



*Explore The Possibilities*

WPAFB Educational Outreach

A Puzzle and an Adventure



Have you ever asked yourself,

***“Why would I want to learn science over any other subject?”***



**Science is unique in that science facts are not determined by man, it is not a language or history of man, it is not governed by the rules of man.**

**Science is not subjective since the facts of science would be true without their discovery.**

## Periodic Table of the Elements

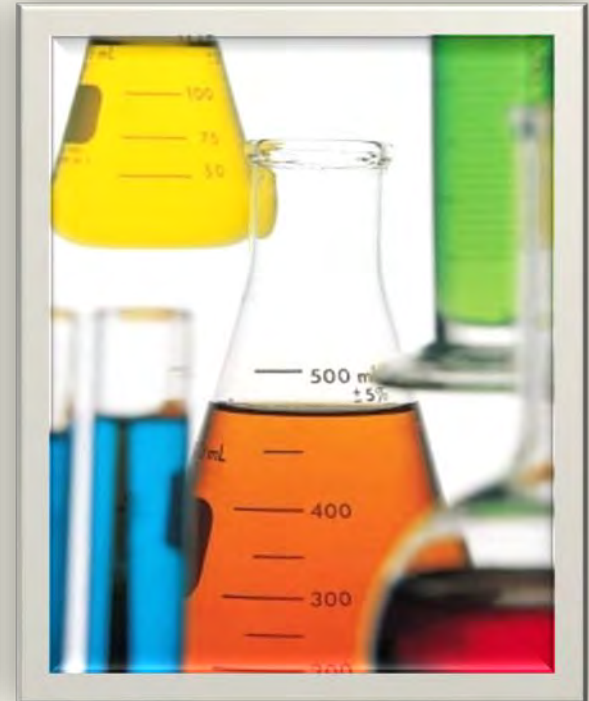
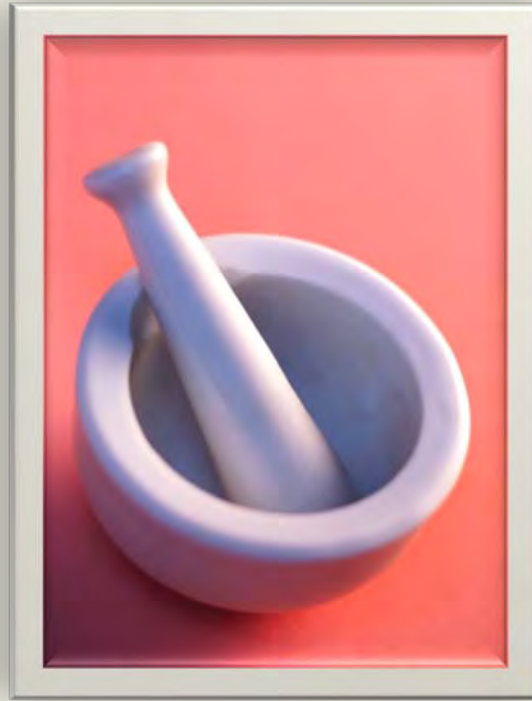
Atomic Number    Boiling Point  
**Symbol**  
 Name  
 Atomic Mass

Normal boiling points are in °C.  
 SP = Triple Point  
 Pressure is listed if not 1 atm.  
 Allotrope is listed if more than one allotrope.

