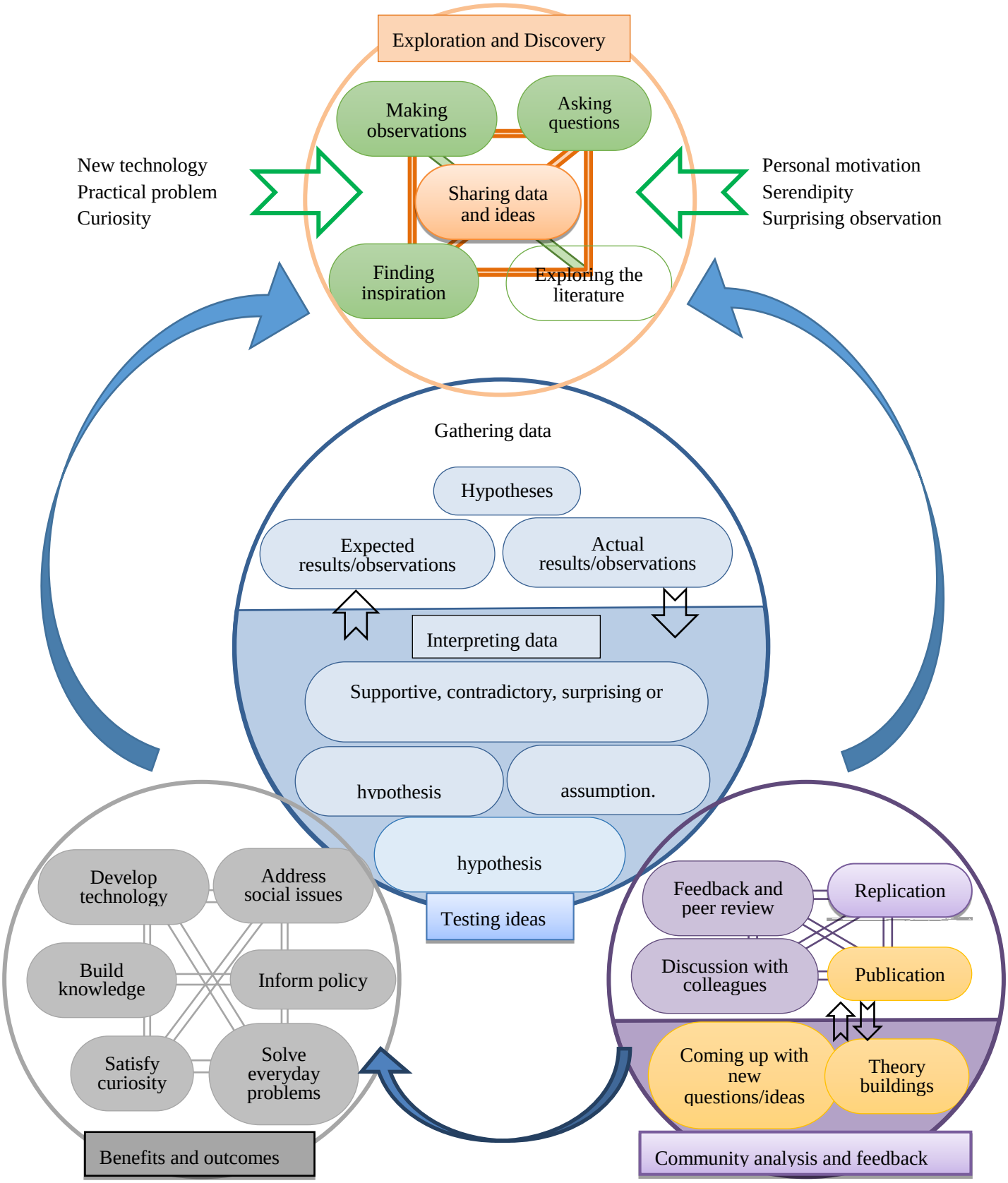
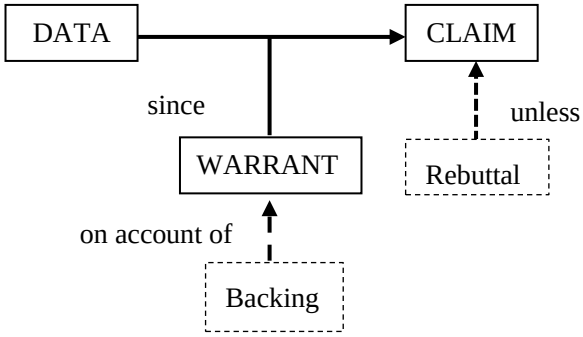
1. How science works

