Simple Observations

Volume #1
In Search of Understanding

Math

Figures &
Diagrams

Computer
Programming

The

Dynamic Quality

Static Quality

Trial &
Error

Geometric

Logic

Mind

Narrative

Ambitious
Target

Research
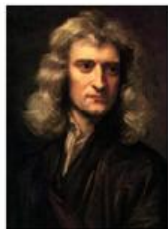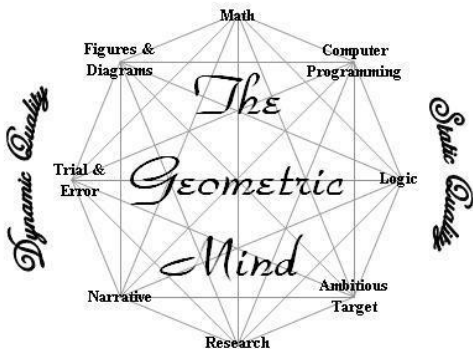
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Five Short Stories

A Simple Observation

An apple fell from the tree. The moon is not falling. *Why not?*
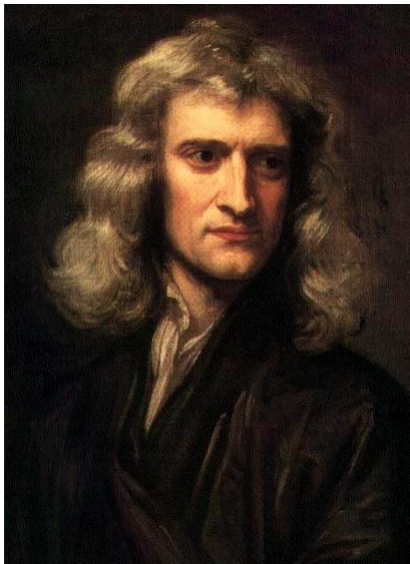
ISAAC NEWTON
1642 – 1727

NEWTON'S APPLE

An Interesting Astronomical Story

Isaac Newton was sitting on the ground when an apple fell from a tree, (maybe) hitting him on the head.

Newton looked up in the sky and saw the moon, NOT falling to earth.

Newton wondered: "Why do some things fall to earth, but others do not"?

The moon doesn't just sit there - it orbits the earth.

The speed of the orbiting moon must be responsible for it not falling to earth.
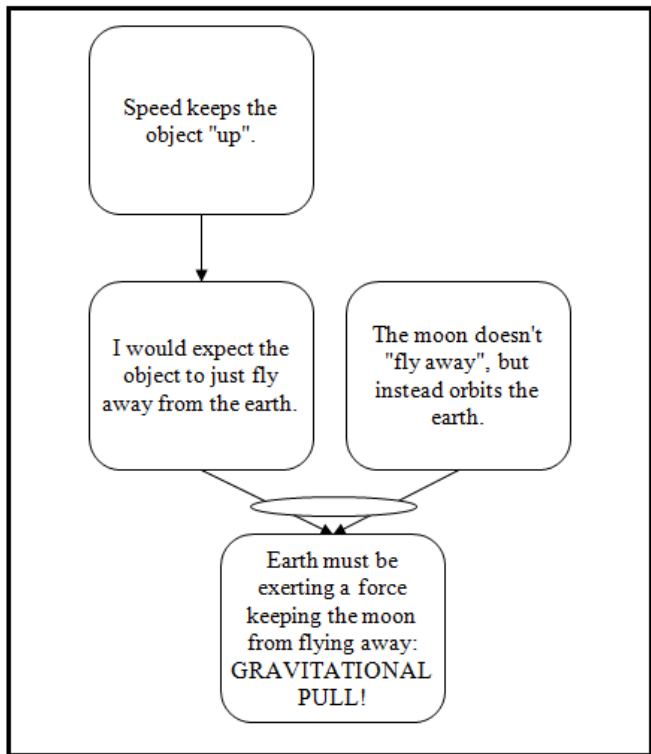
If speed alone was at work, the moon would fly away!

Of course, the moon orbits the earth.

SPEED IS THE KEY

But where does "attraction" come from?

