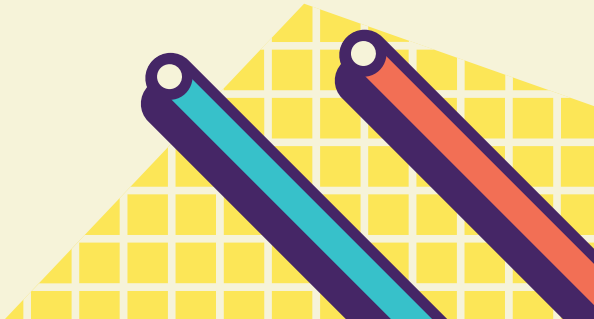
TOK

Mathematics

1. Extended phenotype
2. Solve a quadratic
3. Pascal’s Triangle
4. Metaphors and Algorithms
5. Physics Envy
6. Eyes
7. Pascal’s Wager
8. Good and Bad Explanation



01

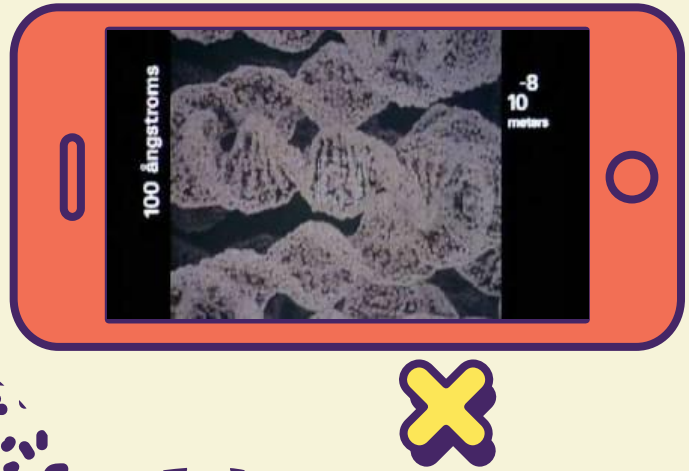
EXTENDED PHENOTYPE—

“

Without the instruments and accumulated knowledge of the natural sciences... humans are trapped in a cognitive prison. They are like intelligent fish born in a deep shadowed pool. Wondering and restless, longing to reach out, they think about the world outside. They invent ingenious speculations and myths about the origin of the confining waters, of the sun and the sky and the stars above, and the meaning of their own existence. But they are wrong, always wrong because the world is too remote from ordinary experience to be merely imagined.

— — Wilson, E. O. (1999: 76-77) Consilience. Random House New York.

Powers of 10



In collaborative pairs, go online to explore the Nikon's interactive Universcale site. Universcale offers a gently unfolding view “from the microworld to the universe,” displaying entities that cannot normally be physically compared against a continuous scale. It is all the better with its ethereal soundtrack turned on. Then, explore the interactive Size and Scale cartoon visualization from the University of Utah's Genetic Science Learning Center.

EXTENDED PHENOTYPES

Look at this presentation

Definition

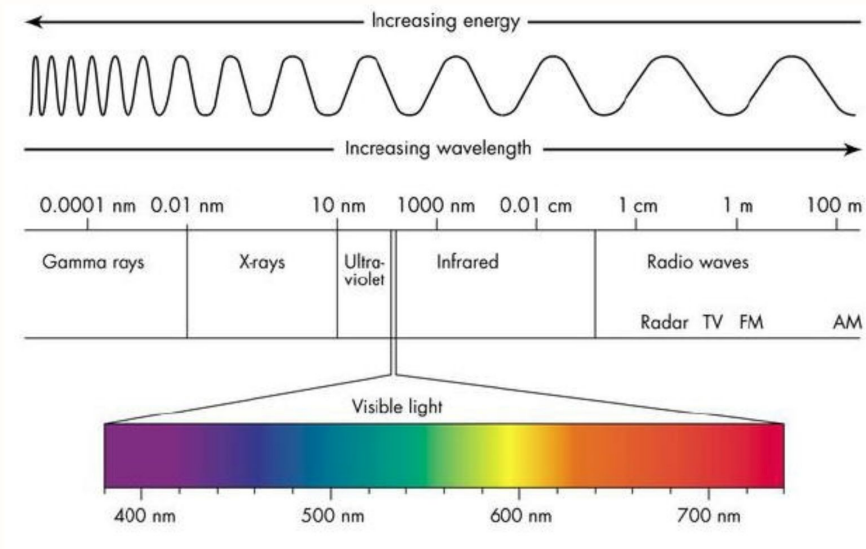
Define the extended phenotype

Read

“Of all our senses it is vision that most informs the mind... It is no great wonder that the instruments of science also favor vision; but they extend it far into new domains of scale, of intensity, and of color... [S]cience has followed into sensory domains beyond any direct biological perception. There, complex instruments assemble partial images of the three-dimensional space in which we dwell, images rich and detailed although at scales outside the physical limits of visible light.”

— From the Introduction to Powers of Ten: A Book about the Relative Size of Things in the Universe and the Effect of Adding Another Zero by Philip and Phylis Morrison and The Office of Charles and Ray Eames (1982) Scientific American Library, New York.

ELECTROMAGNETIC SPECTRUM



The Electromagnetic Spectrum. This diagram spans 15 orders of magnitude.

Move into the 41 orders of magnitude slideshow. The 17 slides range all the way from subatomic interactions to composite visualizations of the very the edge of the known universe.

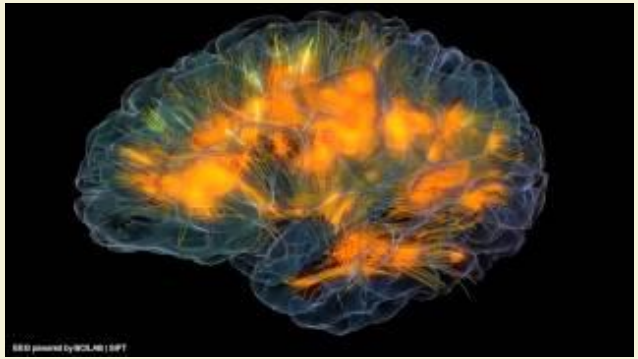
It worth pausing a moment to appreciate the significance of the Hubble Space Telescope. Orbiting Earth for 27 years, NASA's Hubble Space Telescope has changed our fundamental understanding of the universe. It has made more than a million observations, has generated more than 14,000 scientific papers, and is still at the peak of its scientific capability. Hubble does not travel to stars, planets or galaxies. It takes pictures of them as it whirls around Earth outside the haze of our atmosphere. The **Hubble website** is worth a visit.

GLASS BRAIN

Golden Age of Neuroscience

One of the great obstacles to understanding our embodied selves is the self referential problem of using our brains to understand how our brains work. We are both the subject and object of our epistemological and ontological quest.

Much of our knowledge of brain function came from the trickle of evidence gleaned from individual brain-damaged patients. The use of technologies that permit non-intrusive imaging of living brains in action has revolutionized the field.

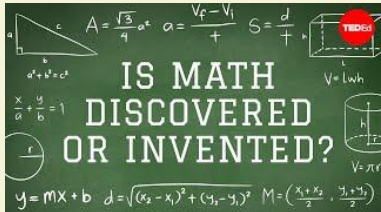




Brain Imaging

The word intuition, as used by mathematicians, carries a heavy load of mystery and ambiguity. Sometimes it seems to be a dangerous and illegitimate substitute for rigorous proof. In other contexts it seems to denote an inexplicable flash of insight by which the happy few gain mathematical knowledge which others only attain by long efforts.

—Davis, Philip J. and Hersh, Reuben (1981)



02

SOLVE A QUADRATIC

Black Box

Look intensely at the equation below, and think carefully about how to approach solving it

$$6x^{(2)}-5x-4=0$$

Now, solve the equation showing all stages of your working, using the step-by-step formal conventions used in their IB math classes. If time permits, continue solving the same equation using multiple methods.

If you were an octopus how would you have approached solving the quadratic? A KG student?

GOING DEEPER

- To what extent are the various elements of the quadratic equation an extension of the idea of counting numbers?
- What is the relationship between algebra and simple arithmetic?
- What is the relationship between algebra and geometry?

SUM OF THE ANGLES IN A TRIANGLE



1. Look at the image on the right and think of how to reverse engineer the paper model.

2. Quickly grab a piece of paper, and cut out a random triangle; then rip off the corners, and arrange the angles, more or less, in a straight line.

Proof

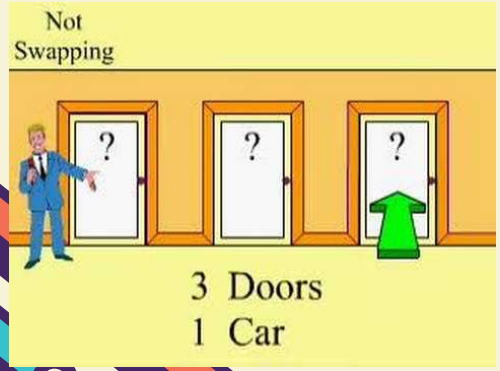
3. Without using any mathematical symbols write out your proof in full English prose so that your reader would have to visualize your diagram and proof based on only the words you have written on the page (as if it had been written in a novel without the aid of a diagram).

sit back-to-back with your partners. Here are the instructions:

You will read your prose proof from #3. The rule for this task is that your partner can ask you to pause or repeat what you read; but you cannot change what was written. Your partner must sketch or otherwise validate your proof only by listening to your text.

When finished, switch roles. Critique the validity of each other's work.

1. Does folding down the corners of a single triangle or ripping off the corners and arranging them in a straight line count as proof that the sum of the angles of a triangle add up to 180 degrees?
2. Is performing the corner ripping technique more convincing as proof when it is done carefully and accurately, using the ruler to construct the triangle by joining the randomly points marked by crosses?



Monty Hall Problem

01

"Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the other doors, opens another door, say No. 3, which has a goat. He then says to you, 'Do you want to pick door No. 2?' Is it to your advantage to take the switch?"
— Marylin Vos Savant

02

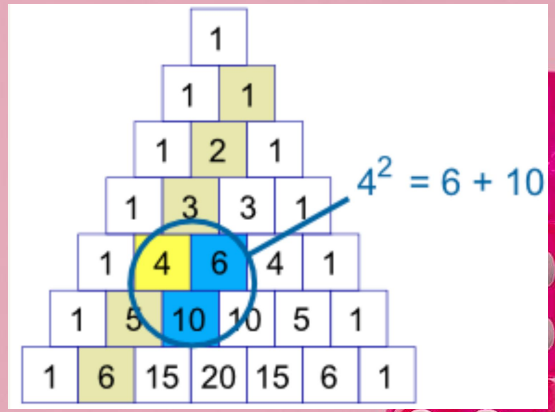
"You blew it, and you blew it big! Since you seem to have difficulty grasping the basic principle at work here, I'll explain. After the host reveals a goat, you now have a one-in-two chance of being correct. Whether you change your selection or not, the odds are the same. There is enough mathematical illiteracy in this country, and we don't need the world's highest IQ propagating more. Shame!"
— Scott Smith, Ph.D. from the University of Florida

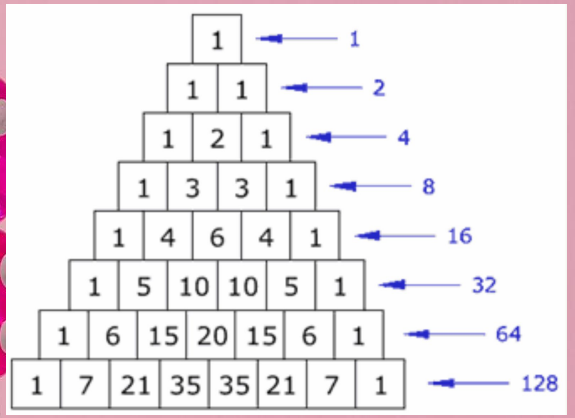
To what extent does the explanation for the Monty Hall Problem, outlined in the video, hold up as proof?
To what extent are probability and certainty in the statistical branch of mathematics mutually exclusive?

