



*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.

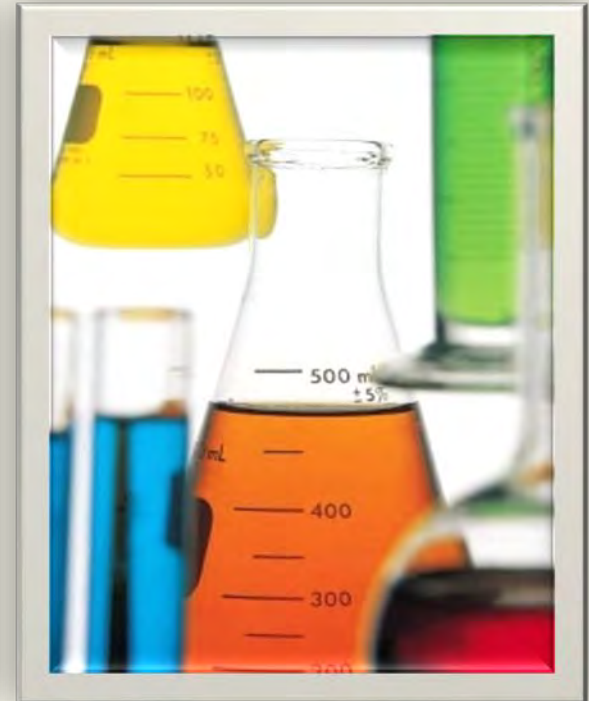
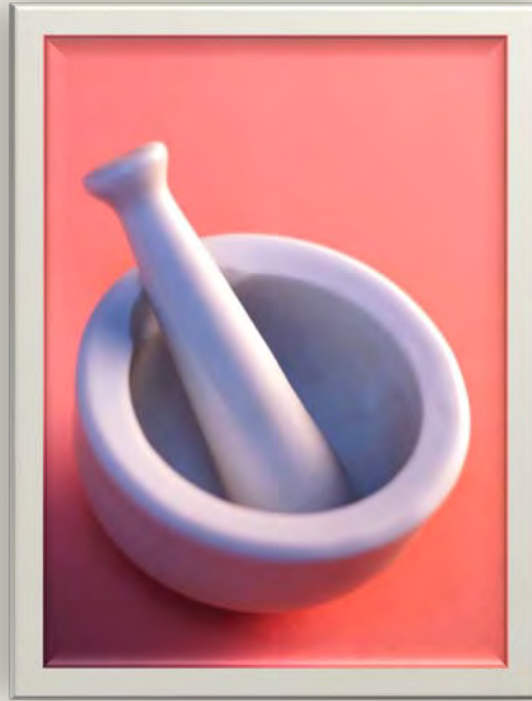
|                                              |                                             |                                             |                                                |                                             |                                             |                                              |                                          |                                             |                                               |                                              |                                               |                                               |                                              |                                                 |                                              |                                                 |                                                |                                             |                                              |                                                |                                              |                                                |                                              |
|----------------------------------------------|---------------------------------------------|---------------------------------------------|------------------------------------------------|---------------------------------------------|---------------------------------------------|----------------------------------------------|------------------------------------------|---------------------------------------------|-----------------------------------------------|----------------------------------------------|-----------------------------------------------|-----------------------------------------------|----------------------------------------------|-------------------------------------------------|----------------------------------------------|-------------------------------------------------|------------------------------------------------|---------------------------------------------|----------------------------------------------|------------------------------------------------|----------------------------------------------|------------------------------------------------|----------------------------------------------|
| 1<br>1A<br>1A<br>1<br>H<br>Hydrogen<br>1.008 | 2<br>2A<br>2A<br>4<br>He<br>Helium<br>4.003 |                                             |                                                |                                             |                                             |                                              |                                          |                                             |                                               |                                              |                                               |                                               |                                              |                                                 |                                              |                                                 |                                                | 13<br>3A<br>3A<br>5<br>B<br>Boron<br>10.811 | 14<br>4A<br>4A<br>6<br>C<br>Carbon<br>12.011 | 15<br>5A<br>5A<br>7<br>N<br>Nitrogen<br>14.007 | 16<br>6A<br>6A<br>8<br>O<br>Oxygen<br>15.999 | 17<br>7A<br>7A<br>9<br>F<br>Fluorine<br>18.998 | 18<br>8A<br>8A<br>10<br>Ne<br>Neon<br>20.180 |
| 3<br>1342<br>Li<br>Lithium<br>6.941          | 4<br>2471<br>Be<br>Beryllium<br>9.012       |                                             |                                                |                                             |                                             |                                              |                                          |                                             |                                               |                                              |                                               |                                               |                                              |                                                 |                                              |                                                 |                                                | 13<br>2538<br>Al<br>Aluminum<br>26.982      | 14<br>3265<br>Si<br>Silicon<br>28.086        | 15<br>white 280.5<br>P<br>Phosphorus<br>30.974 | 16<br>444.61<br>S<br>Sulfur<br>32.066        | 17<br>-101.5<br>Cl<br>Chlorine<br>35.453       | 18<br>-185.847<br>Ar<br>Argon<br>39.948      |
| 11<br>882.940<br>Na<br>Sodium<br>22.990      | 12<br>1090<br>Mg<br>Magnesium<br>24.305     | 3<br>2836<br>3B<br>Sc<br>Scandium<br>44.956 | 4<br>3287<br>4B<br>Ti<br>Titanium<br>47.88     | 5<br>3407<br>5B<br>V<br>Vanadium<br>50.942  | 6<br>2671<br>6B<br>Cr<br>Chromium<br>51.996 | 7<br>2061<br>7B<br>Mn<br>Manganese<br>54.938 | 8<br>2861<br>8<br>Fe<br>Iron<br>55.933   | 9<br>2927<br>VIII<br>Co<br>Cobalt<br>58.933 | 10<br>2913<br>VIII<br>Ni<br>Nickel<br>58.693  | 11<br>2942<br>1B<br>Cu<br>Copper<br>63.546   | 12<br>907<br>2B<br>Zn<br>Zinc<br>65.39        | 13<br>2004<br>Ga<br>Gallium<br>69.732         | 14<br>2262<br>32<br>Ge<br>Germanium<br>72.61 | 15<br>616 SP<br>As<br>Arsenic<br>74.922         | 16<br>685<br>Se<br>Selenium<br>78.972        | 17<br>58.8<br>Br<br>Bromine<br>79.904           | 18<br>-153.34<br>Kr<br>Krypton<br>84.80        |                                             |                                              |                                                |                                              |                                                |                                              |
