

# Making science familiar with figurative language: autobahn, bypass, or cul-de-sac?

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SUMMER SYMPOSIUM ON SCIENCE EDUCATION



Taber, K. S. (2024) Making science familiar with figurative language: autobahn, bypass, or cul-de-sac? Invited presentation: Summer Symposium on Science Education organised by Ludwig-Maximilians-Universität München / University of Bremen (online)

This presentation presents a simple model encompassing different forms of figurative language used in communicating science, and consider the requirements for using familiar comparisons to introduce science concepts.

# Plan of talk

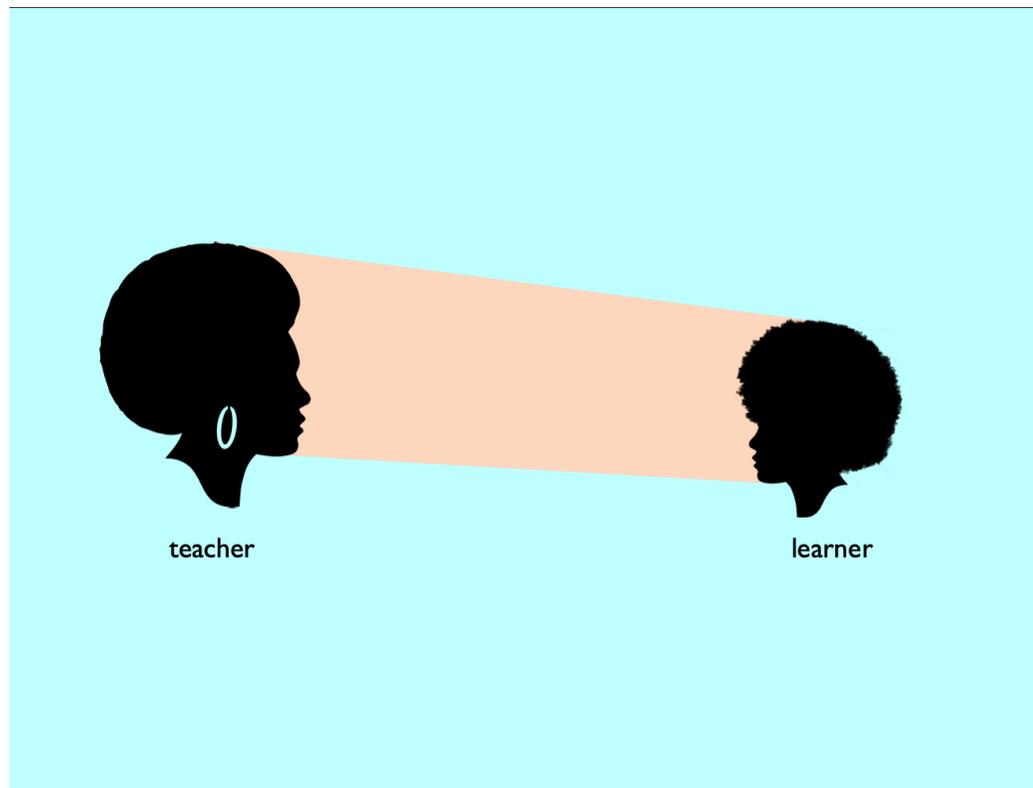
Motivation: teaching as  
making the unfamiliar  
familiar

The teacher-learner system  
and the role of  
interpretation

Types of figurative language

Interpreting some  
examples





The focus is here is on teaching as requiring the learner to appreciate the teacher's meanings.

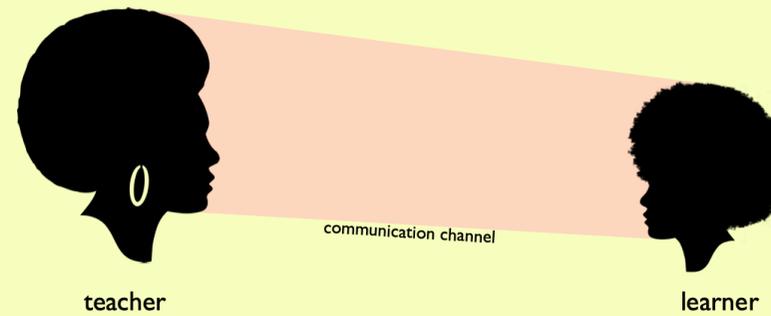
# Motivation

Teaching is about making the unfamiliar familiar

by pointing, showing, modelling, gesturing, telling, narrating,  
simulating...



# The teacher-learner system



The communication channel may simple mean the learner watching and listening to a teacher in class (which requires a clear view, low level of background noise, etc)., but it could be via a video link etc.

# A text...

has no inherent meaning

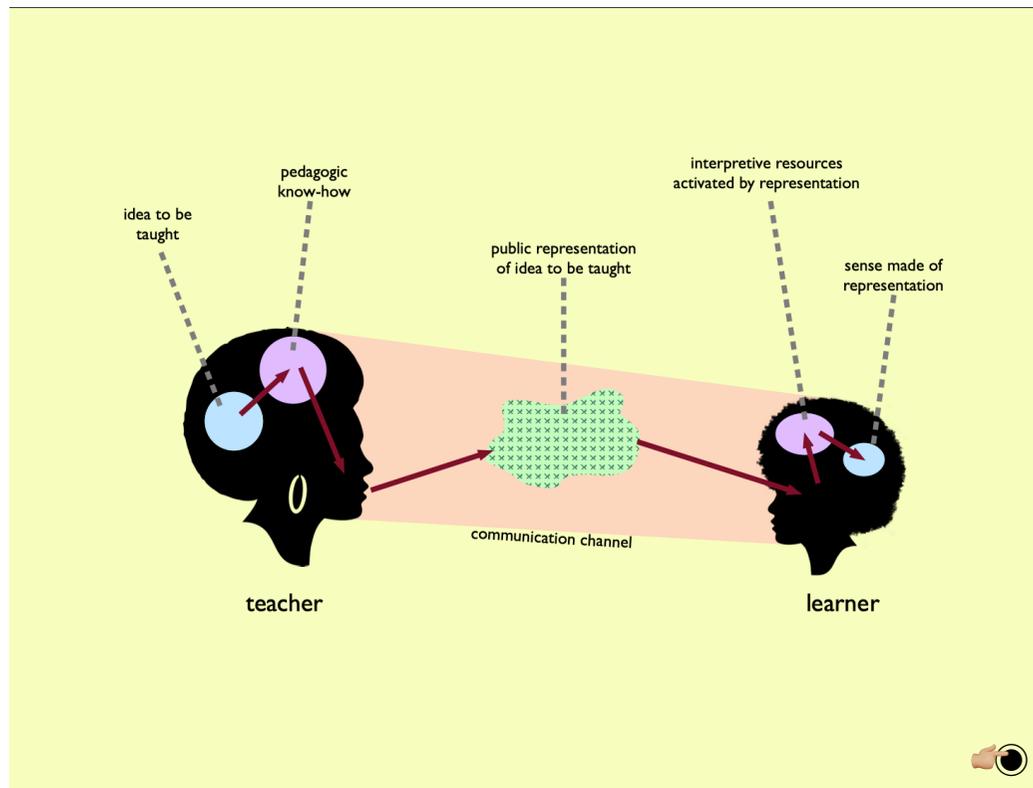
may have an intended meaning

may have an interpreted meaning

*(may have multiple interpreted meanings)*

these need not be the same





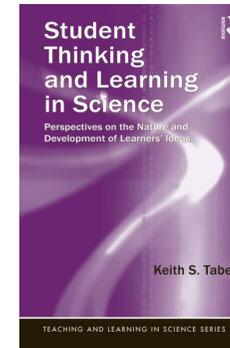
What is publicly available is not the teacher's ideas, but a representation of them (in speech drawing etc.) that the learner has to make sense of, drawing on the mental 'interepretive resources' they have available.

# learning is

incremental

interpretive

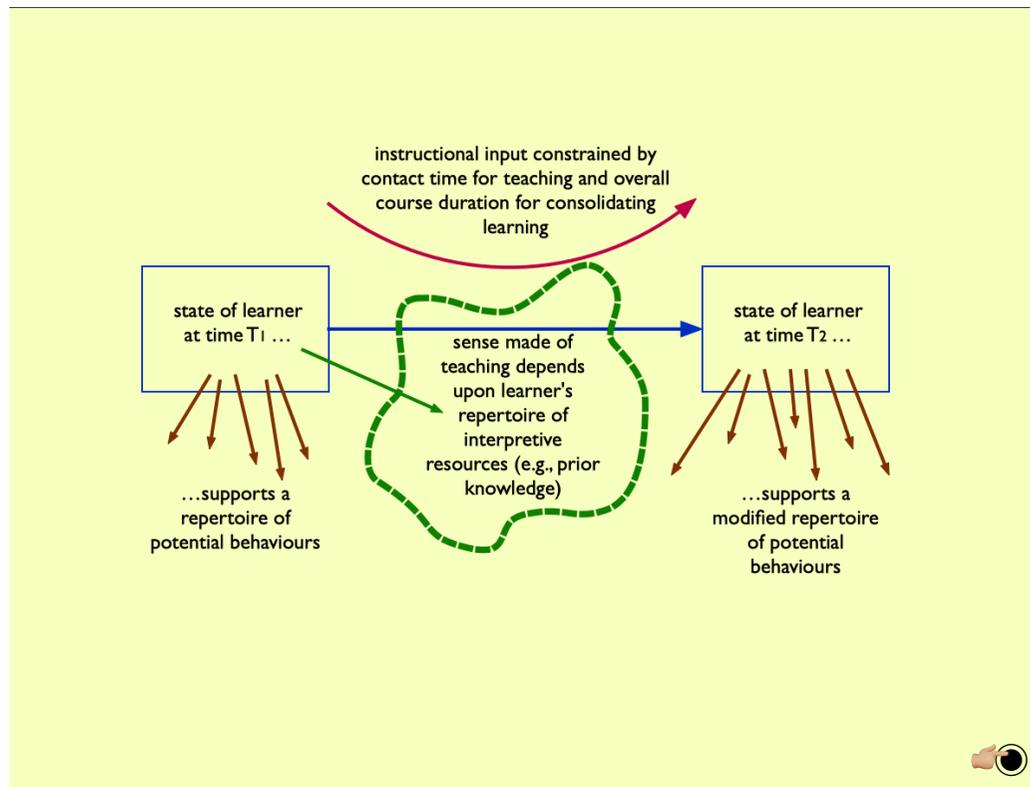
iterative



## A Constructivist Perspective

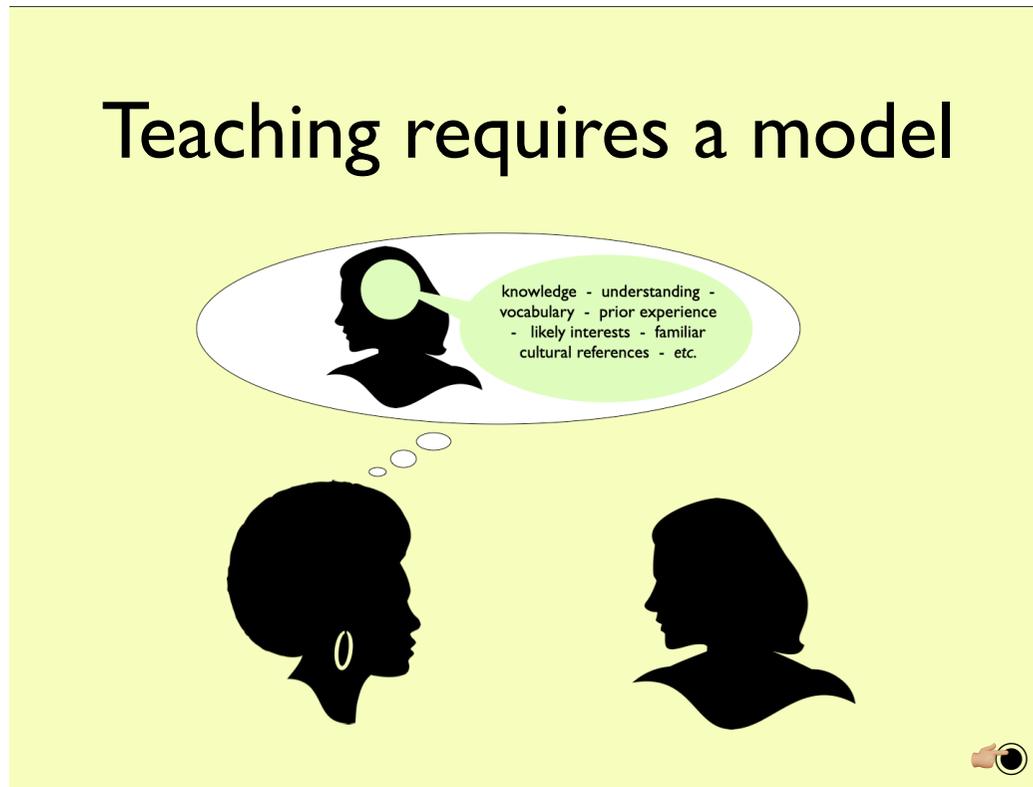
Put simply, the constructivist perspective rejects the notion of the learner as computer-like device with an input channel that allows a large amount of data to be fed in, and a memory store that can keep neatly catalogued and discrete inputs for future reference. Instead the apparatus of human cognition is understood quite differently (and indeed more in keeping with what research in cognitive psychology and the learning sciences suggest is really going on). Learning is seen as being iterative, interpretive, and incremental.





