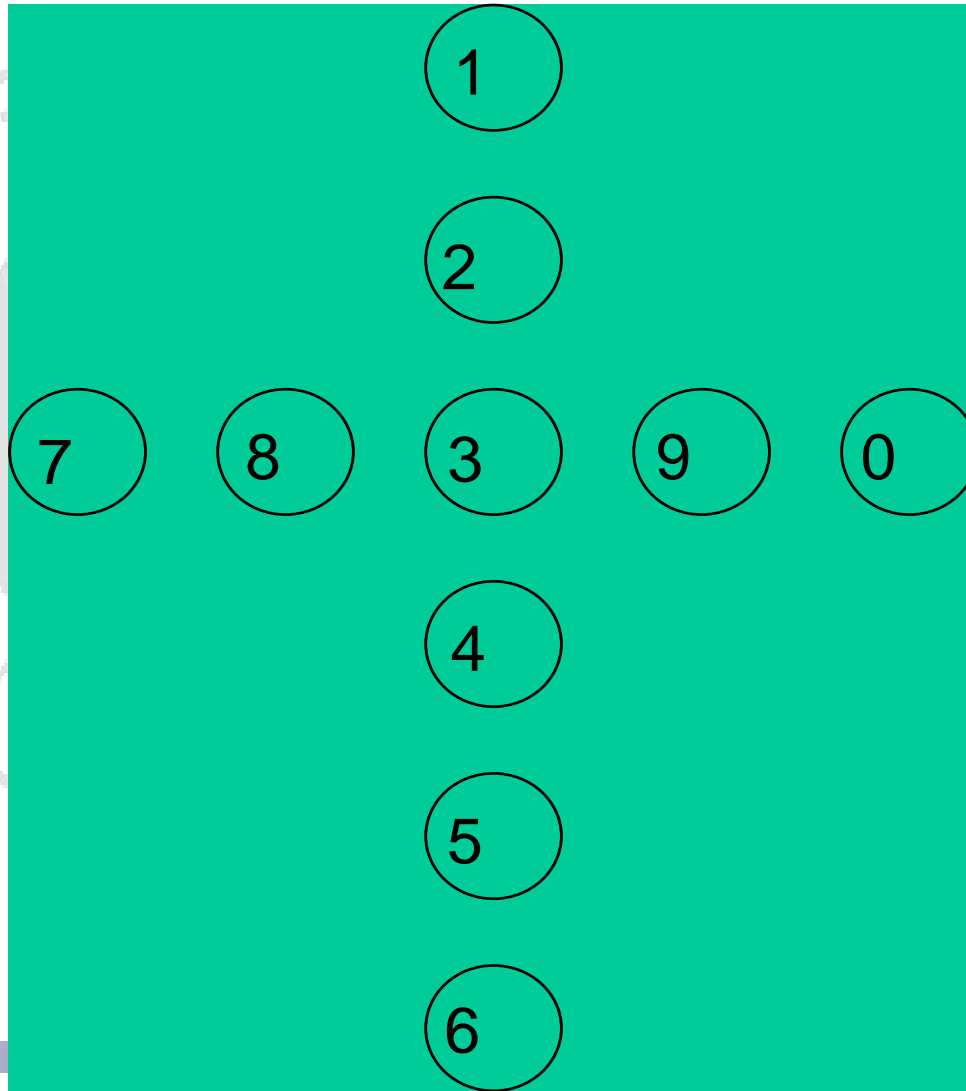
- ❑ Using twelve coins, create a square that has five coins along each side.



