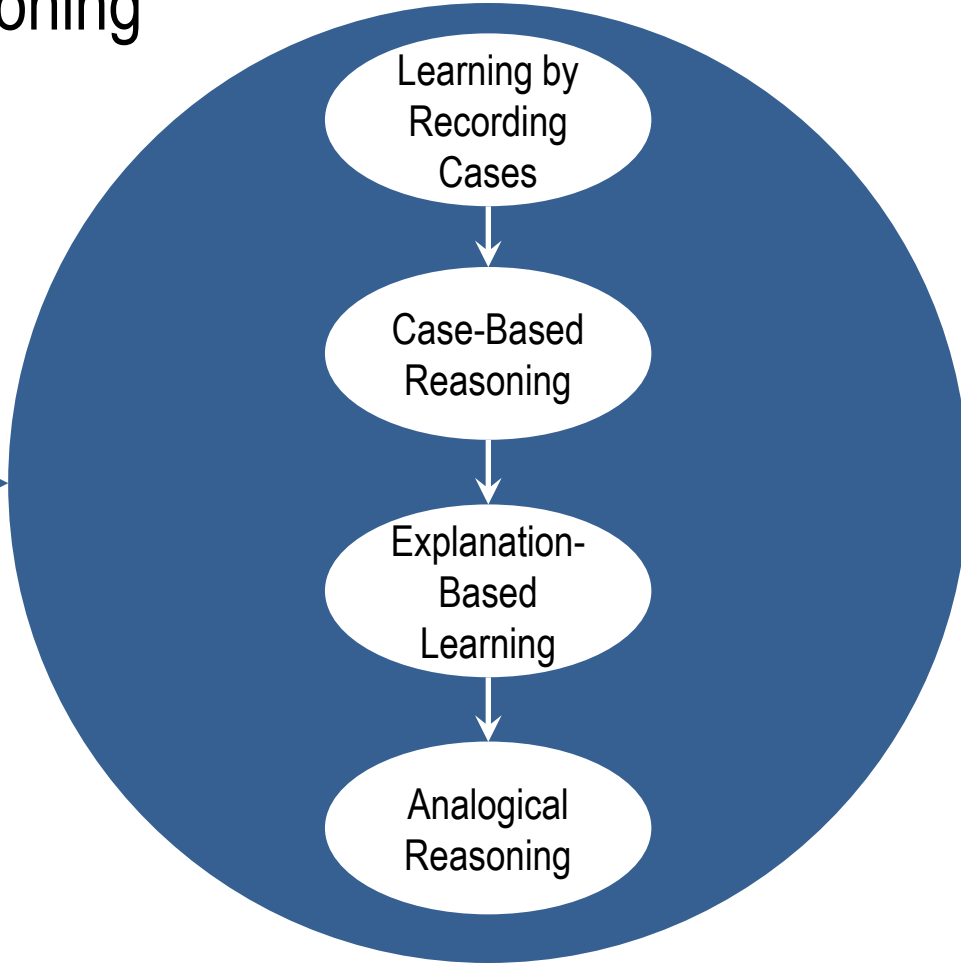




Analogical Reasoning

Analogical Reasoning



Lesson Preview

- Similarity and case-based reasoning
- Process of analogical reasoning
- Design by analogy

A woman is climbing a ladder.

Which of the situations on the right is most similar to the situation above?

Rank them from 1 (most similar) to 7 (least similar)

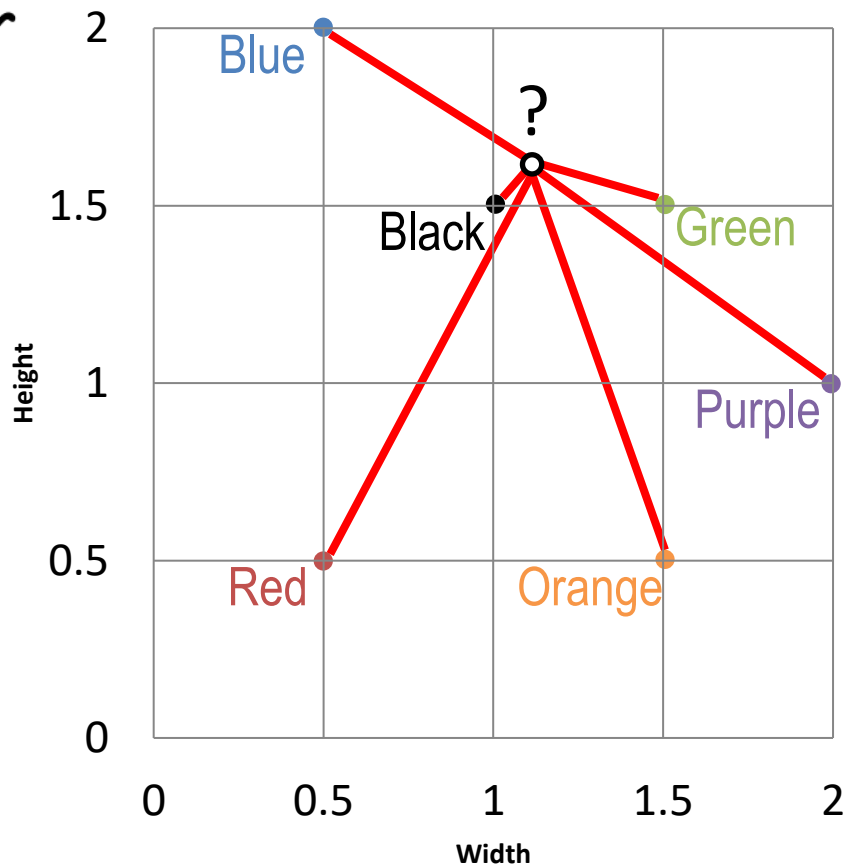
- | | |
|---|--|
| 2 | A woman climbing a set of stairs. |
| 3 | An ant walking up the wall. |
| 6 | A woman painting a ladder. |
| 4 | A woman climbing the corporate ladder. |
| 7 | A water bottle sitting on a desk. |
| 1 | A woman climbing a step ladder. |
| 5 | A plane taking off into the sky. |

Finding the Nearest Neighbor

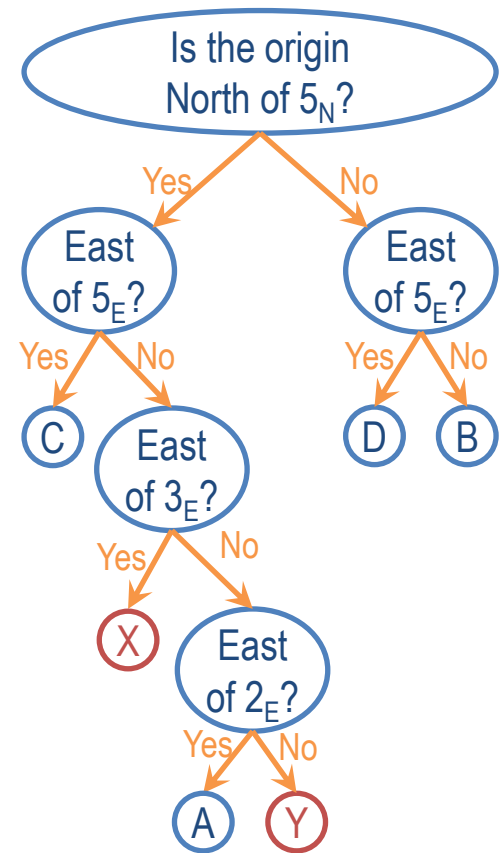
Given existing case at (x_c, y_c)
and new problem at (x_n, y_n)

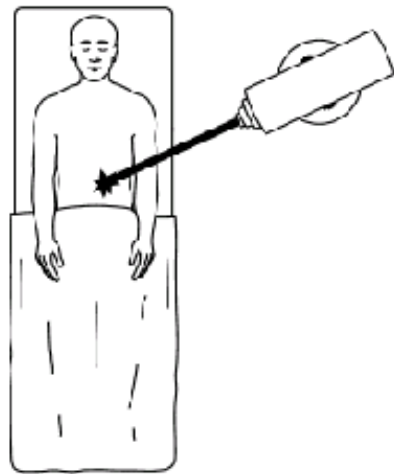
$$d = \sqrt{(y_c - y_n)^2 + (x_c - x_n)^2}$$

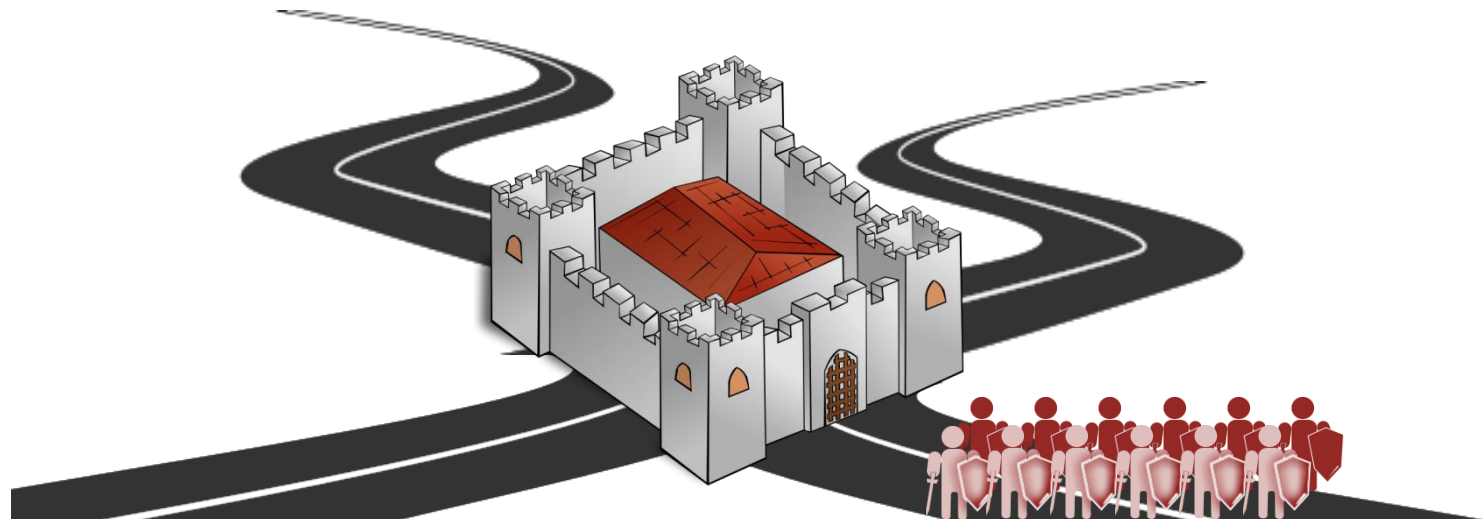
Block	x_c	y_c	x_n	y_n	d
Blue	0.5	2.0	1.1	1.6	0.72
Red	0.5	0.5	1.1	1.6	1.25
Black	1.0	1.5	1.1	1.6	0.14
Green	1.5	1.5	1.1	1.6	0.41
Orange	1.5	0.5	1.1	1.6	1.17
Purple	2.0	1.0	1.1	1.6	1.08