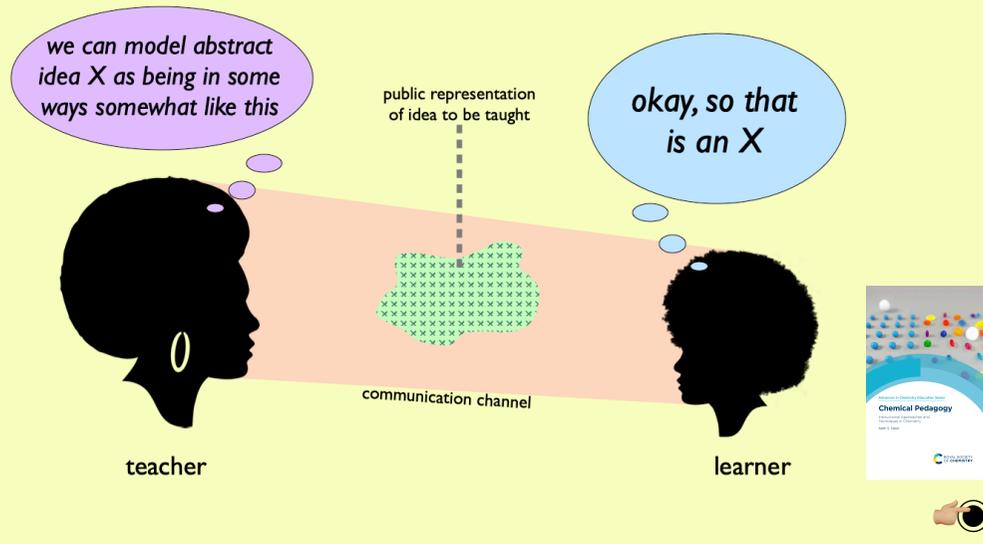
The learner's set of interpretive resources is developed by teaching - but also determines how that teaching is understood. (That is, misinterpretation can happen, leading to new misconceptions. Newly acquired interpretive resources can then themselves lead to misinterpreting subsequent teaching.)

# Teaching requires a model



Effective teaching relies on the teacher having a mental model of the learner, so to represent ideas in ways the learner is ready to make sense of.

# learners may lack *epistemological* sophistication





## Figurative language



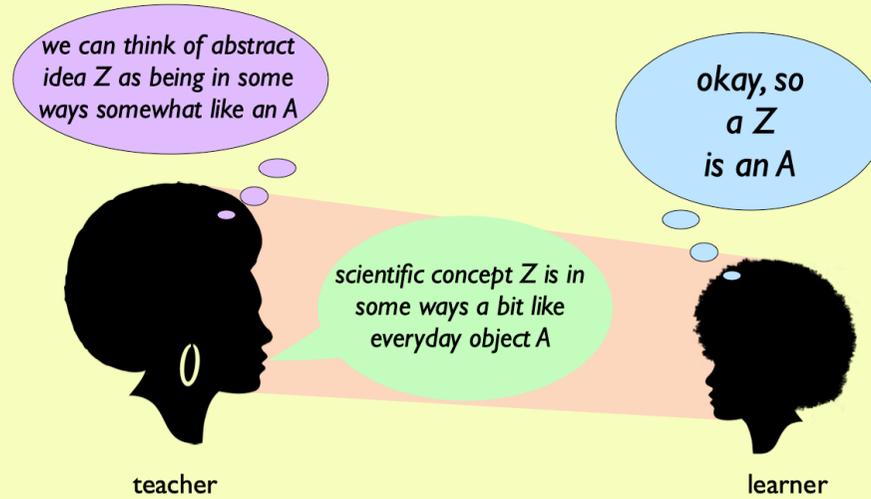
**autobahn - fast, direct route**

**bypass - avoids slow roads  
and traffic (but by missing  
the town)**

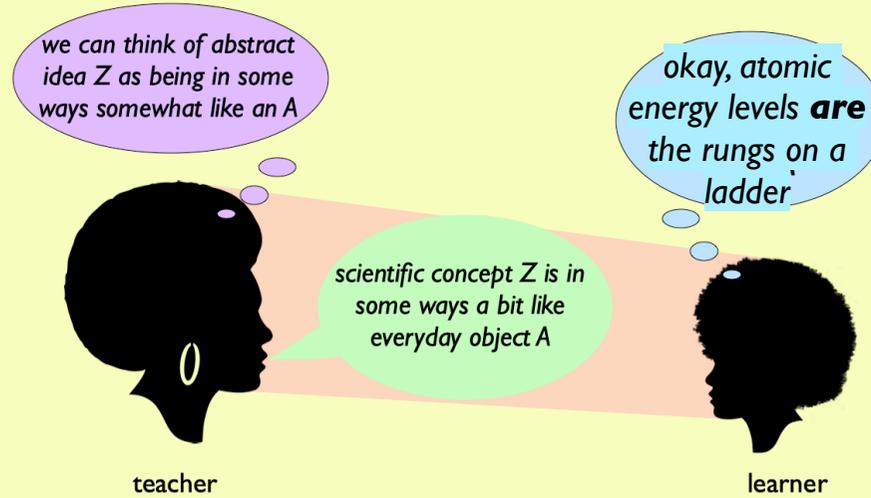
**cul-de-sac - road that does  
not lead you anywhere**

My title makes use of figurative language, offering metaphors for possible teaching-learning outcomes.

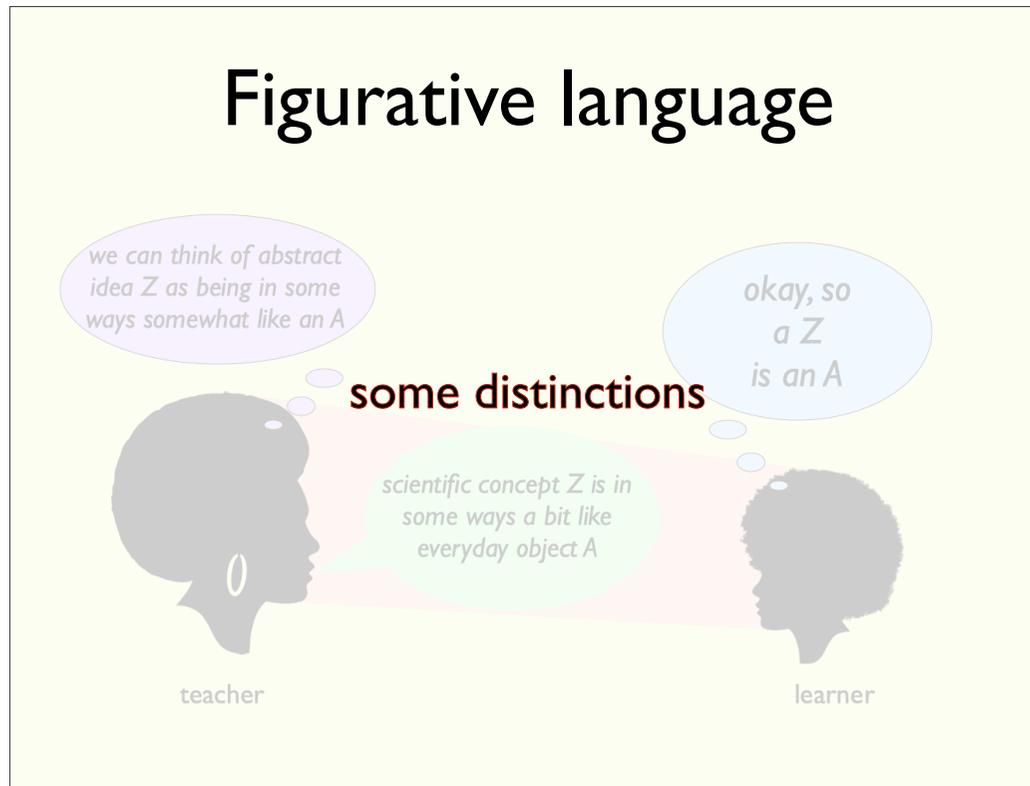
# Figurative language



# Figurative language



# Figurative language



I am going to offer a simple model of types of figurative language used to communicate science.

# Figurative language

simile

Starting with simile.

# simile

*...is like a...*

*...as a...*

simile

*...is, so to speak / in a manner of speaking / so to say, a...*

*...is a '...'...*

*...kind of...*

*...sort of...*



# simile

*...is like a...*

*...-like...*

*...as a...*

simile

*...is, so to speak / in a manner of speaking / so to say, a...*

*...is a '...'...*

*...kind of...*

*...sort of...*



# simile

*...is like a...*

*...-like...*

*...as a...*

simile

*...is, so to speak / in a manner of speaking / so to say, a...*

“*...hair-like...*

*wire-like...*

*vase-like...*

*urn-like...*

*...is a ‘...’...*

*necklace-like*

*...kind of...*

*...cushion-like*

*...sort of...*

*...wart-like...”*



# Figurative language

adjectives: tall, strong,  
flexible, labile, bright,  
powerful, indistinct,  
colourless...

simile

*adjectivised nouns*

nouns: membrane, lance...

“...hair-like...wire-like...vase-like...urn-like...necklace-  
like...cushion-like...wart-like...”

“...yellowish brown membranaceous lanceolate scales...”

# Figurative language

adjectives: tall, strong,  
flexible, labile, bright,  
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simile

*adjectivised nouns*

nouns: membrane, lance...

“...hair-like...wire-like...vase-like...urn-like...necklace-  
like...cushion-like...wart-like...”

membrane-like

“...yellowish brown membranaceous lanceolate scales...”

lance-like



# Figurative language

“For example, the *Vaucheria sessilis* consists of one long branched cell; on the same side of it two swellings appear near to each other, one of which elongates, curls round **like a horn**, and is soon filled with **snake-shaped** filaments having long cilia at their thin end, with which they move rapidly both within the horn, and after they come out of it into the water.”

# Figurative language

“They appear in large expansions of red, golden yellow, grey or white, on barren heaths, under plantations, and on the stems of aged trees; while others of them often hang from the branches like long shaggy grey hair, and many form forests of miniature bushes on the northern plains.”

# Figurative language

“The order Calicieae consists of horizontal lichens, with generally an ill-developed crust; the discs, which are at first covered by a veil, are contained in a stalked, or more rarely sessile, excipulum, **looking like little flat headed pins** stuck into the crust; the veil at length vanishes, and exposes a pulverulent mass of spores, which adhere so loosely in the *Calicium inquinans*, that they soil the finger if touched; in other cases they come out of their ascus **like little necklaces.**”

# Figurative language

“This is the youthful state of the *Marchantia polymorpha*, but after a time green points appear from under little reddish scales on the surface, and these are developed into stalks an inch or less in height, which terminate differently, some in lobed shields, others in spoked whorls, **like a carriage wheel without the rim**”

# Figurative language

Mary Somerville (1869). *On Molecular and Microscopic Science*

these types of similes are  
descriptive and generally clear

but they *rely on shared cultural  
references*



# Figurative language

“The fertile fronds, in certain groups, differ in form from the sterile, generally by the greater or less contraction of their parts. In most ferns the full-grown fronds are flat, that is, with all their parts lying in one plane; but, during their vernation, that is, when they first rise from the stem, they are circinate or curled inwards, **like a crosier**”

**simile**

**genes and genetics**

- *bands in prepared chromosomes* (Required: Decoding four billion years of life, from ancient fossils to DNA)
- *dead viruses sit like courtiers* (Required: Decoding four billion years of life, from ancient fossils to DNA)
- *gene was like molecular typewriter* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)
- *genetic control regions are like room thermostats* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)
- *genome is like a graveyard filled with ghosts* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)
- *genome resembles a musical score* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)
- *outbreak of disease is like a breach in a force field* (The Remedy: Robert Koch, Art Doyle, and the quest to cure tuberculosis)
- *radiation inducing mutations is like bombing* (Mario Bunge)
- *Sonic hedgehog gene is a general purpose tool* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)

**nucleic acids**

- *DNA strands attract like magnets* (Professor Anne Ferguson-Smith, University of Cambridge)

**physics**

- *physics cannot be distilled by induction* (Albert Einstein)

**physiology**

- *Mastocyst is like a feral animal* (Immune: How your body defends and protects you)
- *brain area is like a junction box* (The Drugs That Changed Our Minds)
- *damaged nerves sort of scream* (BBC Inside Science)
- *placenta acts like a gatekeeper* (Prof. Rebecca Reynolds, University of Edinburgh)
- *sensory organs serve as a sieve* (Jakob von Uexküll)

**plants**

- *labellum is shaped like the mouth of a decoy* (Charles Darwin)
- *leaf canopy serves as an umbrella* (Jakob von Uexküll)

**radioactivity and nuclear reactions**

- *a nuclear chain reaction is like an avalanche* (Max Planck)

**Solar system**

- *comets are the fluff of the solar system* (Catching Stardust: Comets, asteroids and the birth of the solar system)
- *optical mirring sweeps water from asteroids and comets* (Catching Stardust: Comets, asteroids and the birth of the solar system)

**waves**

- *a high-frequency wave is like a Toblerone bar* (Explaining Humans: What science can teach us about life, love and relationships)
- *a low-frequency wave is similar to a loosely coiled snake* (Explaining Humans: What science can teach us about life, love and relationships)

**elementary particles can be organised into kinship groups** (The Dream Universe: Fundamental physics lost its way)

**alternative conceptions are like weeds** (William Gilbert)

**interferons languished in a sort of scientific Siberia** (British Journal of Clinical Pharmacology)

**splitters and lumpers are the two feet of science** (Gerald Holton)

**suppressing explanation in science is like killing the golden egg hen** (Mario Bunge)

**Earth and geology**

- *catastrophism was like an epic poem* (Memory Practices in the Sciences)
- *the Earth's crust is its rind* (William Gilbert)
- *uniformitarianism is like bookkeeping* (Memory Practices in the Sciences)

**electricity and electronics**

- *Empress Cixi learnt the circuit board of the Qing court* (Prof. Rana Mitter, Harvard)
- *fulgurites are fossilized lightning* (Physics World)

**energy**

- *conservation of energy is like a sacred commandment* (Max Planck)
- *trust changes form like energy* (Rachel Botsman, University of Oxford)

**ethology**

- *an animal's Umwelt is like a spider web* (Jakob von Uexküll)
- *spider webs are found in fly-mechanics* (Jakob von Uexküll)

**evolution**

- *evolution is like a copycat* (Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA)
- *selection theory is like a Tibetan prayer-wheel* (Ludwig von Bertalanffy)

**excretion**

- *the skin acts like a handkerchief* (Jacobus Cateaneus de Lacumarcino)

**gravitation**

- *gravity kind of goes into overdrive near a black hole* (Prof. Andrew Pontzen, UCL)

**magnetism**

- *iron is like spiritual food to a lodestone* (Robert Fludd)
- *lodestone pines away with age* (William Gilbert)

**materials**

- *a crystal lattice is a pattern like wolf paper* (Professor Sir Harry Bhadeshia, Univer Cambridge and Queen Mary University)
- *laser creates a ladder through a Bose-Einstein condensate* (Light Years: The extraterrestrial of mankind' fascination with light)
- *snowflake imitates precisely the skeleton of the octahedron* (Johannes Kepler)

**medicine**

- *patterns on brain scans resemble Captain Scarlet's Mysterons* (Immune: How your body defends and protects you)
- *vaccine acts like a 'wanted poster'* (BBC News)

<https://science-education-research.com/public-science/examples-of-science-similes/>

Some examples.