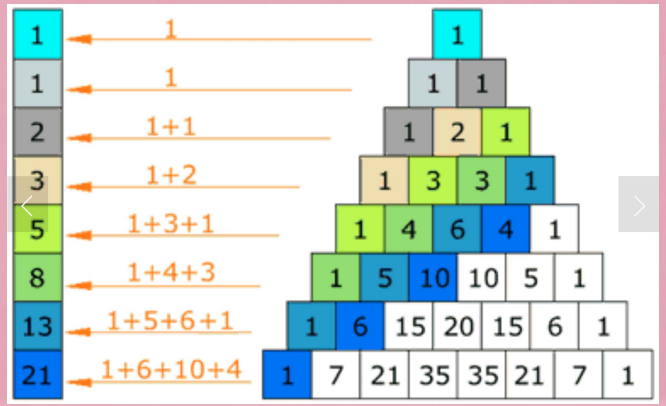
03

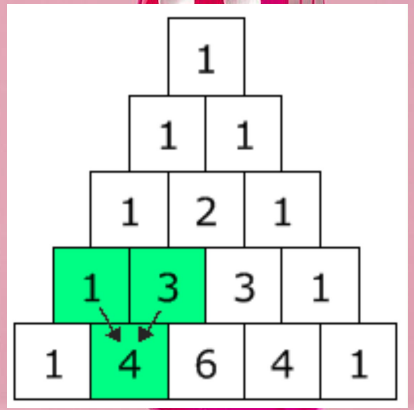
Pascal's Triangle

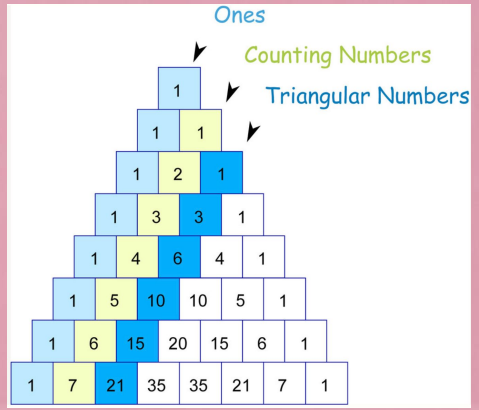
PASCAL'S TRIANGLE











Solve this Sudoko

BUILD A HOUSE OF CARDS

2, 5, 8... The number of cards needed for each of first three levels (rows) of the House of Cards.

Work in pairs to build a classic House of Cards. A small prize should be awarded to the pair with the most levels that can stand alone for at least 10 seconds!

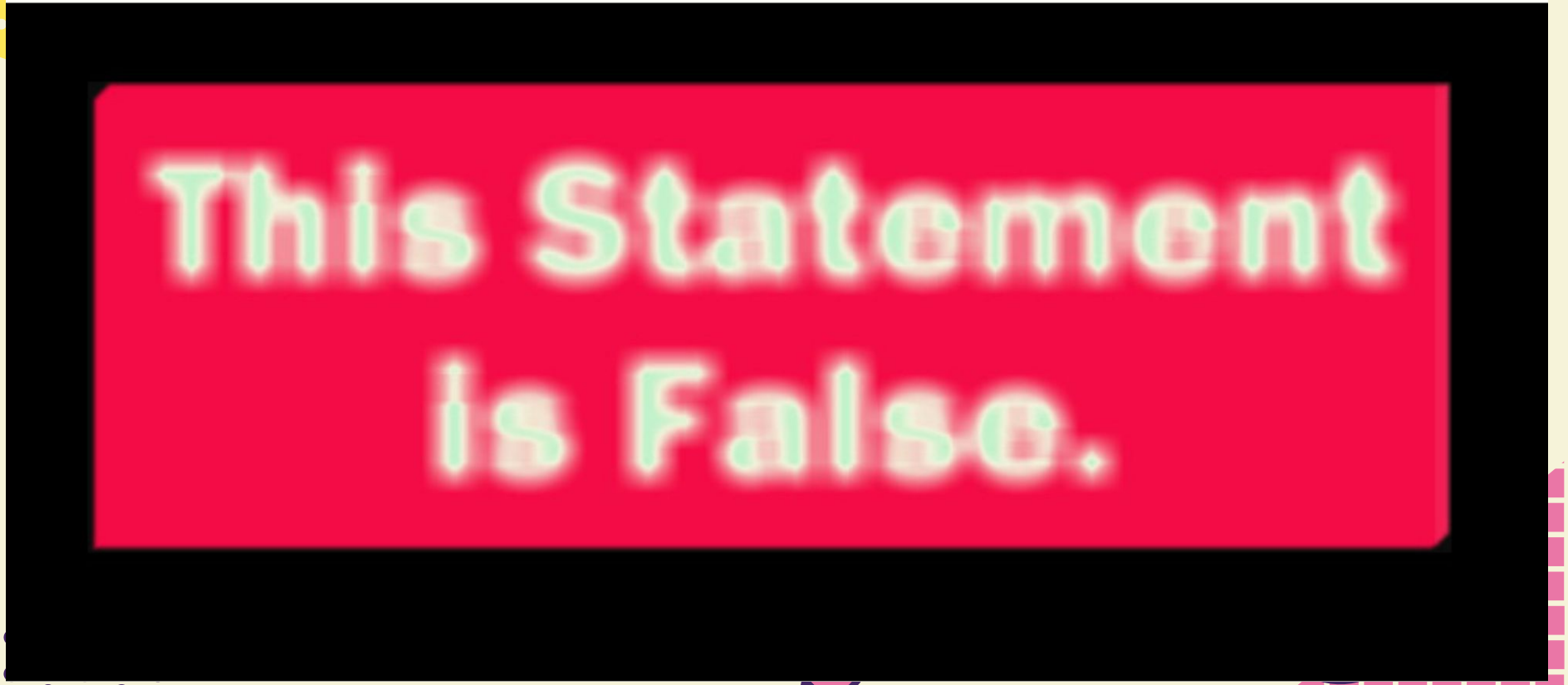
1. Write, using the fewest possible words, a grammatical prose paragraph that provides definitive instructions to construct a classic house of cards.

2. What is the largest House of Cards that can be made with a single pack of cards?

3. What is the longest single row that can be made with a single pack of cards? (Don't forget the horizontal lids.)

4. Invent or discover a universal formula for total number cards needed to construct a House of Cards with n rows. There are multiple ways to approach this. Be rigorous. Diagram and present your proof succinctly and clearly. Be prepared to present your findings to the entire class.

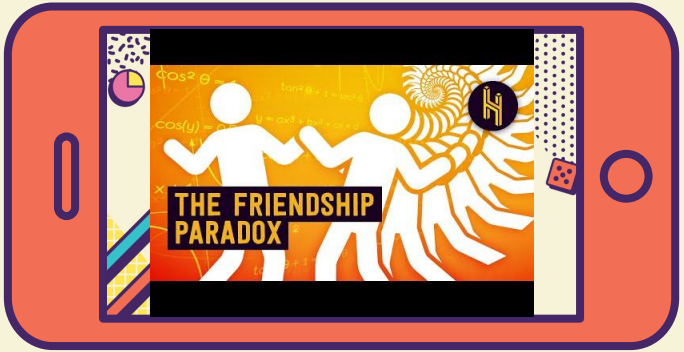




One version of the Liar's paradox first described by Zeno of Elea [495-430 BC]

Paradox

What does paradox mean? Compare it to other similar terms



Quotes

I wanted certainty in the kind of way in which people want religious faith. I thought that certainty is more likely to be found in mathematics than elsewhere. But I discovered that many mathematical demonstrations, which my teachers expected me to accept, were full of fallacies, and that, if certainty were indeed discoverable in mathematics, it would be in a new field of mathematics, with more solid foundations than those that had hitherto been thought secure. But as the work proceeded, I was continually reminded of the fable about the elephant and the tortoise. having constructed an elephant upon which the mathematical world could rest, I found the elephant tottering, and proceeded to construct a tortoise to keep the elephant from falling. But the tortoise was no more secure than the elephant, and after some twenty years of very arduous toil, I came to the conclusion that there was nothing more that I could do in the way of making mathematical knowledge indubitable.

— Bertrand Russell in "Portraits from Memory and Other Essays" (1956)

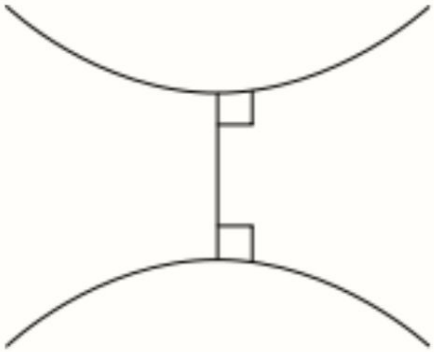
The goal of my theory is to establish once and for all the certitude of mathematical methods… The present state of affairs where we run up against the paradoxes is intolerable. Just think, the definitions and deductive methods which everyone learns, teaches and uses in mathematics, the paragon of proof and certitude, lead to absurdities! If mathematical thinking is defective, where are we to find truth and certitude?

— David Hilbert: On the infinite (1926)

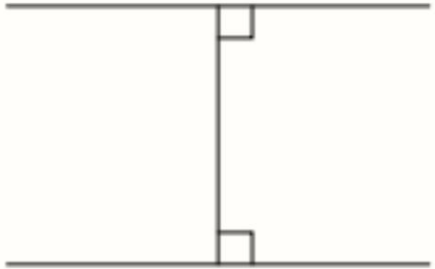
Try drawing a geometric shape on the back of a classmate

NON-EUCLIDEAN GEOMETRY

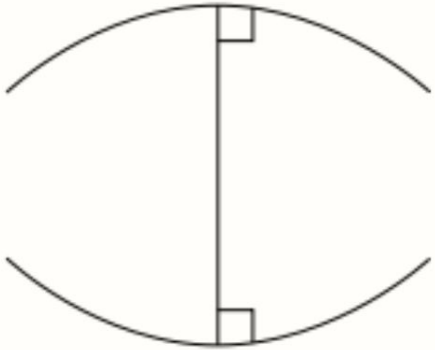
Remember that all of Euclidean geometry is built on five self-evident axioms and postulates. Over the centuries it became apparent that proving Euclid's fifth postulate (the postulate of parallels) was problematic.



Hyperbolic



Euclidean



Elliptic

Hyperbolic non-Euclidean surfaces are convex and saddle-shaped. Parallel lines converge. Elliptic non-Euclidean surfaces are concave. Parallel lines diverge. A familiar example is the surface of a sphere.

NON-EUCLIDEAN GEOMETRY

1. Ensure that you know the difference between lines of latitude and lines of longitude. The most famous line of latitude is the equator. All the other lines of latitude are parallel to the equator and get smaller as they approach the poles. The lines of longitude are all "great circles" like the equator and pass through the North and South poles. The lines of longitude are conventionally 15 degrees apart. Why?



2. On a globe mark 3 random crosses on three different continents, (to allow significant distance between them). Use a stretched string and tape to define the triangle made by joining up the points. Use a protractor to measure carefully sum of the angles of the triangle.
3. First choose your favorite European city. Next identify two different flight paths between San Francisco and your chosen destination based on the Google map above
A. Going directly West to East.
B. Going East to West but veering North along the way, so you go over arctic Canada Greenland and Iceland.
Use stretch string and tape to mark the two journeys. Finally using a ruler measure the two lengths of string that you used.


THE
INFINITE
HOTEL
WELCOME TO
THE
INFINITE HOTEL
TEDEd


TO INFINITY
AND BEYOND!

The World



Read the following

Article 1
Article 2



Data

Look at the World in Data



Risk Assessment

Predict the cards
Assess these risks



News of Death

Does the news reflect what we die from?



Factfulness

Take this test

DALY



KQ

How far is intuition used in maths? Is maths the most certain area of knowledge?

03

Mathematical Beauty

Beautiful

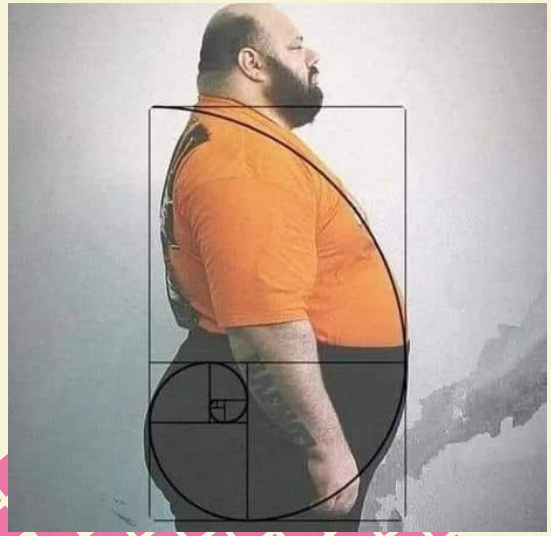


Try it out

Type the words out in Google images, what do you get?
Is Mathematics the base of everything?
Can something be beautiful with the interference of mathematics?
What is the golden ratio theory?

Golden Ratio

What is it?