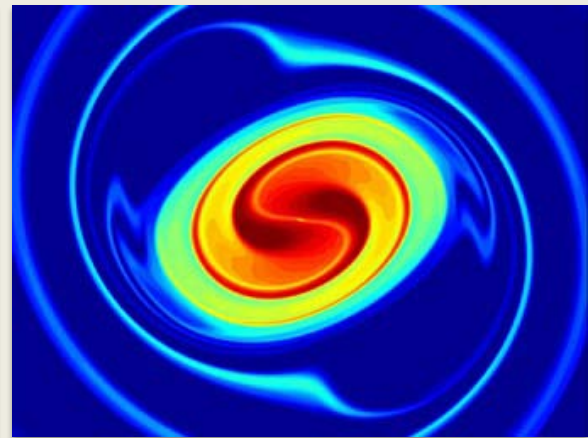
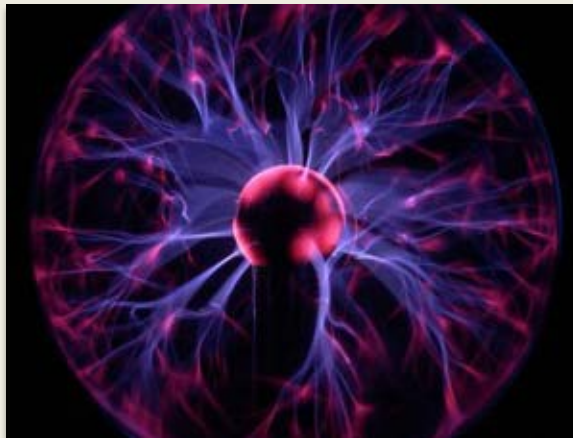
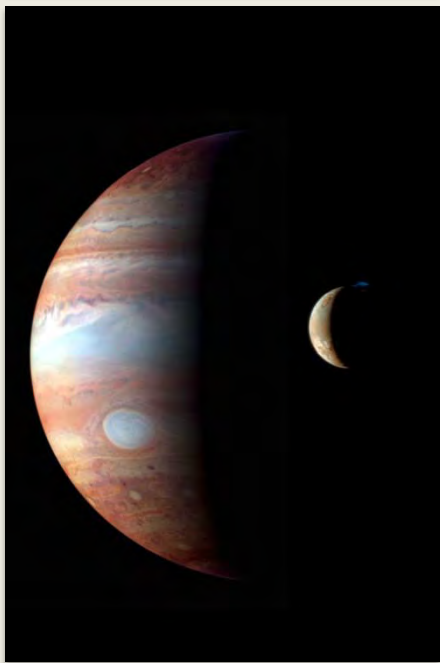
1 1A 1A 1 H Hydrogen 1.008	2 2A 2A 4 He Helium 4.003																	13 3A 3A 5 B Boron 10.811	14 4A 4A 6 C Carbon 12.011	15 5A 5A 7 N Nitrogen 14.007	16 6A 6A 8 O Oxygen 15.999	17 7A 7A 9 F Fluorine 18.998	18 8A 8A 10 Ne Neon 20.180
3 1342 Li Lithium 6.941	4 2471 Be Beryllium 9.012																	13 2539 Al Aluminum 26.982	14 3265 Si Silicon 28.086	15 white 280.5 P Phosphorus 30.974	16 444.61 S Sulfur 32.066	17 -101.5 Cl Chlorine 35.453	18 -185.847 Ar Argon 39.948
11 882.940 Na Sodium 22.990	12 1090 Mg Magnesium 24.305	3 2836 3B 3B 21 Sc Scandium 44.956	4 3287 4B 4B 22 Ti Titanium 47.88	5 5B 5B 23 V Vanadium 50.942	6 6B 6B 24 Cr Chromium 51.996	7 7B 7B 25 Mn Manganese 54.938	8 2861 8 26 Fe Iron 55.933	9 2927 8 27 Co Cobalt 58.933	10 2913 8 28 Ni Nickel 58.693	11 2962 1B 1B 29 Cu Copper 63.546	12 907 2B 2B 30 Zn Zinc 65.39	13 2004 31 Ga Gallium 69.723	32 2833 32 32 Ge Germanium 72.61	33 616 SP 33 33 As Arsenic 74.922	34 685 34 34 Se Selenium 78.972	35 58.8 35 35 Br Bromine 79.904	36 -153.34 36 36 Kr Krypton 84.80						
19 759 K Potassium 39.098	20 1484 Ca Calcium 40.078	39 2836 Y Yttrium 88.906	40 3345 Zr Zirconium 91.224	41 4603 Nb Niobium 92.906	42 4639 Mo Molybdenum 95.95	43 4265 Tc Technetium 98.907	44 4150 Ru Ruthenium 101.07	45 3695 Rh Rhodium 102.906	46 2963 Pd Palladium 106.42	47 2162 Ag Silver 107.868	48 767 Cd Cadmium 112.411	49 2072 In Indium 114.818	50 2802 Sn Tin 118.71	51 1587 Sb Antimony 121.760	52 968 Te Tellurium 127.6	53 184.4 I Iodine 126.904	54 -108.09 Xe Xenon 131.29						
55 671 Cs Cesium 132.905	56 1897 Ba Barium 137.327	57-71 72 4603 Hf Hafnium 178.49	73 5458 Ta Tantalum 180.948	74 5555 W Tungsten 183.85	75 5596 Re Rhenium 186.207	76 5012 Os Osmium 190.23	77 4428 Ir Iridium 192.22	78 3825 Pt Platinum 195.08	79 2854 Au Gold 196.967	80 356.62 Hg Mercury 200.59	81 3478 Tl Thallium 204.383	82 1749 Pb Lead 207.2	83 1564 Bi Bismuth 208.980	84 962 Po Polonium [208.982]	85 337 At Astatine 209.987	86 -61.7 Rn Radon 222.018							
87 677 Fr Francium 223.020	88 1737 Ra Radium 226.025	89-103 104 unknown Rf Rutherfordium [261]	105 unknown Db Dubnium [262]	106 unknown Sg Seaborgium [266]	107 unknown Bh Bohrium [264]	108 unknown Hs Hassium [269]	109 unknown Mt Meitnerium [268]	110 unknown Ds Darmstadtium [269]	111 unknown Rg Roentgenium [272]	112 unknown Cn Copernicium [277]	113 unknown Uut Ununtrium unknown	114 unknown Fl Flerovium [289]	115 unknown Uup Ununpentium unknown	116 unknown Lv Livermorium [293]	117 unknown Uus Ununseptium unknown	118 unknown Uuo Ununoctium unknown							
Lanthanide Series		57 3464 La Lanthanum 138.906	58 3443 Ce Cerium 140.115	59 3520 Pr Praseodymium 140.908	60 3074 Nd Neodymium 144.24	61 3000 Pm Promethium 144.913	62 1794 Sm Samarium 150.36	63 1529 Eu Europium 151.966	64 3273 Gd Gadolinium 157.25	65 3230 Tb Terbium 158.925	66 2567 Dy Dysprosium 162.50	67 2700 Ho Holmium 164.930	68 2868 Er Erbium 167.26	69 1950 Tm Thulium 168.934	70 1196 Yb Ytterbium 173.04	71 3402 Lu Lutetium 174.967							
Actinide Series		89 3198 Ac Actinium 227.028	90 4788 Th Thorium 232.038	91 4027 Pa Protactinium 231.036	92 4331 U Uranium 238.029	93 4274 Np Neptunium 237.048	94 3228 Pu Plutonium 244.064	95 2011 Am Americium 243.061	96 3100 Cm Curium 247.070	97 2627 Bk Berkelium 247.070	98 unknown Cf Californium 251.080	99 unknown Es Einsteinium [254]	100 unknown Fm Fermium 257.095	101 unknown Md Mendelevium 258.1	102 unknown No Nobelium 259.101	103 unknown Lr Lawrencium [262]							
		Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetal	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide												

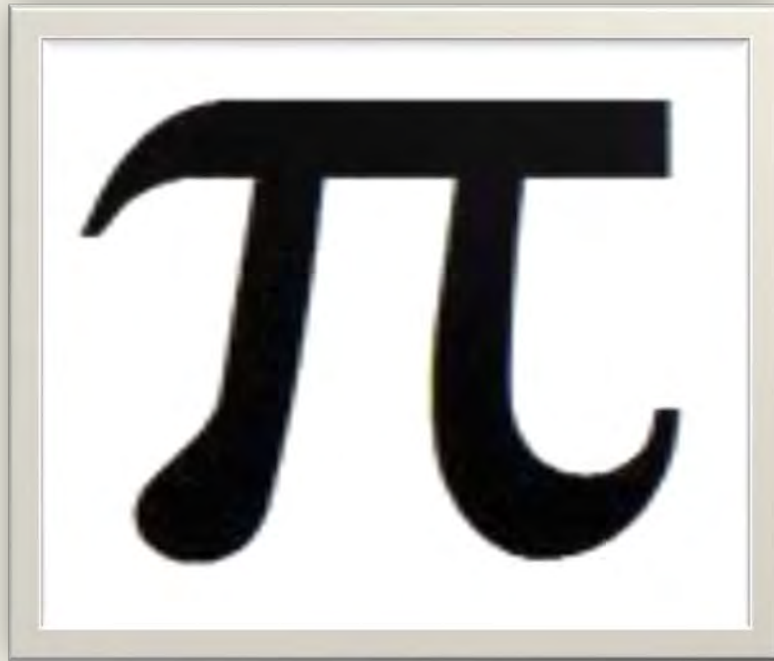
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Yet learning science is not the memorization of facts.