A document with many more examples – **Creative Comparisons: Making Science Familiar through Language**. An illustrative catalogue of figurative comparisons and analogies for science concepts – can be downloaded from: <https://science-education-research.com/downloads/publications/2025/Taber-Science-Comparisons.pdf>

# Figurative language

simile

*adjectivised nouns*

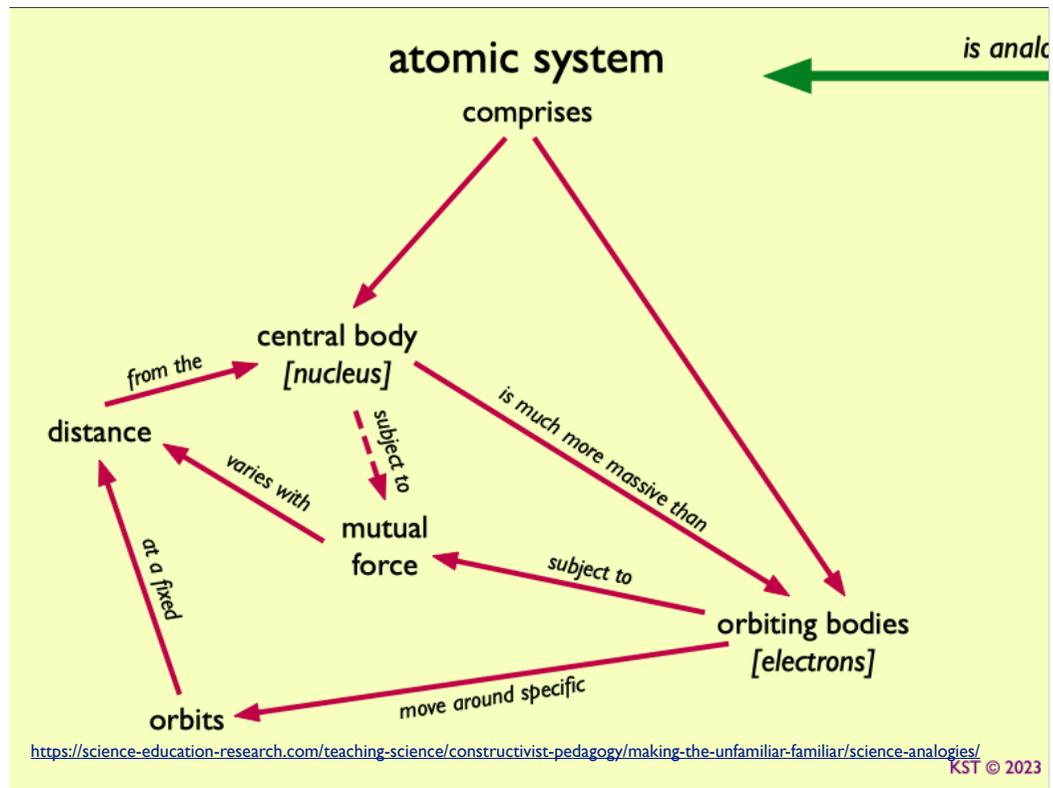
analogy

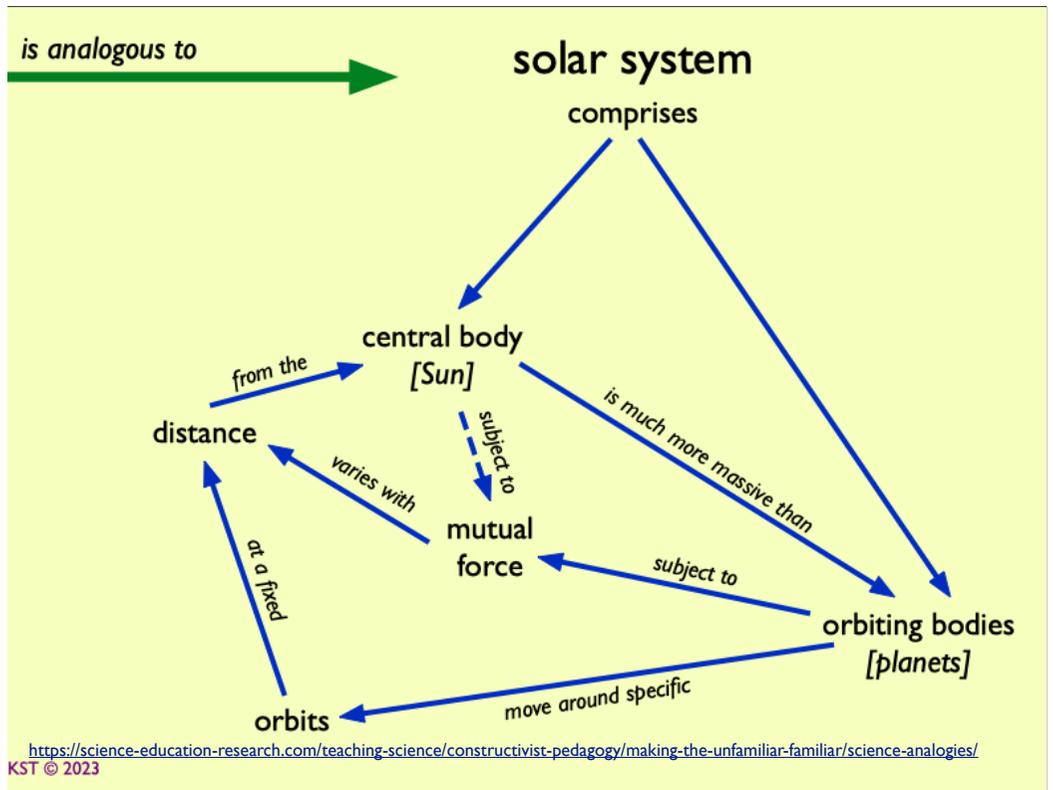
# analogy

An analogy is a comparison between two things that shows how they are in some sense structurally similar. The analogue (the thing that something of interest is said to be like) is said to map onto the target (the thing of focal interest).

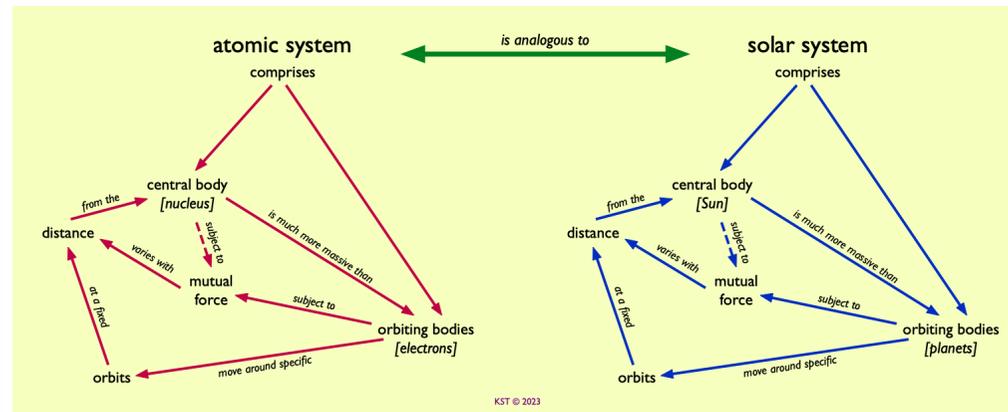


Analogy goes beyond simile.





# analogy

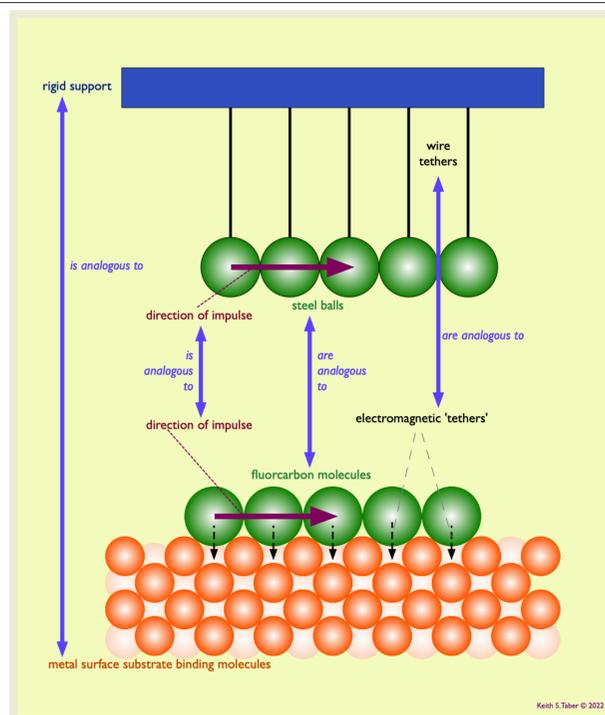


analogy

<https://science-education-research.com/teaching-science/constructivist-pedagogy/making-the-unfamiliar-familiar/science-analogies/>

"Scientists in Canada have succeeded in setting off a chain of reactions in which fluorine atoms are passed between molecules tethered to a copper surface. The sequence can be repeated in alternating directions, **mimicking the to-and-fro motions of a Newton's cradle.**"

*Chemistry World*



<https://science-education-research.com/a-molecular-newtons-cradle/>

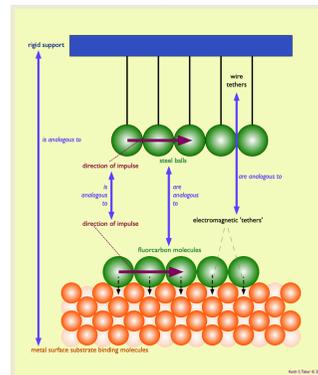


"Scientists in Canada have succeeded in setting off a chain of reactions in which fluorine atoms are passed between molecules tethered to a copper surface. The sequence can be repeated in alternating directions, **mimicking** the to-and-fro motions of a Newton's cradle."

"What was more, each  $\text{CF}_3$  had been flipped in the process, so **the Newton's cradle** as a whole was a mirror image of how it had begun, giving the potential for a reverse swing. Unlike a desk Newton's cradle, it did not swing back on its own accord, but another electron impulse could be used to set it off."

*Chemistry World*

<https://science-education-research.com/a-molecular-newtons-cradle/>



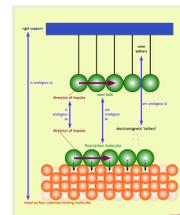
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significant 'negative analogy' feature!

*Chemistry World*

<https://science-education-research.com/a-molecular-newtons-cradle/>



"...most nerve cells receive inputs, in the form of neurotransmitters, from many different cells, so the 'decision' about whether or not the cell should fire depends on the net effect of all the different inputs, some of which will be excitatory, and some inhibitory, with the pattern of input perhaps varying all the time.

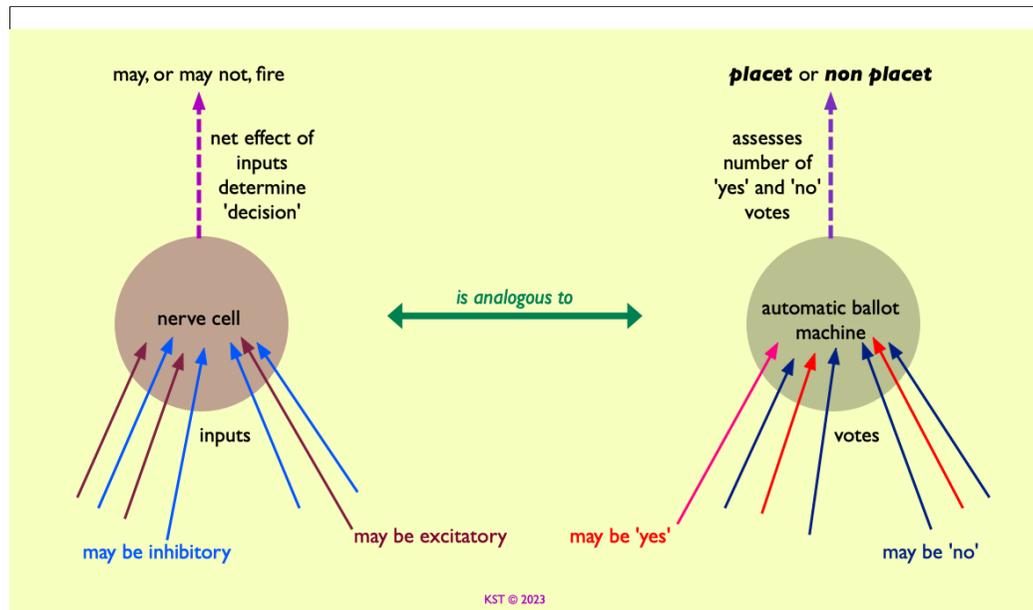


So any single nerve cell acts like an [sic] tiny automatic ballot machine, assessing the number of 'yes' and 'no' votes entering it at any one time and either firing or not firing depending on which type of vote predominates at any one time.

...Nerve cells receive electrochemical signals from other cells, and each signal represents a 'yes' or a 'no' vote in an election to determine whether the cell should fire."

*Vital Principles: The molecular mechanisms of life.*

<https://science-education-research.com/making-molecular-mechanisms-familiar/>

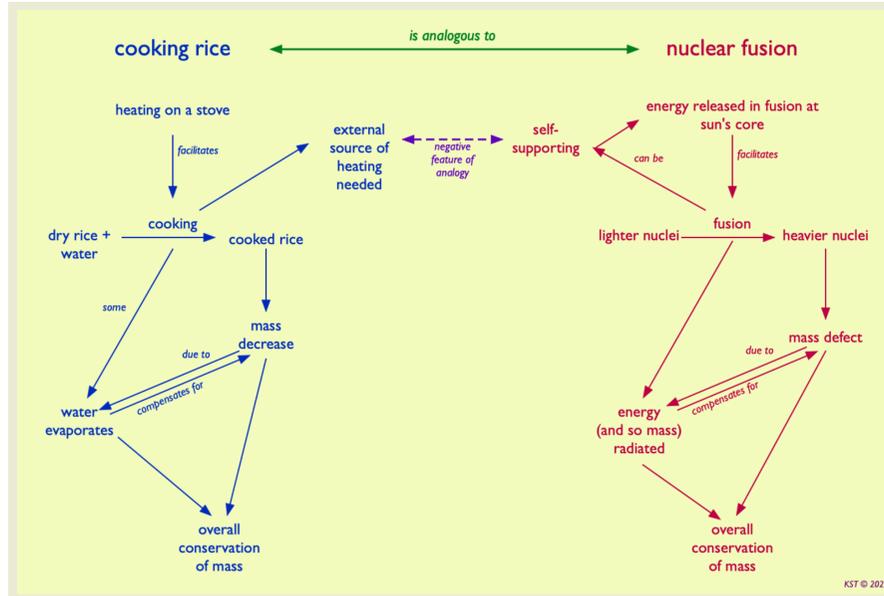


*Vital Principles: The molecular mechanisms of life.*

<https://science-education-research.com/making-molecular-mechanisms-familiar/>



# a teaching analogy for explaining why mass defect does not contradict conservation of mass



<https://science-education-research.com/the-complicated-social-lives-of-stars/>



a teaching **simile** for explaining why mass defect does not contradict conservation of mass

mass - energy is like

pounds **X** euros?