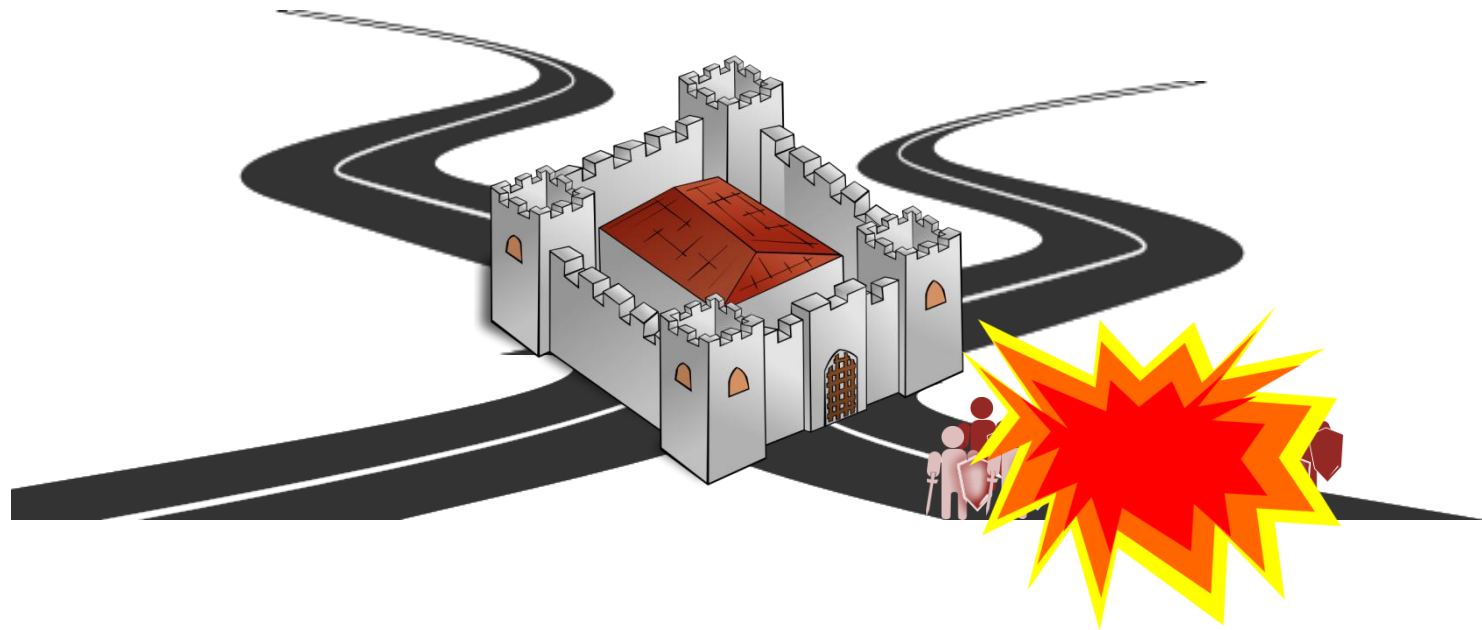


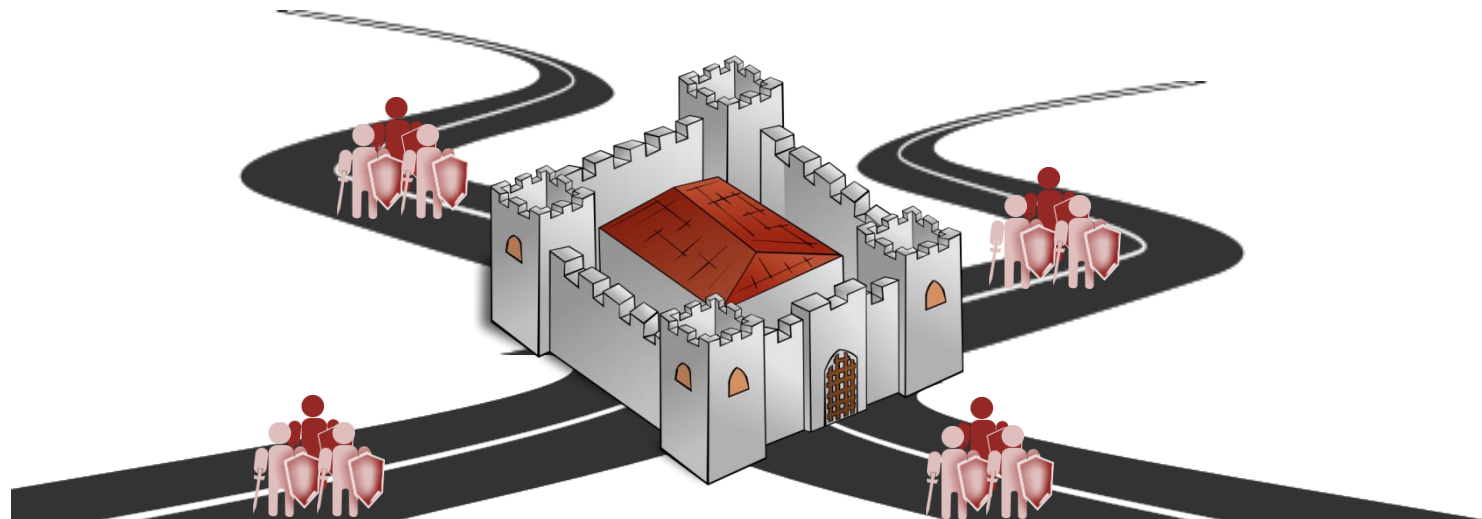
Route	Destination _X	Destination _Y
A	10 _E	8 _N
B	1 _E	8 _N
C	10 _E	4 _N
D	2 _E	1 _N
X	8 _E	2 _N
Y	8 _E	2 _N
Z	1 _E	9 _N

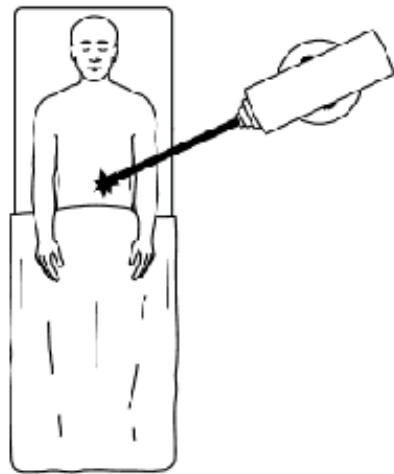


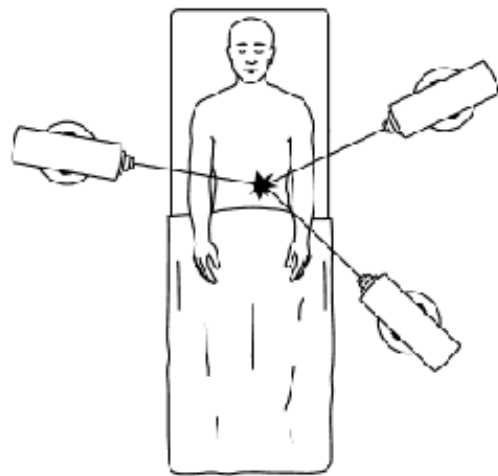




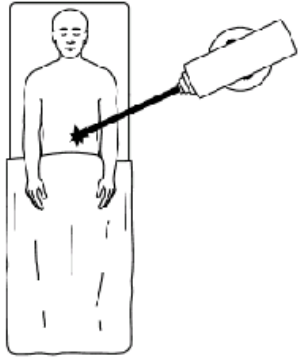




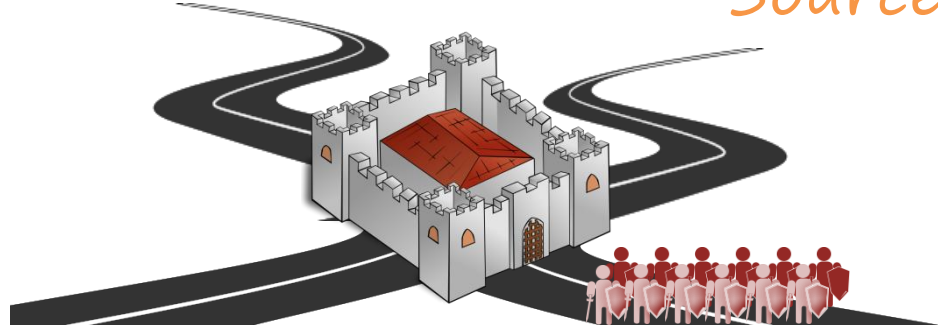




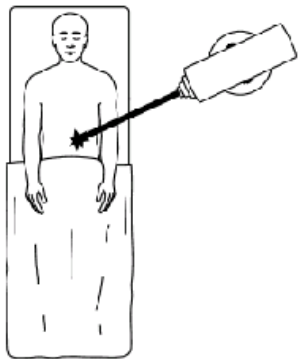
Target



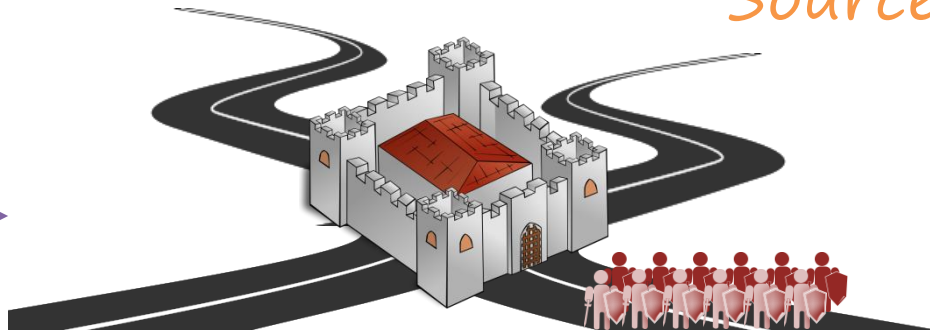
Source



Target



Source



More similar

Relations?

Objects?

Features?

Values?