# Prior knowledge

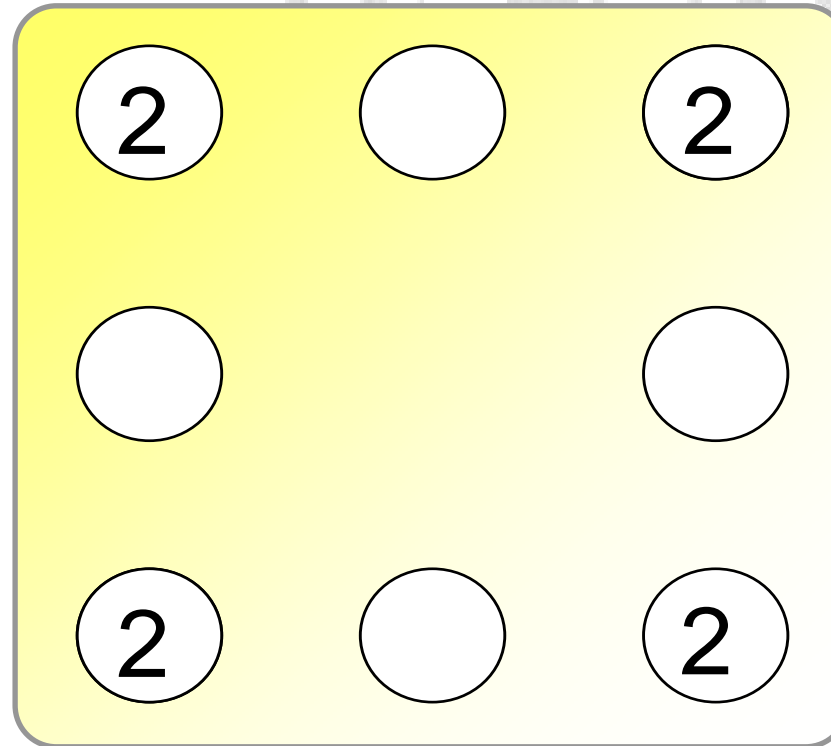
□ This problem might remind you of one you saw before.

Move one coin so that there are two straight lines of six coins which cross each other at the center point of each line.



# Prior knowledge

□ You might try a similar solution for the new problem.



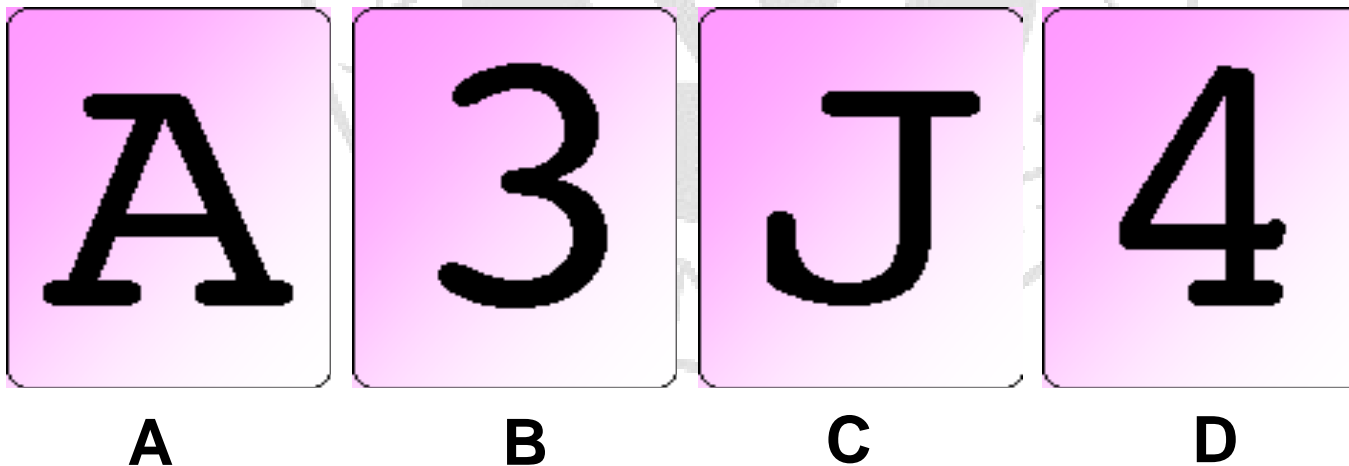
Some work still needs to be done even after similarity between problems is noticed.

*We will discuss access of prior knowledge more next class.*

## An example

- Each card has a letter on one side, and a number on the other.
- Which Cards must you turn over to test the rule:

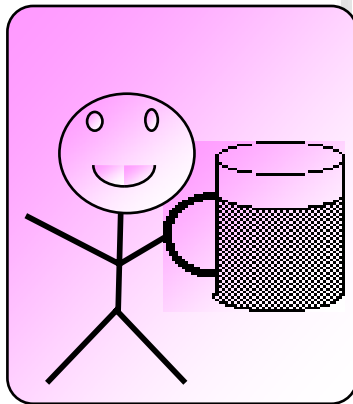
*“If there is a vowel on one side of the card, then there is an odd number on the other side.”*



# What about this case?

- Who do you have to check?