Allow me to explain why I believe science is both an **adventure** and a **puzzle**.





Could someone tell me what is Pi?

$\pi$

3.141

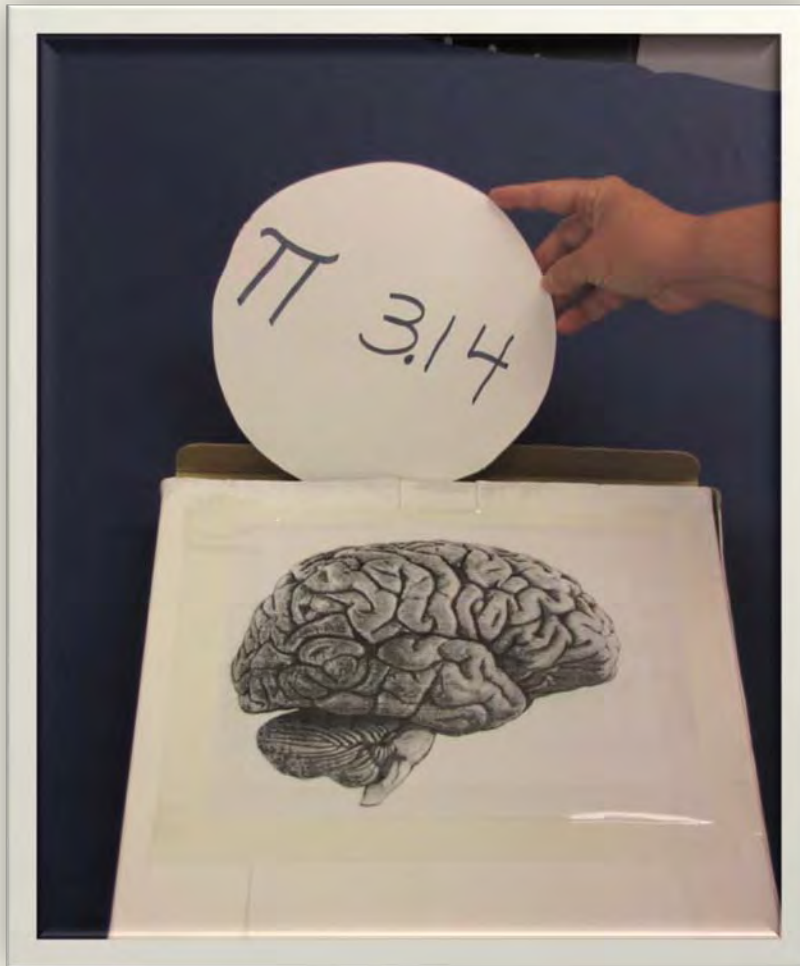
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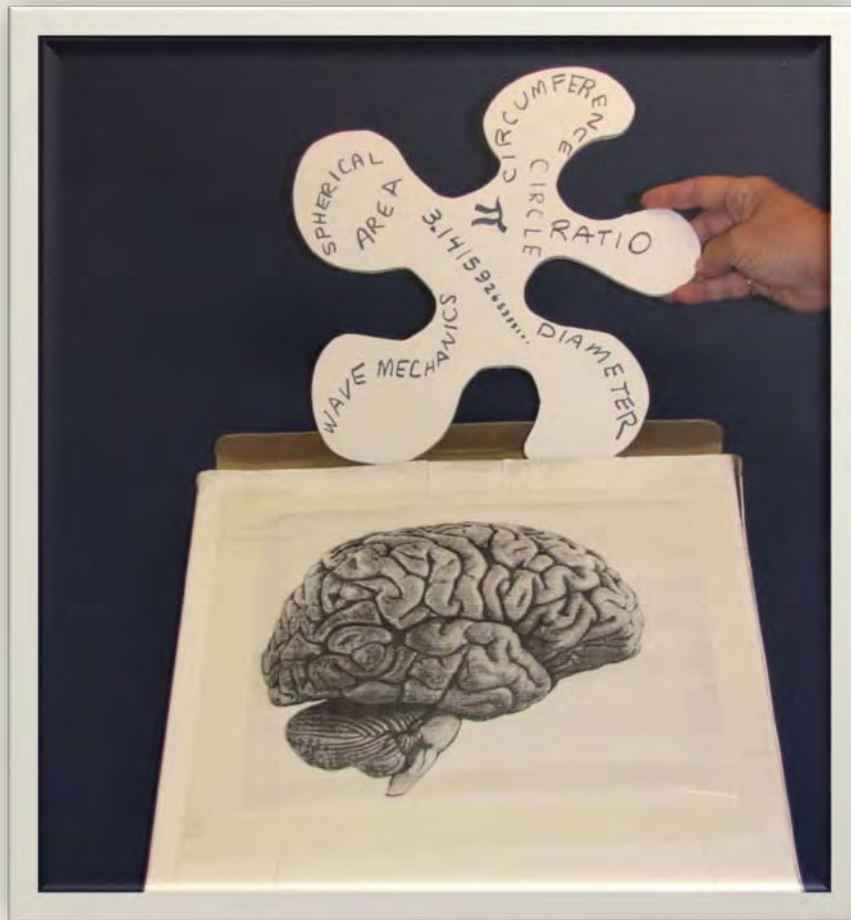
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Think of your brain as a Puzzle. The simple memorization of this fact (Pi) doesn't result in a puzzle piece that fits and connects well to other pieces. It's just a "fact".



To connect Pi in our memory we need better understanding.

It is the ratio of a circle's circumference to diameter and allows spherical area and wave mechanics calculations.



It is the text or teacher's job to provide good puzzle pieces that can link to other pieces.



It is the student's responsibility to fit the puzzle together by thinking of relationships and solving problems.



If the student is handed too many pieces at one time, some are dropped. The student must start fitting the pieces together or they will just end up with a larger and larger stack of pieces.



If the student only memorizes, like remembering your phone number, the student only has a stack of facts- just a collection of puzzle pieces.

**This is not solving the puzzle, it is not learning.**



It is only when you connect the puzzle piece within your present knowledge puzzle picture are you capable of critical thinking.



A teacher cannot place a piece within the puzzle picture for the student.





The teacher only helps the student develop that piece – viewing it from different perspectives.



Only the student  
can place the fact  
within their  
knowledge base.



# EUREKA!

Learning this way is satisfying.



Again, learning science is not memorization and acceptance of faith, it is acceptance by recognizing the connection with what you already know...