Speed keeps the object "up".

I would expect the object to just fly away from the earth.

The moon doesn't "fly away", but instead orbits the earth.

Earth must be exerting a force keeping the moon from flying away: GRAVITATIONAL PULL!

UNIVERSAL GRAVITATION

Newton's Famous Law

The earth exerts a force - a gravitational pull - on the moon.

If the moon were twice as big as the earth, likely we'd be pulled towards the moon!

The "pulling force" depends on the mass of the the objects in question.

All planets, stars, etc., are masses like the earth.

All bodies exert a pull on each other: **THE LAW OF UNIVERSAL GRAVITATION.**

A FEW EXAMPLES

Planetary Systems

If there are no other forces acting, and these bodies are completely stationary, and if Newton is right about the Law of Universal Gravitation is correct, then where will these planets meet?
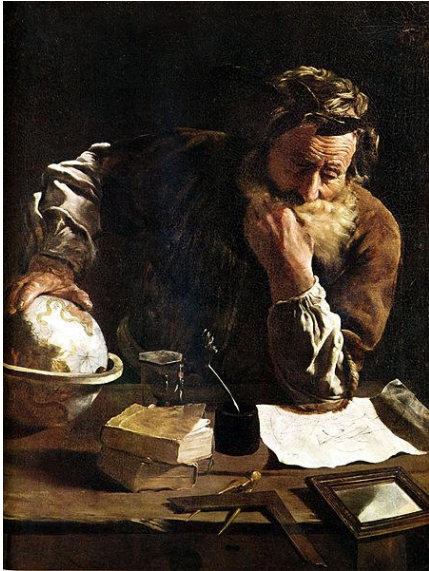

Set 1
2 Bodies

Set 2
2 Bodies

Set 3
3 Bodies

A Simple Observation

**I sit in the bathtub and the water overflows.
I've solved the problem of the Gold Crown!**

ARCHIMEDES
287 BC – 212 BC

A CROWN MADE OF GOLD

How Does One Solve a Difficult Problem?

King Hiero of Syracuse wanted a crown made of gold.

King Hiero found a goldsmith with a good reputation, and employed him to make the crown.

King Hiero had a beautiful crown made of solid gold.

King Hiero saw the goldsmith living beyond his means.

King Hiero feared his crown was not solid gold.

THE EUREKA MOMENT

Archimedes Discovers the Principle of Buoyancy

Archimedes was asked to determine the pureness of the crown.

Archimedes could find the volume of a regular shape, but not the shape of a crown.

Archimedes could not solve the problem.

Archimedes took a bath to think about the problem, and watched the water overflow.

He dashed through the streets of Syracuse, Sicily, yelling EUREKA - I HAVE FOUND IT!

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WHAT ARCHIMEDES' FOUND

What Does Overflowing Water Have to do With Anything?

Archimedes sat in the bathtub and watched the water rise.

Archimedes realized the amount of water displaced was equal to his volume.

He could find the volume of anything by dipping it in water and seeing how much water was moved.
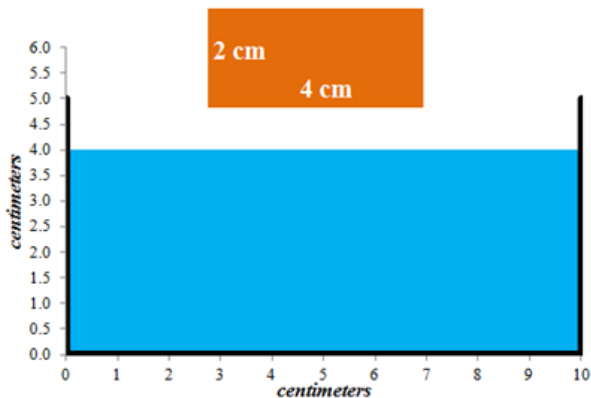
A bar of gold similar to the one given to the goldsmith displaces a certain amount of water.

If the crown is pure gold, it should displace the same amount of water as the simple bar of gold.

BUOYANCY

What Did Archimedes Discover?