*e.g. Recording
Cases*

Similar

Similar

Similar

Similar

*e.g.
Configuration*

Similar

Similar

Similar

Dissimilar

*e.g. Case-Based
Reasoning*

Similar

Similar

Dissimilar

Dissimilar

*e.g. Analogical
Reasoning*

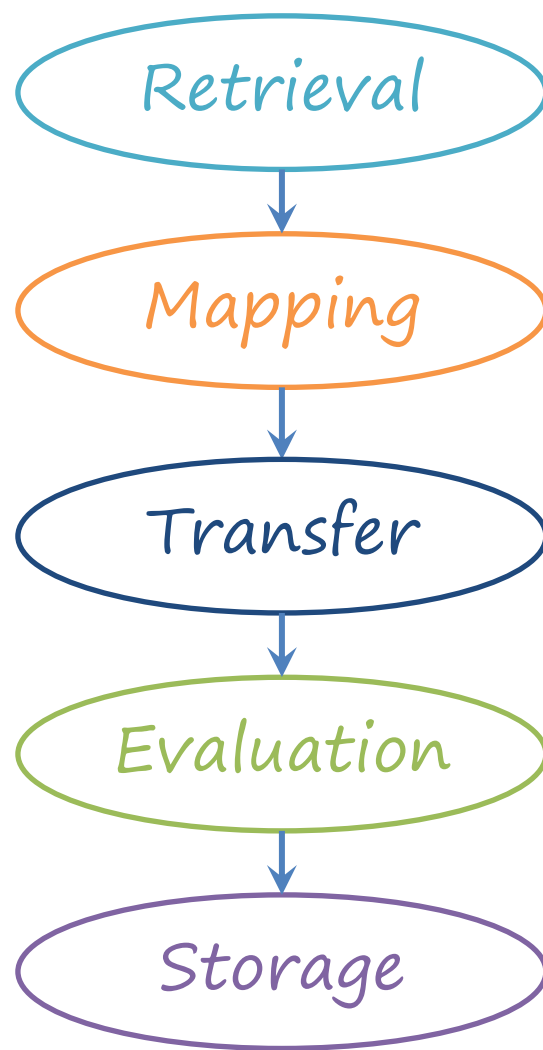
Similar

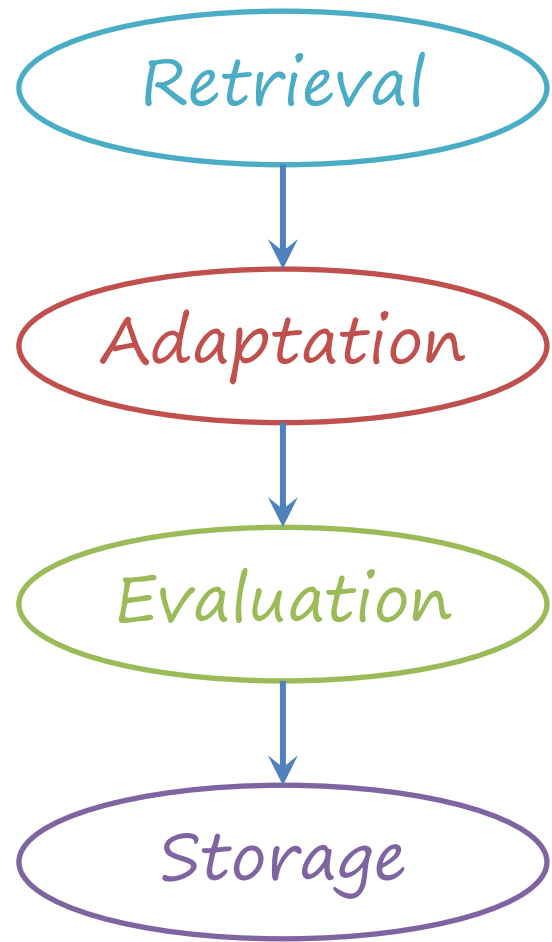
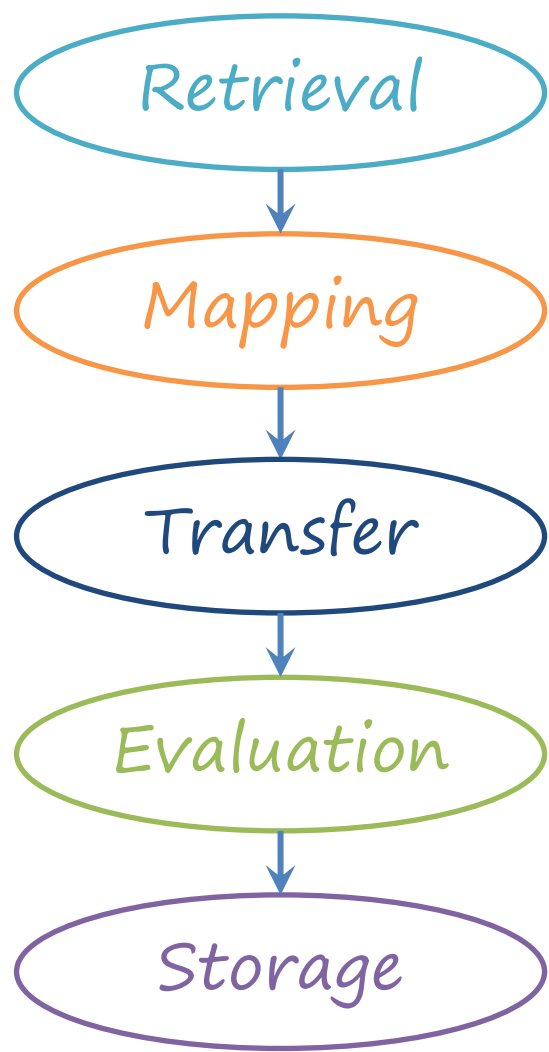
Dissimilar

Dissimilar

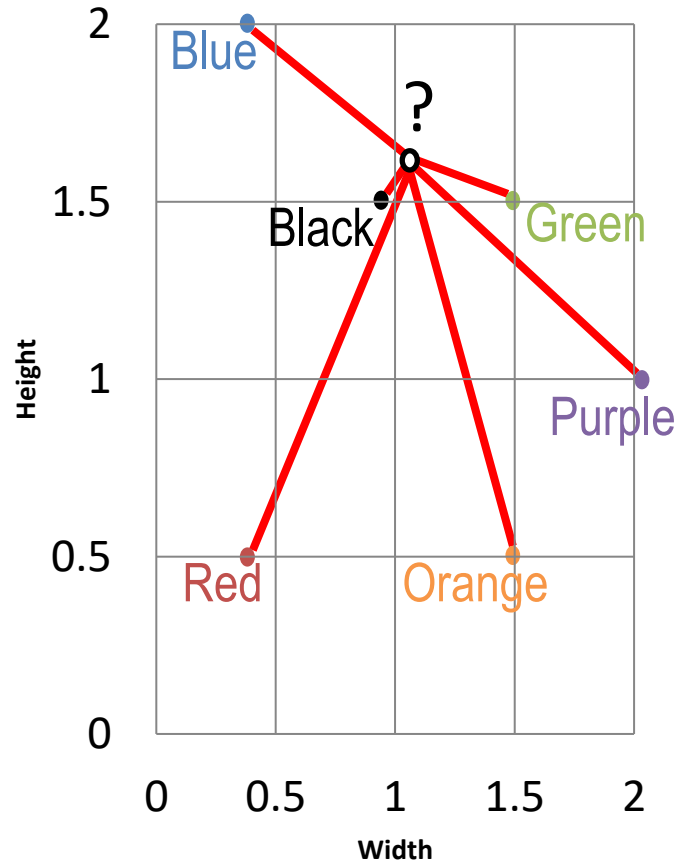
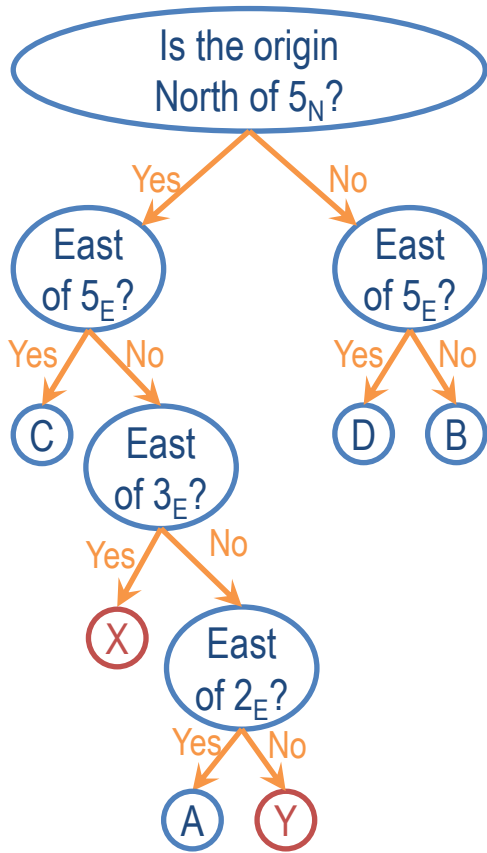
Dissimilar

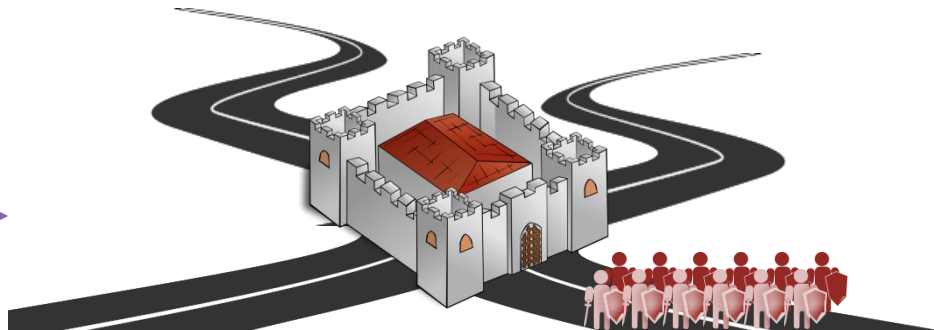
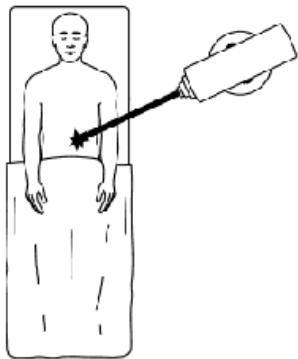
Less similar