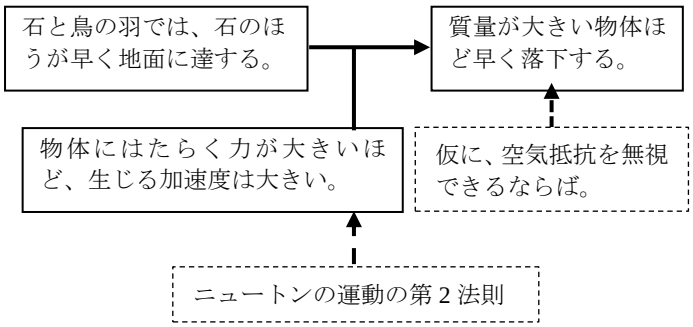


How
2013<http://undsci.berkeley.edu/article/scienceflowchart>

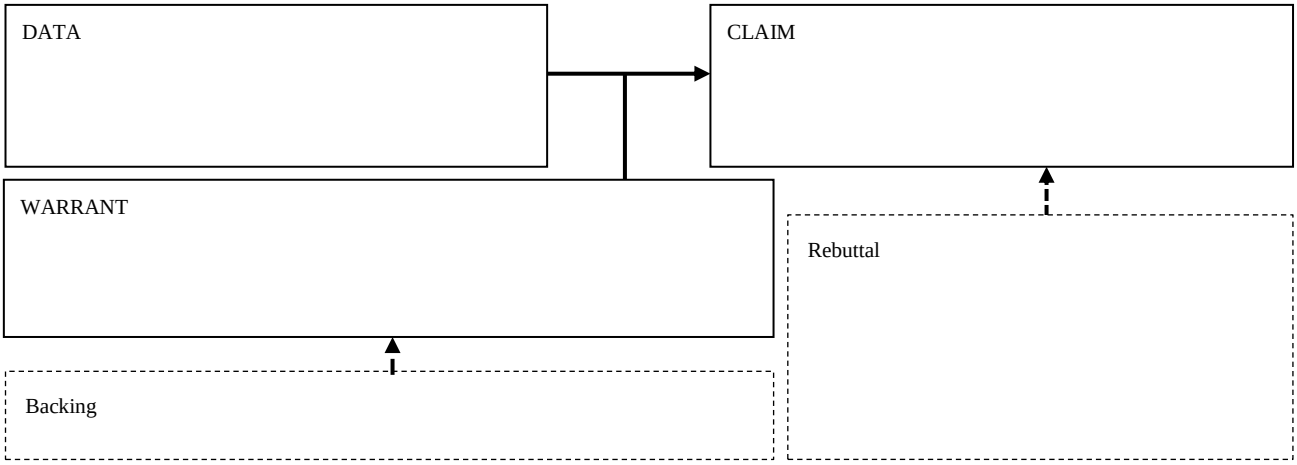
2. Structure of argumentation

T **Example**





A Toulmin amework for argumentation



Example1: Competing theories

Theory 1: Light rays travel from our eyes to the objects and enable us to see them.

Theory 2: Light rays are produced by a source of light and reflect off objects into our eyes so we can see them.

Which of the following pieces of evidence supports Theory 1, Theory 2, both or neither.

Discuss.

A Light travels in straight lines.

B We can still see at night when there is no sun.

C Sunglasses are worn to protect our eyes.