| 19<br>759<br>K<br>Potassium<br>39.098        | 20<br>1484<br>Ca<br>Calcium<br>40.078       | 21<br>2836<br>Y<br>Yttrium<br>88.906        | 22<br>3287<br>Zr<br>Zirconium<br>91.224        | 23<br>3407<br>Nb<br>Niobium<br>92.906       | 24<br>2671<br>Mo<br>Molybdenum<br>95.95     | 25<br>2061<br>Mn<br>Manganese<br>54.938      | 26<br>2861<br>Fe<br>Iron<br>55.933       | 27<br>2927<br>Rh<br>Rhodium<br>102.906      | 28<br>2913<br>Pd<br>Palladium<br>106.42       | 29<br>2942<br>Ag<br>Silver<br>107.868        | 30<br>907<br>Cd<br>Cadmium<br>112.411         | 31<br>2072<br>In<br>Indium<br>114.818         | 32<br>2262<br>Sn<br>Tin<br>118.71            | 33<br>1587<br>Sb<br>Antimony<br>121.760         | 34<br>685<br>Te<br>Tellurium<br>127.6        | 35<br>184.4<br>I<br>Iodine<br>126.904           | 36<br>-108.09<br>Xe<br>Xenon<br>131.29         |                                             |                                              |                                                |                                              |                                                |                                              |
| 37<br>688<br>Rb<br>Rubidium<br>84.468        | 38<br>1382<br>Sr<br>Strontium<br>87.62      | 39<br>3345<br>Y<br>Yttrium<br>88.906        | 40<br>4409<br>Zr<br>Zirconium<br>91.224        | 41<br>4744<br>Nb<br>Niobium<br>92.906       | 42<br>4639<br>Mo<br>Molybdenum<br>95.95     | 43<br>4265<br>Tc<br>Technetium<br>98.907     | 44<br>4150<br>Ru<br>Ruthenium<br>101.07  | 45<br>3695<br>Rh<br>Rhodium<br>102.906      | 46<br>2963<br>Pd<br>Palladium<br>106.42       | 47<br>2142<br>Ag<br>Silver<br>107.868        | 48<br>767<br>Cd<br>Cadmium<br>112.411         | 49<br>2072<br>In<br>Indium<br>114.818         | 50<br>2602<br>Sn<br>Tin<br>118.71            | 51<br>1587<br>Sb<br>Antimony<br>121.760         | 52<br>948<br>Te<br>Tellurium<br>127.6        | 53<br>184.4<br>I<br>Iodine<br>126.904           | 54<br>-108.09<br>Xe<br>Xenon<br>131.29         |                                             |                                              |                                                |                                              |                                                |                                              |
| 55<br>671<br>Cs<br>Cesium<br>132.905         | 56<br>1897<br>Ba<br>Barium<br>137.327       | 57-71<br>Lanthanide Series                  | 72<br>4603<br>Hf<br>Hafnium<br>178.49          | 73<br>5458<br>Ta<br>Tantalum<br>180.948     | 74<br>5555<br>W<br>Tungsten<br>183.85       | 75<br>5596<br>Re<br>Rhenium<br>186.207       | 76<br>5012<br>Os<br>Osmium<br>190.23     | 77<br>4428<br>Ir<br>Iridium<br>192.22       | 78<br>3825<br>Pt<br>Platinum<br>195.08        | 79<br>2854<br>Au<br>Gold<br>196.967          | 80<br>356.62<br>Hg<br>Mercury<br>200.59       | 81<br>3478<br>Tl<br>Thallium<br>204.383       | 82<br>1749<br>Pb<br>Lead<br>207.2            | 83<br>1564<br>Bi<br>Bismuth<br>208.980          | 84<br>962<br>Po<br>Polonium<br>[208.982]     | 85<br>337<br>At<br>Astatine<br>209.987          | 86<br>-61.7<br>Rn<br>Radon<br>222.018          |                                             |                                              |                                                |                                              |                                                |                                              |
| 87<br>677<br>Fr<br>Francium<br>223.020       | 88<br>1737<br>Ra<br>Radium<br>226.025       | 89-103<br>Actinide Series                   | 104<br>unknown<br>Rf<br>Rutherfordium<br>[261] | 105<br>unknown<br>Db<br>Dubnium<br>[262]    | 106<br>unknown<br>Sg<br>Seaborgium<br>[266] | 107<br>unknown<br>Bh<br>Bohrium<br>[264]     | 108<br>unknown<br>Hs<br>Hassium<br>[269] | 109<br>unknown<br>Mt<br>Meitnerium<br>[268] | 110<br>unknown<br>Ds<br>Darmstadtium<br>[269] | 111<br>unknown<br>Rg<br>Roentgenium<br>[272] | 112<br>unknown<br>Cn<br>Copernicium<br>[277]  | 113<br>unknown<br>Uut<br>Ununtrium<br>unknown | 114<br>unknown<br>Fl<br>Flerovium<br>[289]   | 115<br>unknown<br>Uup<br>Ununpentium<br>unknown | 116<br>unknown<br>Lv<br>Livermorium<br>[293] | 117<br>unknown<br>Uus<br>Ununseptium<br>unknown | 118<br>unknown<br>Uuo<br>Ununoctium<br>unknown |                                             |                                              |                                                |                                              |                                                |                                              |
|                                              |                                             | 57<br>3464<br>La<br>Lanthanum<br>138.906    | 58<br>3443<br>Ce<br>Cerium<br>140.115          | 59<br>3520<br>Pr<br>Praseodymium<br>140.908 | 60<br>3074<br>Nd<br>Neodymium<br>144.24     | 61<br>3000<br>Pm<br>Promethium<br>144.913    | 62<br>1794<br>Sm<br>Samarium<br>150.36   | 63<br>1529<br>Eu<br>Europium<br>151.966     | 64<br>3273<br>Gd<br>Gadolinium<br>157.25      | 65<br>3230<br>Tb<br>Terbium<br>158.925       | 66<br>2567<br>Dy<br>Dysprosium<br>162.50      | 67<br>2700<br>Ho<br>Holmium<br>164.930        | 68<br>2868<br>Er<br>Erbium<br>167.26         | 69<br>1950<br>Tm<br>Thulium<br>168.934          | 70<br>1196<br>Yb<br>Ytterbium<br>173.04      | 71<br>3402<br>Lu<br>Lutetium<br>174.967         |                                                |                                             |                                              |                                                |                                              |                                                |                                              |
|                                              |                                             | 89<br>3198<br>Ac<br>Actinium<br>227.028     | 90<br>4788<br>Th<br>Thorium<br>232.038         | 91<br>4027<br>Pa<br>Protactinium<br>231.036 | 92<br>4331<br>U<br>Uranium<br>238.029       | 93<br>4274<br>Np<br>Neptunium<br>237.048     | 94<br>3228<br>Pu<br>Plutonium<br>244.064 | 95<br>2011<br>Am<br>Americium<br>243.061    | 96<br>3100<br>Cm<br>Curium<br>247.070         | 97<br>2627<br>Bk<br>Berkelium<br>247.070     | 98<br>unknown<br>Cf<br>Californium<br>251.080 | 99<br>unknown<br>Es<br>Einsteinium<br>[254]   | 100<br>unknown<br>Fm<br>Fermium<br>257.095   | 101<br>unknown<br>Md<br>Mendelevium<br>258.1    | 102<br>unknown<br>No<br>Nobelium<br>259.101  | 103<br>unknown<br>Lr<br>Lawrencium<br>[262]     |                                                |                                             |                                              |                                                |                                              |                                                |                                              |