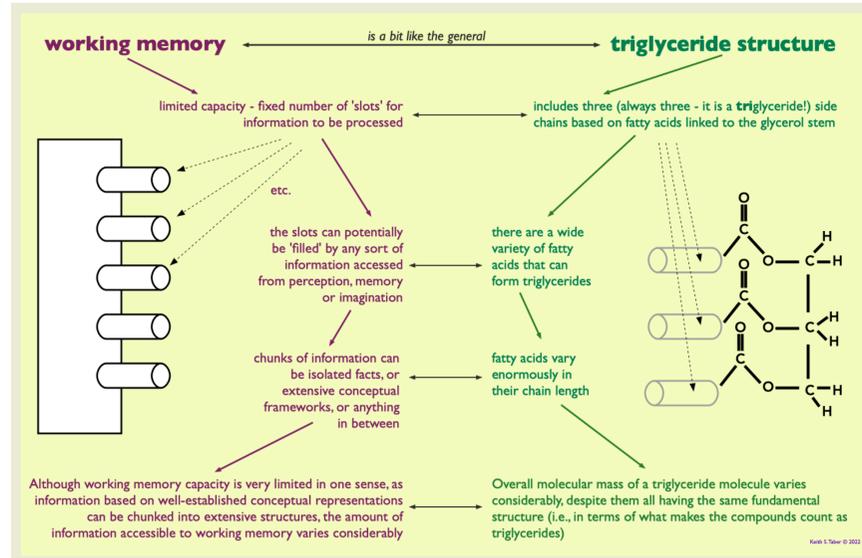
pounds - pence

(or euros - cents)

<https://science-education-research.com/the-complicated-social-lives-of-stars/>



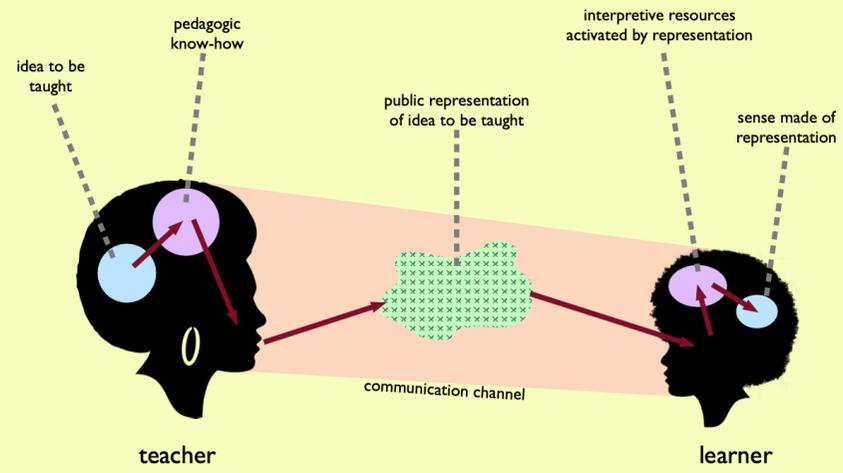
# an analogy for explaining how chunking allows experts to hold more information in mind than novices with the same working memory capacity

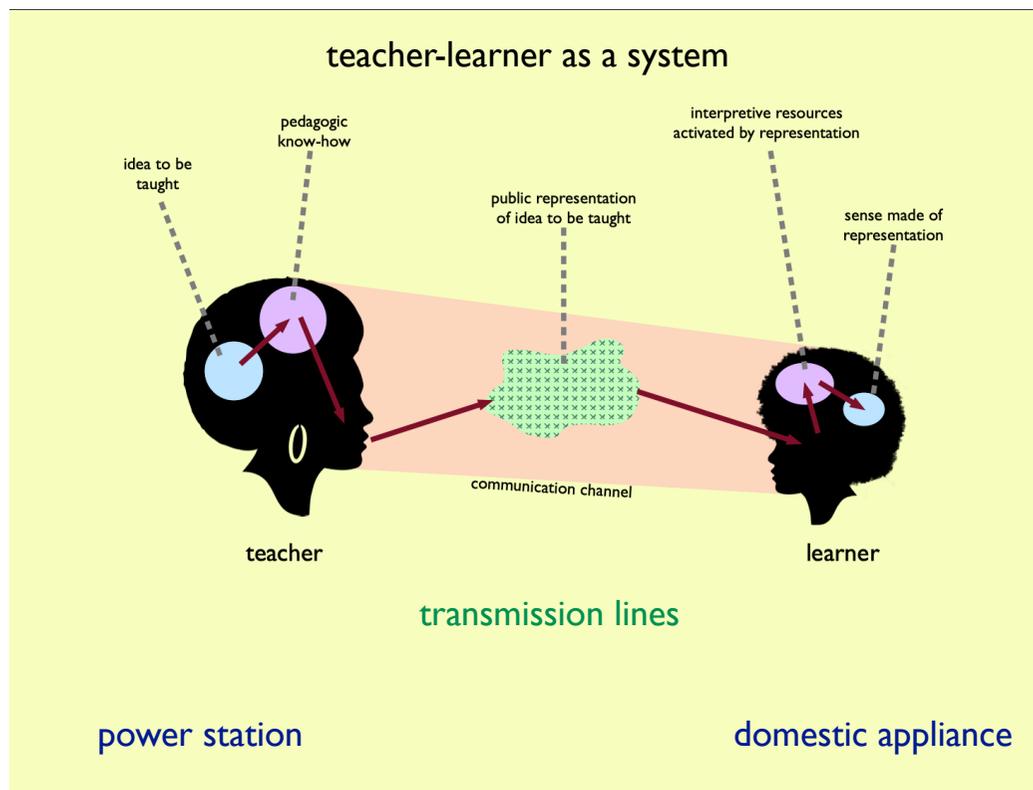


<https://science-education-research.com/how-fat-is-your-memory/>

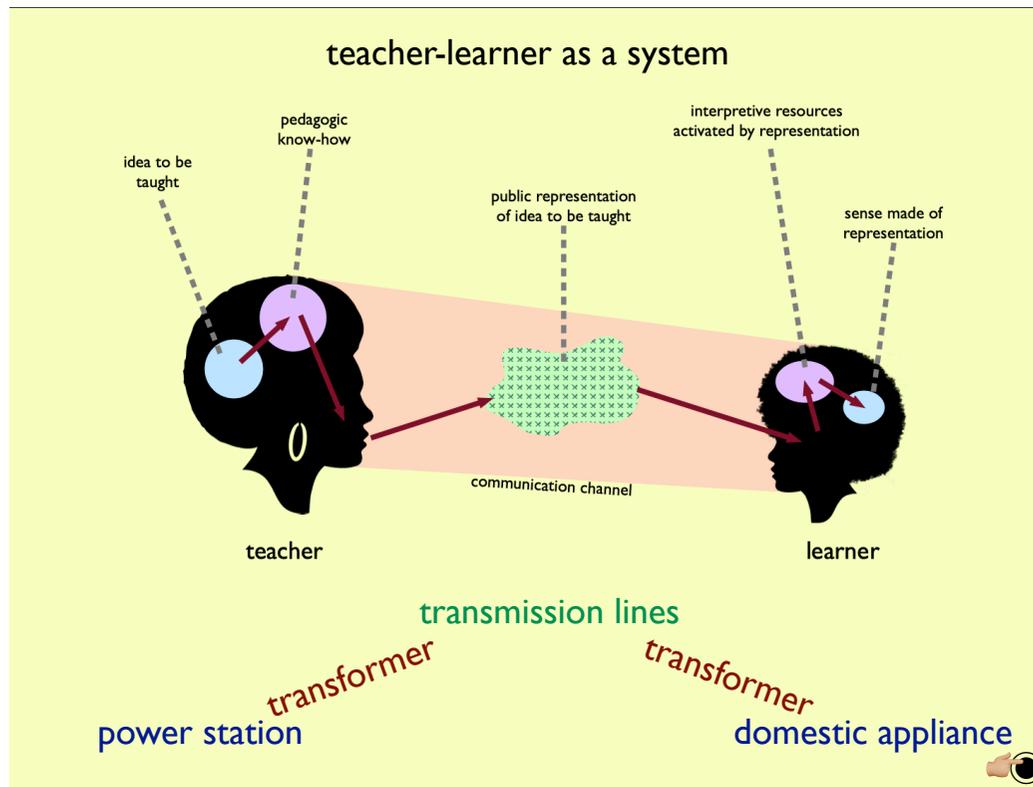


# teacher-learner as a system





To offer an analogy...



Analogy discussed in Taber, K. S. (2024). Chemical Pedagogy. Instructional Approaches and Teaching Techniques in Chemistry. Royal Society of Chemistry.

**analogy**

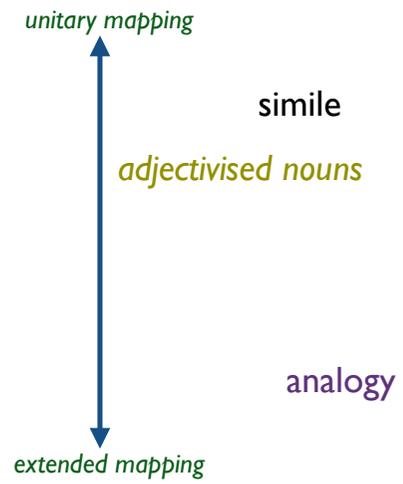
<https://science-education-research.com/public-science/examples-of-science-analogies/>

|  |   |  |
|--|---|--|
| <ul style="list-style-type: none"> <li>• <i>a beetle's mate can change significance like a stone on the path</i> (Jakob von Uexküll)</li> </ul> <p><b>atoms and molecules</b></p> <ul style="list-style-type: none"> <li>• <i>atoms are like letters of an alphabet</i> (Robert Boyle)</li> <li>• <i>atoms are like people in seeking out one or several partners</i> ('Explaining Humans: What science can teach us about life, love and relationships')</li> <li>• <i>covalent and ionic bonds are like different kinds of human relationships</i> ('Explaining Humans: What science can teach us about life, love and relationships')</li> <li>• <i>diatomic molecule is a discuss thrower that can spin only at certain speeds</i> (Norwood Russell Hanson)</li> <li>• <i>electrons circling the nucleus as planets might have mountains and oceans</i> ('Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science')</li> <li>• <i>if men were like atoms we could not detect them</i> (L. J. Thomson)</li> <li>• <i>molecules can be like gloves or socks</i> ('Serendipity: Accidental Discoveries in Science')</li> </ul> <p><b>astronomy</b></p> <ul style="list-style-type: none"> <li>• <i>Betelgeuse is ringing at a changed frequency</i> (Dr Andrea Dupree, Harvard &amp; Smithsonian)</li> <li>• <i>star after mass ejection is like a washing machine out of balance</i> (Dr Andrea Dupree, Harvard &amp; Smithsonian)</li> <li>• <i>the Solar System is like a city</i> ('Catching Stardust: Comets, asteroids and the birth of the solar system')</li> </ul> <p><b>biodiversity</b></p> <ul style="list-style-type: none"> <li>• <i>Banca species are as if the Isle of Man had distinct fauna from the rest of the British Isles</i> (Alfred Russel Wallace)</li> </ul> <p><b>cells</b></p> <ul style="list-style-type: none"> <li>• <i>relationships are like cell division</i> ← ('Explaining Humans: What science can teach us about life, love and relationships')</li> </ul> <p><b>chemical bonding and structure</b></p> <ul style="list-style-type: none"> <li>• <i>chemical bonds are like relationships</i> ('Explaining Humans: What science can teach us about life, love and relationships')</li> </ul> <p><b>chemical substances</b></p> <ul style="list-style-type: none"> <li>• <i>a field called 'hot-guest' chemistry</i> ('Serendipity: Accidental Discoveries in Science')</li> <li>• <i>microcomponents of matter collectively give new properties like the assembled parts of a watch</i> (Robert Boyle)</li> <li>• <i>trace elements are like seasoning added to food</i> (Allison Britt, Geoscience Australia)</li> </ul> | <ul style="list-style-type: none"> <li>• <i>compound formation is like a marriage</i> ('The Chemical Philosophy of Robt Mechanicism, Chymical Atoms, and Emergence')</li> <li>• <i>conservation of mass in chemical reactions is like not distinguishing Eskimos</i></li> </ul> <p><b>cosmology</b></p> <ul style="list-style-type: none"> <li>• <i>investigating objects in space is like measuring the timbers of a ship</i> (Henri Le...)</li> <li>• <i>Newton's universe should be an island</i> (Albert Einstein)</li> </ul> <p><b>electricity</b></p> <ul style="list-style-type: none"> <li>• <i>to cross a pn junction holes have to climb a hill</i> (Alan Holden)</li> </ul> <p><b>evolution</b></p> <ul style="list-style-type: none"> <li>• <i>life claws its way up the tree of life</i> (Geoffrey C. Bowker: 'Memory practice')</li> </ul> <p><b>genetics</b></p> <ul style="list-style-type: none"> <li>• <i>a chromosome is like a string of pearls</i> (Ludwig von Bertalanffy)</li> <li>• <i>genes on a chromosome are like beads on a string</i> ('Some Assembly Required: billion years of life, from ancient fossils to DNA')</li> <li>• <i>the genetic code is a written text</i> (Wolfgang Smith)</li> </ul> <p><b>geology</b></p> <ul style="list-style-type: none"> <li>• <i>the underground world is like a house</i> (Athanasius Kircher)</li> <li>• <i>ores develop from seed like an embryo in the womb</i> (William Gilbert)</li> </ul> <p><b>gravitation</b></p> <ul style="list-style-type: none"> <li>• <i>gravitation is like an uneven building</i> (Albert Einstein)</li> </ul> | <ul style="list-style-type: none"> <li>• <i>mixing of ocean water is like ploughing a field</i> (Professor Angus Addison, Plymouth Marine Laboratory)</li> </ul> <p><b>nature of science and scientific methodology</b></p> <ul style="list-style-type: none"> <li>• <i>a black box resembles a company's annual report</i> (Mario Bunge)</li> <li>• <i>bifurcationists in the laboratory would be like atheists in the trenches</i> (Wolfgang Smith)</li> <li>• <i>concept to sense experiences is like ticket number to overcoat</i> (Albert Einstein)</li> <li>• <i>describing science as a language is like taking cans for canned food</i> (Mario Bunge)</li> <li>• <i>doing an experiment is like asking a friend to take a risk</i> (Mario Bunge)</li> <li>• <i>hypothesis-observation is like chicken-egg</i> (Sir Karl Popper)</li> <li>• <i>hypotheses may be hatched by theories of other species</i> (Mario Bunge)</li> <li>• <i>physics is like an organism not a machine</i> (Ernst Cassirer)</li> <li>• <i>pseudo-explanations are like false pearls</i> (Mario Bunge)</li> <li>• <i>science advances like a column of troops</i> (Ludwik Fleck)</li> <li>• <i>scientific dialogue is like a game of football</i> (Ludwik Fleck)</li> <li>• <i>source of scientific problems is its birth</i> (Mario Bunge)</li> <li>• <i>theories are like true love</i> (Mario Bunge)</li> <li>• <i>uncoordinated hypotheses are like protoplasm</i> (Mario Bunge)</li> </ul> <p><b>nuclear processes</b></p> <ul style="list-style-type: none"> <li>• <i>nuclear fission is like cellular fission</i> (Otto Robert Frisch)</li> <li>• <i>the strong force is like love</i> ('Explaining Humans: What science can teach us about life, love and relationships')</li> <li>• <i>unstable atom is like a miser</i> (Albert Einstein)</li> </ul> <p><b>organisms</b></p> <ul style="list-style-type: none"> <li>• <i>an organism is like a symphony</i> (Jakob von Uexküll)</li> </ul> <p><b>physics</b></p> <ul style="list-style-type: none"> <li>• <i>quantum formalism is like attempting to breathe in space</i> (Albert Einstein)</li> <li>• <i>quantum physics is pianistic: where classical physics is violinistic</i> (Norwood Russell Hanson)</li> </ul> <p><b>physiology</b></p> <ul style="list-style-type: none"> <li>• <i>blood maturation is like wine fermentation</i> (Abū Bakr al-Rāzī)</li> <li>• <i>reflexes can operate in peaceful republics</i> (Jakob von Uexküll)</li> </ul> <p><b>plants</b></p> <ul style="list-style-type: none"> <li>• <i>a plant is like an animal turned upside down</i> (Carl Linnaeus)</li> <li>• <i>fruit-body is the plant's genitals</i> (Carl Linnaeus)</li> <li>• <i>rostellum partially closes the mouth of the nectary like a trap placed in a run for game</i> (Charles Darwin)</li> </ul> |
|--|---|--|