Assume this is a 2-dimensional bathtub below. The bar of gold
(also 2-dimensional) will sink. How high will the water rise?

A Simple Observation

Milkmaids have pot marks on their arms but not their faces. *Why not?*

EDWARD JENNER
1749 - 1823

A BEAUTIFUL MILKMAID

Relatively Speaking

Smallpox was a deadly disease, killing one of every ten people who contracted the disease.

Survivors of smallpox were covered with pot-marks.

Many people were disfigured by awful looking pot marks.

Milkmaids had pot-marks on their arms but not their faces.

Milkmaids were beautiful.
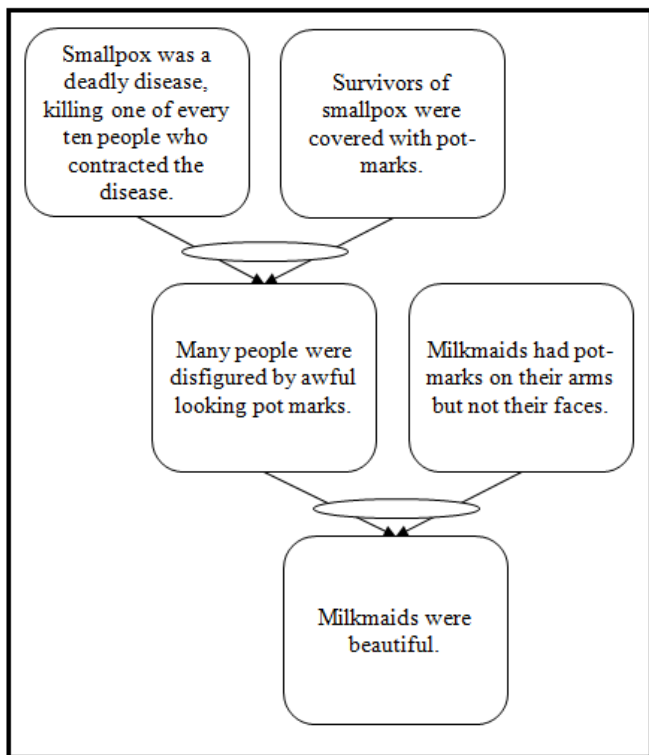
THE COWPOX ENMITY

Cowpox as a Clue

It was reported in Gloucester, England, there was an "enmity" between cowpox and smallpox.

A person who caught the milder cowpox did not catch the more dangerous smallpox.

A person catching cowpox first was probably less disfigured than one catching smallpox.

Cowpox was transferred to milkmaids on their hands, as they were milking the cows.

A milkmaid was more beautiful than most women.

The hand of a person
infected with cowpox

THE IMMUNE SYSTEM

Memory and Recognizing Danger

The Immune System recognizes a foreign attack and attempts to defend the body.

The attack is unknown to the immune system, so it must learn how to defend the body.

Catching the mild cowpox allows the body to build up "knowledge", i.e., antibodies, against cowpox.

Cowpox is similar to smallpox.

A person having caught cowpox is immune from smallpox.

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EDWARD JENNER

A Brave Experiment

Edward Jenner found a milkmaid with cowpox, took fluid from the blisters, and injected this into a young boy.

A person having caught cowpox is immune from smallpox.

The boy should be immunized against smallpox.

Jenner injected smallpox into the boy.

The boy DID NOT contract smallpox!

VACCINATION

From Cowpox to Prevention

Jenner used cowpox to immunize a person against smallpox.

The Latin word for "cow" is "vacca", and the Latin word for "cowpox" is "vaccinia".

"Vaccination" owes it's origin to disease prevention using cowpox.

Medicine prior to Jenner focused on curing diseases, and not preventing them.

Jenner's "vaccination" revolutionized medicine and health!

A Simple Problem

Why can't we make steel cheaply?

HENRY BESSEMER
1813 - 1898

IN SEARCH OF CHEAP STEEL

The Need for Better Materials

Bridges, ships, etc., in the 1800s were constructed of wrought iron.

There were many accidents in the mid-1800s.

Wrought iron was proving unreliable in the industrial world.