Alkali Metal
Alkaline Earth
Transition Metal
Basic Metal
Semimetal
Nonmetal
Halogen
Noble Gas
Lanthanide
Actinide

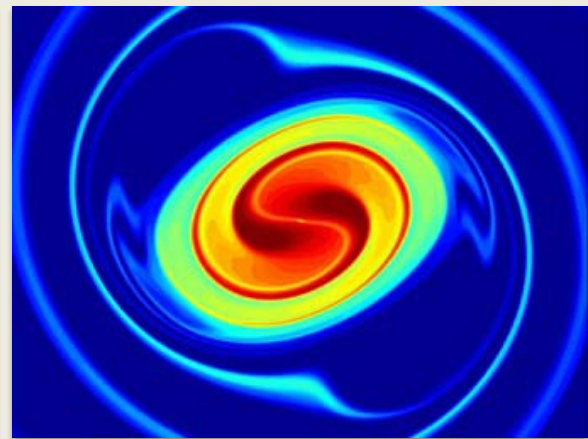
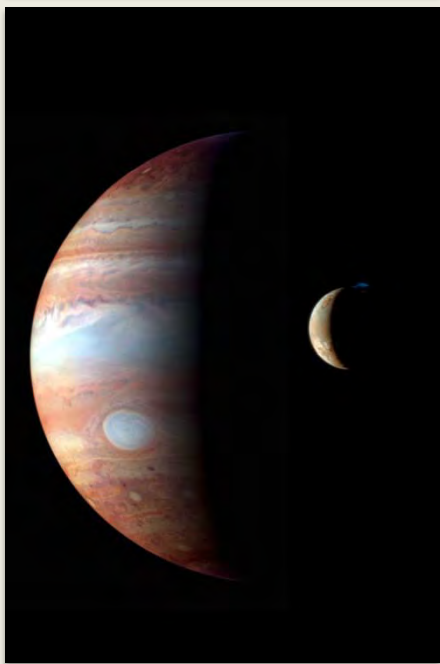
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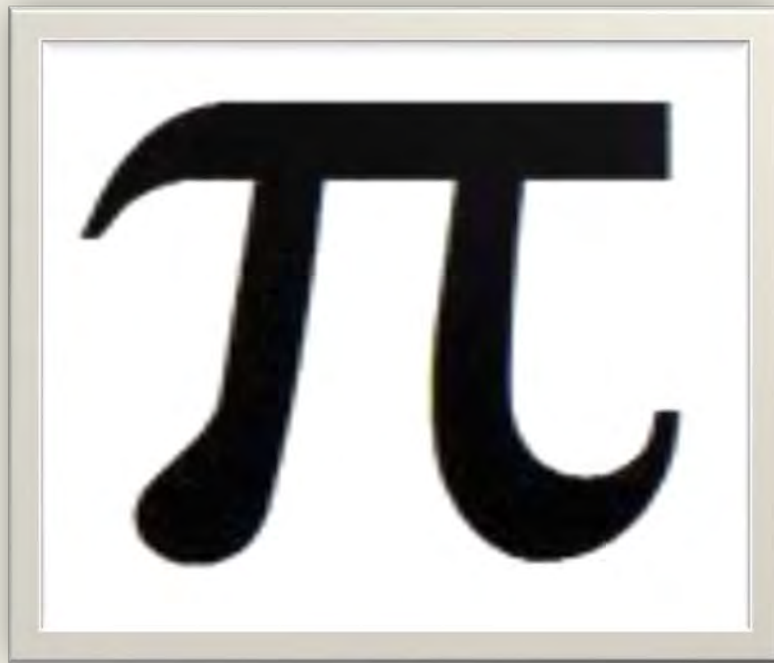
Yet learning science is not the memorization of facts.