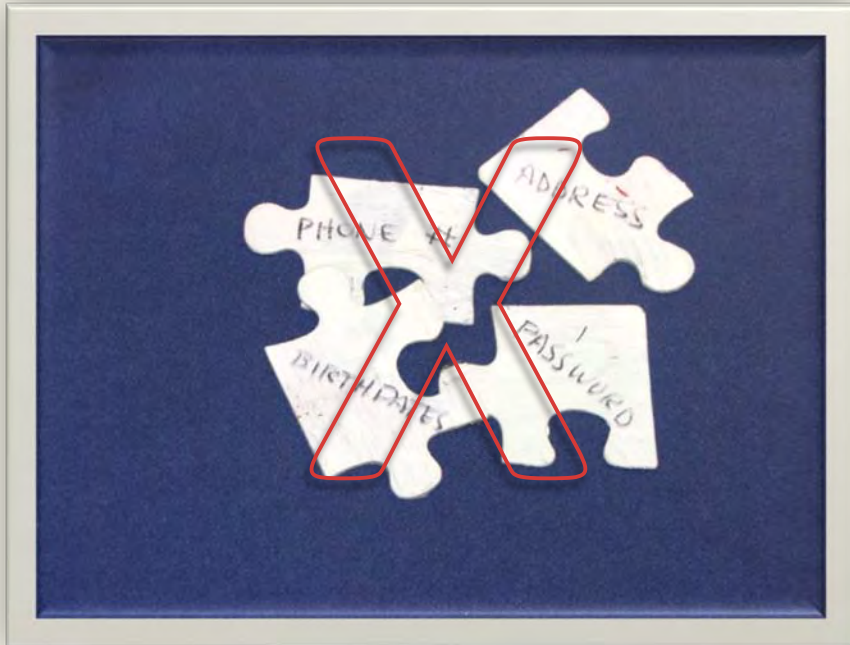
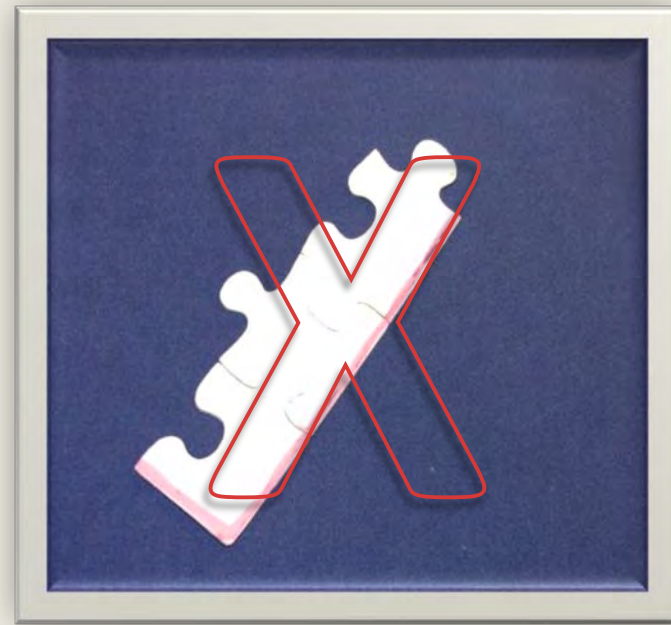
...like fitting in a new puzzle piece into each of our personal picture of rules of nature.





Let us take a look  
at a symbolic  
two-dimensional  
version of a  
three-  
dimensional  
puzzle picture in  
our brain.

Each of our puzzle pictures look different, but there are features in common. There can be no straight borders or corners of our puzzle...



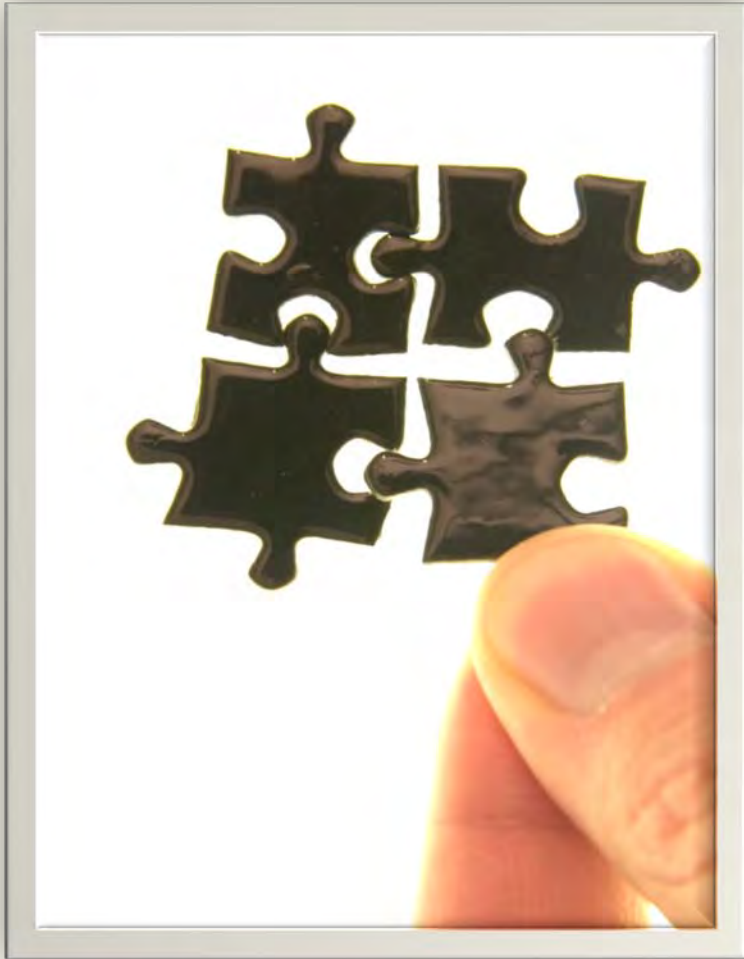
...if there are edges and borders, additional knowledge could not be connected to pieces of pre-existing knowledge.