The process of making steel from wrought iron was too high to be practical.

Bessemer sought a means to make "cheap steel".

CAST IRON

A Chemical Revolution

Mined Iron Ore contains impurities that can be burned off, at high temperatures.

Coke and limestone burn at a high temperatures.

Heated iron ore nearly becomes iron, but now contains carbon from the fire.

This heated iron is poured into casts (molds).

Iron ore has become cast iron.

WROUGHT IRON

Removing the Impurities

In the burning process, cast iron contains carbon (from the coke).
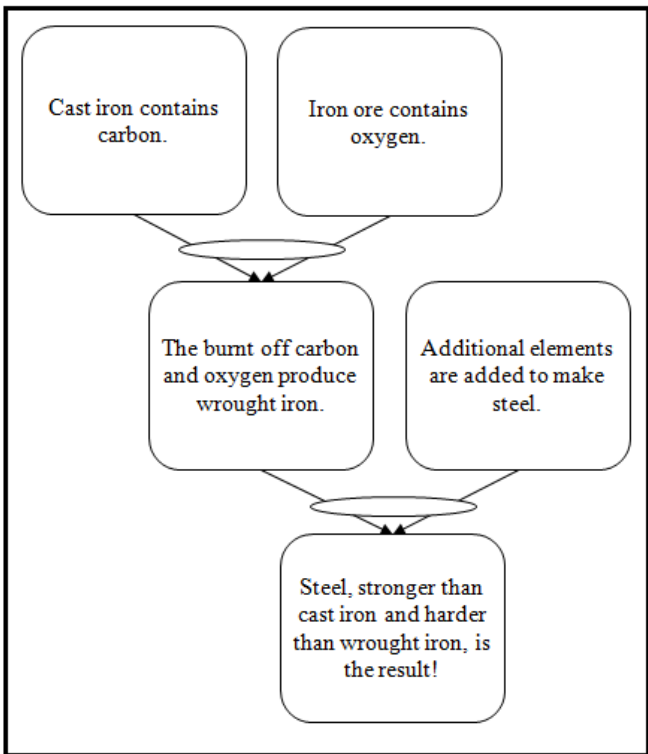
Carbon mixes with oxygen to form carbom monoxide.

Mixing more iron ore (containing oxygen) with cast iron (containing carbon) will burn off the CO.

The more pure iron was soft and could be "worked", ie., "wrought".

Cast iron has become wrought iron!

STEEL

Metallurgical Magic!

Cast iron contains carbon.

Iron ore contains oxygen.

The burnt off carbon and oxygen produce wrought iron.

Additional elements are added to make steel.

Steel, stronger than cast iron and harder than wrought iron, is the result!

STEEL

A Dilemma

Steel consisted of transforming iron ore to cast iron to wrought iron to steel.

The costly step - going from cast iron to wrought iron - involved burning off the carbon with more iron ore containing oxygen.

The problem: removing carbon from cast iron cheaply.

During the molten iron stage, insert a blast of air.

The carbon would mix with the air, burning off as CO, leaving pure iron!

JUST TRY IT!

From Theory to Practice

Doubters said the added air would simply cool the molten iron and solidify it.

Bessemer blew air in through the molten iron.

Impurities were removed from the iron by oxidation.

The oxidation also raises the temperature of the iron mass and keeps it molten.

Steel could be made cheaply!

A Simple Observation

The sun is straight overhead here – but not there.   Now I can find distances!   How?

ERATOSTHENES
276 BC – 194 BC

THE LIFE OF ERATOSTHENES

Access to Information

Eratosthenes was the third chief librarian of the Great Library of Alexandria.

The Great Library of Alexandria was the center of science and learning in the ancient world.

Eratosthenes had access to an incredible amount of information.

Eratosthenes knew on the summer solstice at noon, the sun shone straight down a deep well in Syene (now Aswan).

Eratosthenes reasoned standing on the well, there would be no shadow.
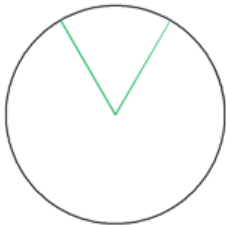
SHADOWS IN THE LIGHT

The Importance of the Shadow

Eratosthenes reasoned standing on the well, there would be no shadow in Aswan.