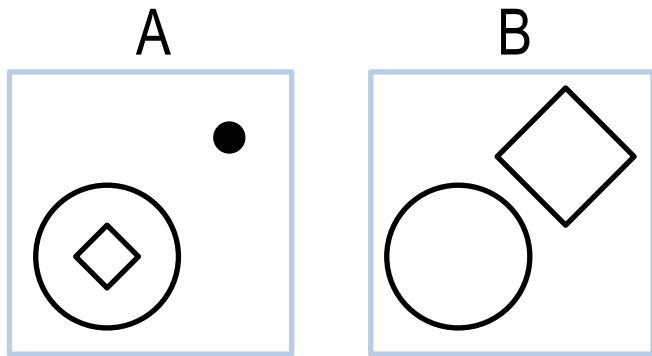
Route	Destination _x	Destination _y
A	10 _E	8 _N
B	1 _E	8 _N
C	10 _E	4 _N
D	2 _E	1 _N
X	8 _E	2 _N
Y	8 _E	2 _N
Z	1 _E	9 _N





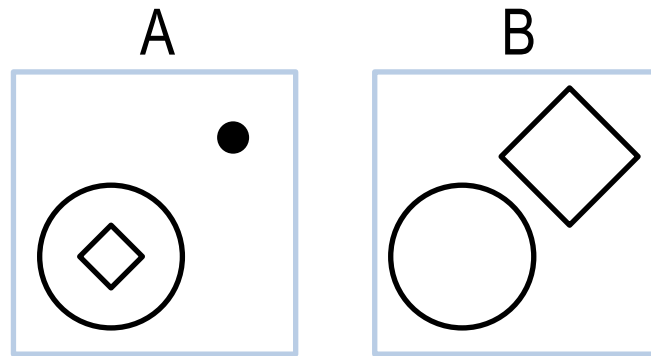
Superficial Similarity

- Features
- Counts
- Objects



Deep Similarity

- Relationships between objects
- Relationships between relationships



Types of Similarity

Semantic
Conceptual
similarity
between the
target problem
and the source
case.

Pragmatic
Similarity of
external factors,
such as goals.

Structural
Similarity
between
representational
structures.

A woman is climbing a ladder.

Mark whether each situation has deep similarity, superficial similarity, both, or neither with the situation above.

Deep

Superficial



A woman climbing a set of stairs.



An ant walking up the wall.



A woman painting a ladder.



A woman climbing the corporate ladder.



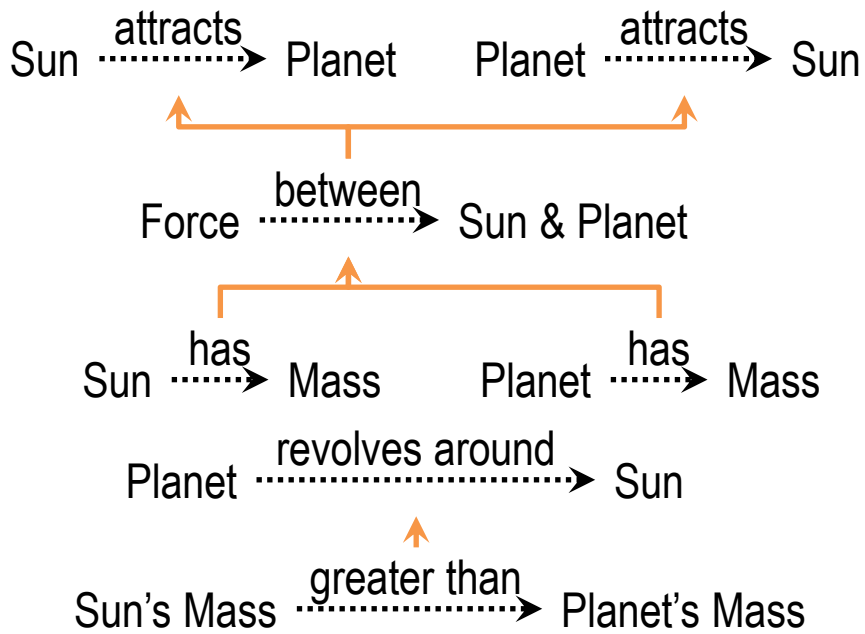
A water bottle sitting on a desk.



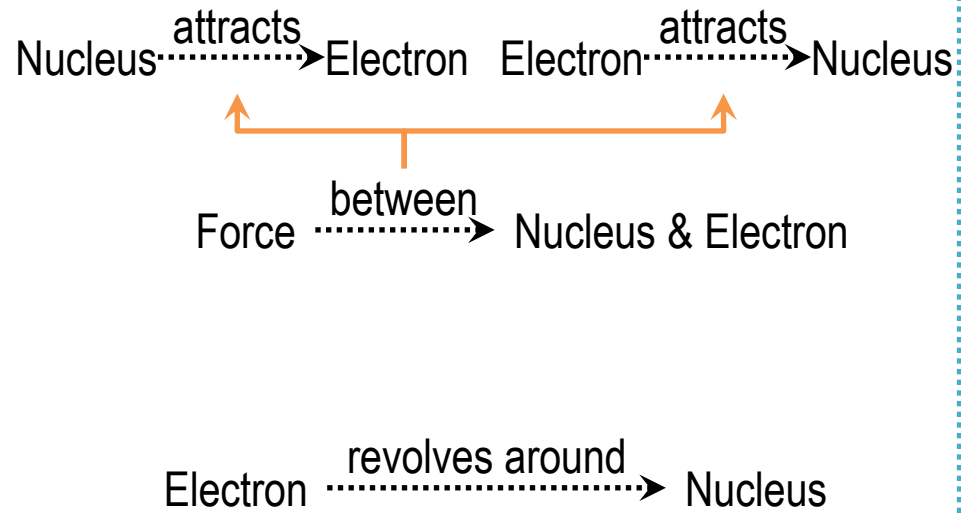
A woman climbing a step ladder.



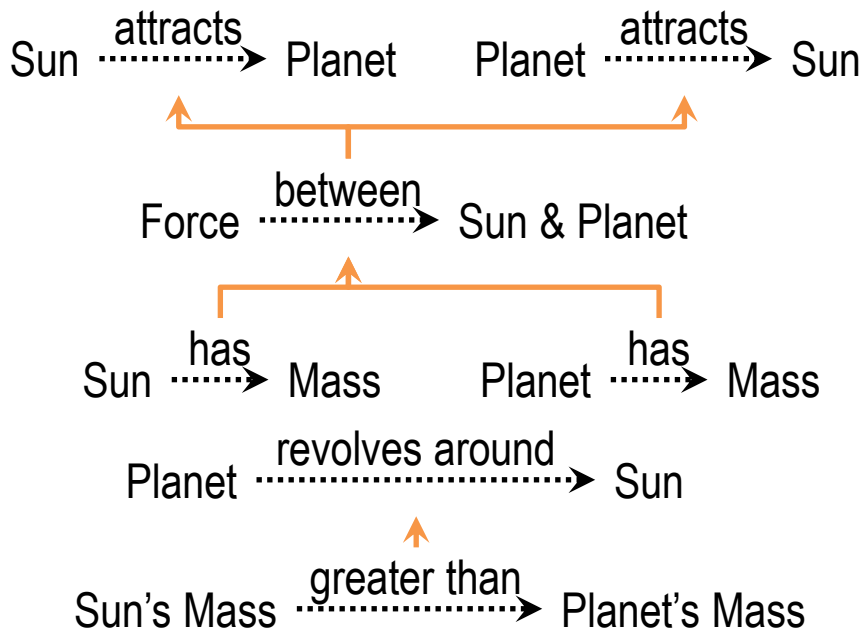
A plane taking off into the sky.



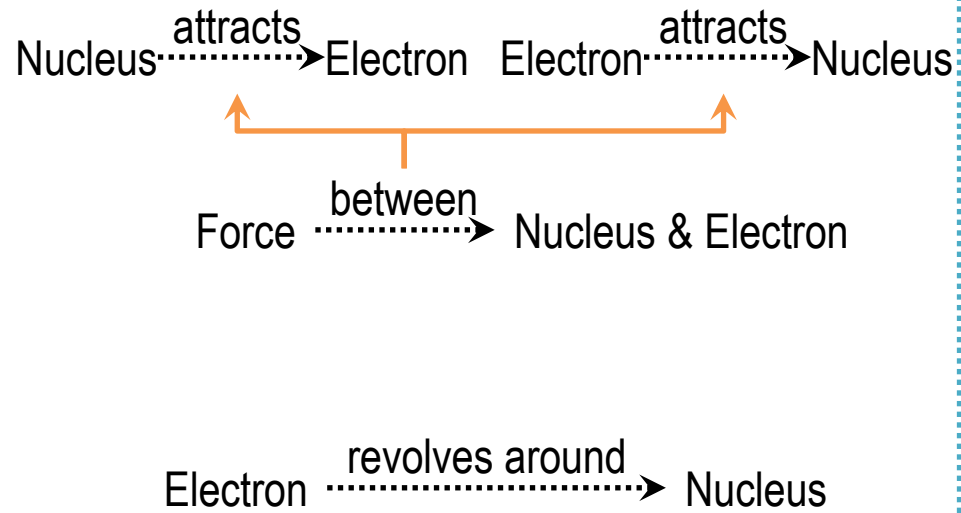
Solar System



Atomic Structure



Solar System



Atomic Structure

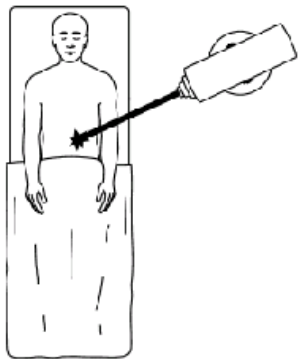
What are the deep similarities between these two models?

- Something revolves around something else.
- o Two things each have mass.

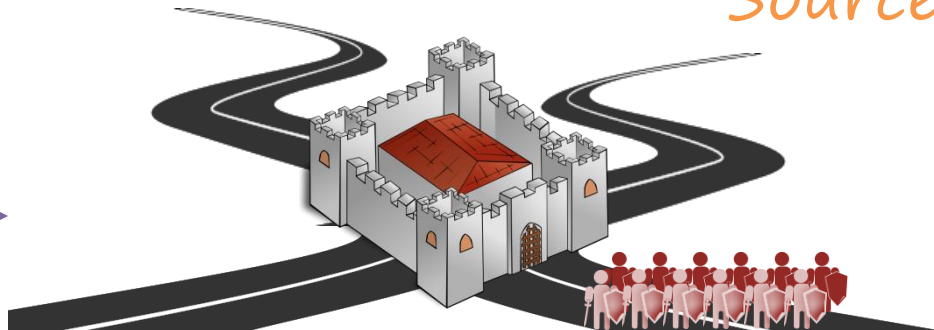
- o Mass & force are present.
- A force exists between two objects.