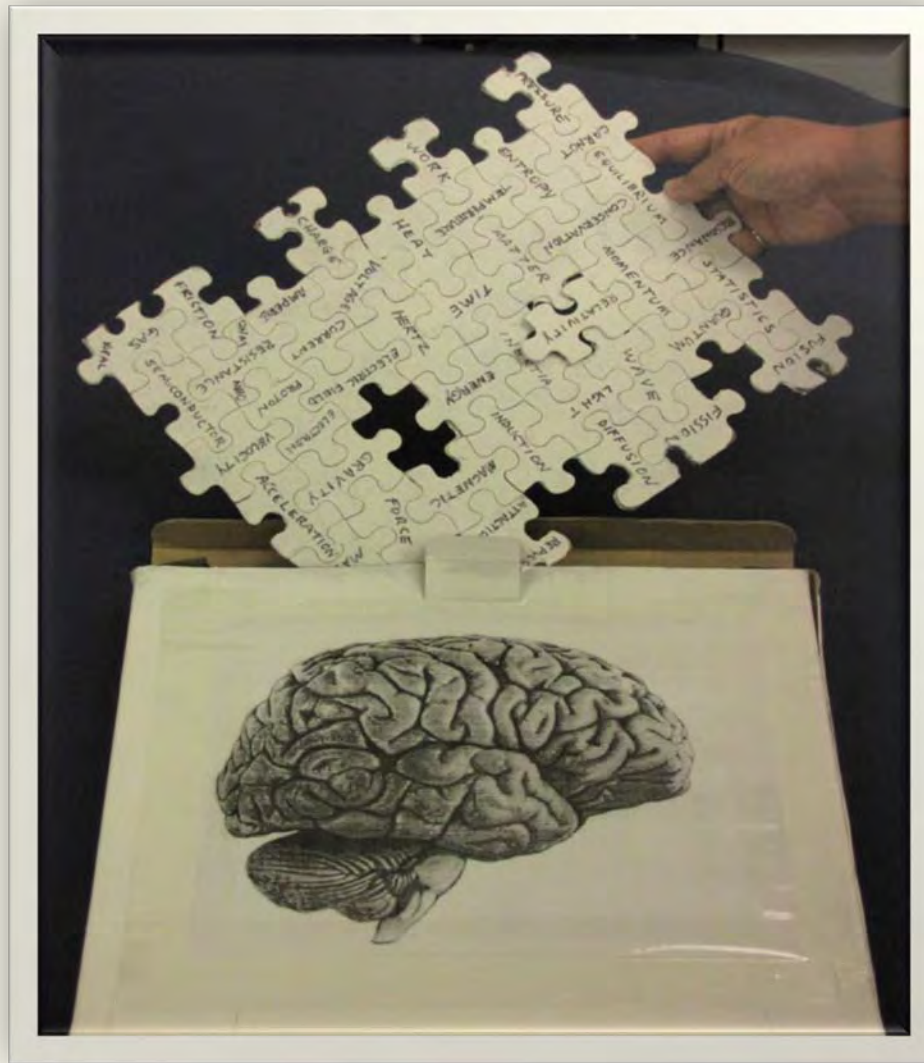




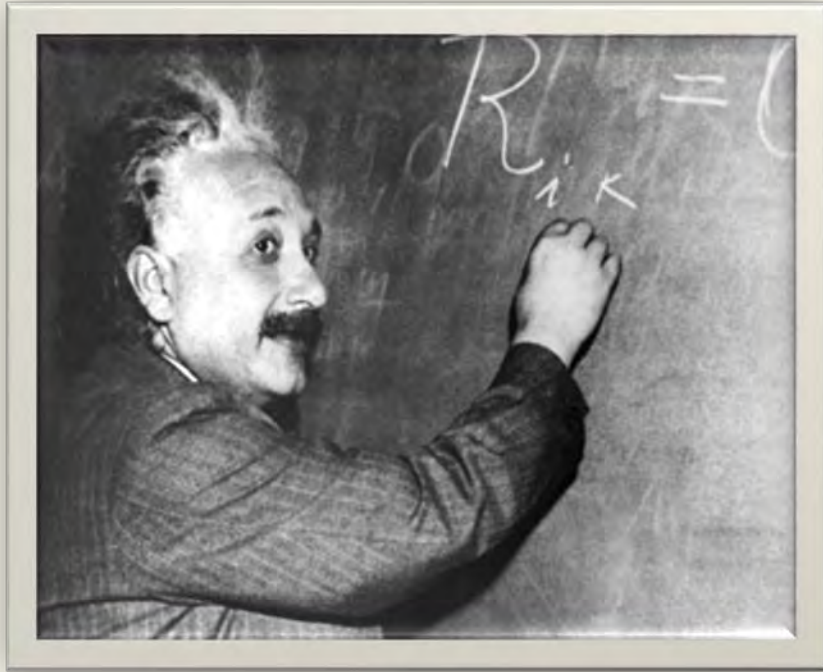
We can never have the complete picture. There will always be more pieces to add and holes in our understanding that challenges us.



The most difficult part of the science puzzle is the pieces that are misplaced or forced into our picture because of faulty understanding or due to theories subject to later clarification.