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

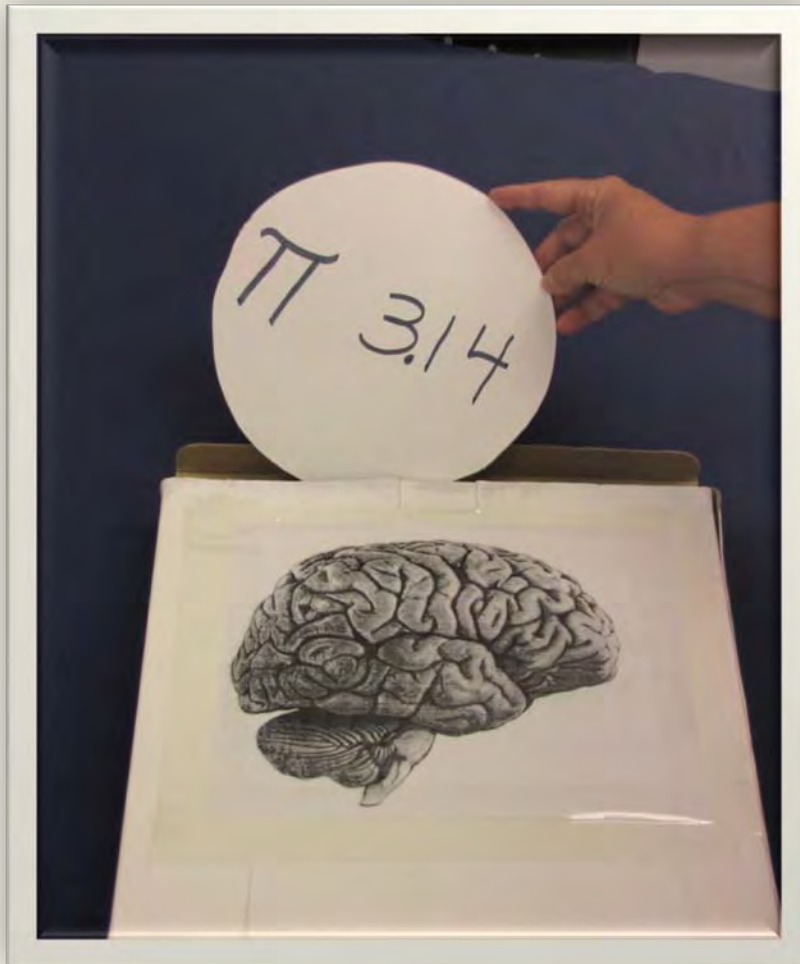
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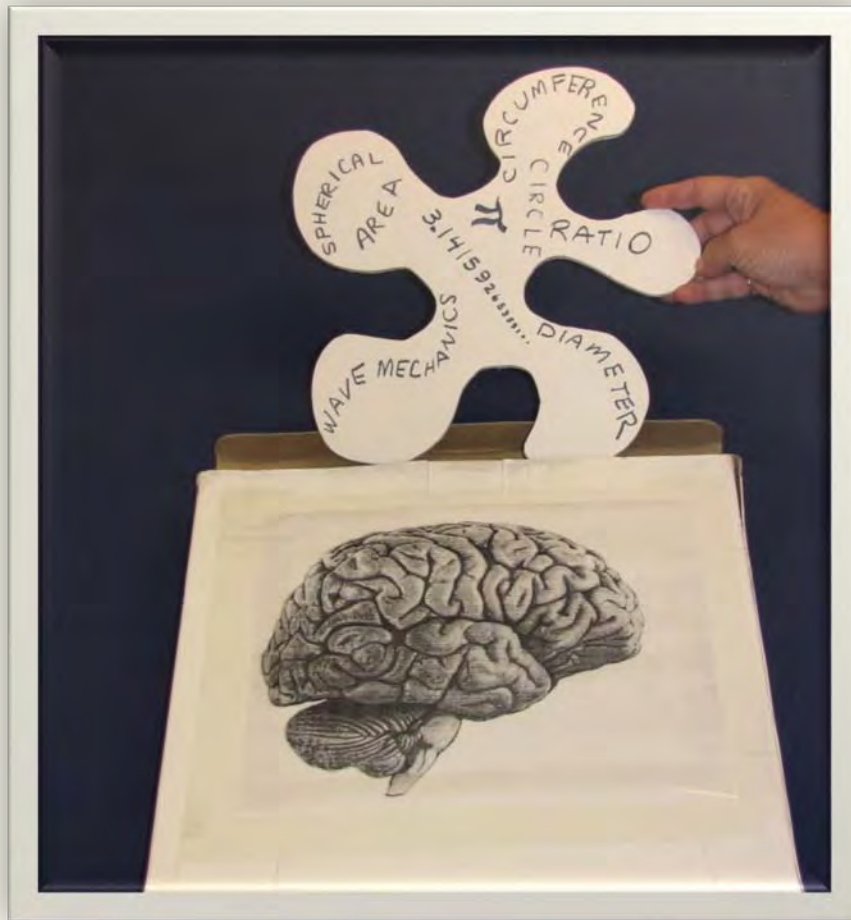
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Think of your brain as a Puzzle. The simple memorization of this fact (Pi) doesn't result in a puzzle piece that fits and connects well to other pieces. It's just a "fact".



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...





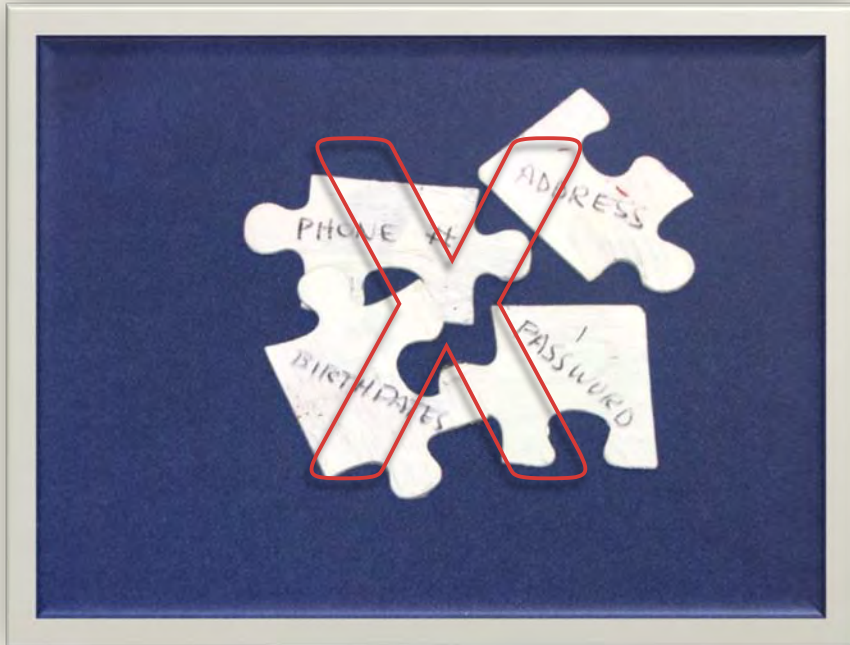
...like fitting in a new puzzle piece into each of our personal picture of rules of nature.





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...