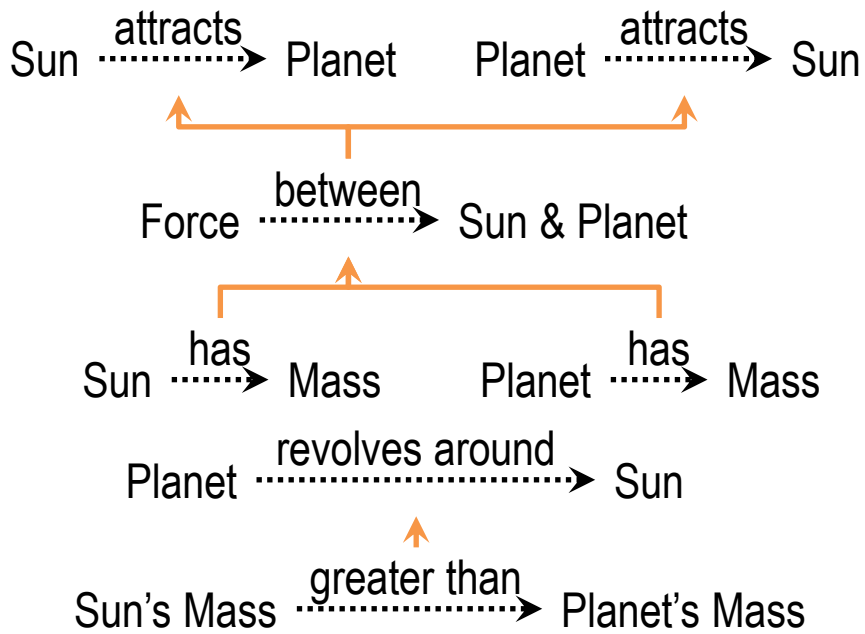
- o The objects' masses differ.
- Two objects attract each other.

Target

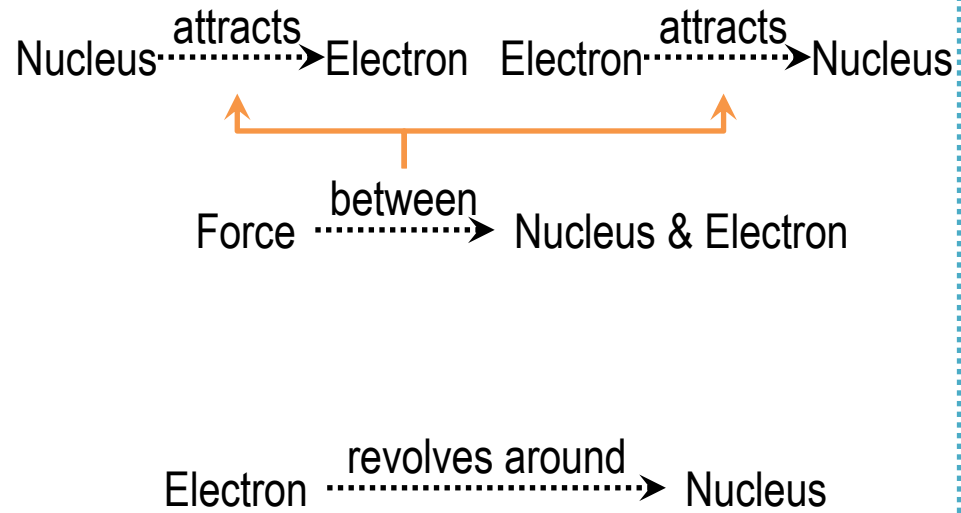


Source





Solar System



Atomic Structure

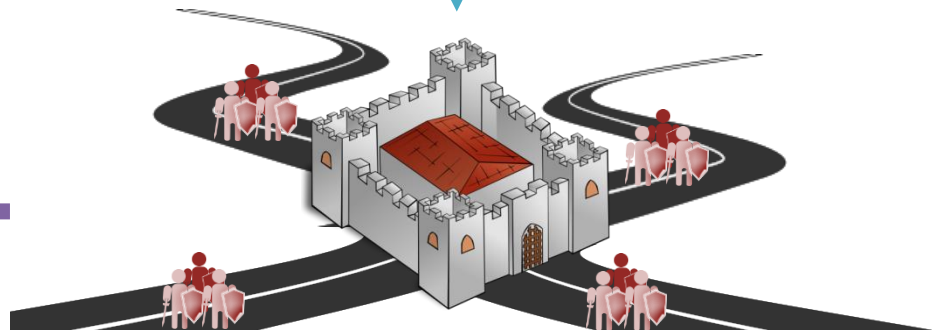
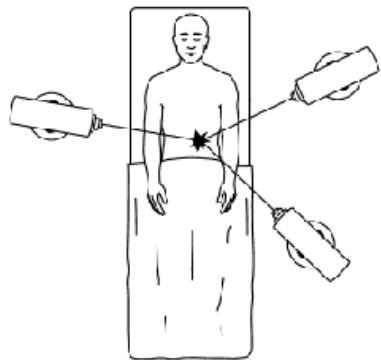
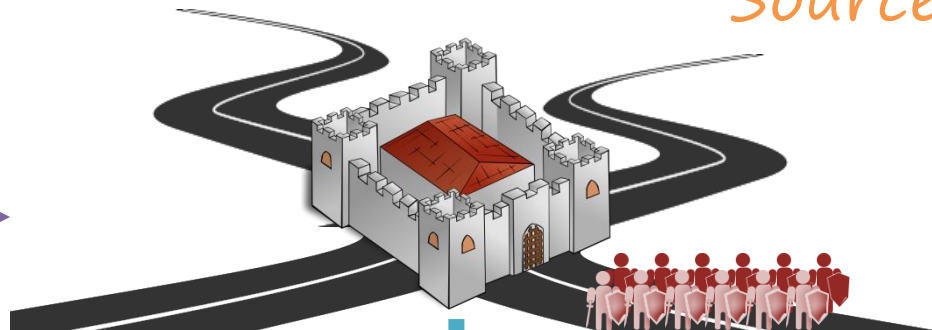
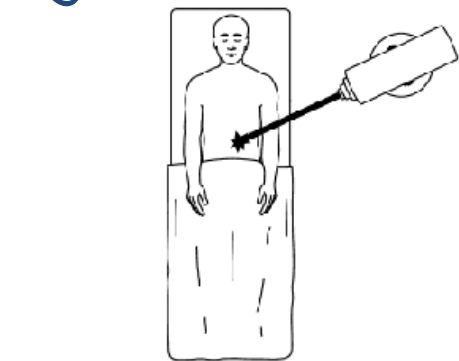
How would you map the solar system to the atomic structure?

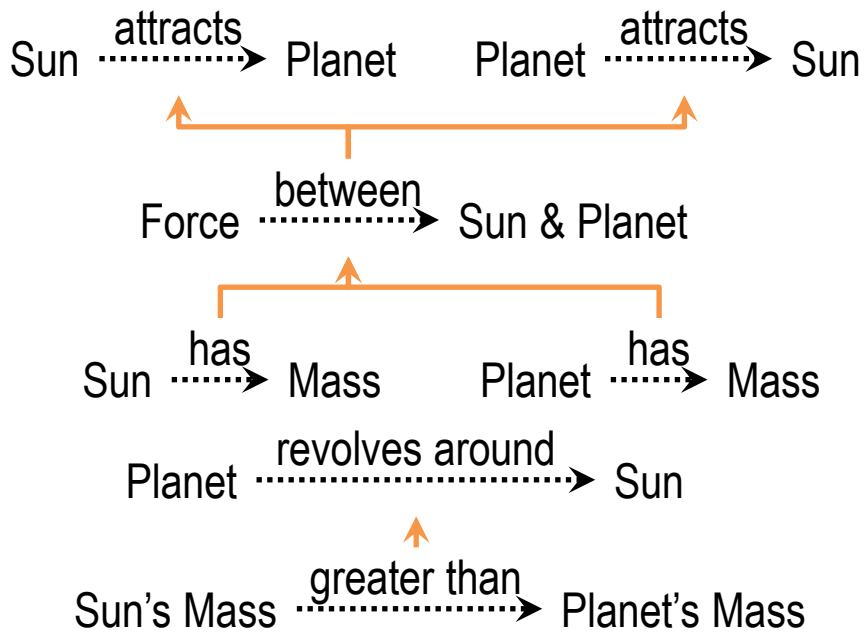
- Sun \rightarrow Nucleus
- Electron \rightarrow Nucleus
- Nucleus \rightarrow Sun
- Sun \rightarrow Planet
- Planet \rightarrow Electron

- Planet \rightarrow Sun
- Planet \rightarrow Nucleus
- Electron \rightarrow Planet
- Sun \rightarrow Electron
- Nucleus \rightarrow Planet