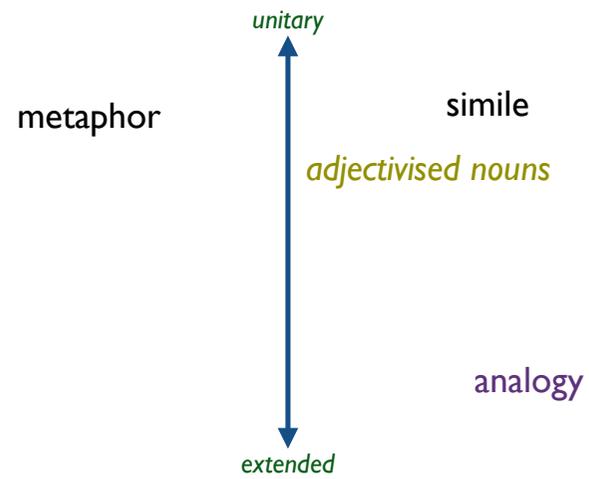
A document with many more examples – **Creative Comparisons: Making Science Familiar through Language**. An illustrative catalogue of figurative comparisons and analogies for science concepts – can be downloaded from:

<https://science-education-research.com/downloads/publications/2025/Taber-Science-Comparisons.pdf>

# Figurative language

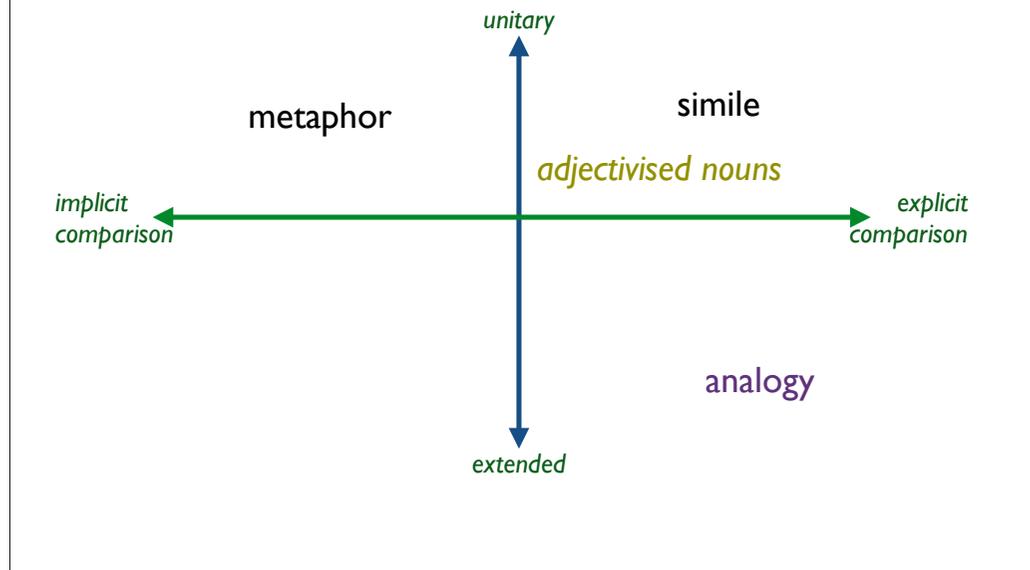


# metaphor



Then there are metaphors (which fall short of simile).

# Figurative language



# Figurative language

“The order Calicieae consists of horizontal lichens, with generally an ill-developed crust; the discs, which are at first covered by a veil, are contained in a stalked, or more rarely sessile, excipulum, looking like little flat headed pins stuck into the crust; the veil at length vanishes, and exposes a pulverulent mass of spores, which adhere so loosely in the Calicium inquinans, that they soil the finger if touched; in other cases they come out of their ascus like little necklaces.”



(Not ‘something like a veil’, but ‘a veil’).

# 'birth' of metaphor?

metaphor ← ..... simile

# Figurative language

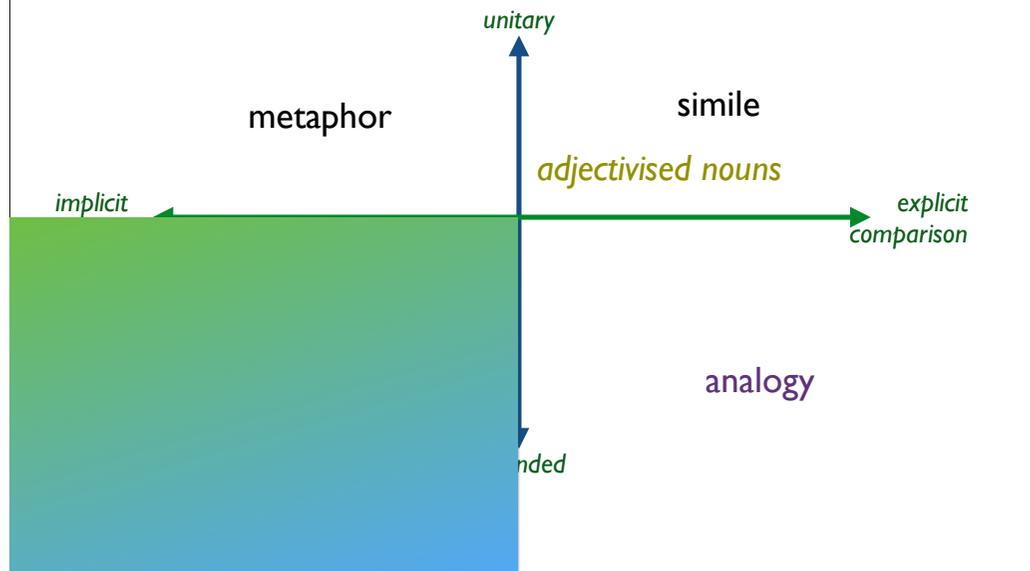
“For example, the *Vaucheria sessilis* consists of one long branched cell; on the same side of it two swellings appear near to each other, one of which elongates, curls round **like a horn**, and is soon filled with snake-shaped filaments having long cilia at their thin end, with which they move rapidly both within **the horn**, and after they come out of it into the water.”



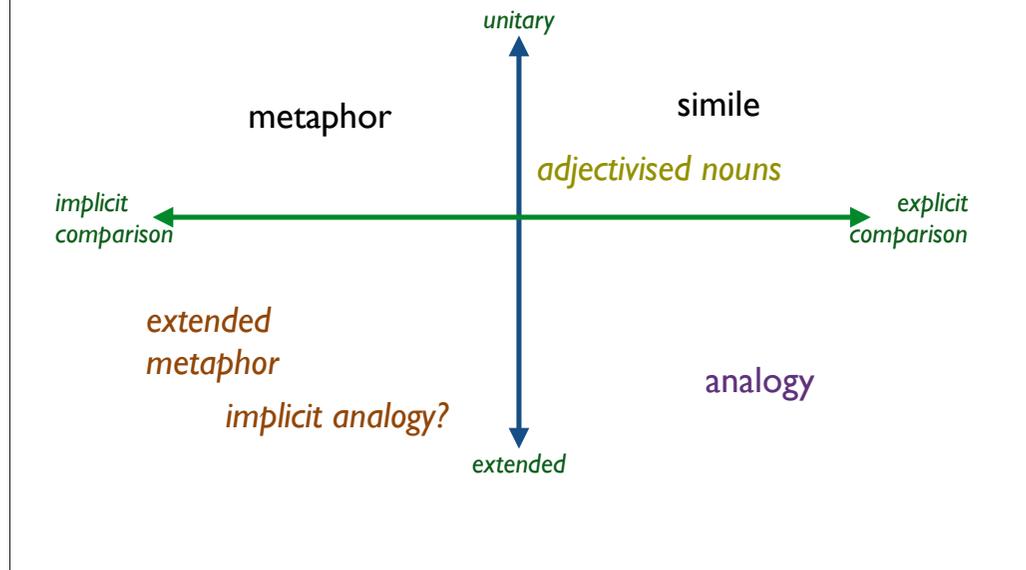
A simile, that slips into metaphor.



# Figurative language



# Figurative language



Extended metaphor goes beyond a simple metaphor.

An implicit analogy is a simile partially explained, but without the full mapping of an analogy.

# extended metaphor

"At the core of nuclear physics lies a tug of war between two of the four fundamental forces: on one side, the strong nuclear force acts to hold the nucleus together by binding the protons to the neutrons; on the other, electromagnetism acts to blow it apart by repelling the positively charged protons. The strong nuclear force is the strongest force in nature, and in the lighter, smaller nuclei it easily wins out, making nuclear fusion of these elements highly exothermic.

The strongest of the forces it may be, but the strong nuclear force only acts over very short distances. The range of the electromagnetic force is infinite, however, despite its strength decaying with distance. As nuclei get larger, therefore, the battle between the two gets more even, and eventually electromagnetism begins to win."

*Chemistry World*

# implicit analogy

"At the core of nuclear physics lies a tug of war between two of the four fundamental forces; on one side, the strong nuclear force acts to hold the nucleus together by binding the protons to the neutrons; on the other, electromagnetism acts to blow it apart by repelling the positively charged protons. The strong nuclear force is the strongest force in nature, and in the lighter, smaller nuclei it easily wins out, making nuclear fusion of these elements highly exothermic. The strongest of the forces it may be, but the strong nuclear force only acts over very short distances. The range of the electromagnetic force is infinite, however, and its strength decaying with distance. As nuclei get larger, therefore, the battle between the two gets more even, and eventually electromagnetism begins to

author assumes we will read this as a comparison not an identity

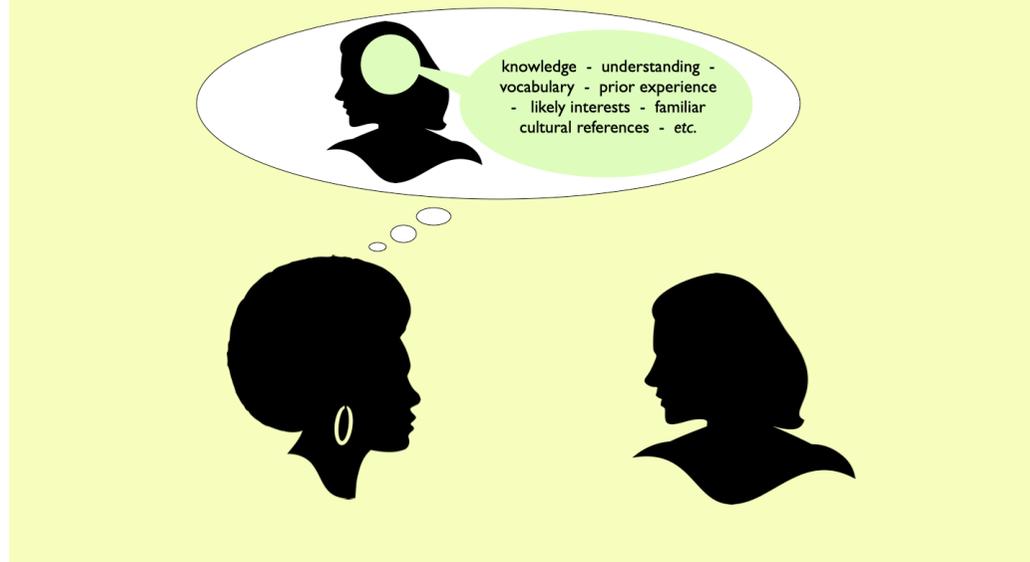
author assumes we know what a tug of war is

author assumes we can map the force sources onto the teams

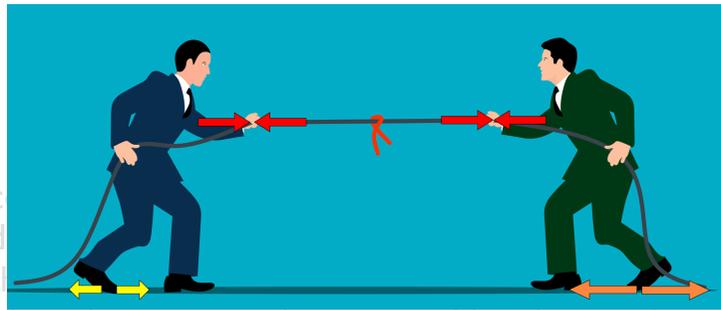
author assumes we know what happens when one side is winning, and how this maps onto the description of the atomic case



# Teaching requires a model



Remember, the teacher needs to have a mental model of the learner to decide on potentially fertile comparisons the learner will be familiar with, and the level of treatment suitable.