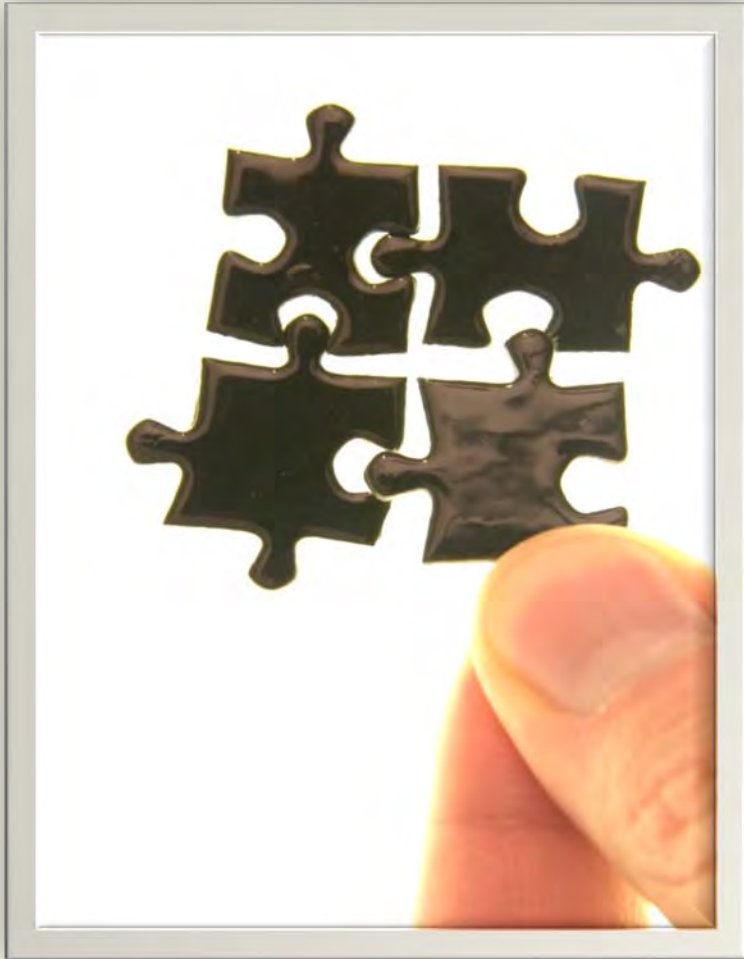
...if there are edges and borders, additional knowledge could not be connected to pieces of pre-existing knowledge.



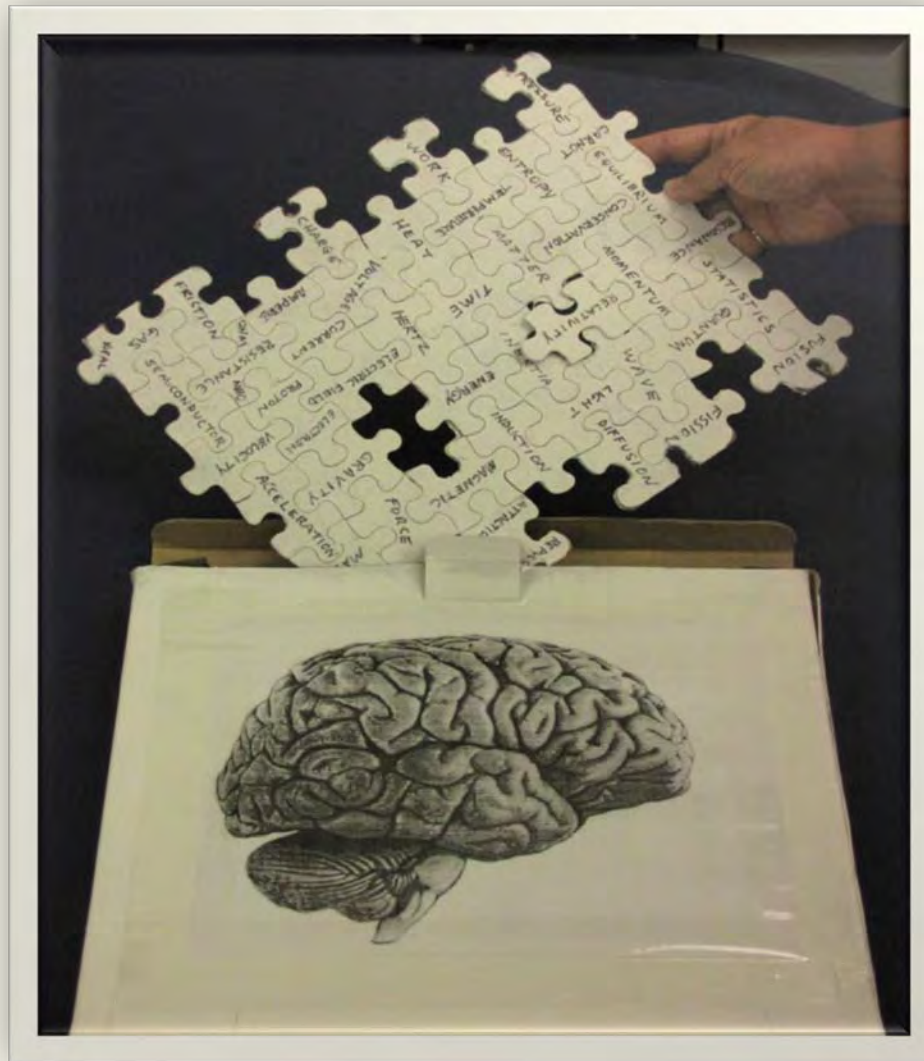




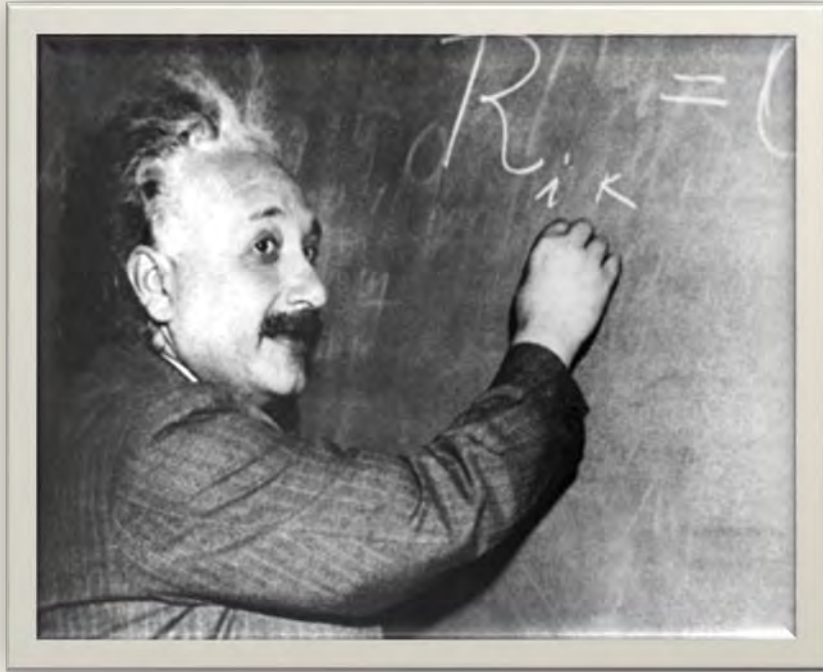
We can never have the complete picture. There will always be more pieces to add and holes in our understanding that challenges us.



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.