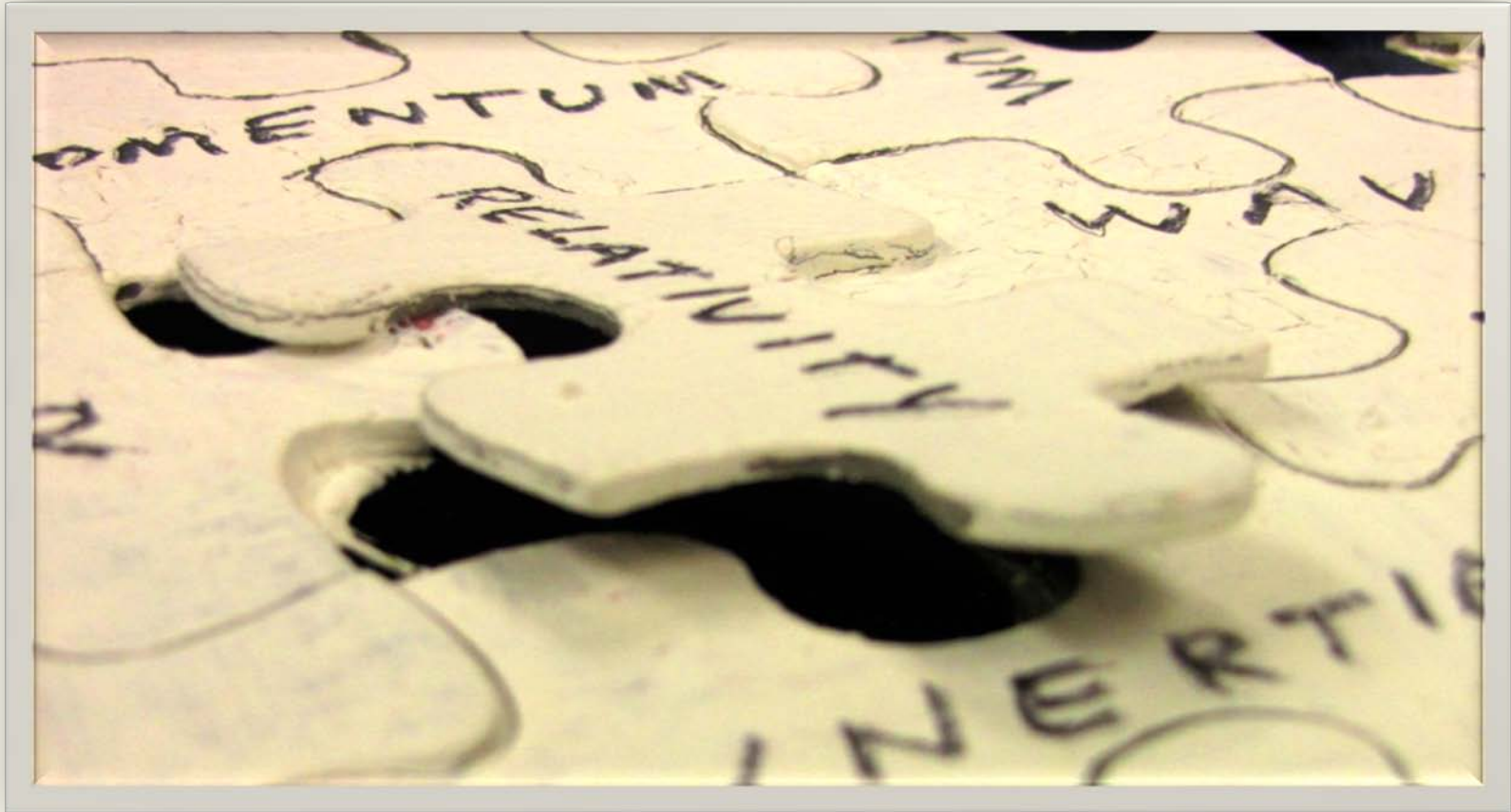


As our knowledge increases and our puzzle is more complete, what were imperfections give insight.

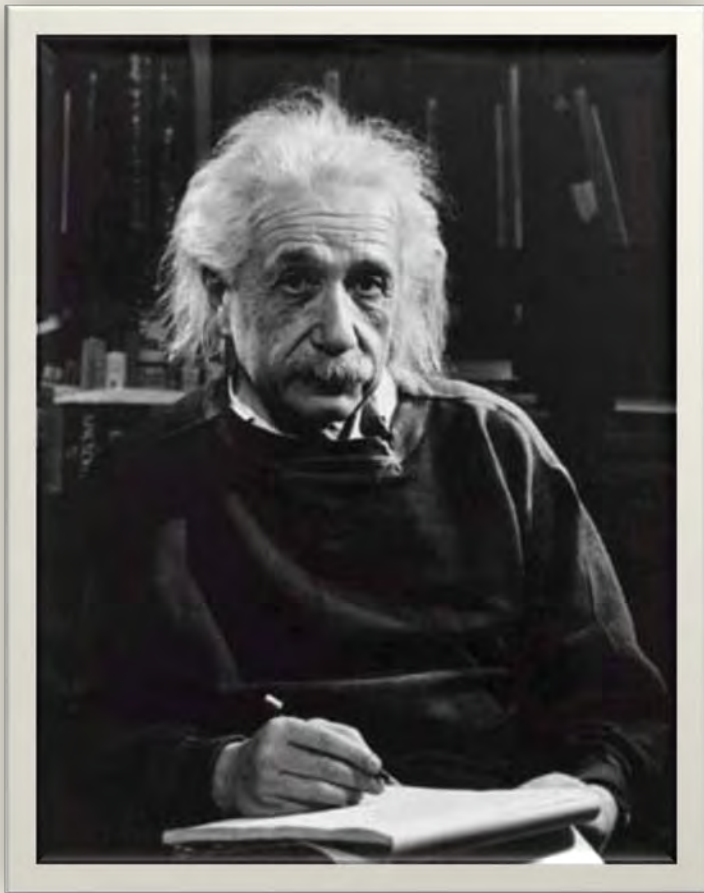


I expect Einstein sensed the error in his puzzle picture between Maxwell's constant light velocity and Newtonian laws.