If you were standing straight up in Alexandria, there would be a shadow.

The earth must be round.

Whereever you are, if you stood straight up and drew a line through you, it would go through the center of the earth.

There would be an angle carving out the arc from Aswan to Alexandria.

A PLAN IN THE MAKING

The Arc and the Circumference

The "Aswan and Alexandria" lines form an angle at the center of the earth.

As an angle of 90° carves out 1/4 of the circumference, and 60° 1/6, there is a relationship between the angle and the circumference.
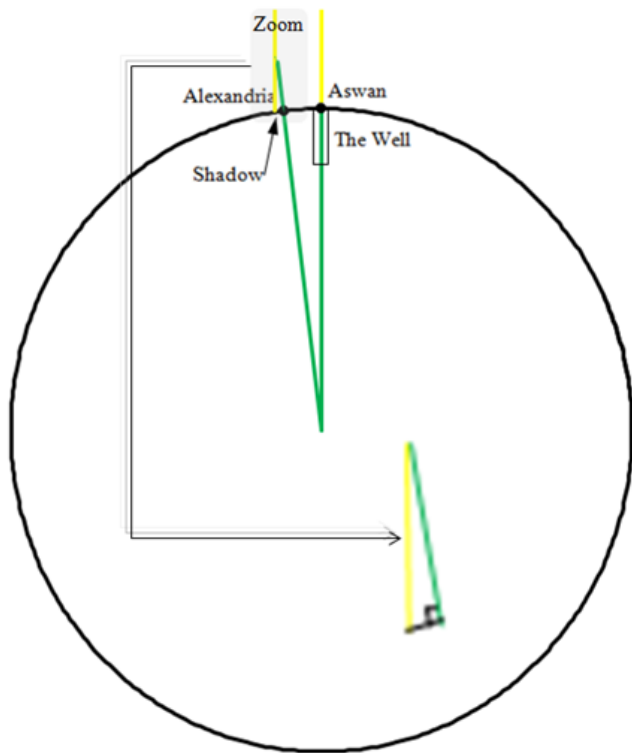
To find earth's circumference, I need this angle.

To use the relationship, I need the distance from Aswan to Alexandria (which I can find).

I am close to estimating the circumference of the earth!

THE LAY OF THE LAND

He's Almost There!

Zoom
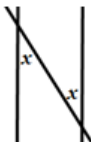
Alexandria

Aswan

The Well

Shadow

THE ANGLE!

I Know the Angle at the Center of the Earth!

The opposite interior angles of two parallel lines cut by a transversal are equal.

The sun rays are always perpindicular to the earth, and therefore parallel to each other.

Measuring one 'x' means I have the angle at the center of the earth.

The shadow's length and the rod's height form a ratio:

$$\tan(\alpha) = \frac{opposite}{adjacent}$$

I know the angle formed by the "Aswan and Alexandria" lines at the center of the earth!

ERATOSTHENES' ESTIMATE

The Circumference of the Earth

He found the angle to be 7.2°.

He measured the distance between Aswan and Alexandria to be approximately 480 miles.

7.2° carves out 480 miles.

360° carves out x miles

ERATOSTHENES' ESTIMATE of Earth's Circumference is remarkably close to the actual value of 24,901 miles

$$\frac{7.2}{480} = \frac{360}{x}$$

$$x = 24000$$

A Summary

Isaac Newton	Archimedes	Edward Jenner	Henry Bessemer	Eratosthenes
An apple fell from the tree. The moon is not falling. Why not?	I sit in the bathtub and the water overflows. I've solved the problem of the Gold Crown!	Milkmaids have pot marks on their arms but not their faces. Why not?	Why can't we make steel cheaply?	The sun is straight overhead here - but not there. Now I can find distances! How?
The Discovery of the Law of Universal Gravitation	The Discovery of the Laws of Buoyancy	The Discovery of Immunization	The Industrial Revolution	The Measurement of the Earth

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