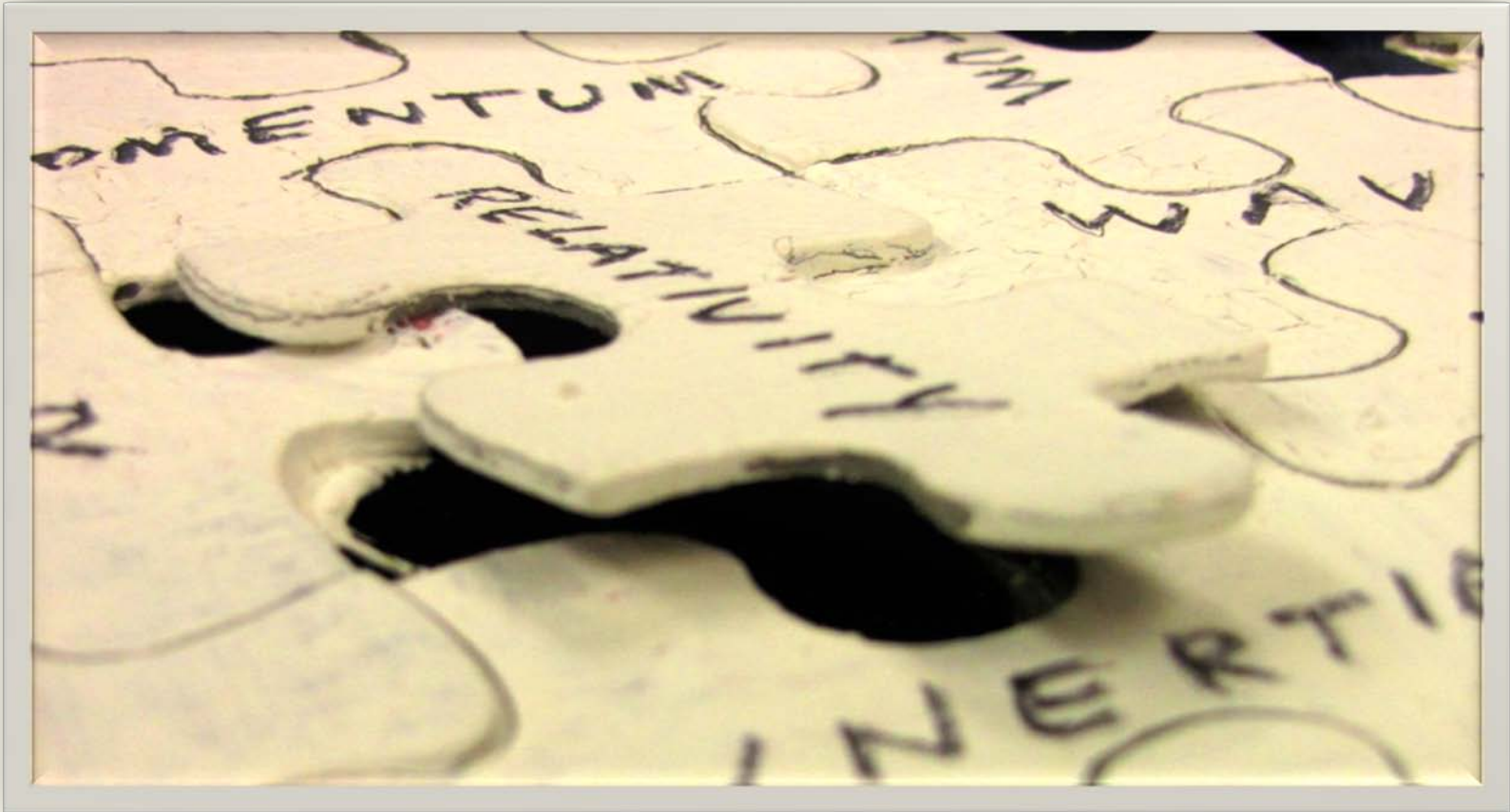
As our knowledge increases and our puzzle is more complete, what were imperfections give insight.



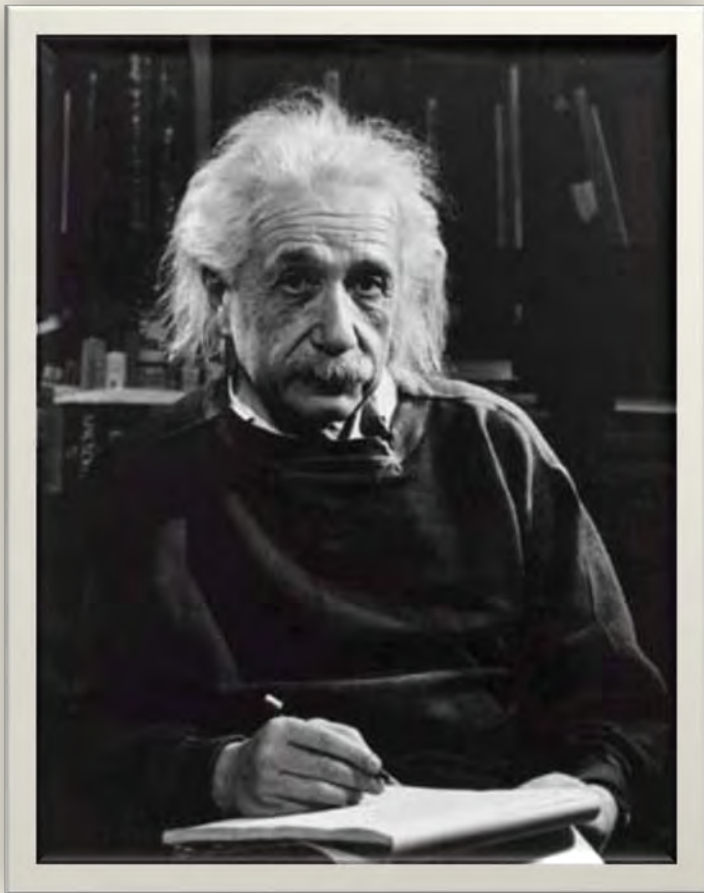
I expect Einstein sensed the error in his puzzle picture between Maxwell's constant light velocity and Newtonian laws.