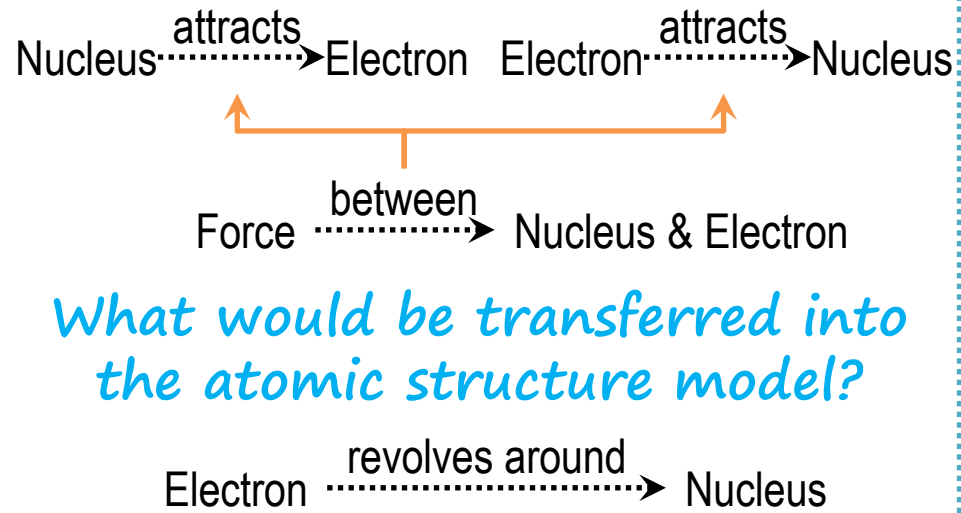
Target

Source





Solar System

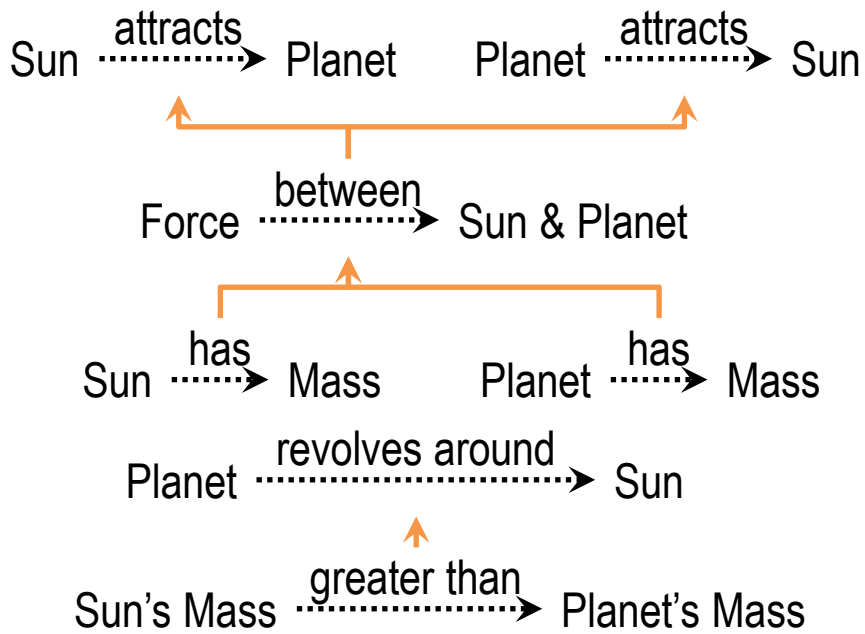


Atomic Structure

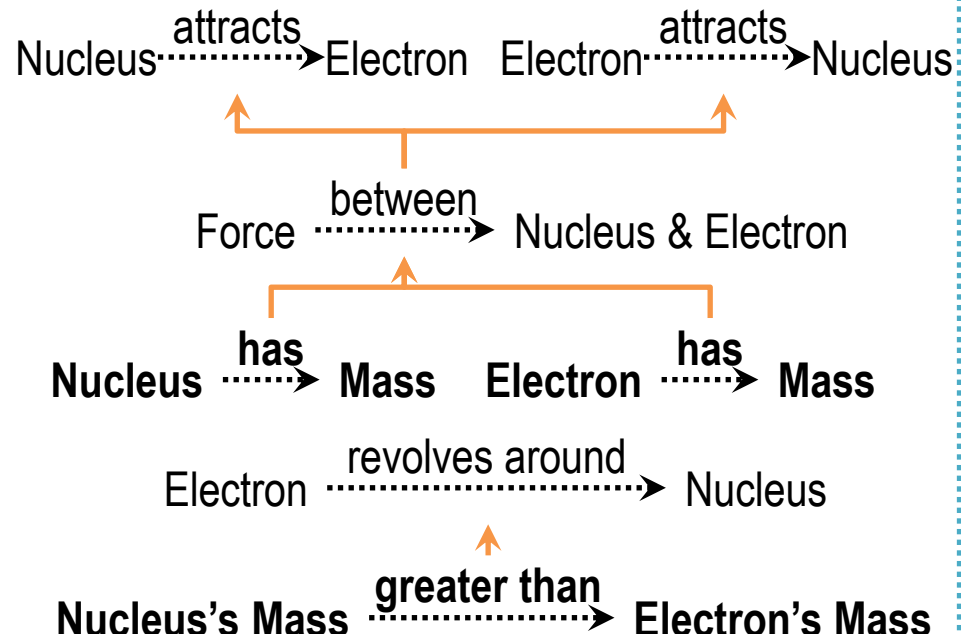
What would be transferred into the atomic structure model?

- Nucleus has mass
- Nucleus is a sun
- Nucleus attracts electron
- Electron's mass greater than nucleus's mass

- Electron revolves around nucleus
- Electron has mass
- Electrons are planets
- Nucleus's mass greater than electron's mass



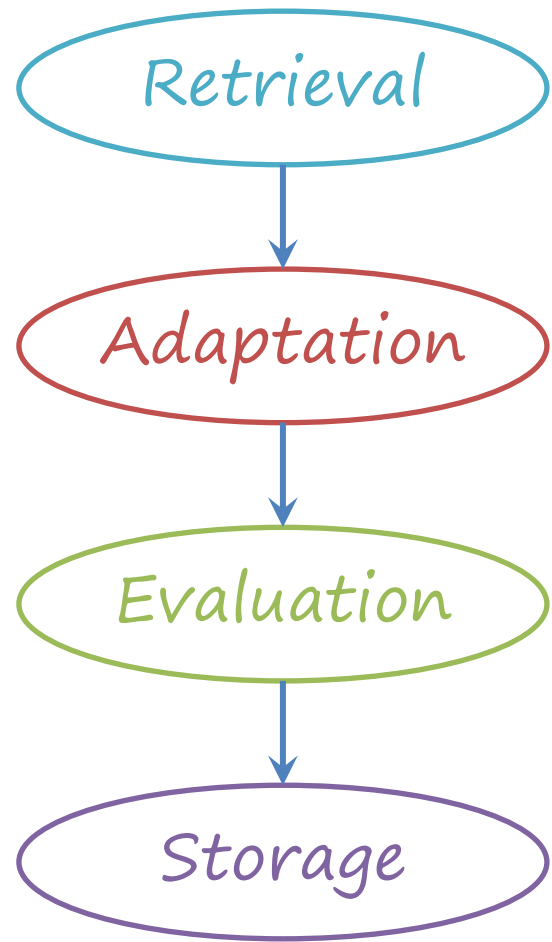
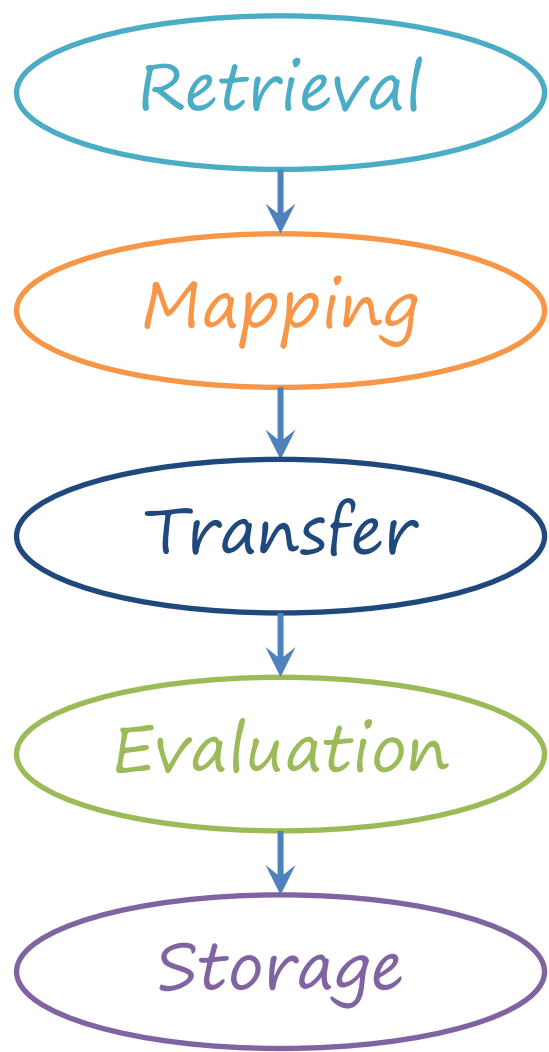
Solar System



Atomic Structure

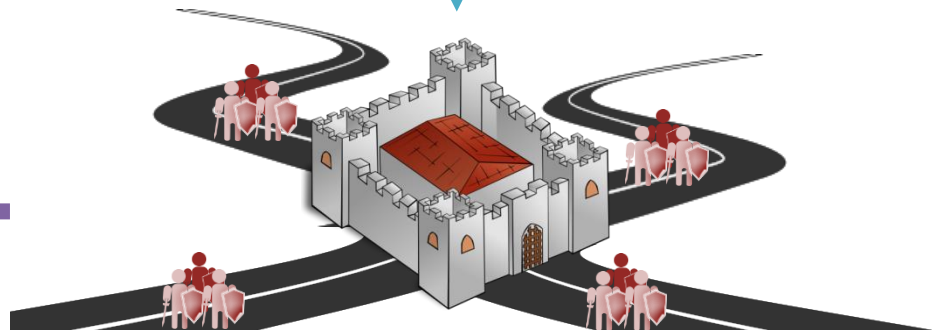
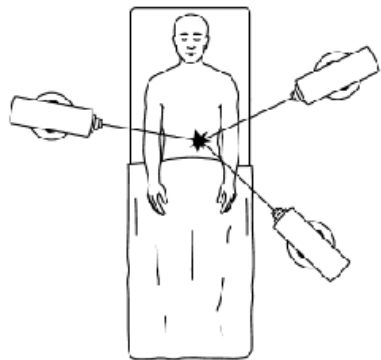
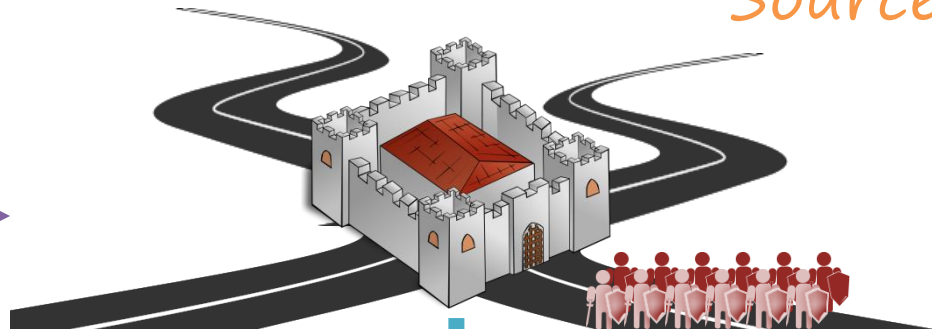
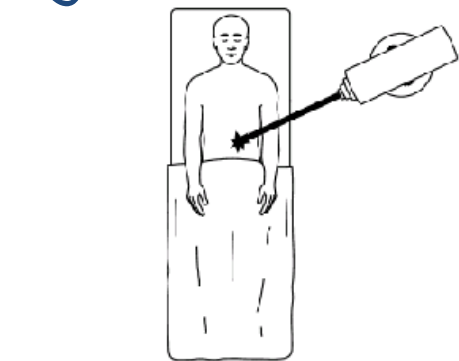
- Nucleus has mass
- Nucleus is a sun
- Nucleus attracts electron
- Electron's mass greater than nucleus's mass