Prezi

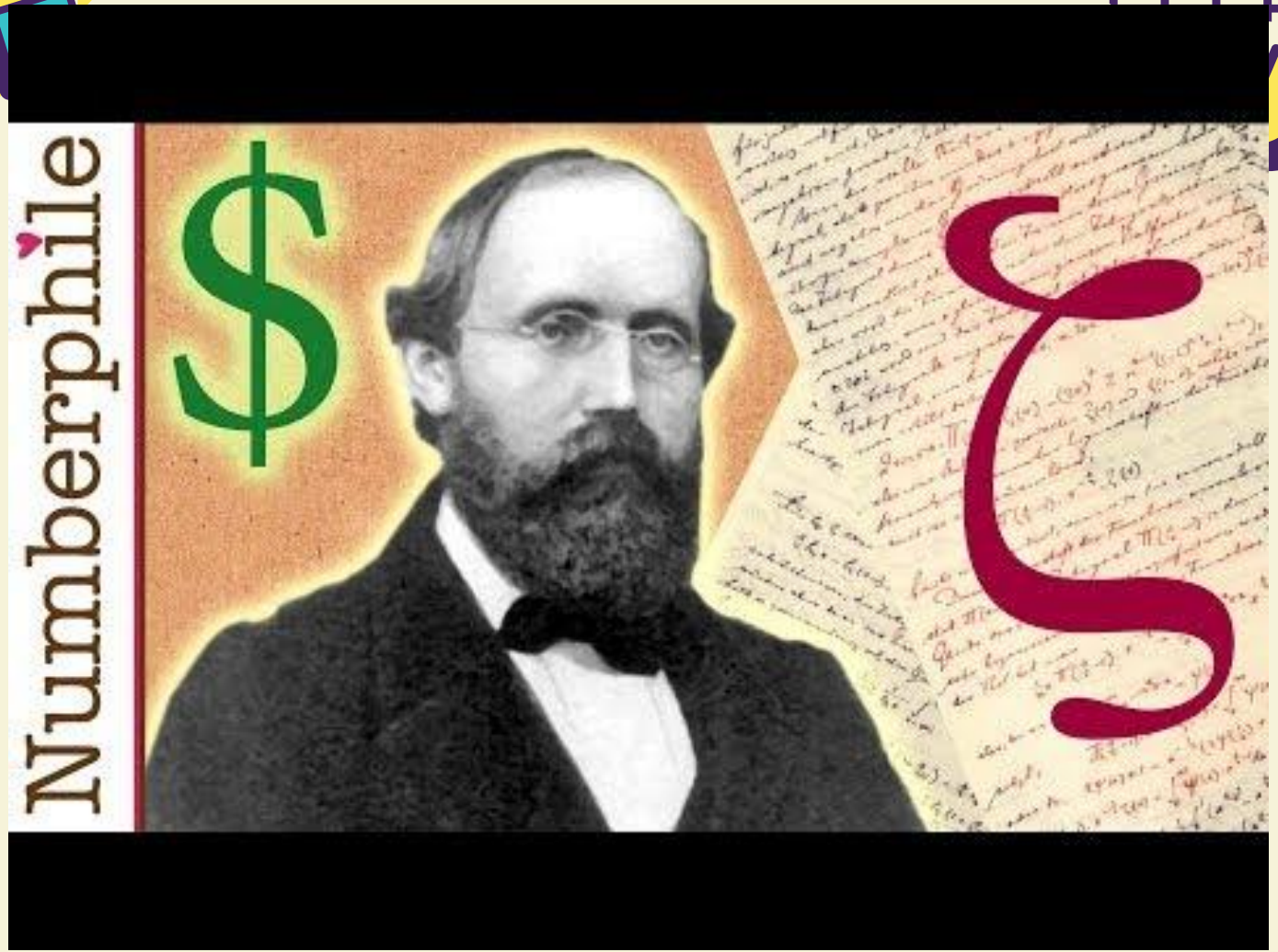
Look at this presentation

How much is it?

How to calculate

04

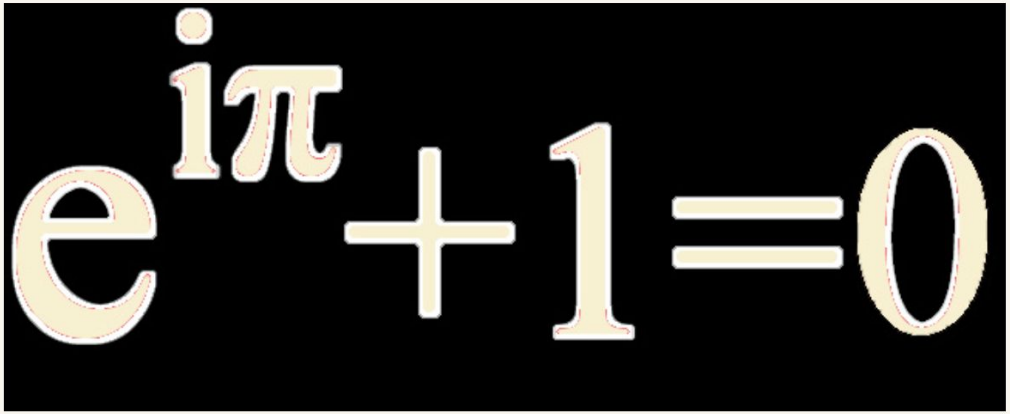
Metaphors and Algorithm


Numberphile

What's so magical?

The knowledge at which geometry aims is the knowledge of the eternal.
— PLATO, REPUBLIC. VII: 527

Euler's Law



Knowledge Questions

Take 5 minutes to discuss the following

- What are the essential differences between equations like the Euler formulation and the applied mathematics of physics and engineering?
- It has often been said that the Euler relation is the most beautiful equation in all of mathematics. What is meant by beauty and elegance in mathematics?
- Based on your own mathematical education so far, do you think that Euler invented or discovered his equation?

$$e^{i\pi} + 1 = 0$$

$$pV = nRT$$

Knowledge Questions

Take 6 minutes to discuss then another 6 minutes to write a quick reflection of questions 5, 6, and 7

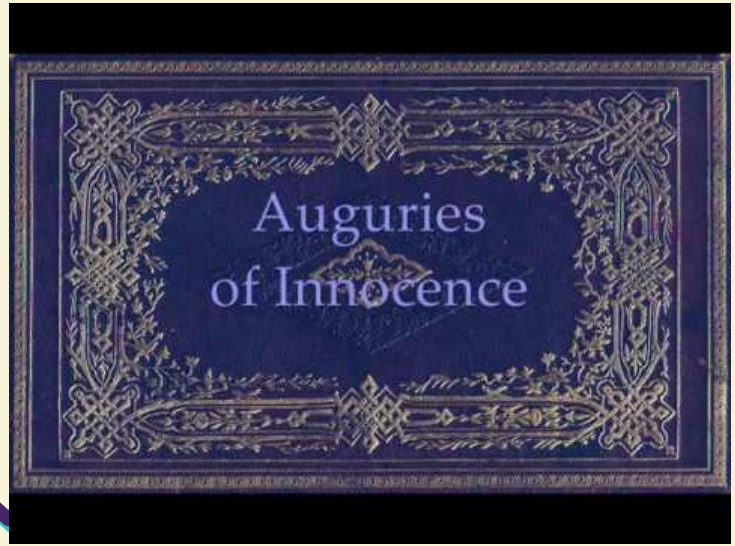
1. What are the similarities and differences between these two equations?
2. Are both equations examples of pure mathematics? Are both firmly in the domain of abstract, analytical knowledge? Do they both convey certainty?
3. The first equation is called Euler's relation and the second equation is known as the Ideal Gas Law. Does knowing the names of the equations change your responses to the previous two questions?
4. For the Ideal Gas Law what do each of the symbols represent? Why do physicists use lower case letters for p and n? What are the SI units for each of the components?
5. What is “ideal” about the Ideal Gas Law?
6. When chemists do real world experiments based on the Ideal Gas Law, actual results come close to predicted results, but they are never identical. Why?
7. What has this got to do with the idea that “The Map is Not the Territory”?

“A robin redbreast in a cage,
Puts all heaven in a rage.”

$$pV = nRT$$

$$e^{i\pi} + 1 = 0$$

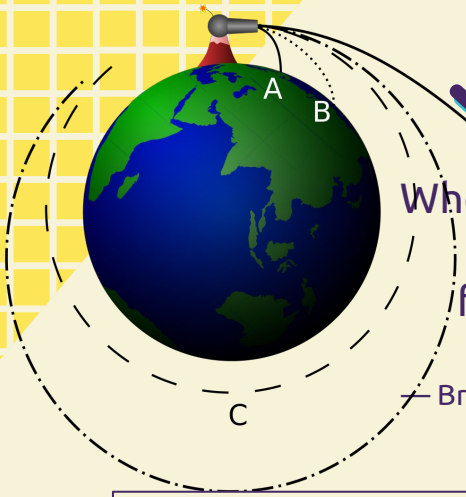
Reflect



Can we agree that the Blake couplet has much more in common with the Ideal Gas Law than the Ideal Gas Law does with the Euler Relation (despite the superficial resemblance of being expressed in mathematical symbols)? Whether you agree or disagree, you must argue your case.

Can we say that the Ideal Gas Law, the Krebs' Cycle, the definition of Osmosis, the Law of Supply and Demand and, for that matter, all other models in the natural and human sciences, have more in common with a Shakespeare soliloquy or a Rembrandt self-portrait than they do with the Euler Relation, the Theorem of Pythagoras or the Sine Rule?

Newton

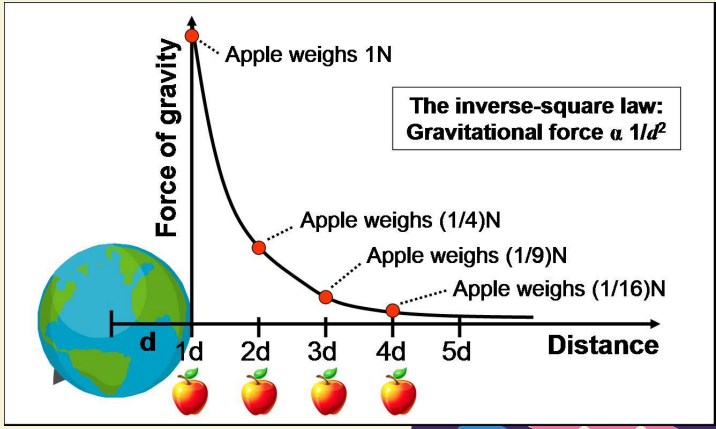


When Newton saw the moon as a ball that had been thrown round the earth, he was initiating a gigantic metaphor. And when it finished up… it was an algorithm (a formula with which you can calculate).

— Bronowski, Jacob (1978: 45) The Origins of Knowledge and Imagination. Yale University Press, Princeton.

Newton's original thought experiment is a powerful metaphor... which he formalized to an algorithm that we now call "Newton's inverse square law of gravitation"... in formal prose the algorithm states that:

The gravitational attraction between two massive bodies is proportional to the product of those two masses and inversely proportional to the square of the distance between them:



$$F_g = G\frac{m_1 m_2}{r^2}$$

Platonism vs Formalism

Read these texts

Images

Left: PHILIP J. DAVIS Professor Emeritus from the Division of Applied Mathematics at Brown University.
Right: REUBEN HERSH Professor Emeritus from the Department of Mathematics and Statistics at the University of New Mexico.