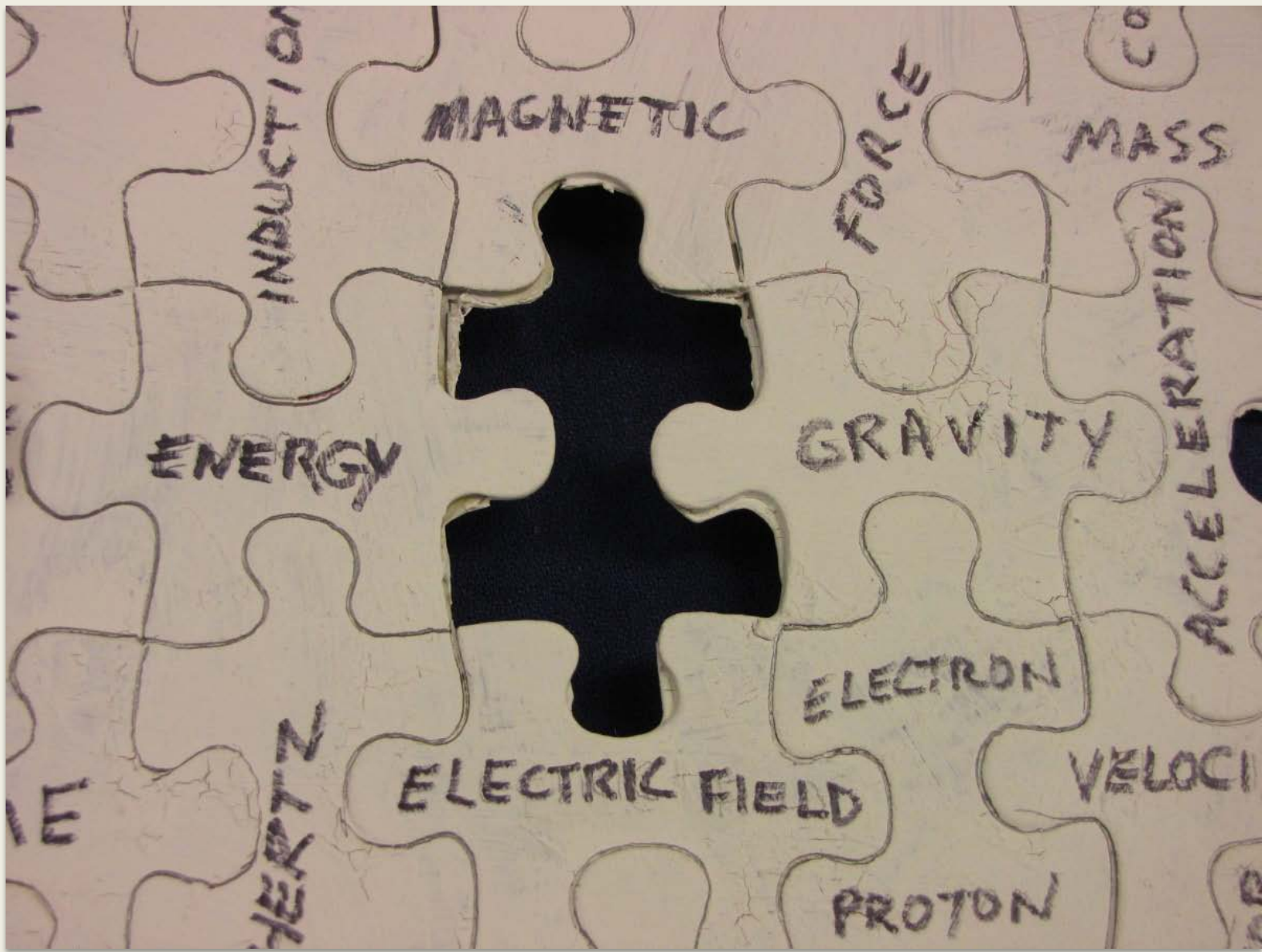


These miss-fitting pieces resulted in his relatively theories.



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





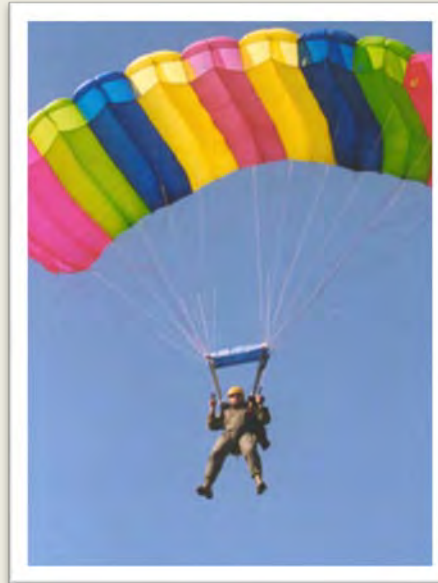
As learners, we must stay open to questioning our understanding and maintain a willingness to rethink our understanding...like refitting puzzle pieces.

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.



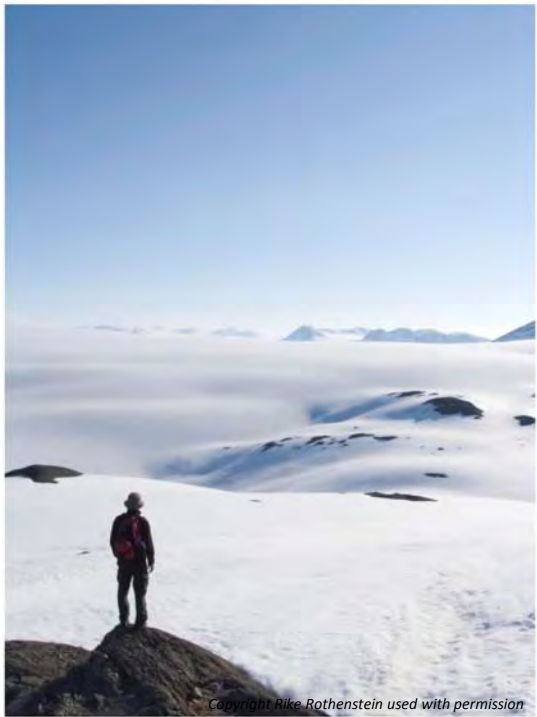


Therefore, learning science is an adventure!



What is an adventure?