*If you have a beer, then you must be 21 or older?*



**A**

**23**

**B**



**C**

**19**

**D**

## In the “A, 3, J, & 4” case...

- ❑ **The most common response by college student is to turn over the “A” and “3”.**
  - But this is not a correct answer.
  - The cards that should be turned over are those corresponding to the two valid conditional reasoning schemas, modus ponens and modus tollens.
  - No information relevant to falsifying the rule can be obtained from turning over the “4”.
  - Therefore, the correct answer is to turn over the “A” and “4”.
- ❑ **Use of strong methods**
  - Many ill-defined problems need background knowledge
  - We call this “strong methods”
  - Independent to the use of general/universal strategies

# So what?

## ❑ For well-defined problems

- We (can) use weak (i.e., general/universal) methods.
- But if the problem space is too big, we often use heuristics

## ❑ For ill-defined problems

- We need background knowledge
- Use of background knowledge (i.e., familiar knowledge) for the problem (i.e., unfamiliar thing) solving? → It's Analogy!!
- But many ill-defined problem is not familiar. This is the problem
- Then, how we can make the unfamiliar problem familiar?

# Analogy

## □ What are analogies?

- Inference that transfers information from one problem or situation to another that is relevantly similar

## □ Use of knowledge for reasoning & problem solving?

- We use prior experience!
- How? By using psychological process of analogy
- How we do perform analogy?: by processing **similarity** between the problem and the relevant background knowledge
- So, if no similarity between the two? → difficult to do analogy → difficult problem!

# For that reason analogy is difficult to do!

## □ August Kekule

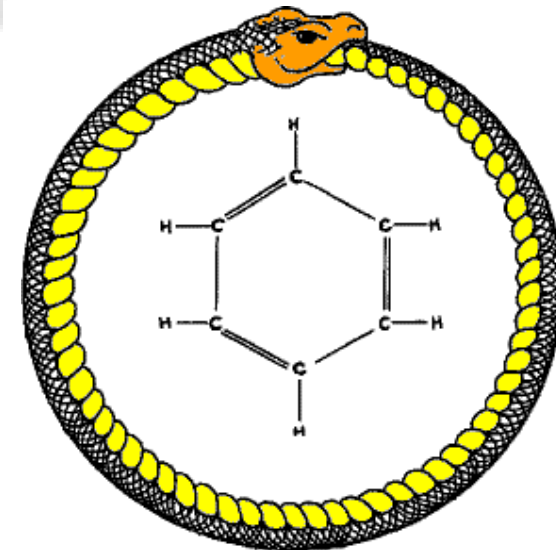
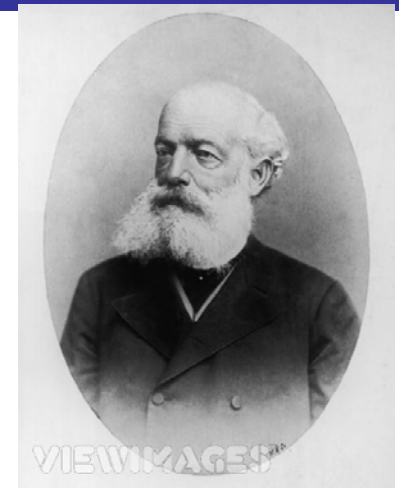
### ● Kekulé and the benzene ring

- ① Chemists were search for the structure of benzene
- ② Kekulé was said to have visualized a snake eating its tail.