05

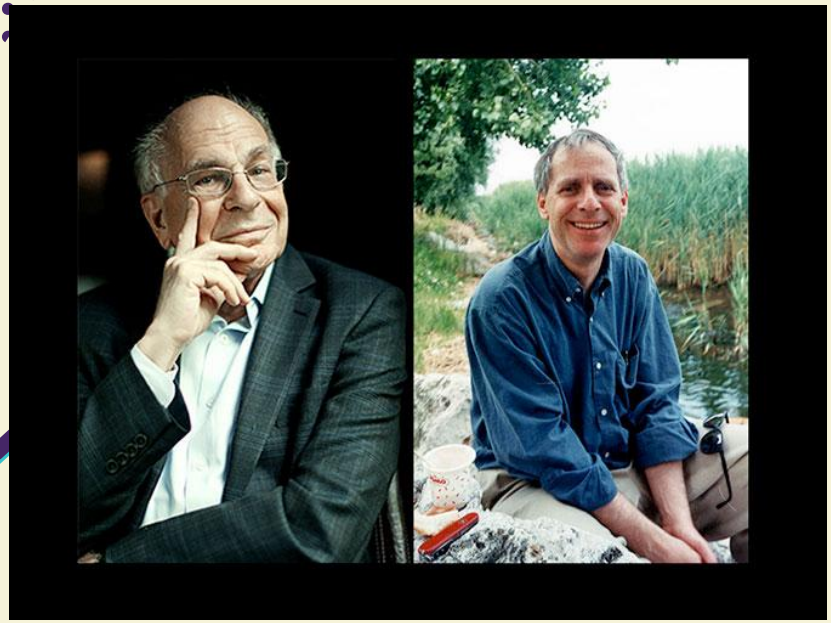
Physics Envy

All science is either physics or stamp collecting.
— Ernest Rutherford 1871–1937 New Zealand physicist: J. B. Birks Rutherford at Manchester (1962)



Could the Economy Tank in 2016? 23 economic forecasts for the new year.
Politico magazine: January 3, 2016. Image credit: AP Photo

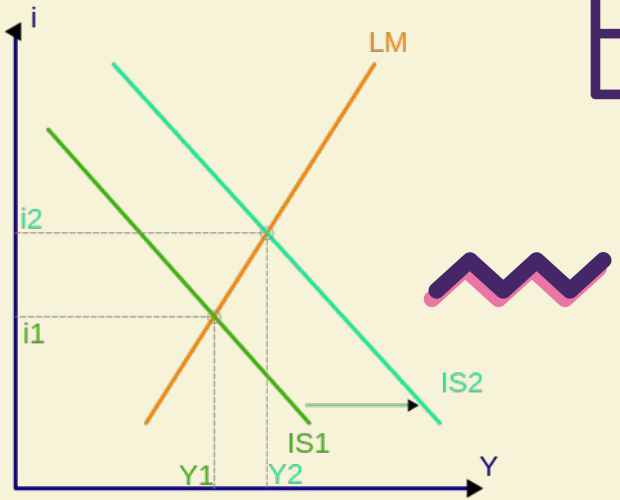
Daniel Kahneman (left) and Amos Tversky (right)



Kahneman and Tvarsky are famous for their longstanding and highly productive collaboration on heuristics--intuitive judgments or pragmatic rules of thumb that speed up and simplify our thinking. In their landmark publication, Judgment under Uncertainty: Heuristics and Biases (Science; 85: 4157, pp. 1124-1131), they outlined their research program in a single ominous sentence:
"In general these heuristics are quite useful, but sometimes they lead to severe and systematic errors."
Kahneman won the 2002 Nobel Prize in Economic Sciences. Kahneman and Tvarsky's research findings in empirical psychology challenged (and have largely toppled) the unexamined assumption, at the core of prevailing economic theoretical models, that human agents always behave rationally. Tvarsky, of course, would have shared the prize, but he died in 1996. The Nobel is not awarded posthumously.

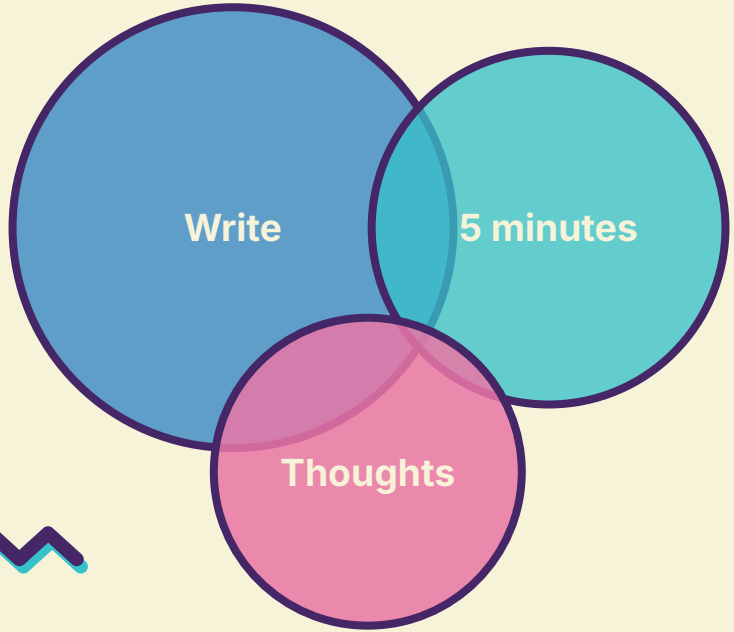
Questions

Everyone knows that the social sciences are hypercomplex. They are inherently far more difficult than physics and chemistry, and as a result they, not physics and chemistry, should be called the hard sciences. They just seem easier because we can talk with other human beings but not with photons, gluons, and sulphide radicals.
— — Wilson, E. O. (1999: 99) Consilience. Random House, New York.



The IS-LM (Investment Saving – Liquidity Preference Money Supply) macroeconomic model:
The IS curve moves to the right, causing higher interest rates (i) and expansion in the "real" economy (real GDP, or Y).
The investment/saving (IS) curve is a variation of the income-expenditure model incorporating market interest rates (demand), while the liquidity preference/money supply equilibrium (LM) curve represents the amount of money available for investing (supply).
Image and caption: Macroeconomics-Wikipedia

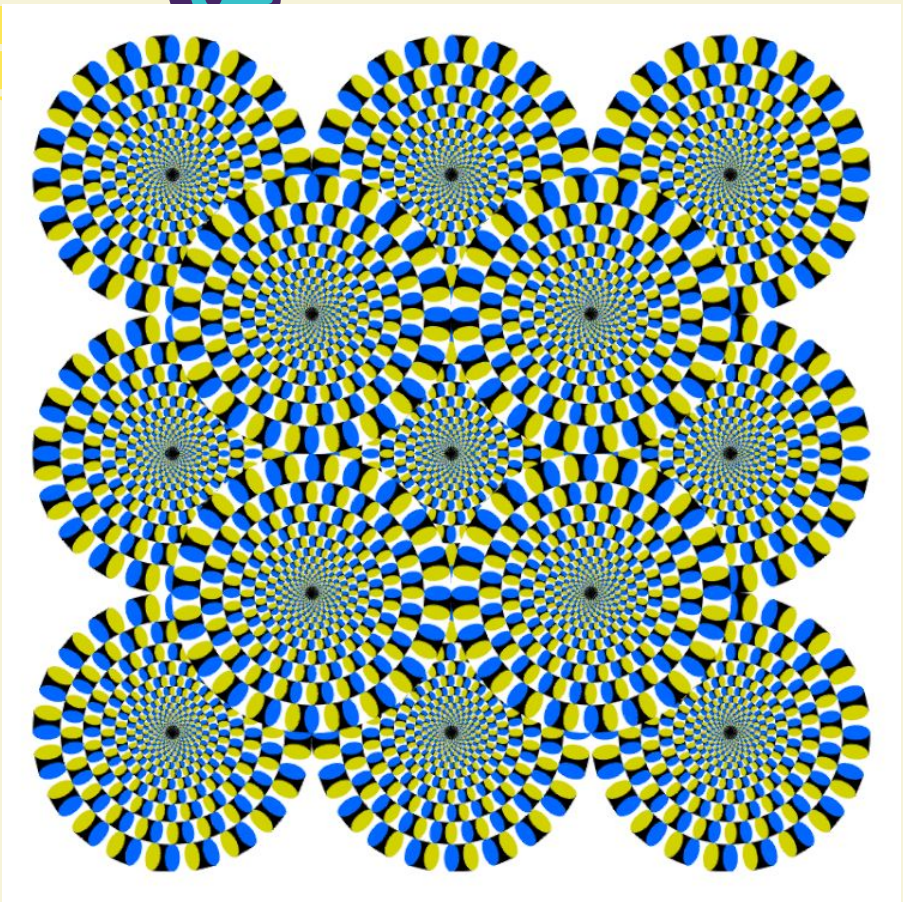
Rotating KQs



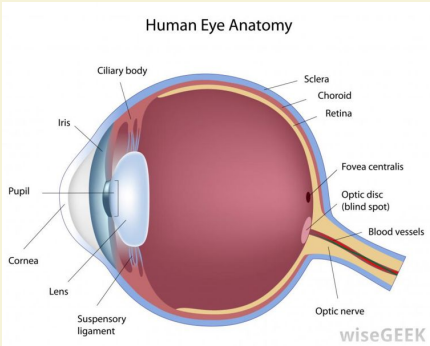
- Write random sentences that would answer the question using your colour.
- When time is up, write a tick (if applicable) and add to what the previous group has written.
- You will present the last question you had.

06

EYES



Rotating Snakes Illusion: Akiyoshi Kitaoka designs static works that generate “anomalous motion.” On his **Illusion Pages website** he warns that his creations “might make sensitive observers dizzy or sick.” You can stop local movements of the concentric circles temporarily by staring into the dark centers. Are the concentric circles really moving? What on earth is going on here?



“Bear in mind that the filling in is not just some odd quirk of the visual system that had evolved for the sole purpose of dealing with the blind spot. Rather, it appears to be a manifestation of a very general ability to construct surfaces and bridge gaps that might be otherwise distracting in an image – the same ability, in fact, that allows you to see a rabbit behind a picket fence as a complete rabbit, not a sliced-up one.

— Ramachandran, V.S. and Blakeshee, Sandra (1998: 90) Phantoms in the Brain - Probing the Mysteries of the Human Mind. William Morrow, New York.

Blindspot activity

EYE TRACKING



Read aloud

A Martian ethologist observing humans using their visual systems would almost certainly include in their report back: ‘they move these small globes around a lot and that’s how they see’... We believe that movements of the eyeballs are a fundamental feature of vision. This viewpoint is not widely current. Many texts on vision do not even mention that the eye can move.

— John M. Findlay and Iain D. Gilchrist (2003; 1) Active Vision: The Psychology of Looking and Seeing. Oxford University Press. Oxford, UK.

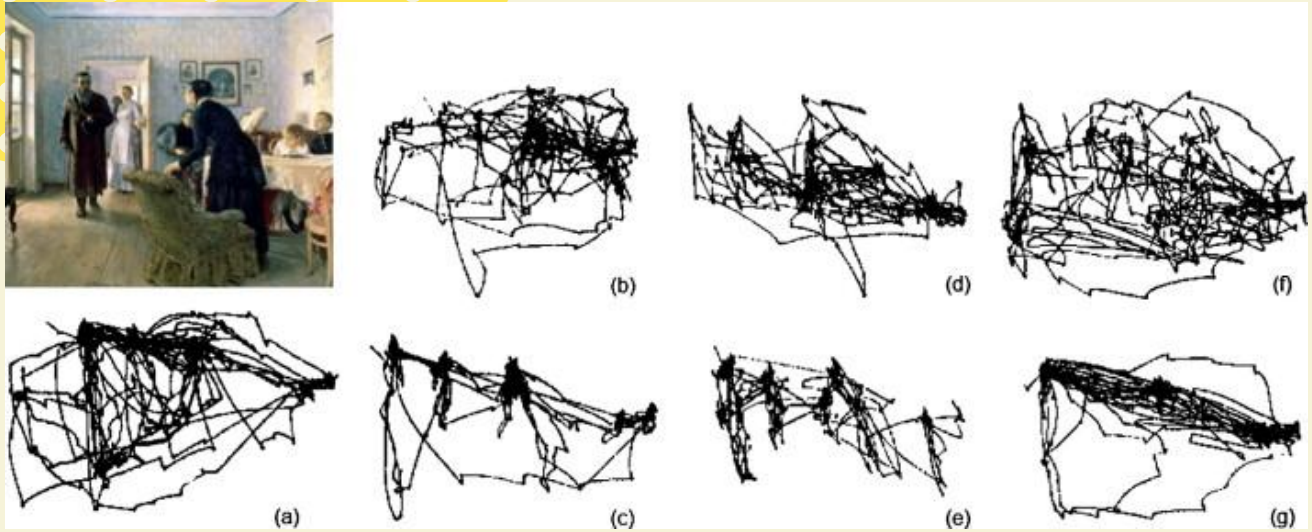
ENCOUNTER WITH YARBUS

Russian psychologist Alfred L. Yarbus investigated the nature of eye movements during the fifties and sixties. His famous eye tracking experiments revealed that subjects who viewed complex scenes, scanned them differently when asked to perform specific tasks. Students should be reminded that the saccadic jumps, of the eye are happening about three times a second; too rapid to be under direct conscious control.

Yarbus used Repin's painting They did not expect him in his most influential study. Repin is revered for his realist painting in Russia, as Tolstoy is for literature.



Repin, Il'ia Efimovich (1884-88) *They Did Not Expect Him.* Oil on canvas. Tretiakov Gallery, Moscow.