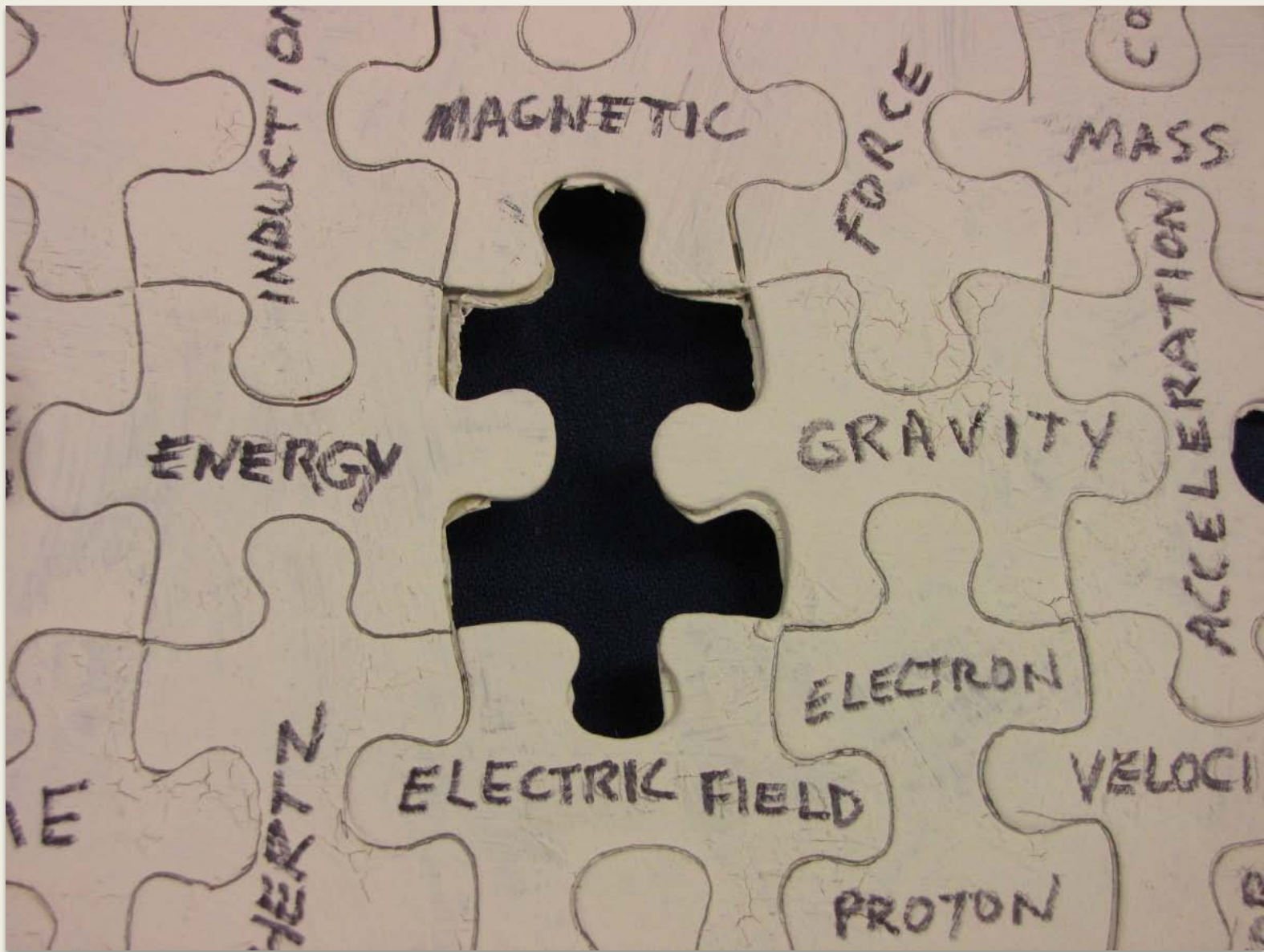




These miss-fitting pieces resulted in his relatively theories.



Einstein also saw a missing piece that caused him to search for a unified field theory.



INDUCTION

MAGNETIC

FORCE

MASS

ENERGY

GRAVITY

ACCELERATION

ELECTRON

VELOCITY

ELECTRIC FIELD

HERTZ

PROTON





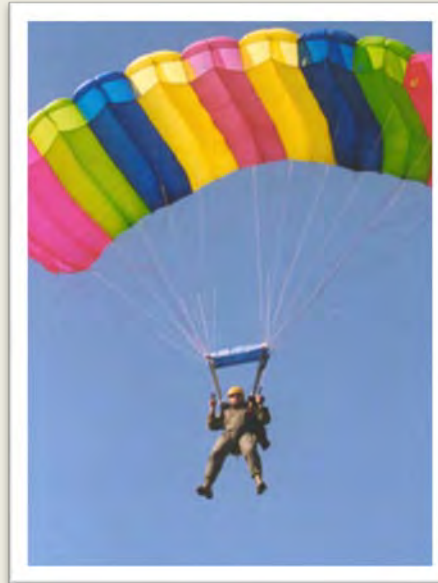
As learners, we must stay open to questioning our understanding and maintain a willingness to rethink our understanding...like refitting puzzle pieces.

Learning science has a similarity with putting a puzzle together, a game, but more than a game, since the results of science affect our lives dramatically.

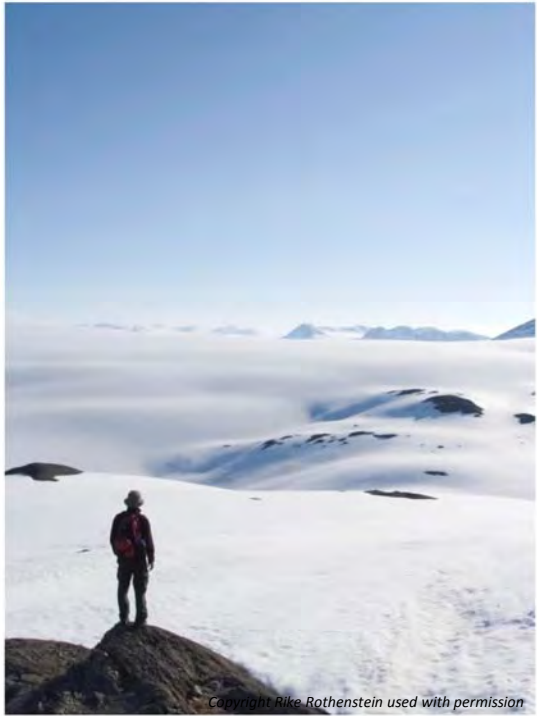




Therefore, learning science is an adventure!



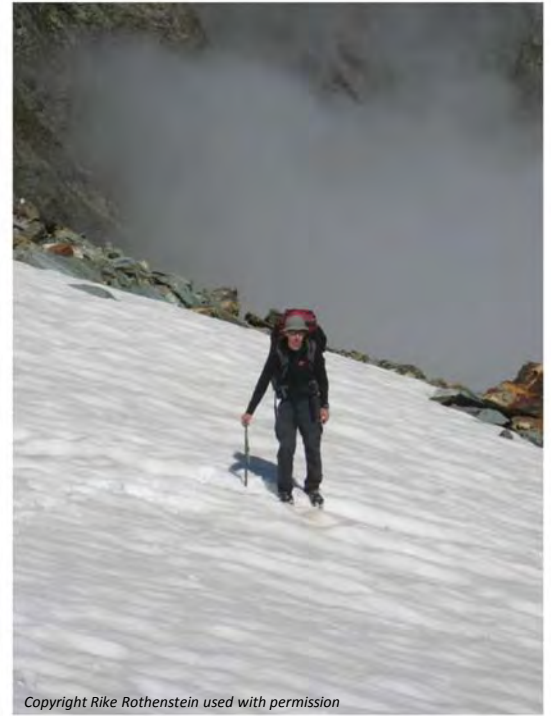
What is an adventure?