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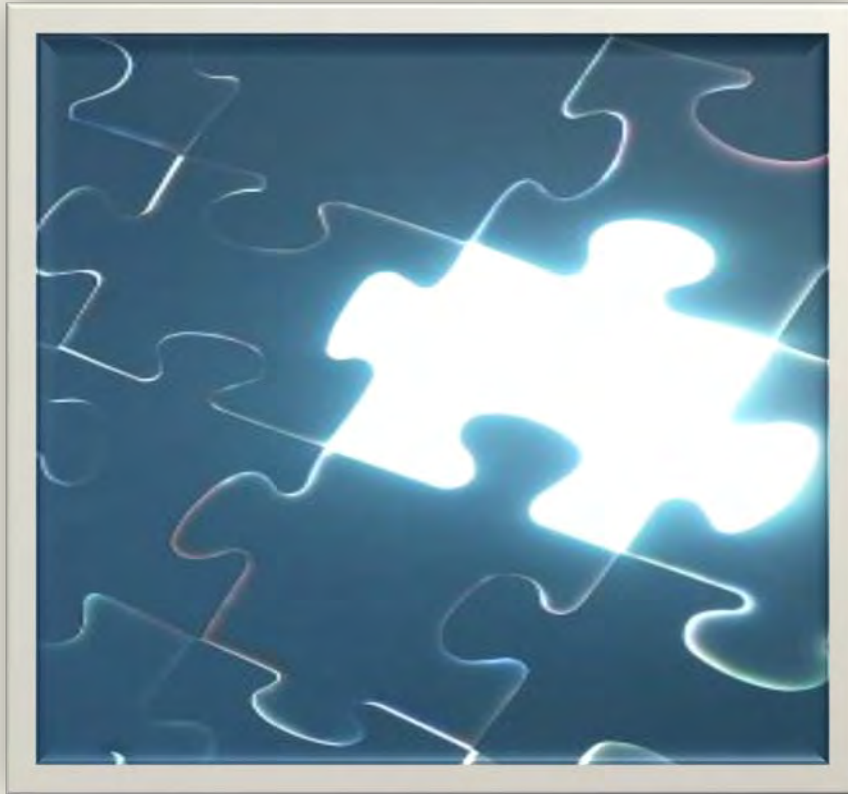
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The answer  
can be  
subjective.  
Part of the  
attraction of  
an adventure  
is figuring out  
a puzzle of  
importance.





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.



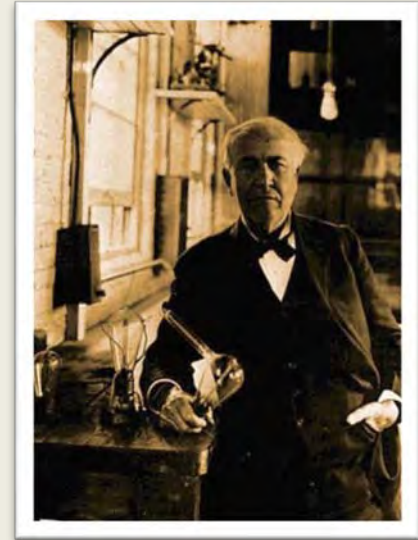
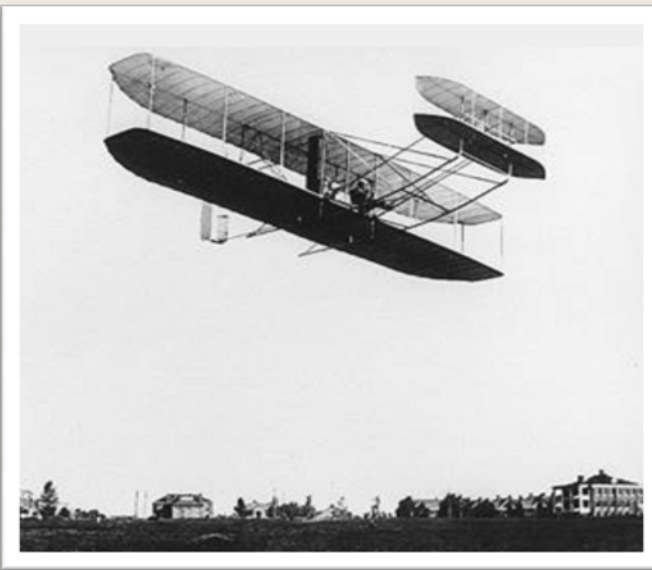




Like a climber needs to learn skills and develop strength to climb a mountain to experience that euphoric view of the blue sky.

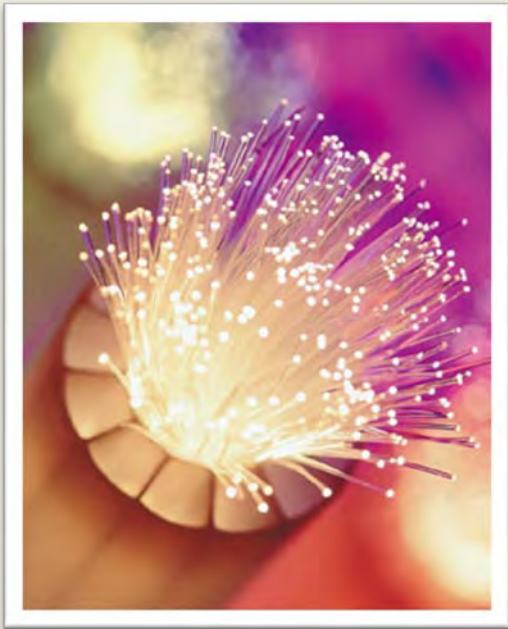
A student of science with knowledge of light and our atmosphere will get a similar rush when he places the puzzle piece of why the sky is blue.





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.

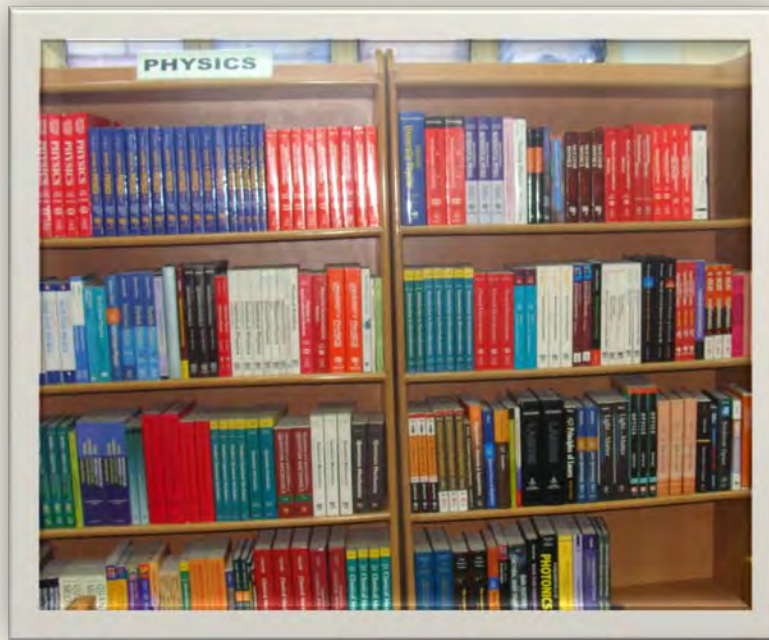








These science facts or theories are now recorded and available to those who want to read, think, and start putting their own puzzle picture of science together.



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.



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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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