"At the center of the atom, two of the four fundamental forces act to hold the nucleus together: the strong nuclear force acts between neutrons; on the other, electromagnetism acts to blow it apart by repelling the positively charged protons. The strong nuclear force is the strongest force in nature, and in the lighter, smaller nuclei it easily wins out, making nuclear fusion reactions generally exothermic.

The strongest of the forces it may be but the strong nuclear force only acts over very short distances. The range of the electromagnetic force is infinite, however, despite its strength decaying with distance. As nuclei get larger, therefore, the battle between the two gets more even and eventually electromagnetism begins to win."

**In a tug of war, both teams pull on the rope with equal force -**

**when the rope is stationary**

**and when the rope is moving to one side**

**Will readers appreciate this?**

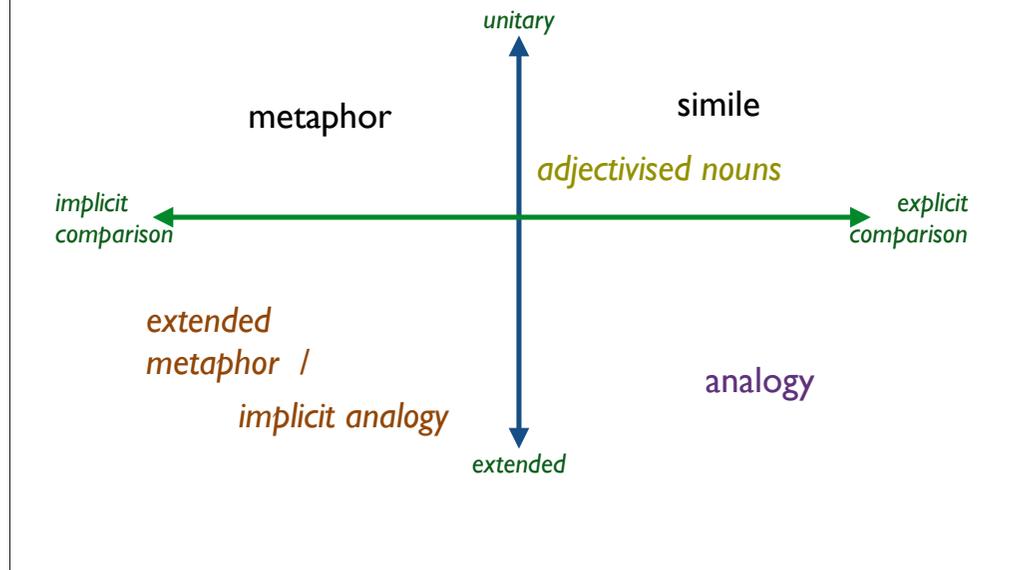
**Does this over-complicate the analogy?**



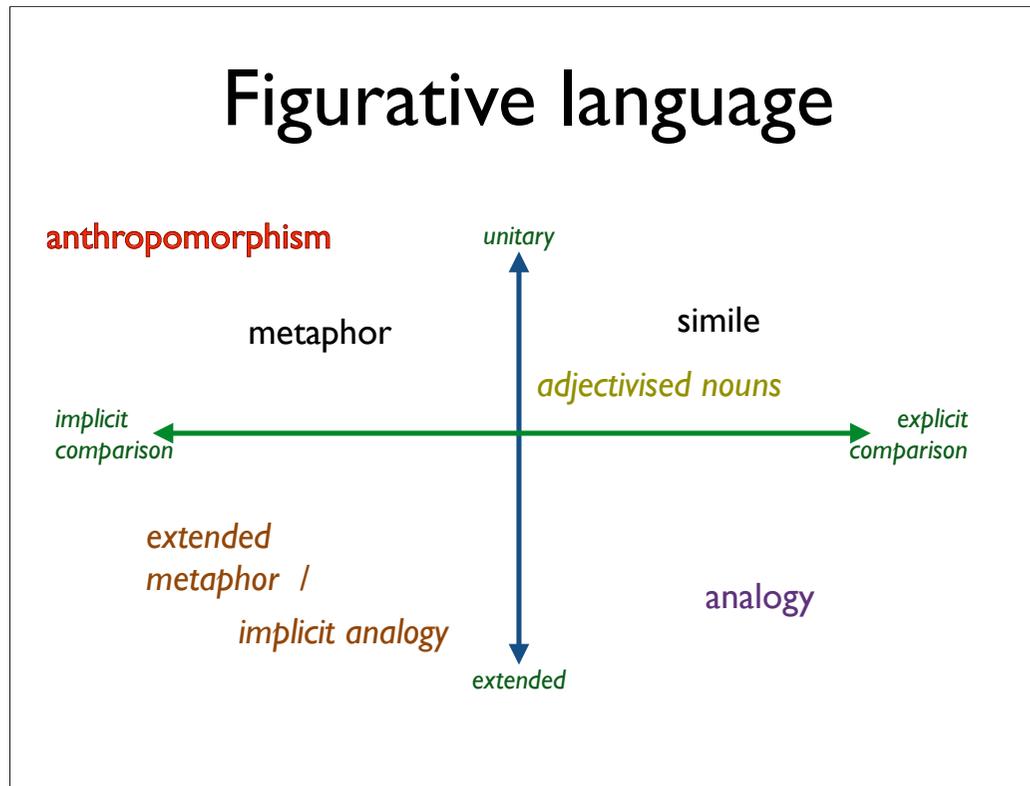
# implicit analogy?

offering a comparison,  
and then developing the analogue,  
but leaving the audience to work out the  
rest of the mapping to the target

# Figurative language



# Figurative language



Then there are those particular types of metaphors that are anthropomorphic.

# anthropomorphism

metaphors that are anthropomorphic use figurative language suggesting a non-human object has the kind of perceptions, conceptions, emotions, drives, etc. that a human does:

the non-human object could be a mouse, a tree, a bacterium, a virus, a rock, a cloud, an atom, a proton, etc.

# anthropomorphism

metaphors that are anthropomorphic use figurative language suggesting a non-human object has the kind of perceptions, conceptions, emotions, drives, etc. that a human does:

the non-human object could be a mouse, a tree, a bacterium, a virus, a rock, a cloud, an atom, a proton, etc.

*a kind of pseudo-explanation?*

<https://science-education-research.com/learners-concepts-and-thinking/pseudoexplanations/>



Anthropomorphism may be intended as metaphor, but can be misunderstood as offering a kind of explanation (and perhaps one that would be acceptable in a science exam?)

# two kinds of understanding

objective  
understanding:

as measured in  
tests / exams

subjective  
understanding:

seems to make  
sense



Anthropomorphism may be very effective at giving learners the impression that they understand the science - but does not reflect the scientific principles and mechanisms at work.

LIVE Westminster

“we are entering Autumn and Winter, something that COVID and other viruses usually like”

ON SUNDAY Health Secretary Sajid Javid MP sky

BBC TODAY Today 15/09/2021

“...we know Autumn and Winter, your COVID is going to like that time of year”

<https://science-education-research.com/what-covid-really-likes/>

I wonder if he really believed this - or what he just trying to get across an important point?

A photograph of Boris Johnson, former Prime Minister of the United Kingdom, sitting at a desk with a microphone, appearing to be in a formal setting like a public inquiry.

“The virus thinks, whatever the SNP may think, the virus thinks this is all one country, and that's the reality.”

Ex-**Prime Minister** Boris Johnson gives evidence to the independent public inquiry set up to examine the UK's response to and impact of the Covid-19 pandemic...

and claims that **the virus knows** about British political geography 🗨️

Surely, he did not mean this?

(The virus does not respect borders, because it knows nothing about them, not because it takes a position on Scottish independence!)

## context may help us understand

context context context context context  
context figurative language context context  
context context context context context

We often need to read figurative language in terms of the surrounding context.

context may help us understand

e.g.,

*how can molecules pledge  
their allegiance to a  
theoretical system?*



"Specifically, Boltzmann and Maxwell pictured a volume of gas as an enormous number of tiny, hard masses speeding about and colliding with each other in mostly empty space. These atoms [sic] **pleaded allegiance** to the Newtonian laws of mechanics: they had velocities and directions, carried momentum and kinetic energy, bounced off one another in predictable ways, and so on."

*The Dream Universe: How fundamental physics lost its way*

"Specifically, Boltzmann and Maxwell pictured a volume of gas as an enormous number of tiny, hard masses speeding about and colliding with each other in mostly empty space. These atoms [sic] pleaded allegiance to the Newtonian laws of mechanics: they had velocities and directions, carried momentum and kinetic energy, bounced off one another in predictable ways, and so on."

*The Dream Universe: How fundamental physics lost its way*

# anthropomorphism

Based on conversation on a BBC Radio 4 programme/podcast: 'Mysterious Plants'

"Oh, what if I looked and smelled like rotting meat?"

"And what if I also emitted heat, just like a pile of rotting meat?"

"Ooh, that smells like food, that looks like food, I'm going to lay my eggs here, it's going to be great, my babies will have a great chance to survive"

"I'm, mimicking the food, come and stay"

Design: KST © 2024

<https://science-education-research.com/and-then-the-plant-said/>



# anthropomorphism

(see) biology: 'The Search for Life Elsewhere in the Universe';

**animals**

- *bees marshall themselves as they think best* (John Marshall, University of Massachusetts Amherst)
- *bees realised meat was available and decided to go* (University of Massachusetts Amherst)
- *bees used geometrical forethought to work out the* Alexandria)
- *baboons can be robbers* (Alfred Russel Wallace)
- *butterflies can be shy* (Alfred Russel Wallace)
- *fish hope some of their eggs survive* (Dr Nandini Ramesh, University of California)
- *monkey is concerned about lack of protein in diet* (Dr Adrian Barnett, Hartpury U)
- *moths thought switching to eating clothes would offer a better life* (BBC Inside Sci)
- *sea-urchins lead a contemplative life* (Ludwig von Bertalanffy)
- *ticks think about when to have a meal* (Prof. Sally Cutler, University of East London)

**astronomy and cosmology**

- *asteroids and comets attempted to deliver volatile substances to Earth* ('Catching Comets, asteroids and the birth of the solar system')
- *Betelgeuse shows petulant behaviour* (NASA website)
- *black holes can compose* (NASA)
- *comets do their best to avoid adhering to the classic Solar System models* ('Catch Comets, asteroids and the birth of the solar system')
- *gravity tries to pull a white dwarf to be even denser* (Prof. Mark Sullivan, University Southampton)
- *interplanetary dust particles really are teaching scientists* ('Catching Stardust. Co and the birth of the solar system')
- *meteors and meteorites are impetuous* ('The Comet is Coming! The feverish leg most stars do not live by themselves' (Prof. Mark Sullivan, University of Southar
- *planets can be stolen by another star* (Prof. Carolin Crawford, University of Cam
- *star is saying 'look at me, look at me - I'm interesting'* (Prof. Paul Murdin, Univ Cambridge)
- *the gravity of dark matter likes to bring everything together* (Prof. Catherine Heyl Astronomer Royal for Scotland)
- *white dwarf steals from its companion star* (Prof. Mark Sullivan, University of S

**atoms and molecules**

- *a covalent bond is like when you meet someone and feel like you have always kno* ('Explaining Humans: What science can teach us about life, love and relations
- *an atom tries to balance competing forces* ('Explaining Humans: What science c life, love and relationships')
- *atomic nucleus tries to get rid of its excitation energy* (Mario Bunge)
- *atoms can be indifferent* (Mario Bunge)
- *atoms laid themselves in orderliness* (Alan Holden)
- *atoms look for others to bond with to complete them* ('Explaining Humans: What teach us about life, love and relationships')
- *atoms search for dance partners* ('Explaining Humans: What science can
- *atoms try to climb out of magnetic trap* (Physics World magazine)
- *covalent bonding is a collaborative effort to create a chemical balance where partn* other' ('Explaining Humans: What science can teach us about life, love and rel
- *electrons arrange to spin in opposite directions* (Alan Holden)

**chemical substances and reactions**

- *lithium is happy to give away an electron* (Jeremy Wrathall of Cornish Lithium)
- *oxygen likes to combine with things* ('Astrobiology: The Search for Life Elsewhere in Universe')
- *radium mimics calcium* (Chemistry World magazine)
- *silicon is happy just to combine with oxygen* ('Astrobiology: The Search for Life Else Universe')

**D.N.A.**

- *D.N.A. strands can be asked to find and bind to each other* (Professor Anne Ferguson-t University of Cambridge)
- *the environment decides how long D.N.A. survives* (Dr David Duffy, University of Flor

**Earth**

- *deep atmospheric convection likes to be over warm water* (Dr Tim Stockdale, Europe Medium Range Weather Forecasts)
- *underground methane tries to get to the Earth surface* (Professor Richard Davies, New University)
- *water wants to move towards South America* (Dr Tim Stockdale, European Centre For Range Weather Forecasts)

**bacteria try to eat natural polyesters** (Professor John McGeehan, University of Portsmouth)

- *predators* (Dr Christopher Lowe, Swansea University)
- *Dr Emily Leeming, King's College London)*
- *ses might try to hide* (Prof. Onar Boyman, University