(a) Free examination

(b) Estimate material circumstances of the family?

(c) Give the ages of the people?

(d) What had the family been doing before the arrival of the unexpected visitor?

(e) Remember the clothes worn by the people

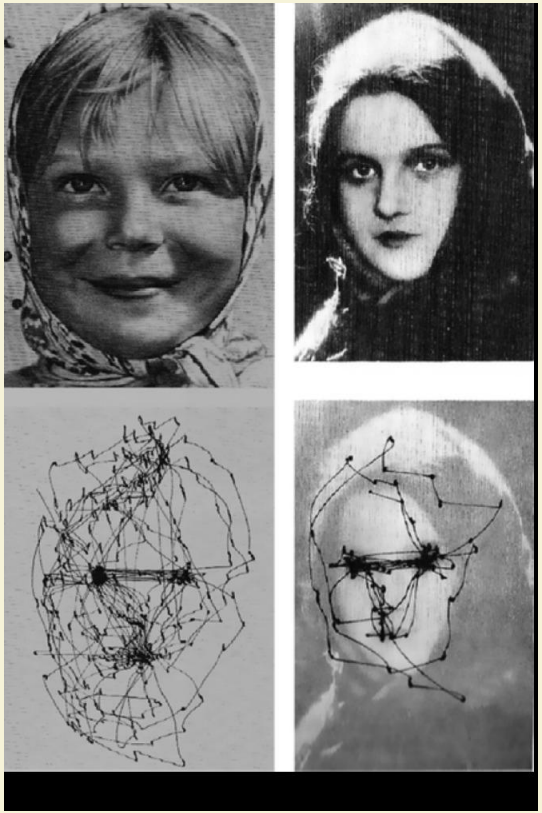
(f) Remember the positions of the people and objects in the room

(g) Estimate how long the visitor had been away from the family

respond to the following questions.

1. For each task scenario encapsulate the result in a single sentence
2. What is the "control" in this experiment?
3. What does this tell us about eye scanning in general?
4. What seem to be some of our default points of interest?
5. What are the big picture implications for sense perception in general are revealed by the Yarbus data?

More iconic Yarbus results



Knowledge Questions



Nielsen lab measures brainwaves and tracks eye movements to provide a real-time picture of consumers' subconscious reactions to brand messages. *Photo: Thinkstock*

"

A fool sees not the same tree that a wise man sees

— William Blake: The Marriage of Heaven and Hell (1790–1793)

Tick Algorithm

“Estonian biologist, Joacob Johann von Uexküll (1864-1944) “coined the term Umwelt—the surrounding world—to describe the unique and therefore limiting, sensory world of each animal species, including our own.”

— Gould, James L. and Gould, Carol Grant (1994: 18) The Animal Mind. Scientific American Library, New York.



Ixodus ricinus Photo: Richard Bartz

More on Ticks

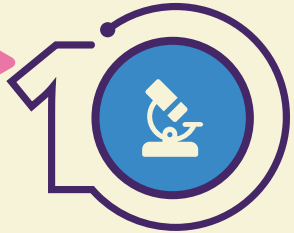
Once the female has copulated, she climbs with her full count of eight legs to the tip of a protruding branch of any shrub in order either to fall onto small mammals who run by underneath or to let herself be brushed off the branch by large ones. The eyeless creature finds the way to its lookout with the help of a general sensitivity to light

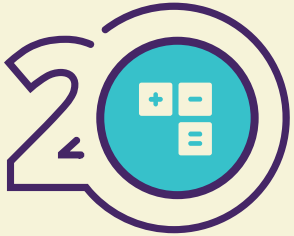
The blind and deaf bandit becomes aware of the approach of its prey through the sense of smell. The odor of butyric acid, which is given off by the skin glands of all mammals, gives the tick the signal to leave its watch post and leap off. If it then falls onto something warm—which its fine sense of temperature will tell it—then it has reached its prey, the warm-blooded animal, and needs only use its sense of touch to find a spot as free of hair as possible in order to bore past its own head into the skin tissue of the prey.

Now, the tick pumps a stream of warm blood slowly into itself. Experiments with artificial membranes and liquids other than blood have demonstrated that the tick has no sense of taste, for, after boring through the membrane, it takes in any liquid, so long as it has the right temperature. If, after sensing the butyric acid smell, the tick falls onto something cold, then it has missed its prey and must climb back up to its lookout post. The tick's hearty blood meal is also its last meal, for it now has nothing more to do than fall to the ground, lay its eggs, and die.

— von Uexküll, Jacob (1934: 44-45) A Stroll through the Worlds of Animals and Men. English translation by O'Neal, Joseph (2010) University of Minnesota Press.

NOW





Compose an original four line poem called The Tick consisting of two sequential rhyming couplets. Use the opening stanza of William Blake's famous 1794 poem The Tyger as your model:

Tyger Tyger burning bright,
In the forests of the night:
What immortal hand or eye,
Could frame thy fearful symmetry?

Address with your partner the following generative questions:

1. To what extent does the tick's sensory input "map" correspond to the actual "territory" of its environment and survival needs?
2. To what extent can meaningful parallels be made between tick and human sense perception?
3. To what extent does the Tick know or understand the algorithm that defines its existence?

Humans have three color cone receptors; mantis shrimps have 12-16, have six more just for the ultraviolet range, and can perceive polarized light.

Experiments have shown they are not good at discriminating color conventionally, when compared to other creatures. Why did such bizarre complexity evolve? What can it be like to dwell in their phantasmagorical sensory world?

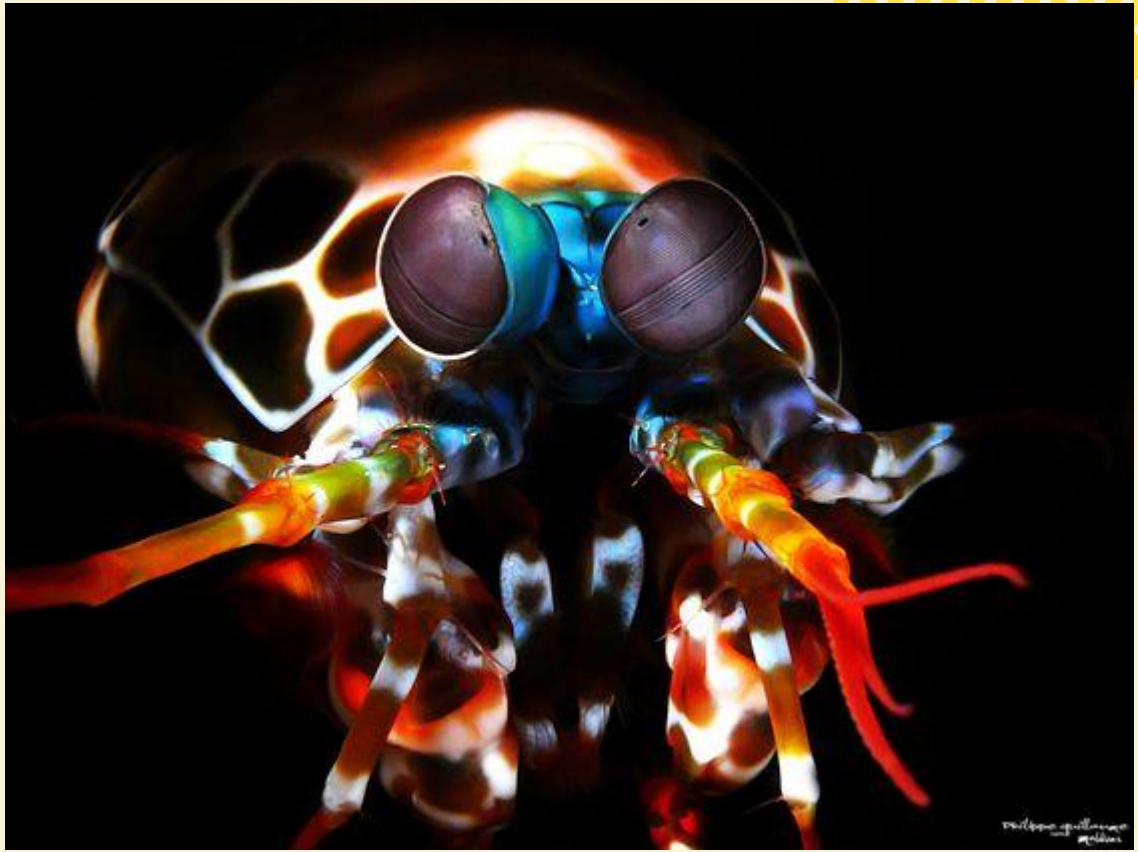
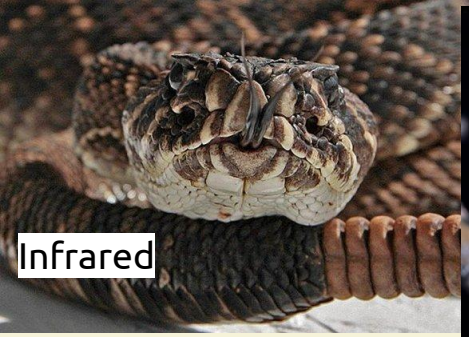


Photo: Philippe Guillaume: *Vert mouche*, Maldives


Infrared

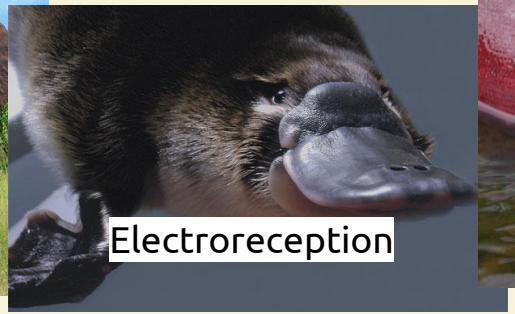

Night vision


Olfaction


Ultraviolet

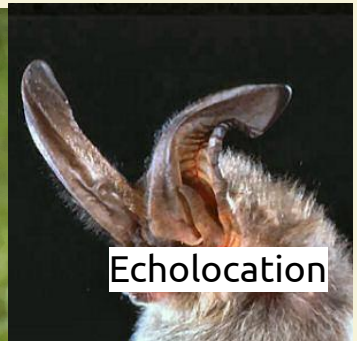

Visual acuity


Subsonic


Electroreception


Magnetic Field


Color vision


Echolocation


Polarized Light


Tactile

Given that these examples of animal sensory ranges are wider than our own; how did we find out about them?
Can we be confident about our findings?

> A well trained human—a perfumer, for example—can identify at best a few thousand smells, while dogs can apparently distinguish any number of individual humans by scent alone. Bloodhounds perform this feat with no more odor than passes through the soles of a person's soles.
>
> — Gould, James L. and Gould, Carol Grant (1994) The Animal Mind. Scientific American Library, New York.

WHAT IS IT LIKE TO BE A BAT?

One way of looking at our own existential predicament is that we live in the metaphorical prison--a unique, embodied subjectivity--with our senses our sole windows to experience.

Umwelt refers the limits imposed by of a particular set of senses operating in a certain range. The tick, sensory world consisted of little more than smelling butyric acid and detecting warm temperature and hairiness. This means that they are oblivious to most aspects of their surrounding environment. This is a stark and far reaching insight that applies to other sentient animals. We can imagine a clown fish and sea anemone living together physically but inhabiting different sensory worlds.



07

I
It was six men of Indostan
To learning much inclined,
Who went to see the Elephant
(Though all of them were blind),
That each by observation
Might satisfy his mind.

II.
The First approached the Elephant,
And happening to fall
Against his broad and sturdy side,
At once began to bawl:
"God bless me!—but the Elephant
Is very like a **wall**!"

III.
The Second, feeling of the tusk,
Cried: "Ho!—what have we here
So very round and smooth and sharp?
To me 't is mighty clear
This wonder of an Elephant
Is very like a **spear**!"

IV.
The Third approached the animal,
And happening to take
The squirming trunk within his hands,
Thus boldly up and spake:
"I see," quoth he, "the Elephant
Is very like a **snake**!"

V.
The Fourth reached out his eager hand,
And felt about the knee.
"What most this wondrous beast is like
Is mighty plain," quoth he;
"'T is clear enough the Elephant
Is very like a **tree**!"

VI.
The Fifth, who chanced to touch the ear,
Said: "E'en the blindest man
Can tell what this resembles most;
Deny the fact who can,
This marvel of an Elephant
Is very like a **fan**!"