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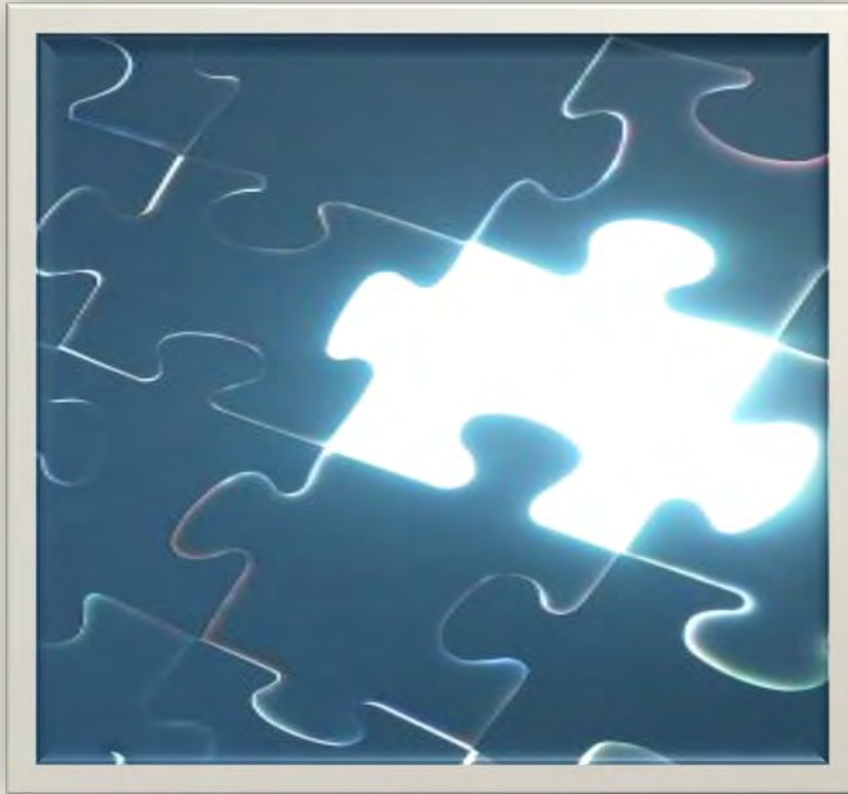
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The answer  
can be  
subjective.  
Part of the  
attraction of  
an adventure  
is figuring out  
a puzzle of  
importance.





The adventure enjoyment, the eureka euphoria, comes from snapping the missing puzzle piece of experience or knowledge into your mind.

You need  
the  
surrounding  
pieces in  
place which  
can seem  
like work.



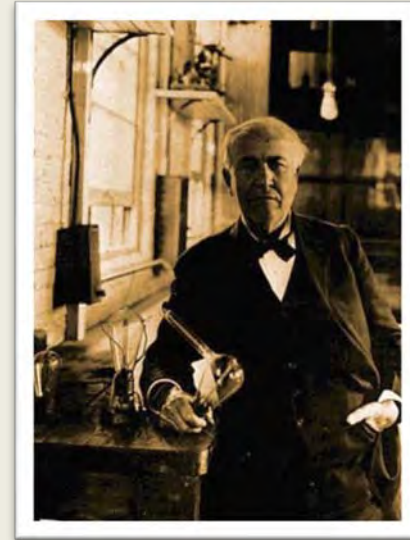
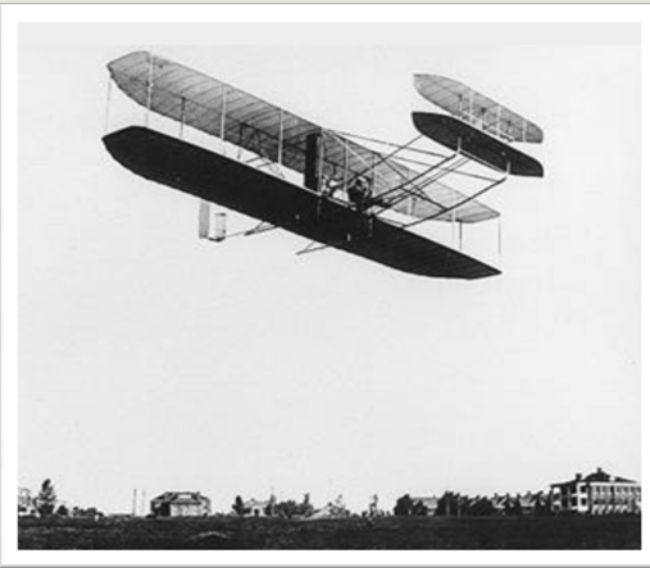




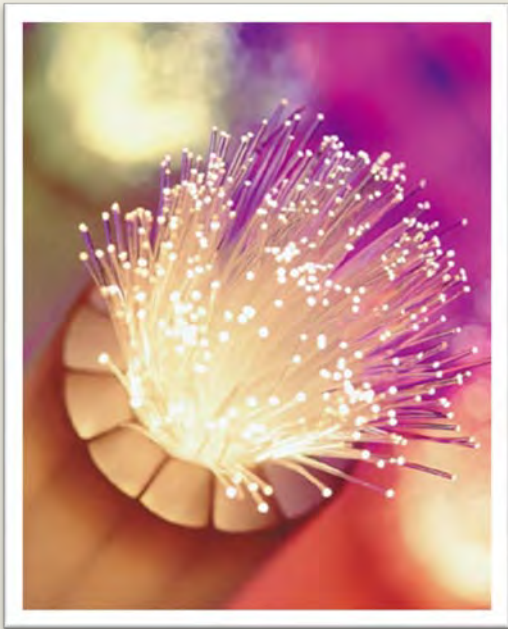
Like a climber needs to learn skills and develop strength to climb a mountain to experience that euphoric view of the blue sky.

A student of science with knowledge of light and our atmosphere will get a similar rush when he places the puzzle piece of why the sky is blue.





Every science fact is a puzzle to understand. If it wasn't, it wouldn't have taken the thousand of years of recorded history to develop the science puzzle pieces we have today.





These science facts or theories are now recorded and available to those who want to read, think, and start putting their own puzzle picture of science together.



We can be a part of the daily science explorations by not only doing (becoming a scientist) but also by just reading newspapers and science magazines.



The unexplored mountains and valleys on earth are few, but there are ever-increasing new science related fields to explore.



Most of us probably missed the chance of exploring new areas in Africa or uncovering ancient Egyptian tombs ...



**There are still adventures in science!**



To be part of this adventure, we need to understand how to fit the recently discovered science puzzle piece into our existing puzzle picture, doing so we become science literate.





I know of no other adventure of less physical risk, yet more intellectual rewards!

Science rewards man with a better life and those that better their lives through science gain meaningful employment as scientists and engineers.





In summary, give learning science a try.

It's a puzzle, it is fun, and there are great rewards.

Learn science and be part of the adventure!!!



**Bob is a former engineer and technical expert for the Wright-Patterson AFB Educational Outreach Office.**

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