**microbes need quality sleep** (Prof. Tim Spector, King's College London)

- *microbes think about where to live* (Dr. Susanne P. Schwenze, Open University)
- *Mycobacterium tuberculosis is content to make itself inconspicuous* ('The Remedy: Robert Koch, Arthur Conan Doyle, and the quest to cure tuberculosis')
- *Mycobacterium tuberculosis perseveres* ('The Remedy: Robert Koch, Arthur Conan Doyle, and the quest to cure tuberculosis')
- *Propionibacterium acnes adores consuming fat* ('Immune: How your body defends and protects you')
- *Propionibacterium acnes has bad table manners* ('Immune: How your body defends and protects you')
- *Propionibacterium acnes loves to picnic* ('Immune: How your body defends and protects you')
- *Propionibacterium acnes smacks its lips* ('Immune: How your body defends and protects you')
- *some bacteria are very happy to feed on hydrogen sulphide* (Dr. Jean-Marie Volland, Laboratory for Research in Complex Systems)
- *some strains of bacteria prefer to live in tumours* (Dr Susan Woods, South Australian Health and Medical Research Institute)
- *virus particles hide beneath a cloak* ('Almost Like a Whale: The origin of species updated')
- *virus will attempt to survive* (Nadhim Zahawi M.P., 'vaccines minister')
- *virus will find ways to infect vaccinated people* (Prof. Andrew Pollard, University of Oxford)
- *virus will try every combination of mutations* (Dr Theodora Hatziloannou, Rockefeller University)
- *viruses like Autumn and Winter* (Rt. Hon. Sajid Javid MP)
- *viruses think England and Scotland are the same country* (Boris Johnson, MP)

**nature**

- *Nature contrives to outwit us* (Wolfgang Smith)
- *nature does not waste energy* (Prof. Roger Rowell, University of Wisconsin-Madison)
- *nature will look at the forces, configurations and energies* (Nancy Cartwright)
- *nature writes down the operator and solves the quantum statistical equation* (Nancy Cartwright)

**plants**

- *plants allocate their resources* (Dr Stuart Farrimond)
- *plants realise when under high stress* (Dr Nicola Cannon, Royal Agricultural University in Cirencester)
- *plants want to be rigid and upright* (Chemistry World)

**physiology**

- *liver will break down anything it does not like the look of* (Prof. Ian Gilmore, University of Liverpool)

<https://science-education-research.com/public-science/examples-of-anthropomorphism/>

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# Figurative language

(teleology)

**anthropomorphism**

*unitary*

metaphor

simile

*adjectivised nouns*

*implicit  
comparison*

*explicit  
comparison*

*extended  
metaphor /*

*implicit analogy*

analogy

*extended*

Then there is teleology, which suggests something happens to meet some end or purpose.

# teleology

*explanation in terms of a purpose*

“Eyes are not **designed** for picking out individual colours, but **for using colour to distinguish shapes and objects.**”

“the mutations are located around the spike protein, and this is indicative of the fact that **the mutations are there to escape antibodies** generated from vaccination or from previous infection...”

“**Nature's plan** for dispersal and reproduction of the cocklebur plant is for the seed burs to become attached to passing birds and [sic] animals.”

<https://science-education-research.com/public-science/examples-of-teleology/>

As with anthropomorphism, teleology can seem to be offering an explanation when it is really just another of describing what has been discovered.

# Your task!

The challenge - please think about these questions:

What does this mean - what is the excerpt *intended* to tell a reader/listener?

How do I know that?

What particular interpretive resources did I used to make sense of the excerpt?

How readily would a student / school pupil / member of the public appreciate the intended meaning?



So, here is a wide range of examples of the use of figurative language in communicating science. Do you understand the intended meanings? Would your students? What needs to be already known/understood to make good sense of the quote?

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"A black hole is a region of space where you have just crammed so much stuff into a such a small space, that gravity kind of goes into **overdrive**, it grabs onto everything, and it won't let go, and that includes light, so even if a light beam goes into a black hole it just kind of gets **sucked in** and stays there."

"The **ultimate waste disposal unit**, stuff gets sucked in and can't escape."

*BBC Inside Science*

What does this mean - what is the excerpt *intended* to tell a reader/listener?

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"The Kupffer cells **hang around like spiders** on the walls of the blood vessels waiting to catch any red blood cells which have passed their **best before date** (typically 120 days)."

*Immune: How your body defends and protects you.*

What does this mean - what is the excerpt *intended* to tell a reader/listener?

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"TNF (tumour necrosis factor) superfamily-mediated cell death involves a receptor (from the TNF superfamily) on the surface of the infected cell, which is **like a magic key** capable of **unlocking** death when **turned** by the right **hand**."

*Immune: How your body defends and protects you.*

What does this mean - what is the excerpt *intended* to tell a reader/listener?

How do I know that?

What particular interpretive resources did I use to make sense of the excerpt?

How readily would a student / school pupil / member of the public appreciate the intended meaning?

"TNF (tumour necrosis factor) superfamily-mediated cell death involves a receptor (from the THN superfamily) on the surface of the infected cell, which is **like a magic key** capable of **unlocking** death when **turned** by the right **hand**."

*but not the left hand?*

What does this mean - what is the excerpt *intended* to tell a reader/listener?

How do I know that?

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How readily would a student / school pupil / member of the public appreciate the intended meaning?

"Every time a cell undergoes mitosis, it loses a little of what is called the telomere, the protective surface on the chromosome, capping the end of each D.N.A. strand. In a process often likened to the **gradual fraying of a shoelace**, the telomere gets a little shorter with every division, until eventually it can no longer guard the D.N.A. effectively, and the cell loses its ability to undergo mitosis and becomes senescent (inert)."

*Explaining Humans: What science can teach us about life, love and relationships*

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"... rare elements and heavy atoms, as trace elements play an important role for life; with their very special qualities they are, in a manner of speaking, the '**spice**' in the **soup** of life."

*The Anthropic Principle: Man as the focal point of nature.*

# making the unfamiliar familiar

other domain → science

one scientific field → another scientific field

science → other domain



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"Cixi...learnt quickly and skilfully how to essentially operate amongst the various characters at court...and also understanding how the family relationship between different parts of the royal family operated. So she learnt the ropes, you know, the kind of **the circuit board** of the Qing court, quickly and effectively"

*BBC In Our Time*

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“The mathematicians proudly claimed that striving for unambiguous definitions was one of the 'specific traits of the mathematical style of thinking', and they insisted that a mathematician in linguistics 'plays **the role of a litmus test**: if a definition satisfied the mathematician, then it must satisfy everyone'.”

*From Newspeak to Cyberspeak: A history of Soviet cybernetics*

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"Like a **Tibetan prayer-wheel**,  
Selection Theory murmurs untiringly:  
'Everything is useful.' But as to what actually  
happened and which lines evolution has  
actually followed, selection theory says  
nothing, for the evolution is the product of  
'chance', and therein obeys no 'law'."

*Problems of Life: An evaluation of modern biological thought*

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"The genome **is the stuff of B movies, like a graveyard filled with ghosts**. Bits and pieces of ancient viral fragments lie everywhere-by some estimates, 8 percent of our genome is composed of dead viruses, more than a hundred thousand of them at last count. Some of these fossil viruses have kept a function, to make proteins useful in pregnancy, memory, and countless other activities discovered in the past five years. Others **sit like corpses** where they attached to the genome only to be extinguished and decay."

*Some Assembly Required: Decoding four billion years of life, from ancient fossils to DNA*

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"The technique was crude: they mashed fly bodies into a paste, isolated their DNA, put the mixture in a gel, and added their gene with a dye. The idea was that the gene would **act like molecular flypaper** and attach to every gene with a similar sequence."

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# puns in science?

“de Sitter was a skilled mathematical astronomer, and his interest in problems of gravitation pulled him into Einstein's orbit.”

“the concept of stress has profitably been exported from physics to psychology and sociology. But, unless carefully performed, such an exploration of technical ideas may result in shear confusion”

“Soon Ghiorso was convinced that Stockholm was 'completely wrong'. Nobelium, he and Seaborg joked in private, was nobelievium.”

<https://science-education-research.com/public-science/science-puns/>



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"What makes the gamma-ray burst ... is **feeding** a newly-formed black hole matter at an extremely high rate...The process that gives rise to the production of this neutron-rich material is actually outflows from the disc that's **feeding** the black hole."

Prof. Brian Metzger (Department of Physics and Columbia Astrophysics Laboratory, Columbia University)

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"When the universe started, essentially all that came out of the big bang in chemical terms was hydrogen, helium and a tiny little bit of lithium. And all the [other] chemical elements that are in the universe have formed since that time, in various processes, in normal stars; in supernovae explosions of stars; some possibly in **the murder of neutron stars.**"

Mike Edmunds (Emeritus Professor of Astrophysics at Cardiff University and President of the Royal Astronomical Society)

## understanding in context

"When the universe started, essentially all that came out of the big bang in chemical terms was hydrogen, helium and a tiny little bit of lithium. And all the [other] chemical elements that are in the universe have formed since that time, in various processes, in normal stars; in supernovae explosions of stars; some possibly in the **murder** of neutron stars."

e.g.,

$$\frac{10^{53}\text{kg}}{10^9}$$

=

$$10^{44}\text{kg}$$

Mike Edmunds (Emeritus Professor of Astrophysics at Cardiff University and President of the Royal Astronomical Society)

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"Not all stars are the same – there's a whole zoo of them, determined by their mass and the stage they're at in their life cycle."

*Astrobiology: The Search for Life Elsewhere in the Universe*

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*would a zoo separate out specimens by life stage?*

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**dead**  
metaphor?

*Astrobiology: The Search for Life Elsewhere in the Universe*

# dead metaphors?

stars are **born**, start **young**, **live**,  
sometimes **living** alone but sometimes not,  
sometimes have complicated **lives**,  
have **lifetimes**, reach the **end of their lives**, and  
**die**,  
so, becoming **dead**, eventually **long dead**;  
and, indeed, there are **generations** of stars  
with **life cycles**

<https://science-education-research.com/the-passing-of-stars/>



**figurative language...**

**...can be used to communicate  
dubious science**

**just as much as canonical science**

What does this mean - what is the excerpt *intended* to tell a reader/listener?

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"Our nuclear charge is located on the surface, since the number of protons and the number of neutrons in the nucleus are such that protons and neutrons should be in the outer layer of the nucleus, and only neutrons inside, that is, a shell forms on the surface of the nucleus. In addition, protons must be repelled, and also attracted by an electronic **fur coat**."

*Journal of Chemistry: Education Research and Practice*

is *NOT*: *Chemistry Education Research and Practice*

| Group→      | 1        | 2        | 3         | 4         | 5         | 6         | 7         | 8         | 9         | 10        | 11        | 12         | 13        | 14         | 15        | 16         | 17         | 18       |         |
|-------------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|-----------|------------|-----------|------------|------------|----------|---------|
| ↓Period     |          |          |           |           |           |           |           |           |           |           |           |            |           |            |           |            |            |          |         |
| 1           | 1<br>H   |          |           |           |           |           |           |           |           |           |           |            |           |            |           |            |            |          | 2<br>He |
| 2           | 3<br>Li  | 4<br>Be  |           |           |           |           |           |           |           |           |           |            | 5<br>B    | 6<br>C     | 7<br>N    | 8<br>O     | 9<br>F     | 10<br>Ne |         |
| 3           | 11<br>Na | 12<br>Mg |           |           |           |           |           |           |           |           |           |            | 13<br>Al  | 14<br>Si   | 15<br>P   | 16<br>S    | 17<br>Cl   | 18<br>Ar |         |
| 4           | 19<br>K  | 20<br>Ca | 21<br>Sc  | 22<br>Ti  | 23<br>V   | 24<br>Cr  | 25<br>Mn  | 26<br>Fe  | 27<br>Co  | 28<br>Ni  | 29<br>Cu  | 30<br>Zn   | 31<br>Ga  | 32<br>Ge   | 33<br>As  | 34<br>Se   | 35<br>Br   | 36<br>Kr |         |
| 5           | 37<br>Rb | 38<br>Sr | 39<br>Y   | 40<br>Zr  | 41<br>Nb  | 42<br>Mo  | 43<br>Tc  | 44<br>Ru  | 45<br>Rh  | 46<br>Pd  | 47<br>Ag  | 48<br>Cd   | 49<br>In  | 50<br>Sn   | 51<br>Sb  | 52<br>Te   | 53<br>I    | 54<br>Xe |         |
| 6           | 55<br>Cs | 56<br>Ba | 72<br>Hf  | 73<br>Ta  | 74<br>W   | 75<br>Re  | 76<br>Os  | 77<br>Ir  | 78<br>Pt  | 79<br>Au  | 80<br>Hg  | 81<br>Tl   | 82<br>Pb  | 83<br>Bi   | 84<br>Po  | 85<br>At   | 86<br>Rn   |          |         |
| 7           | 87<br>Fr | 88<br>Ra | 108<br>Rf | 109<br>Db | 110<br>Sg | 111<br>Bh | 112<br>Hs | 113<br>Mt | 114<br>Ds | 115<br>Rg | 116<br>Cn | 117<br>Uut | 118<br>Fl | 119<br>Uup | 120<br>Lv | 121<br>Uus | 122<br>Uuo |          |         |
| Lanthanides | 57<br>La | 58<br>Ce | 59<br>Pr  | 60<br>Nd  | 61<br>Pm  | 62<br>Sm  | 63<br>Eu  | 64<br>Gd  | 65<br>Tb  | 66<br>Dy  | 67<br>Ho  | 68<br>Er   | 69<br>Tm  | 70<br>Yb   | 71<br>Lu  |            |            |          |         |
| Actinides   | 89<br>Ac | 90<br>Th | 91<br>Pa  | 92<br>U   | 93<br>Np  | 94<br>Pu  | 95<br>Am  | 96<br>Cm  | 97<br>Bk  | 98<br>Cf  | 99<br>Es  | 100<br>Fm  | 101<br>Md | 102<br>No  | 103<br>Lr |            |            |          |         |

Are there two 'islets' of elements (Z = 72-75, 108-111) still to be discovered?

Are the atomic numbers assigned to the heaviest elements wrong?