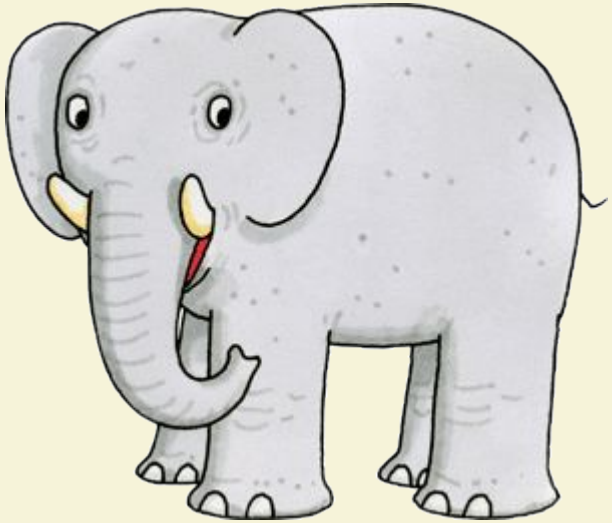
VII.
The Sixth no sooner had begun
About the beast to grope,
Than, seizing on the swinging tail
That fell within his scope,
"I see," quoth he, "the Elephant
Is very like a **rope**!"

VIII.
And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong,
Though each was partly in the right,
And all were in the wrong!

MORAL.
So, oft in theologic wars
The disputants, I ween,
Rail on in utter ignorance
Of what each other mean,
And prate about an Elephant
Not one of them has seen!

John Godfrey Saxe (1872)

Sketch a cartoon of an elephant with a wall, a spear, a snake, a fan, a tree, and a rope in place of their respective anatomical features.



Elephant societies are matriarchal because all the males leave the herd when they become sexually mature. Elephants have a 22 month gestation period. Elephant calves require constant maternal care or at least six months. Elephants have 2 nipples. Elephants communicate subsonically across many kilometers. Can you suggest an additional fun fact about elephants not perceived by the blind men?

Differentiate between *Loxodonta africana* and *Elephas maximus*?

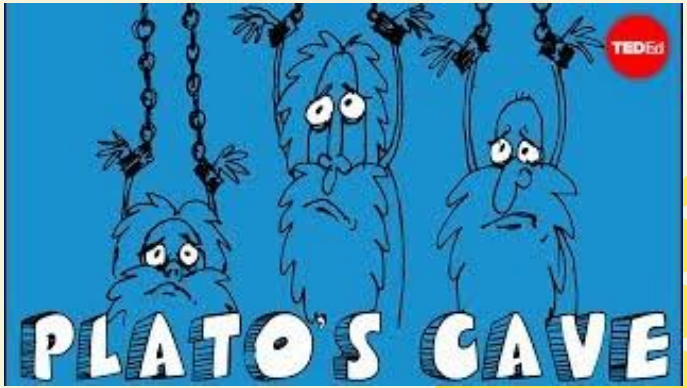
1. What insights into knowledge acquisition can be made from reading the Parable of the Blind Men and the Elephant?

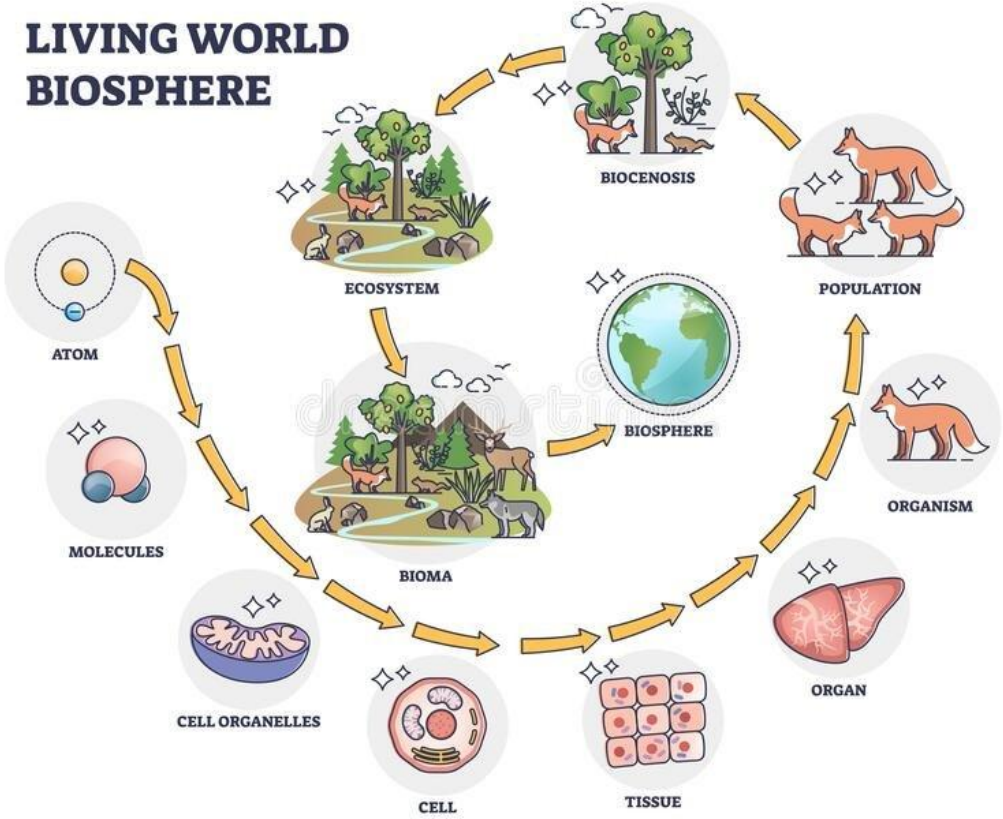
2. Does it matter if our acquisition of knowledge happens in “bubbles” where some information and voices are excluded?

3. What parallels can be made with regard to the human condition when comparing the Blind Men and the Elephant, Plato’s *Allegory of the Cave*, and *The Truman Show* (2008)?

4. Differentiate between reductionism and holism?






LIVING WORLD
BIOSPHERE
BIOCENOSIS
POPULATION
ECOSYSTEM
ATOM
BIOSPHERE
ORGANISM
MOLECULES
BIOMA
CELL ORGANELLES
ORGAN
CELL
TISSUE

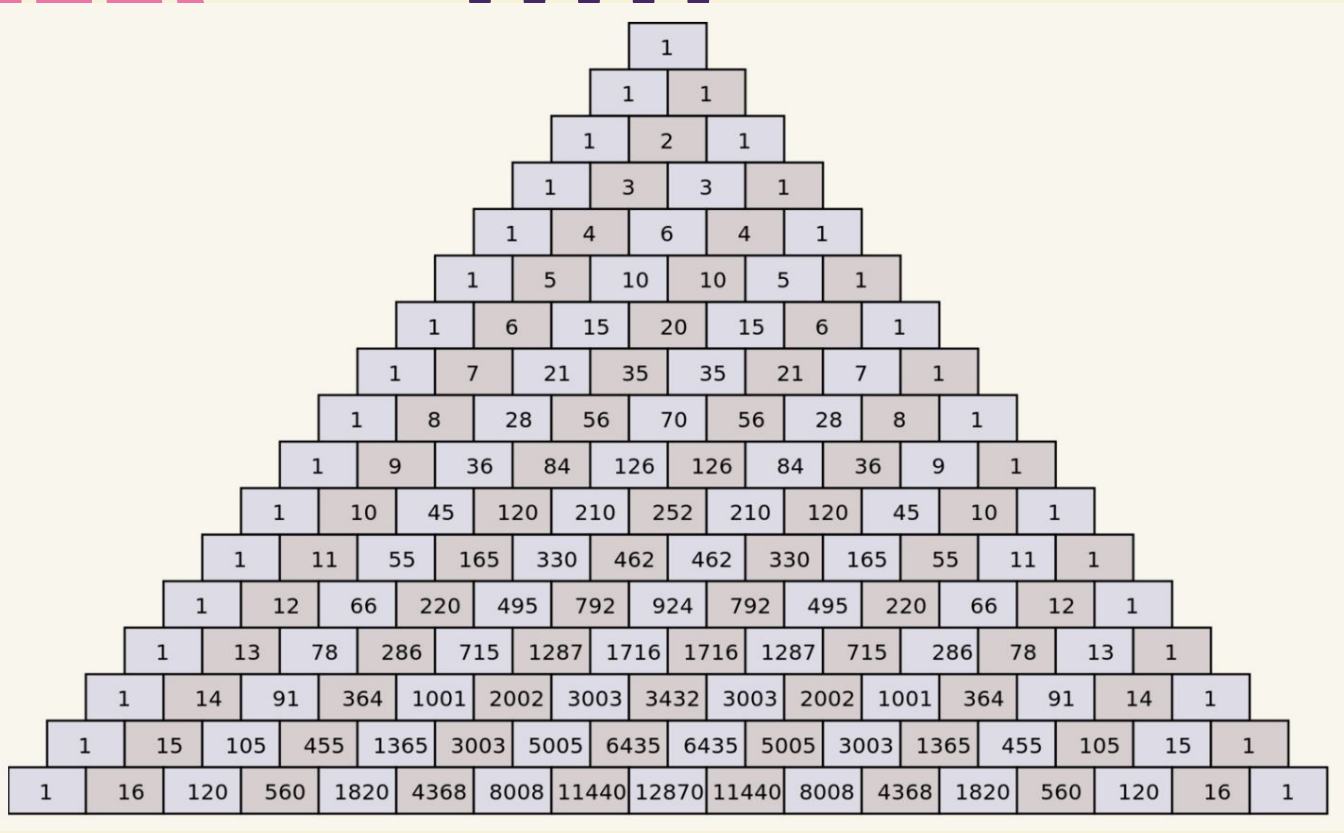

genetic
bio-neurological
psychological
social
cultural

If we could get the hang of it entirely
It would take too long;
All we know is the splash of words in passing
and falling twigs of song…

Louis MacNeice, *Entirely*, 1940

08

Pascal's Wager



Pascal's Triangle.

Blaise Pascal (1623-62) was a French mathematician and theologian. Pascal's triangle is wonderful example of why mathematics is often referred to as "the science of pattern." Warm up the TOK class by putting a HL math student on the spot. Ask them to:

a. Explain the pattern of the triangle

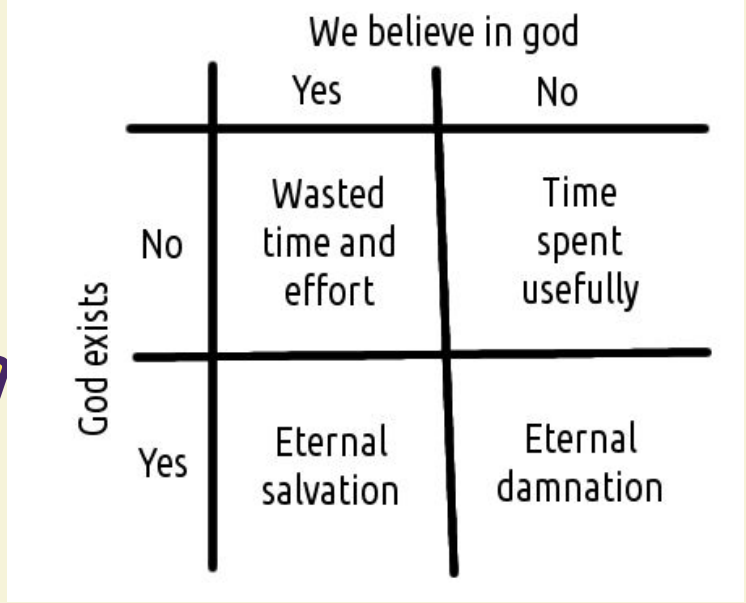
b. Remind the class how the rows the correspond the coefficients of binomial expansions

c. Show that shallow diagonals sum to the Fibonacci sequence (1, 1, 2, 3, 5, 8, 13, 21, 34...)

d. Show that the 3rd diagonals are the Triangle numbers (1, 3, 6, 10, 15, 21, 28...)

Pascal's Wager

Arguments resembling Pascal's wager appeared in Chinese, Greek and other ancient civilizations. Pascal is famous because he framed his version in terms of probability theory that lends itself to simple decision table.



Pascal's wager appears in the *Pensées*, Here is a truncated extract from the relevant passage translation from the very eloquent French.

If there is a God, He is infinitely incomprehensible, since, having neither parts nor limits, He has no affinity to us. We are then incapable of knowing either what He is or if He is....

"God is, or He is not." But to which side shall we incline?...[Y]ou must wager... Which will you choose then? Let us see... Let us estimate these two chances. If you gain, you gain all; if you lose, you lose nothing.

Wager, then, without hesitation that He is.