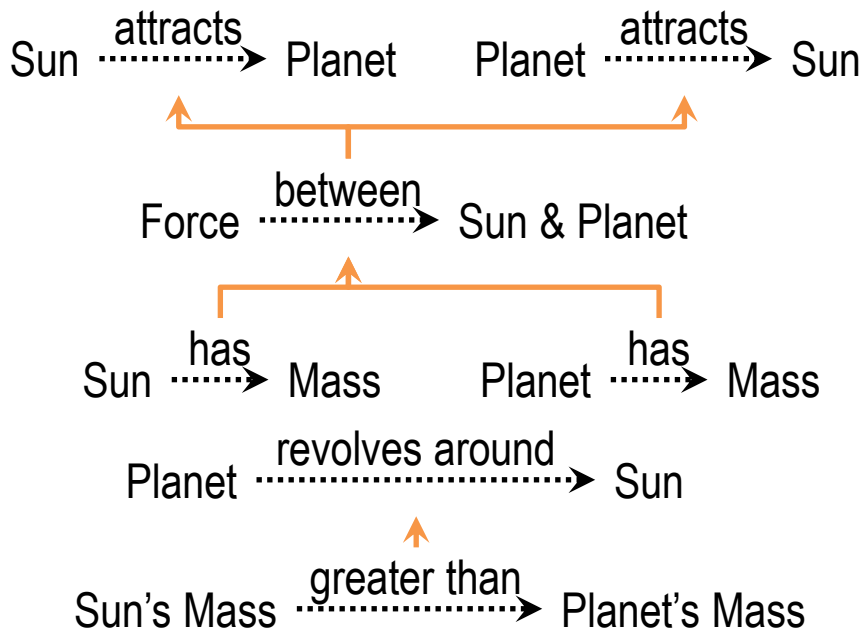
- Electron revolves around nucleus
- Electron has mass
- Electrons are planets
- Nucleus's mass greater than electron's mass



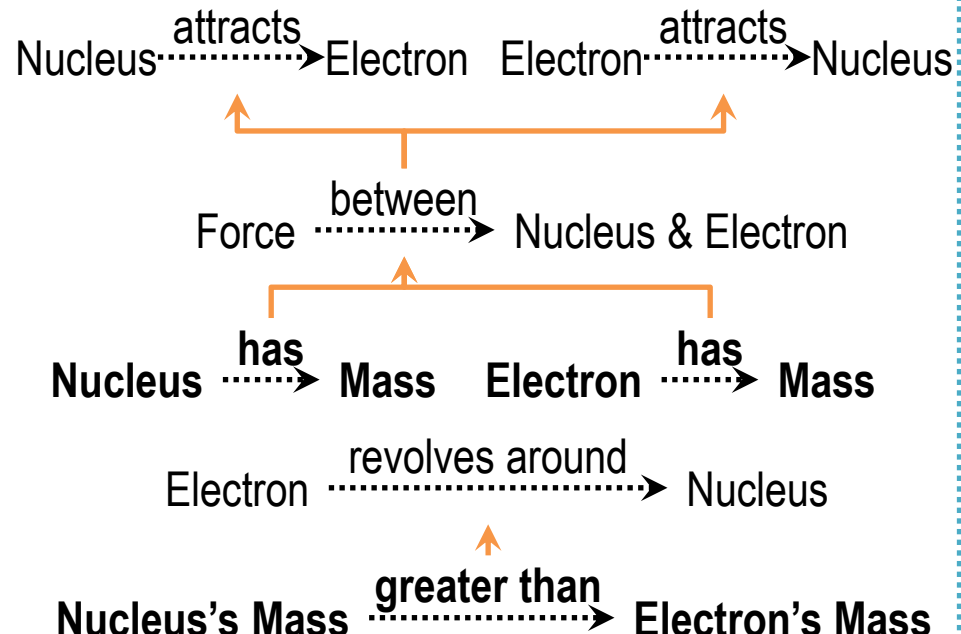
Target

Source





Solar System

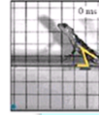


Atomic Structure



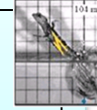


F: Walk on Water (Lizard)
Initial Cause: Muscle Movement



Pos: p1
Lift: 0
Thrust: 0
Leg
Shape: starting
Pos: above water

By-Behavior:
Bipedal motion on water

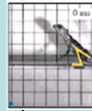


Pos: p2
Lift: 0 (4)
Thrust: 0 (2)
Leg
Shape: recover
Pos: above water

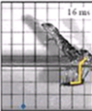
Behavior: Walk on Water

Structure: Lizard

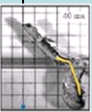
Pos: p1
Lift: 0
Thrust: 0
Single Leg
Shape: starting
Pos: above water



Pos: p1+Δp0
Lift: +1.13 (1.13)
Thrust: +.63 (.63)
Single Leg
Shape: slap
Pos: in water



Pos: p1+Δp1
Lift: +.39 (1.52)
Thrust: +.47 (1.10)
Single Leg
Shape: stroke
Pos: in water



Pos: p2
Lift: 0 (1.52)
Thrust: 0 (1.10)
Single Leg
Shape: recover
Pos: above water



Transition: Initial Slap

F: Leg Slap (Lizard)
Cause: Muscle Movement

F: Push Water Down & Away (Leg)
Principle: Fluid Dynamics

F: Exert Lift (Water)
Principle: Newtonian Physics

F: Exert Thrust (Water)
Principle: Newtonian Physics

Transition: Slap to Stroke

F: Leg Stroke (Lizard)
Cause: Muscle Movement

F: Push Water Down & Away (Leg)
Principle: Fluid Dynamics

F: Exert Lift (Water)
Principle: Newtonian Physics

F: Exert Thrust (Water)
Principle: Newtonian Physics

Transition: Stroke to Recover

F: Leg Recover (Lizard)
Cause: Muscle Movement

F: Transform Air Pocket to Vortex (Water)
Principle: Fluid Dynamics

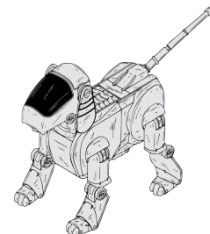
Substance: Water

Lift: 0
Thrust: 0

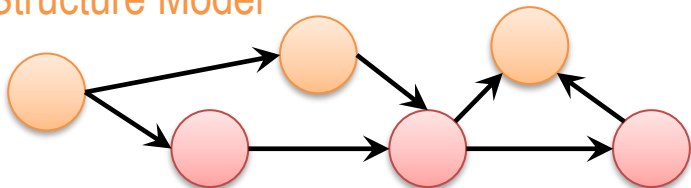
Lift: -1.13 (-1.13)
Thrust: -.63 (-.63)
Air Pocket
Shape: shallow depression
Pos: below leg

Lift: -.39 (-1.52)
Thrust: -.47 (-1.10)
Air Pocket
Shape: deep depression
Pos: behind leg

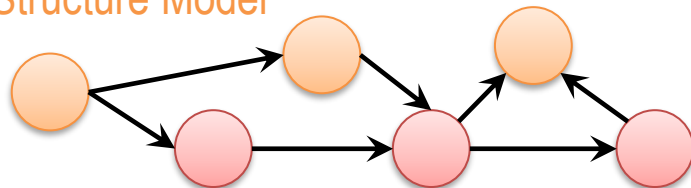
Lift: 0 (-1.52)
Thrust: 0 (-1.10)
Vortex
Shape: ring
Pos: far behind leg