72-75

108-111

<https://science-education-research.com/move-over-mendeleev-here-comes-the-new-mendel/>



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“...the beauty of click chemistry...and bioorthogonal chemistry which is a **cousin** of click chemistry, these reactions have the special quality that they are so incredibly selective that the **two reacting partners** just **ignore** all the other functional groups even on really large molecules and even on large objects like human cells for example... they **find each other**, but also like they might like bounce around each other until the right two functional groups **find each other**, right, and they'll **click**, and all the rest of the stuff on the molecule just, you know, just **along for the ride.**”

Carolyn R. Bertozzi (Professor of Chemistry at Stanford)

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“atoms...**look for** others to bond with, in ways that will complete them (aww). In this, atoms are really no different from the people they ultimately create, **looking** for others to form connections with for a **happier** and, perhaps, **easier life**. ...Sometimes there is a true **meeting of minds**, in the form of an electron being shared; others happen when one atom **gives up an electron for the sake of another**; still more are the product of the electrical charges created as electrons are **traded**.”

*Explaining Humans: What science can teach us about life, love and relationships*

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"Any NK cell that finds itself shaking hands with a ULBP receptor knows it has found a stressed-out cell. The same is true if the NK cell extends its receptors to the cell only to find it omits parts of the secret-handshake expected from a normal cell."

<https://science-education-research.com/reference/pseudo-explanations/natural-killer-cells-know-about-stress/>

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"Normally the [Bose-Einstein] condensate would be totally opaque, but the first laser creates a sort of **ladder** through the condensate that the second light beam can **claw** its way along – at vastly reduced speeds."

*Light Years: The extraordinary story of mankind's fascination with light*

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"What ground is there to accept the principle of lawfulness: might it not be just **the carrot** that keeps science going?

... the search for law – **the marrow** of scientific research...the principle of lawfulness, as usually understood, is far from being **hollow** and there is no advantage to **emptying** it....

And no science lover could sensibly reject this protective and programmatic hypothesis, because to **kill** the principle of lawfulness would be a worse **crime** than **killing the golden egg hen**: it is not just a piece of knowledge but **a motor** of knowledge."

Mario Bunge

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"But by the 1970s, nuclear power was a pariah...

Climate change had been there all along: skies had been warming, glaciers melting and seas slowly rising for decades. Until the 1980s, few humans had regarded the beast as a serious threat. No longer. But the only force that was truly able to combat it – according to the movie – was largely regarded as a pariah, beset by a cultural hysteresis that associated it with bombs and meltdowns."

Film review in *Physics World*

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How readily would a student / school pupil / member of the public appreciate the intended meaning?

"These are more specialised bees that once they were vegetarian for a really long time and they actually decided to change their ways, there's all of this meat in the forest, why not take advantage?...

so potentially this specialised group of bees realised that, and maybe there's enough competition on the flowers that they decided to switch..."

BBC Science in Action





**I was going to have that rotting monkey carcass for my main course, but would you believe they have sold out of the house red?**

<https://science-education-research.com/of-opportunistic-viruses-and-meat-eating-bees/>

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"...the common clothes moth is what is called synanthropic, it actually depends entirely on man, so you don't find it in the wild"

"yeah, so there must have been a point when they were feeding on something else, and they thought 'actually, here's a better life, clothes'..."

BBC Inside Science



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"it's the  
gravity of  
dark matter  
that likes to  
kind of bring  
everything  
together"

Professor Catherine Heymans (Professor of Astrophysics at the University of Edinburgh, Astronomer Royal for Scotland)

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"you see a little drop of water, a tiny drop. And the atoms [sic, molecules] attract each other, **they like** to be next to each other. **They want** as many partners as they can get. Now **the guys** that are at the surface have only partners on one side here, in the air on the other side, so **they're trying** to get in. And you can imagine...this teeming **people**, all moving very fast, **all trying** to have as many partners as possible and **the guys** at the edge are **very unhappy and nervous** and they keep pounding in, **trying to** get in, and that makes it a tight ball instead of a flat, **and that's** what, you know, **surface tension**. When you realise when you see how sometimes a water drop sits like this on a table then you start to imagine why it's like that because **everybody is trying** to get into the water"

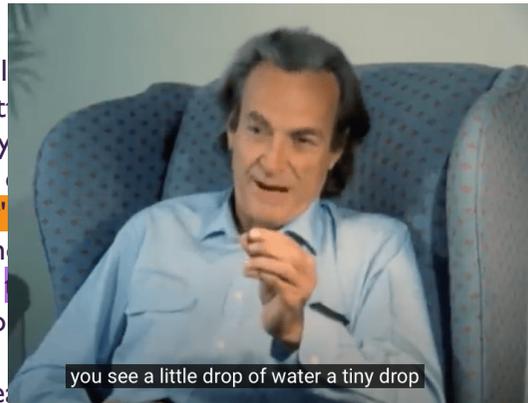
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"you see a lot of molecules] at the surface have a **want** as many as many on the other side, so **they** **people**, all molecules possible and they keep pushing instead of a When you see this on a table then you start to imagine why it's like that because **everybody is trying** to get into the water"



the atoms [sic, which other. **They** that are at the surface on the other side. this teeming with molecules. **people** partners as **nervous** and it's like a tight ball of **surface tension**. drop sits like

<https://science-education-research.com/surface-tension-is-due-to-everybody-trying-to-get-into-the-water/>

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"It comes from plate tectonics. So, essentially the earth has one objective, it has had one objective for four and half billion years, and that's to cool down. We're a big lump of rock floating in space, and it's got all this primordial energy, so we are going right back here, there's all this primordial energy from the the material coming together, and it's trying to cool down."

Dr James Hammond (Reader in Geophysics at Birkbeck, University of London)

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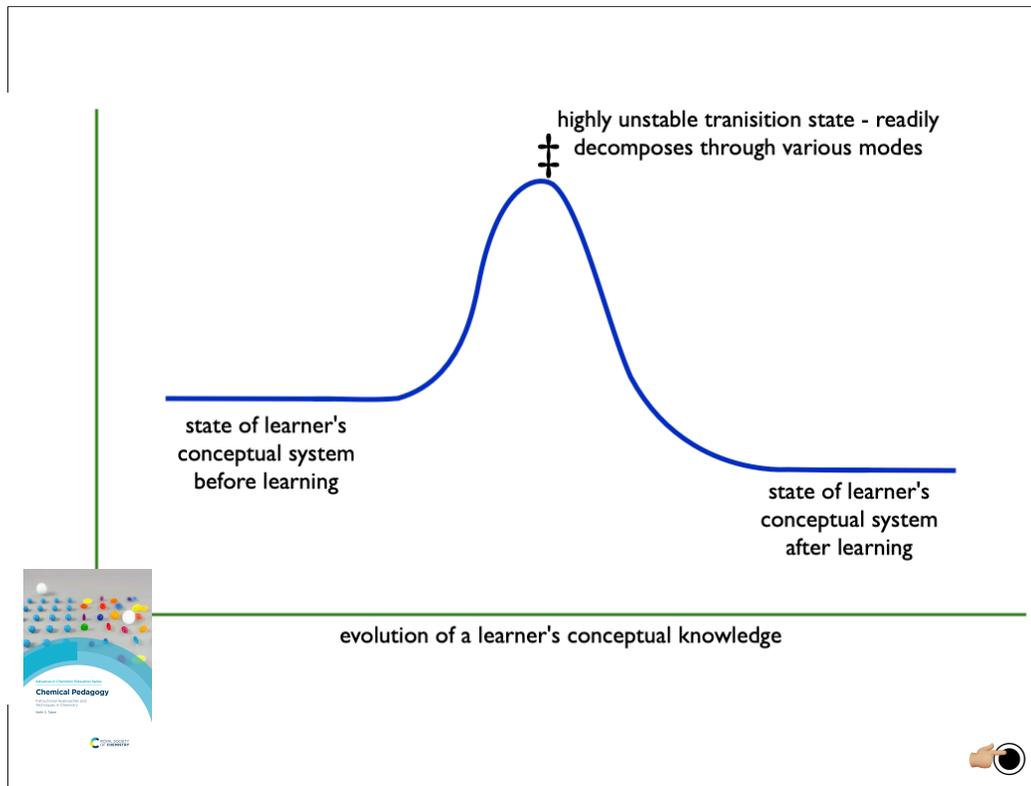
How readily would a student / school pupil / member of the public appreciate the intended meaning?

"...earth's biogeochemical cycles where there is no waste, everything is repurposed and recycled at different timescales. And I always think of the example of phosphorus in nature. Phosphorus is an element which that's really important for the biosphere, but it is really scarce in rocks, and so **the biosphere has learned to** recycle it ferociously."

Prof. Marcia Bjornerud (Professor of Geology and Environmental Studies, Lawrence University)

autobahn  
bypass  
cul-de-sac  
?

Are these examples autobahns getting meaning across quickly;  
bypasses that might lead to learners missing the scientific principle;  
or cul-de-sacs which lead the learner nowhere: so nothing valuable is learned?  
(And that question needs to be asked with a particular group of learner, or strictly even a specific learner, in mind.)



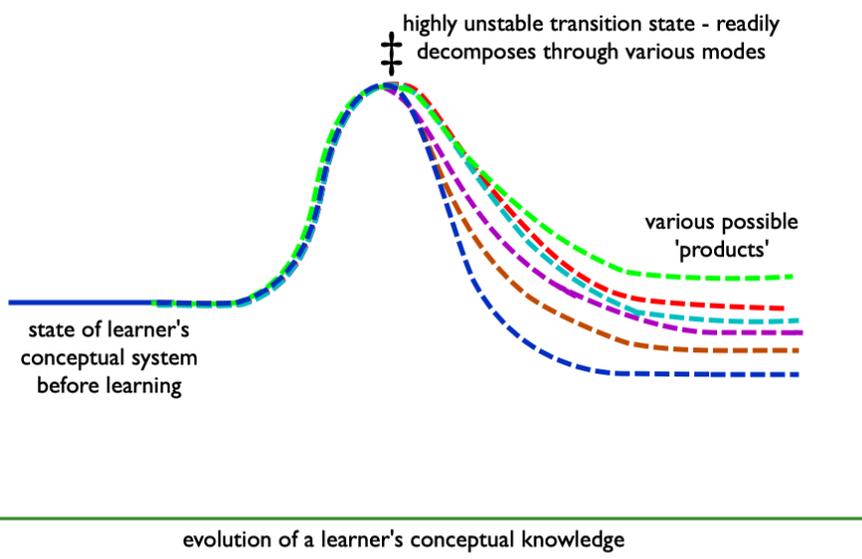
Another analogy (explained in detail in Taber, K. S. (2024). *Chemical Pedagogy. Instructional Approaches and Teaching Techniques in Chemistry*. Royal Society of Chemistry.)

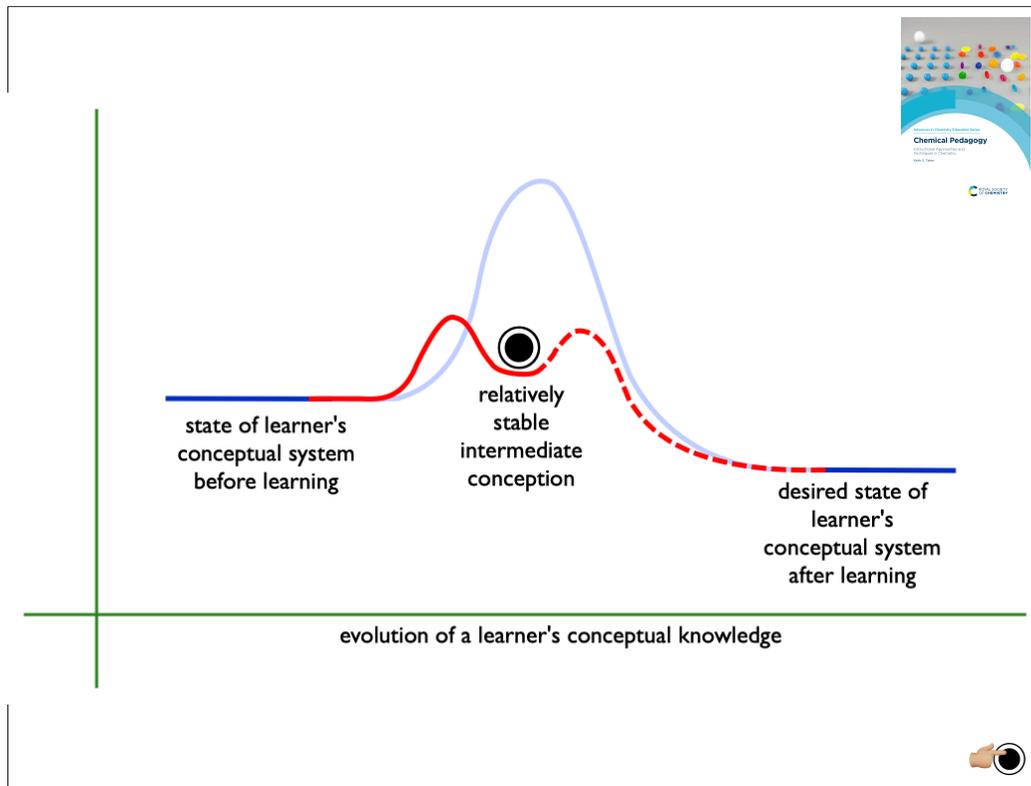


Chemical Pedagogy

University of Cambridge

2018





When used well, comparisons with what is already familiar may help the learning process - like a catalyst (but there is much to go wrong). Catalysts tend to be selective: you need to use the right catalyst for a particular reaction.

The teacher (or other science communicator) needs tools to help 'make the unfamiliar familiar'

Figurative language has a key role to play

But it also risks learners motoring past our intended destination because their interpretation of a figure of speech was not what we intended

And it risks the representation being taken for the target, and the learner getting stuck with the metaphor or anthropomorphic explanation

The teacher (or other science communicator) needs tools to help 'make the unfamiliar familiar'

Figurative language has a key role to play

But it also risks learners motoring past our intended destination because their interpretation of a figure of speech was not what we intended

so, always be explicit that one is using a figure of speech, and in fully mapping across

And it risks the representation being taken for the target, and the learner getting stuck with the metaphor or anthropomorphic explanation

so, always move the learners on as soon as possible, so that what is intended as a transition state does not become a long-lived intermediate



Some key points for teaching.

*“... more research is needed...”*

objective  
understanding:

as measured in  
tests / exams

subjective  
understanding:

seems to make  
sense



Thank you

Keith S. Taber

[science-education-research.com](http://science-education-research.com)

This document contains an edited set of the slides presented, with some brief explanatory notes.

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A document with many more examples – ***Creative Comparisons: Making Science Familiar through Language***. An illustrative catalogue of figurative comparisons and analogies for science concepts – can be downloaded from:

<https://science-education-research.com/downloads/publications/2025/Taber-Science-Comparisons.pdf>