Pascal’s Wager

You should work in groups of three. First read the Pascal's wager text extract and make sure that everyone in the group fully understands how it relates to the table.

1. Now make your own decision table. We will start with an easy one: whether or not to wear a seat belt.

2. Next try the following. Read what linguist and activist Noam Chomsky had to say about man's capacity for self destruction in a June 14, 2013 Guardian comment editorial entitled How to destroy the future.

For the first time in the history of the human species, we have clearly developed the capacity to destroy ourselves. That's been true since 1945. It's now being finally recognized that there are more long-term processes like environmental destruction leading in the same direction, maybe not to total destruction, but at least to the destruction of the capacity for a decent existence.

Chomsky is referring to nuclear weapons and human-enhanced global warming. Make a fully labeled decision table, patterned on Pascal's wager, that summarizes the consequences of acting or not acting to prevent catastrophic global warming.

3. Try constructing a decision table for nuclear disarmament. You may need an extra column.

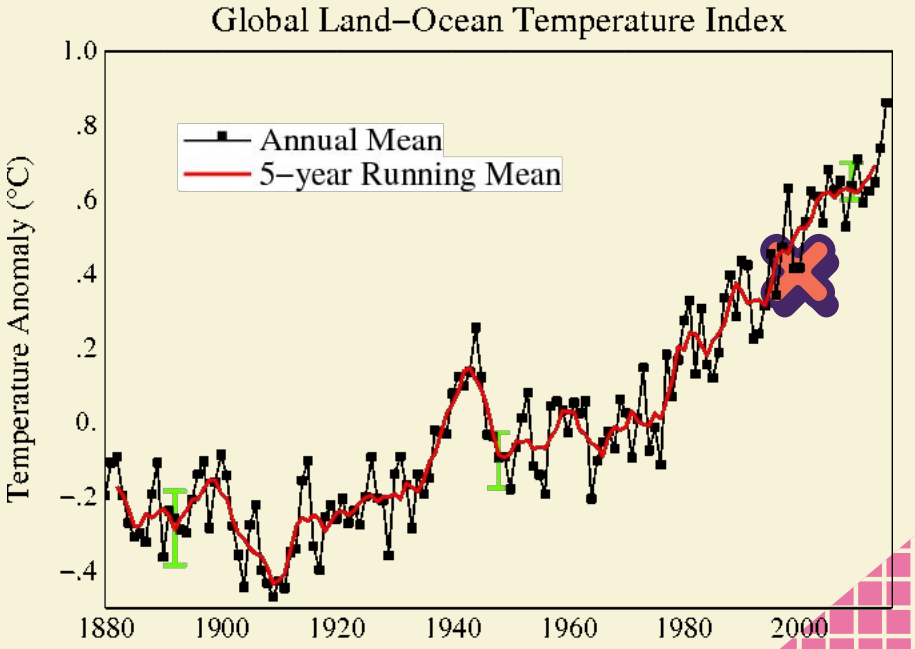
Pascal’s Wager

What aspects are certain in Pascal's wager table and your own catastrophic human induced global warming wager table?

What aspects are either unknowable or highly contentious in Pascal's wager table, and your own catastrophic human induced global warming wager table?

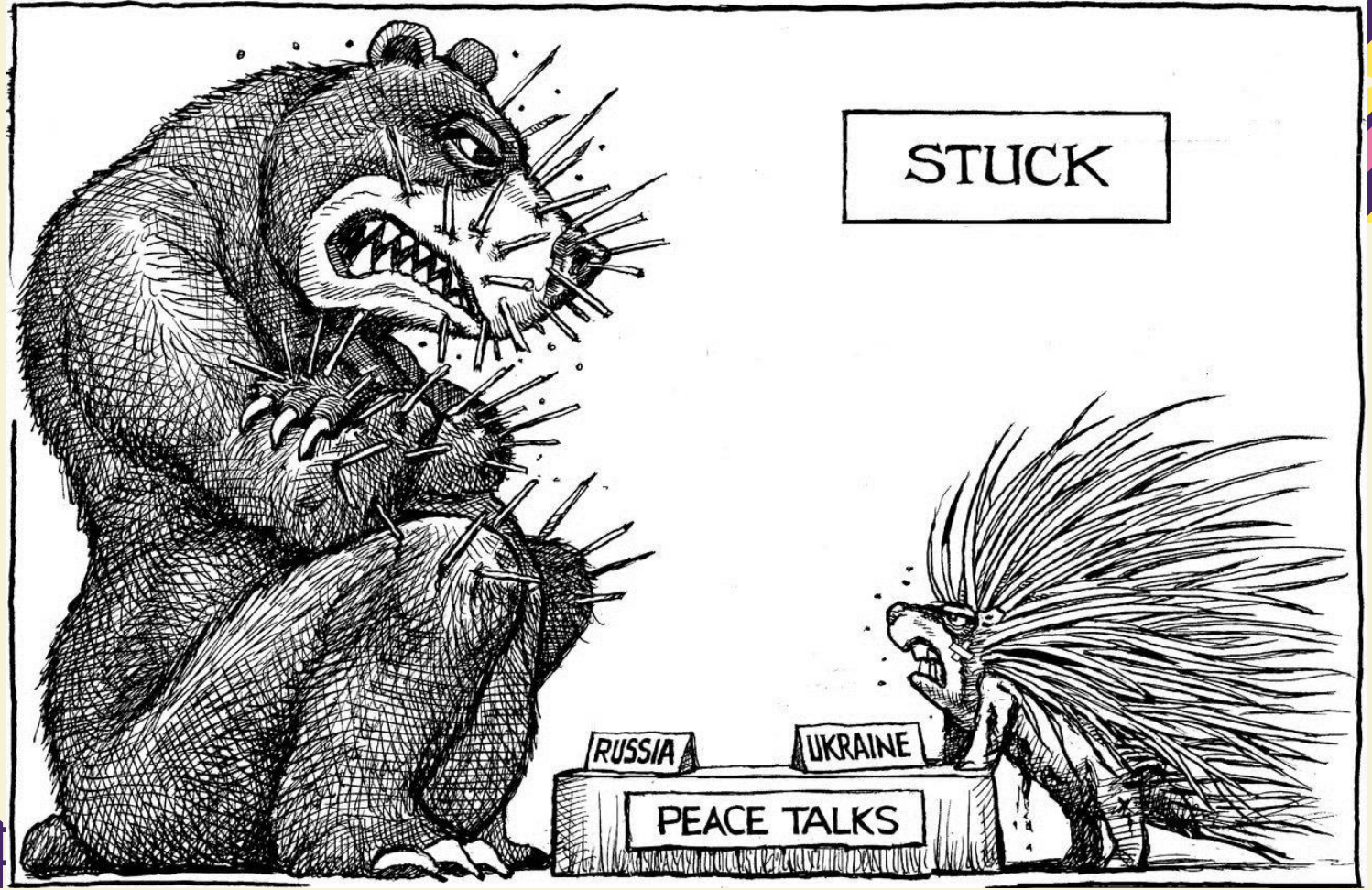
To what extent do these decisions tables successfully use reason and the laws of mathematics in a very simple way to avoid the impasse of getting bogged down in complexity and controversy?

To what extent does Pascal's wager foster, or undermine, religious faith?



09

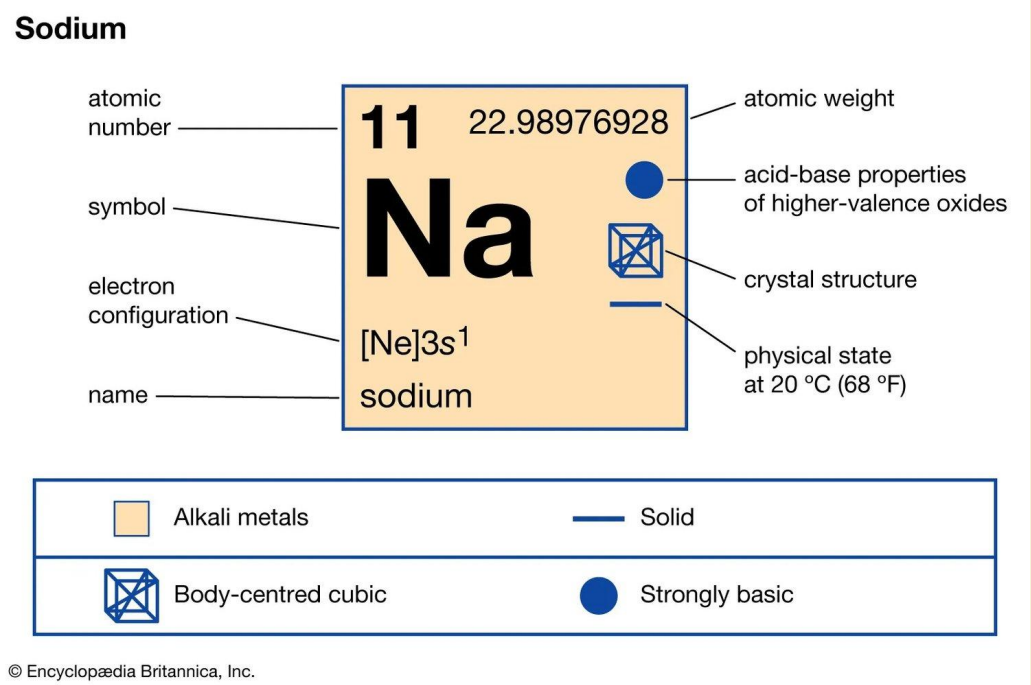
Good & Bad Explanation



Can a well chosen metaphor be a good explanation?

*Source: **KAL's cartoon in the Economist**—March 31, 2022. Visit **Kaltoons** official site.*

The products of human ingenuity span an enormous range. It is almost impossible to know what Hieronymous Bosch was attempting to explain in his enigmatic masterpiece five hundred years after it was created. Contrast this with the Sodium (Na) graphic on the right. Sodium is just one of the hundred or so chemical elements mapped in the periodic table. Even as a standalone, this block entry depicting Na atom characteristics, has remarkable explanatory power.



Long ago, Hades, god of the underworld, kidnapped and raped Persephone, goddess of the spring. Then Persephone's mother, Demeter, goddess of the Earth and agriculture, negotiated a contract for her daughter's release, which specified that Persephone would marry Hades and eat a magic seed that would compel her to visit him once a year thereafter. Whenever Persephone was away fulfilling this obligation, Demeter became sad and would command the world to become cold and bleak so that nothing could grow...

…if the cause of winter is the Demeter's periodic sadness, then winter must happen everywhere on earth at the same time. Therefore, if the ancient Greeks had known that a warm growing season occurs in Australia at the very moment when, as they believed, Demeter is at her saddest, they could have inferred that there was something wrong with the explanation of seasons…

In Nordic mythology, seasons are caused by the changing fortunes of Freyr, the god of spring, in his eternal war with the forces of cold and darkness. Whenever Freyr is winning, the Earth is warm; when he is losing, it is cold.

…we are left with the same core explanation in both cases: the gods did it.

— Deutsch, David (2011: 19-21) The Beginnings of Infinity: Explanations that Transform the World. Penguin, New York.

1. What is good and what is bad about this prescientific explanation?

2. The myth is at least two and a half thousand years old. How useful or reliable do you think the explanation would have been back then?