D If there is no light we cannot see a thing.

E We stare at people, look daggers and catch people s eye .

F You have to look at something to see it.

Weak argument

We must see because light enters the eye. You need light to see by. After all, otherwise we would be able to see in the dark.

Stronger argument

Seeing because light enters the eye makes more sense. We can t see when there is no light at all. If something was coming out of our eyes, we should always be able to see even in the pitch dark. Sunglasses stop something to see it is because you need to catch the light coming from that direction. The eye is rather like a camera with a light-sensitive coating at the back which picks up light coming in, not something going out.

Explanation (Claim)
Evidence (Data)
Reasoning (Warrants)
Rebuttal
Backing

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Example2: Understanding an argument

Which of the following arguments provide good evidence that matter is made up of particles, and why?

A Air in a syringe can be squeezed.

B All the crystals of any pure substance have the same shape.

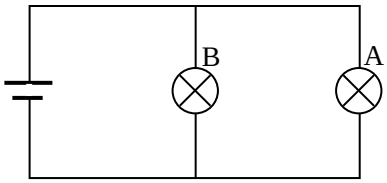
C Water in a puddle disappears.

D Paper can be torn into very small pieces.

Explanation (Claim)
Evidence (Data)
Reasoning (Warrants)
Rebuttal
Backing

Example 3: Experimental data

Example4: Predicting, observing and explaining



Bulb A and Bulb B are two identical bulbs.

Which will happen to the brightness of lamp B when lamp A is unscrewed?

Discuss in your group and give reasons for what you think will happen.

Explanation (Claim)
Evidence (Data)
Reasoning (Warrants)
Rebuttal
Backing

Reference; Jonathan Osborne, Sibel Erduran, Shirley Simon, Martin Monk, *Enhancing the quality of argument in school science*, School Science Review, June 2001,82(301) pp.63-70

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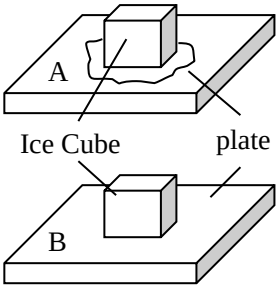
Example 5-1: The Ice-Melting Blocks Problem

On the table in front of you are two different types of metal plates. One is made of cupper; A and the other is made of aluminum; B. Place an ice cube on each plate and watch how long it takes for the ice cube to melt on each of these plates. Use the data provided to you in order to answer the following research question:

Why does the ice melt faster on cupper plate; A?



Material	Density (g/cm^3)	Specific heat(J/(g·K)	Electrical resistivity (·m)×10^{-8}	Melting point( )	Thermal conductivity (W/(m·K))
cupper	8.93	0.38	1.55	1084.5	403
aluminum	2.69	0.90	2.50	660.37	236

Explanation (Claim)
Evidence (Data)
Reasoning (Warrants)
Rebuttal
Backing

Example 5-2: Why Do Objects Feel Different Problem

Examine the following data table. It provides information about five different objects that have been sitting in the same room for 24 hours. The thermostat on the wall is set at 23 .

Object	Mass (g)	Density (g/mL)	Temperature)	How It Feels	Thermal Conductivity	Temperature Change When Placed in a 65 Over for 15 Minutes ( )
Metal Spoon	48	7.4	23.0	Cold	High	26
Pencil	20	0.7	23.1	Warm	Low	17
Empty Glass	64	2.6	23.0	Cool	Medium	21
Styrofoam Cup	34	0.01	23.0	Warm	Low	14
Penny	5	8.9	22.9	Cold	High	34

Use this information to answer the following research question:

Why do some objects feel hotter or colder than others even though they have been sitting in the same room for long periods of time?

Explanation (Claim)
Evidence (Data)
Reasoning (Warrants)
Rebuttal

Reference: VICTOR SAMPSON, DOUGLAS CLARK, *The Impact of Collaboration on the Outcomes of Scientific Argumentation*, Science Education, 2008, pp.448-484

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