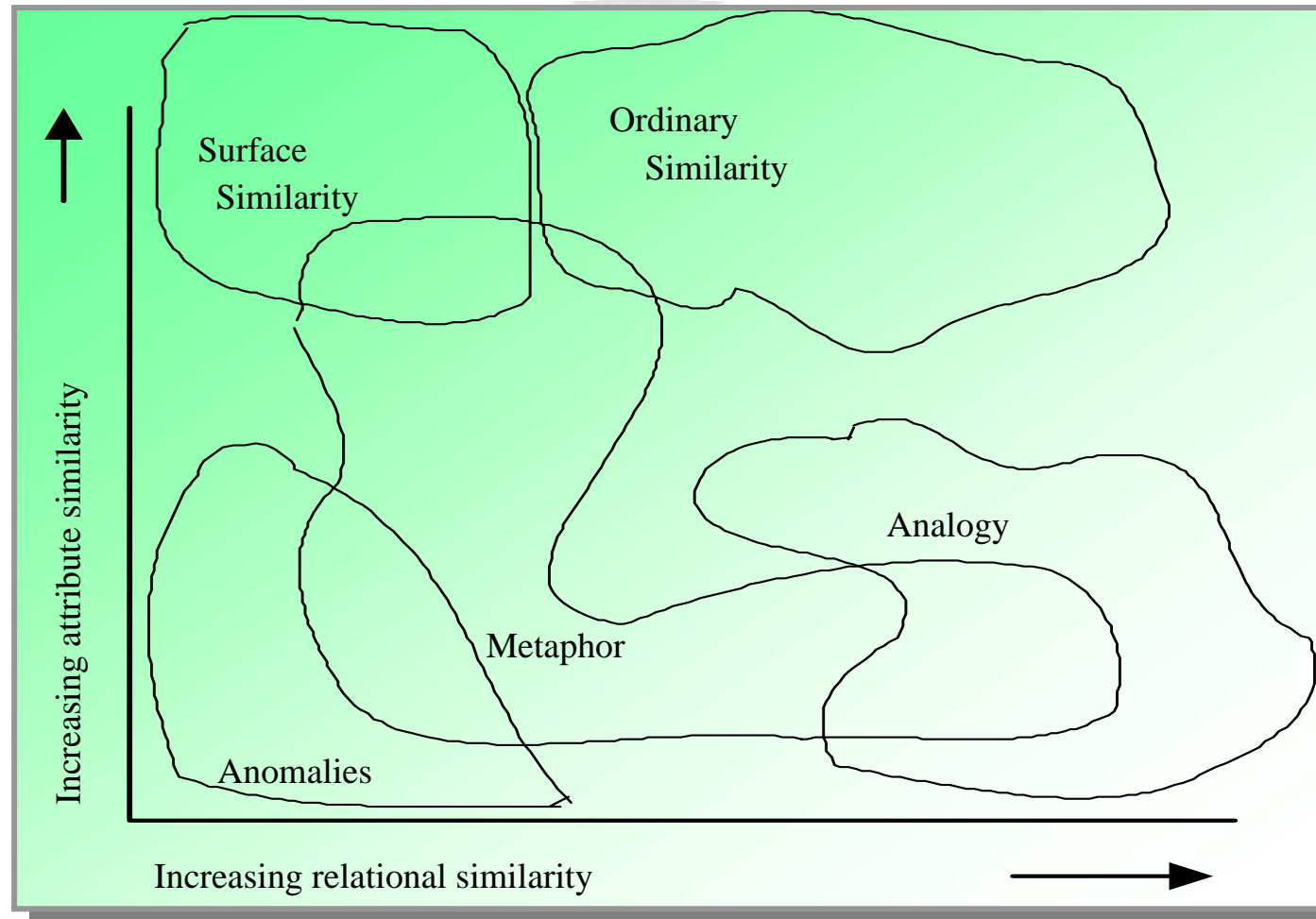
## □ Why not everybody dreamed snake could solve the benzene ring problem?

- The less perceptual similarity between snake and benzene ring

## □ So, we need something else to put the dissimilar two things into analogical process.



# Metaphor and Analogy



# Similarity, metaphor, and analogy

## □ Note metaphor!

- It involves across perceptual similarity and analogy
- Therefore, practice of metaphor facilitate the use of analogy

## □ And metaphor includes high load of cognition

- In sum, that's why we have to **hear** books and **see** music!!
- Genres rich in metaphors
  - ① poem
  - ② Opera / ballet
  - ③ game: multi-sense control games

# Simplicity by metaphor

"making the simple complicated is commonplace;  
making the complicated simple, awesomely simple,  
that's creativity."  
- Charles Mingus



*"Making the simple complicated is commonplace, making the complicated simple, awesomely simple, that's creativity." - Charles Mingus*