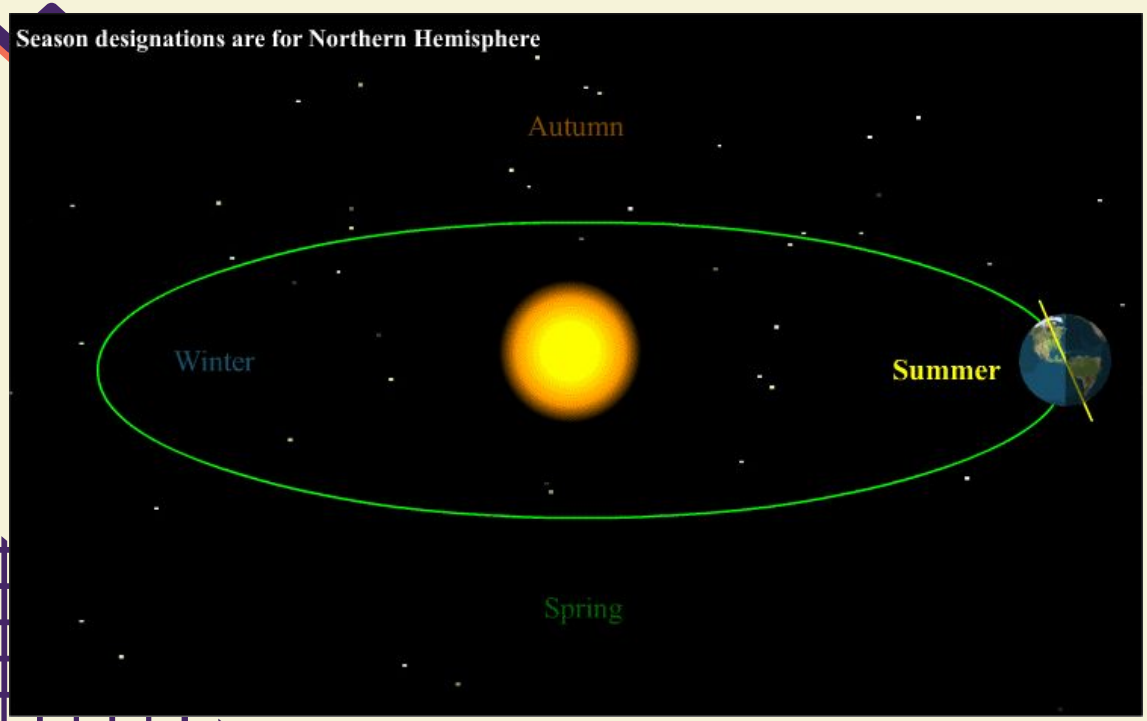
3. What assumptions are contained in this explanation?

4. Does the explanation have reach—wider applications and connections?

5. Is the explanation hard to vary? Can we change some of the characters or details in this explanation without it making a difference to its predicted outcomes?

6. How emotionally satisfying is the explanation? Provide reasons.

7. Why has this ancient myth persisted?

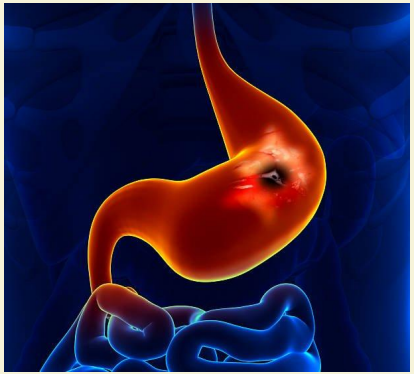


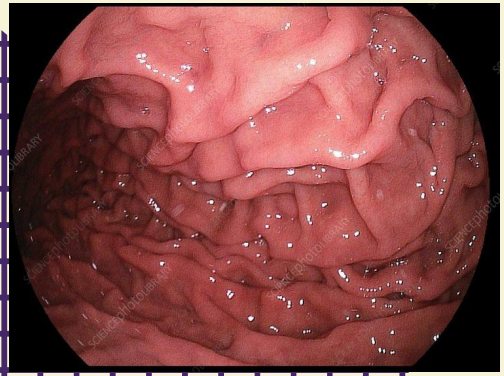
visit briefly **Nasa's *What causes the seasons?***

Apply **generative questions 3 through 6** systematically to the accepted scientific explanation for the seasons.



WHY DOESN'T THE STOMACH DIGEST ITSELF?





WRITTEN ASSIGNMENT—400 WORDS

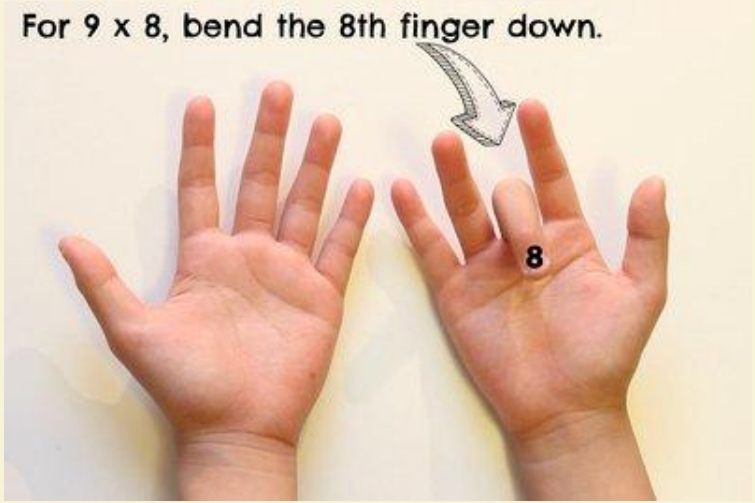
The stomach produces hydrochloric acid to kill dangerous organisms in the diet. It also produces Pepsin, an enzyme that digests protein. A potential problem arises. The stomach is a muscular organ that is mostly made of protein! Why doesn't the stomach digest itself?

(a) Research this problem online. Provide a convincing written explanation for why the stomach does not digest itself?

(b) Justify whether or not your explanation is a good explanation.

COINCIDENCE?
I THINK *NOT*!

Young children are taught the elegant and surprising fingers trick for the 9 times table. We can quickly demonstrate that it works for all 10 fingers. Our intuition tells us this cannot be a coincidence; and demonstration is not explanation.



Work in pairs to find a lucid mathematical explanation for the multiples of 9 finger trick.

DO GOOD EXPLANATIONS HAVE TO BE TRUE?

Exhibit #1 includes imagery of Richard Feynman in action and his famous “key to science” quote. A live video link is included.

Exhibit #2 is a TEDEd video about Nobel Prize winning work on what causes stomach ulcers. In 1984 Barry Marshall silenced fierce resistance from the established scientific community by deliberately infecting himself with *Heliobactor pylori* bacteria.

Exhibit #3 includes the opening paragraph of Kafka’s *Metamorphosis*, a quote from Orwell’s *Animal Farm*, and a Calvin and Hobbes cartoon. Noam Chomsky’s assertion that we can learn more from literature than neuroscience is also included. Think of specific examples from their own IB literature studies and personal reading to add a further dimension to the paradoxical and usually unexamined notion that “fiction” may lead us to truth.

Sit in random groups of four, each with an assigned Facilitator, Disruptor, Scribe and Presenter. Allow a timed 12 minutes for in-depth conversation to be followed by presentations and class discussion.

When mathematicians, scientists, historians or novelists claim that they have explained something, are they using the word 'explain' in the same way?

Are some things unknowable?

Which is more important: what can be explained or what cannot be explained?

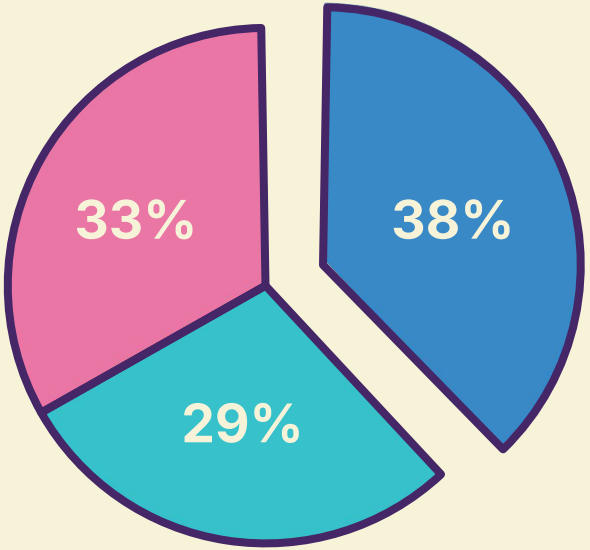
STATISTICS

VENUS

Venus has a beautiful name and is the second planet from the Sun

MARS

Despite being red, Mars is a cold place. It's full of iron oxide dust



MERCURY

Mercury is the closest planet to the Sun and the smallest one

38%

It’s the farthest planet from the Sun

Follow the link in the graph to modify its data and then paste the new one here. **For more info, click here**

MAKING TWO WAY TABLES

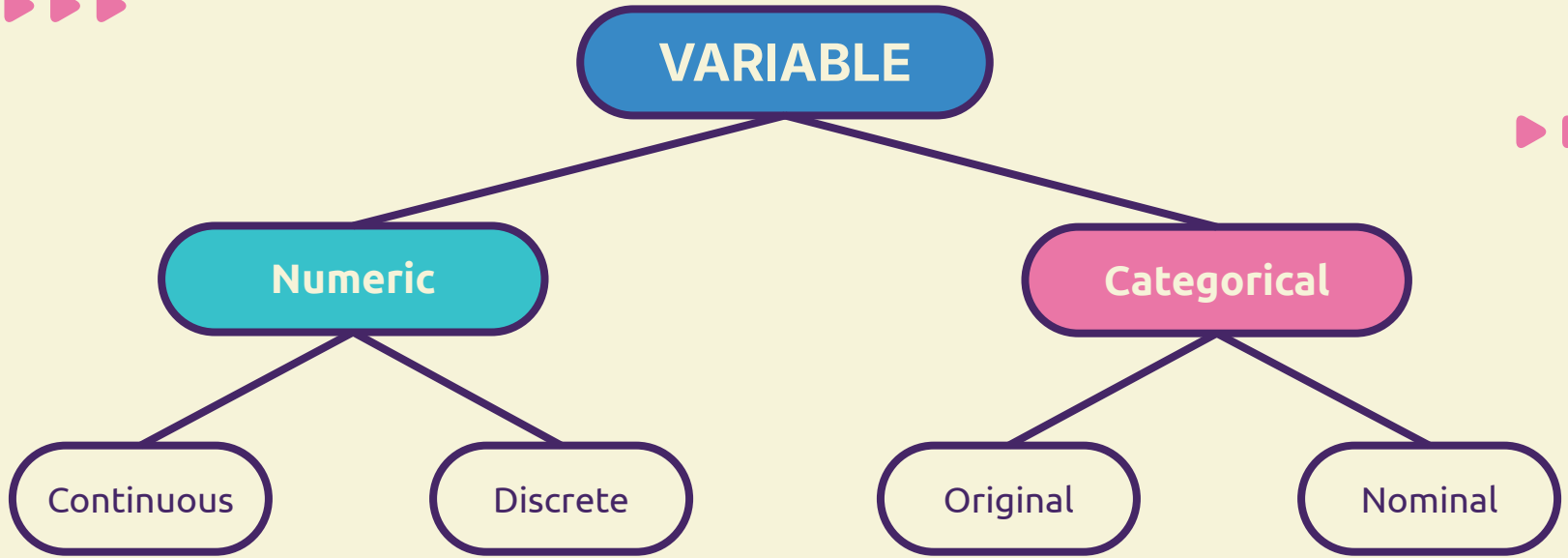
Venus has a beautiful name and is the second planet from the Sun

	VENUS	SATURN	TOTAL
MERCURY	21	39	60
MARS	135	45	180
TOTAL	156	84	240

Row totals

Column totals

DESCRIBING DATA



HYPOTHESIS TESTING



REJECTION

Jupiter is the biggest planet of them all

ACCEPT

Venus is the second planet from the Sun

EXERCISE 2

The twins John and Jenna have created a table of their school grades, which they got throughout the whole semester in certain subjects

	MUSIC	SPANISH	BIOLOGY	PHYSICS
JOHN	1,2,3,5,5,2	3,3,3,1,1,2	1,1,1,3,4,1	2,2,3,1,5,4
JENNA	4,4,1,2,2	2,2,2,2	5,5,4,4,3,4,3,3	1,1,2,1,2,2,2

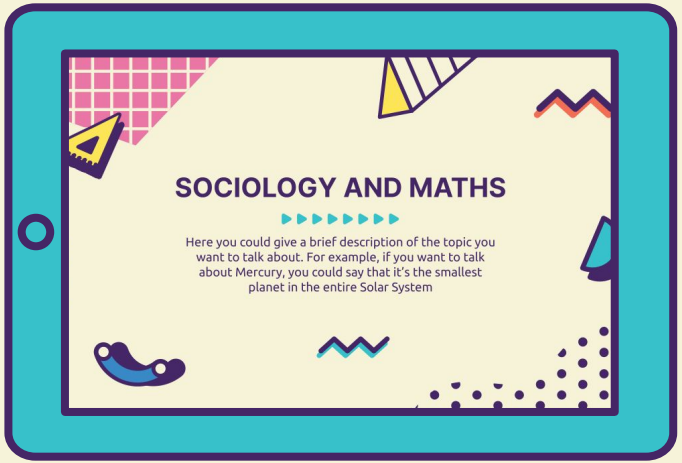
Calculate the final grade of the twins in all subjects, if the range of the school grades is from 1 to 5

TABLE OF CONTENTS

01
Solve a Quadratic
here

02
Pascal's Triangle
here

03
Mathematical Beauty
here



TABLET APP

You can replace the image on the screen with your own work. Just delete this one, add yours and center it properly

THANKS

Do you have any questions?

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