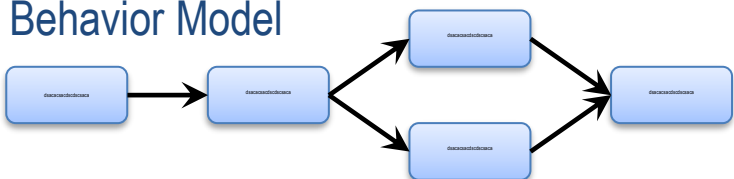
Structure Model



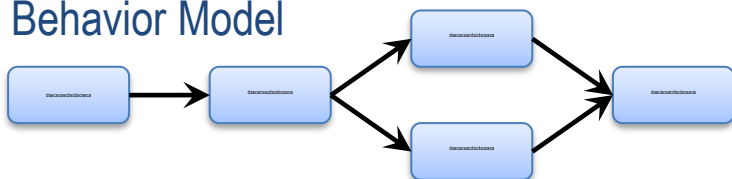
Structure Model



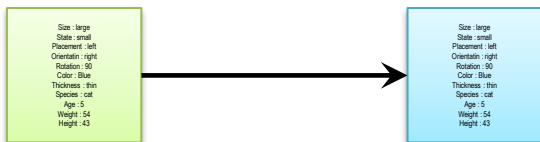
Behavior Model



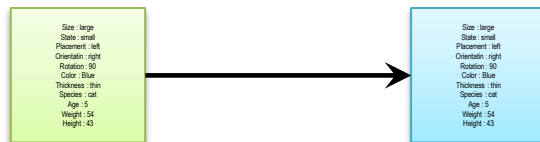
Behavior Model

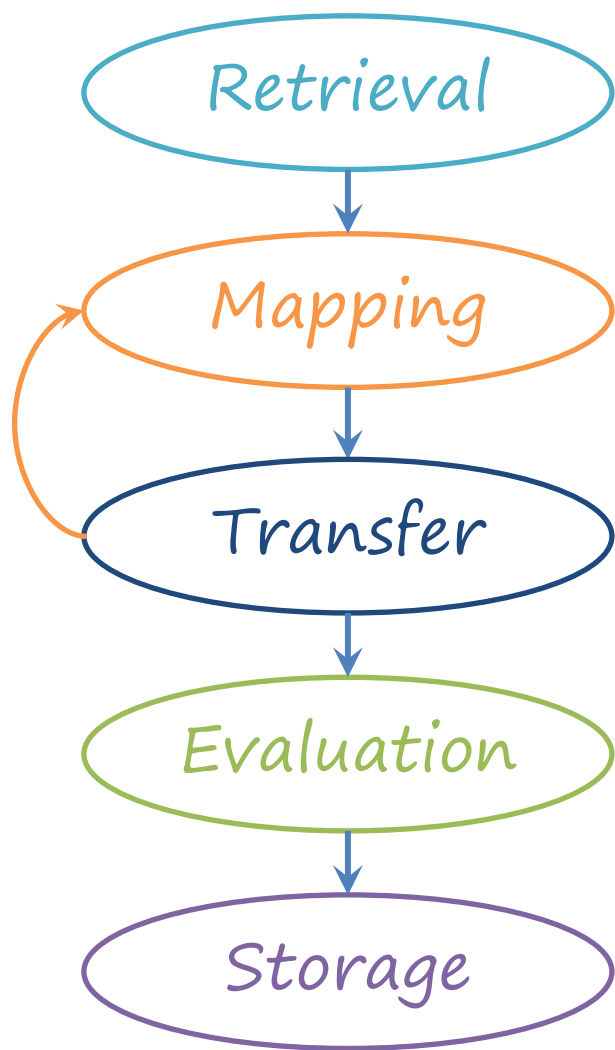


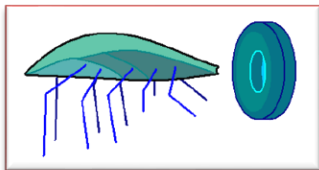
Function Model



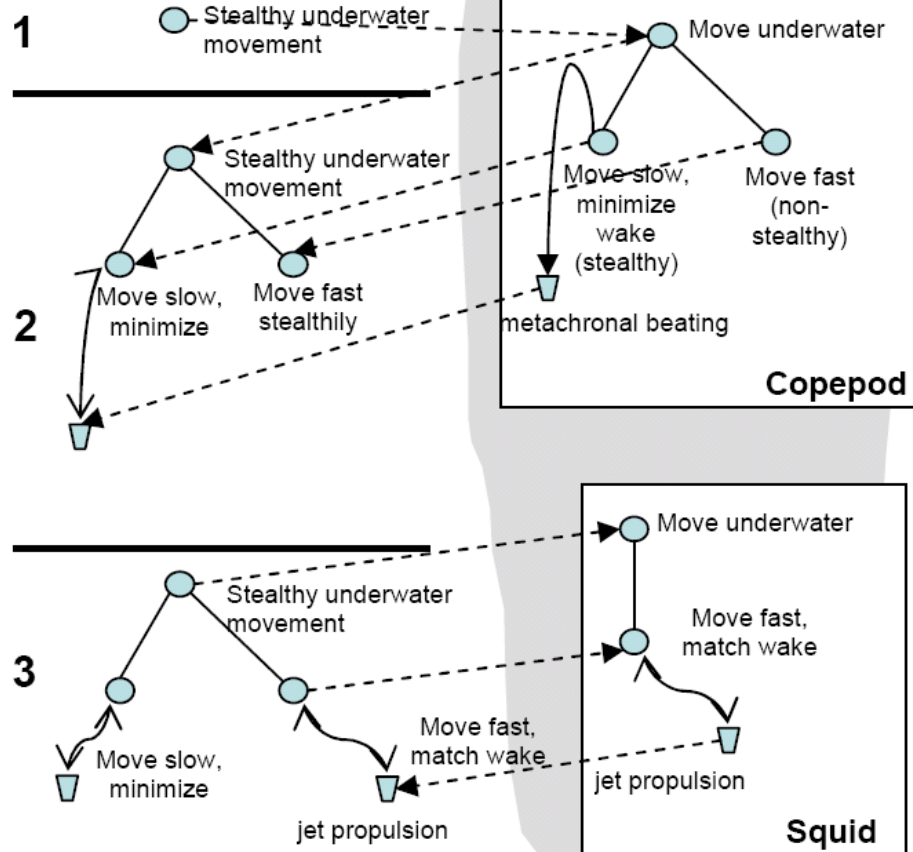
Function Model

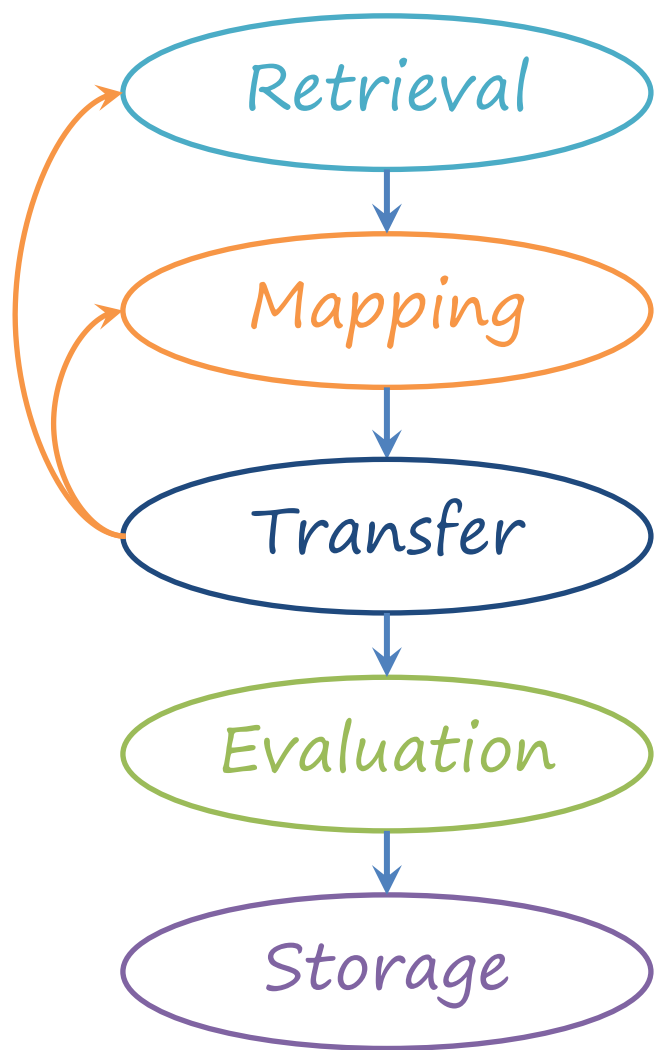


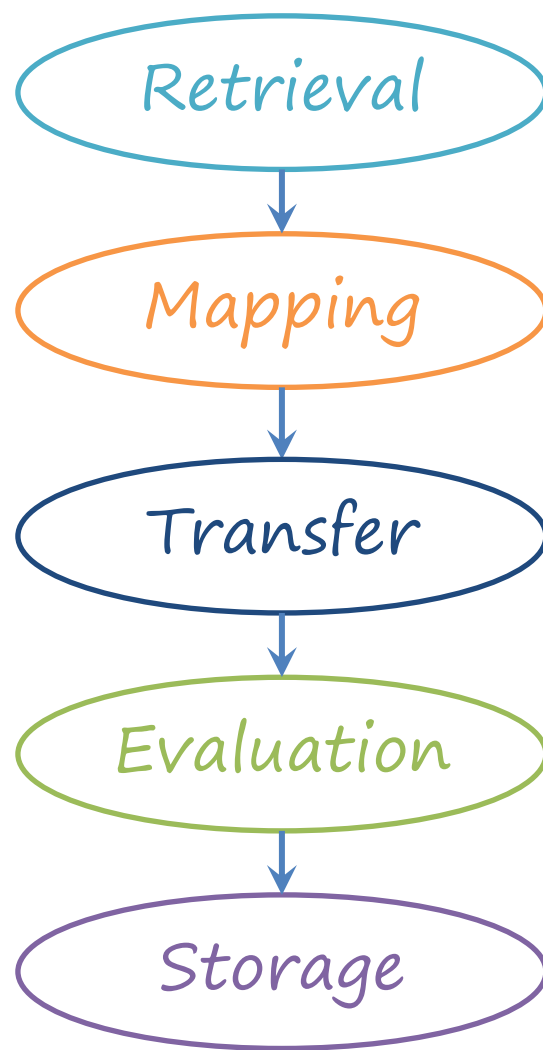


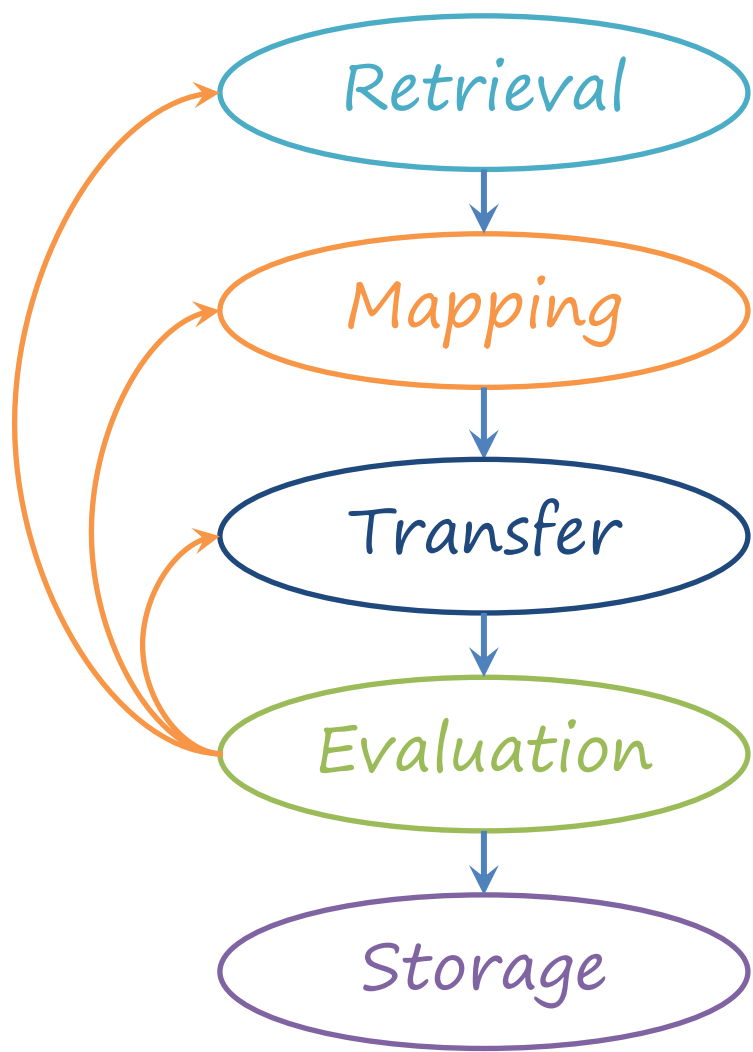


Analogue









Advanced questions in analogical reasoning

- Common vocabulary
- Abstraction and transformation
- Compound and compositional analogies
- Visuospatial analogies
- Conceptual combination

Assignment

How would you use analogical reasoning to design an agent that could answer Raven's progressive matrices?

To recap...

- Similarity
- Analogical retrieval
- Analogical mapping
- Analogical transfer
- Evaluation and storage
- Design by analogy