

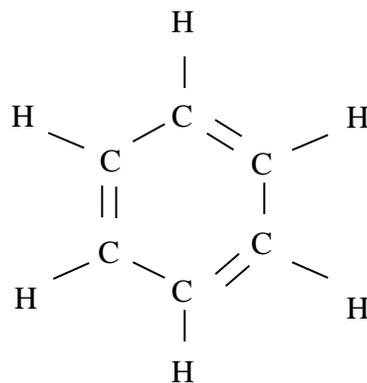
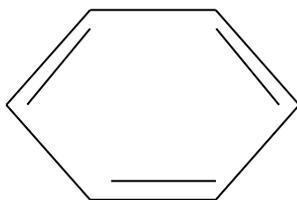
“The 2D Symmetry of Nature”

T.M. Lach April 11, 2005

The structures of nature and the strong nuclear force The Proton the smallest Quantum Vortex

Over the years many new discoveries have taught us that nature works its miracles with very simple structures. Going back 100 years we see this simplicity in structures like the Benzene molecule, Polycyclic Aromatic Hydrocarbons (PAH), the Hydrogen atom, DNA, snowflakes and crystal lattices. (1) In recent years many new discoveries, like the discovery of Quarks, have reinforced this belief. Ninety years ago, Niels Bohr's model of the structure of the hydrogen atom (March 6th 1913) revolutionized science since it brought together a few simple principles that allowed us to understand the nature of why atoms have quantized energy levels. Thus began the new era of Quantum Theory and Quantum Mechanics. Many before Bohr had assumed that the electrons were circling the nucleus. (2) Nicholson earlier had assumed that the angular momentum of the electron was quantized, for 30 years others had tried to explain the Balmer series of the hydrogen spectrum, but Bohr tied it all together into a coherent picture of the hydrogen atom. Bohr had to assume that the circling electrons did not lose energy to radiation and thereby spiral into the nucleus, a big assumption at the time. Ten years later in 1923 DeBroglie proposed the wave nature of particles, which explained why the circling electrons could maintain stable quantized orbits and so began the quantum nature of the universe, with a little help from Plank, Einstein, Shrodinger, Sommerfeld and many others. Simple structures can explain the nature of atomic positions in crystals. Some of these structures such as simple cubic, face-centered cubic, hexagonal close packed are typical examples of these structures in solid- state physics. 6- fold symmetry is common in two dimensions for structures as varied as flowers and snowflakes. (3) The study of crystallography teaches that only 32 symmetries define all the types of structures of solid- state physics. (4) Even structures that show 5- fold symmetry, which crystallography says should not exist, show up in Nature. (5) Let's look at some of the structures both old and new that have supported the premise that nature's secrets are revealed with very simple structures.

Let's first look at the structure of one of the most common materials on earth, organic compounds containing carbon. First let's examine benzene (C_6H_6) a very symmetrical 2- dimensional structure. The structure of a single Benzene ring is usually represented as:

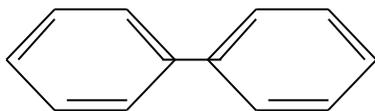


or

Note that not only does the structure look flat in this representation; it is indeed a planar structure. The double bond length is 1.33 Angstroms and the single bond length is 1.54 Angstroms. (6) Benzene is one of a class of organic compounds called Polycyclic Aromatic Hydrocarbons. The term “aromatic” comes from the fact that most of these compounds have a pleasant smell. The stability of the Benzene structure comes not only from the carbon bonds (single and double) but also from the π bonds (from the p-orbital extensions above and below the ring) around the ring. This ring current results in an induced magnetic field that penetrates the ring structure of benzene thereby giving benzene a net magnetic moment. (7) In addition the Polycyclic Aromatic Hydrocarbons are believed to make up the “dust” of interstellar space. (8)

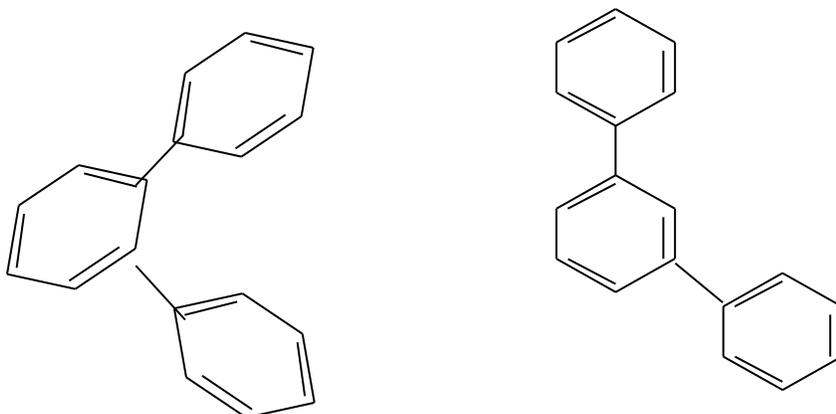
One of the most simple of these Aromatic structures is biphenyl, two benzene rings linked together with a single bond (shared electron).

($C_{12}H_{10}$)



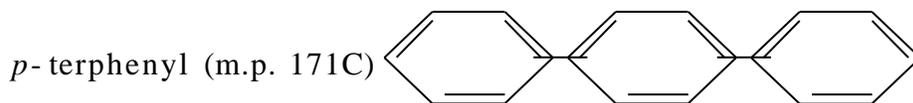
In the solid phase of biphenyl, both benzene rings are in the same plane, while in the liquid or gas phase the planes of the two benzene rings are 45 degrees apart. (9)

Structures having 3 benzene rings linked together with single bonds are known as Terphenyls. Three isomers of this structure are:



o-terphenyl (m.p. 57C),

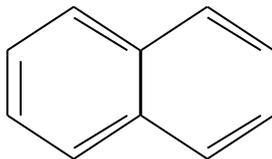
m-terphenyl (m.p. 87C), and



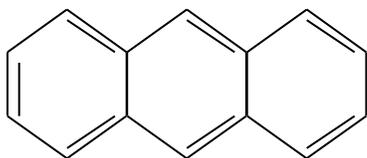
Fused Aromatic Hydrocarbons :

Naphthalene is the parent hydrocarbon of a series of “fused” Polycyclic Aromatic Hydrocarbons (PAH). Naphthalene ($C_{10} H_8$) is made up of two fused benzene structures as seen below. The bond lengths are slightly different than found in the unfused benzene structure and range from 1.393 to 1.424 Angstroms. (10)

($C_{10} H_8$)
m.p. 80.5C
ref. # 9275

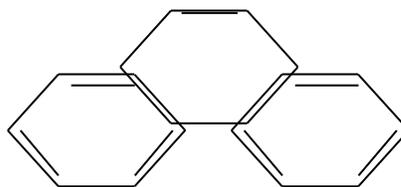


The three benzene fused polycyclic structures take two forms, the linear one called anthracene and the angled form called phenanthrene. Note that the linear form is almost 6 Kcal per mole more stable than the angular form.



Anthracene ($C_{14} H_{10}$)
m.p. = 214- 216 C

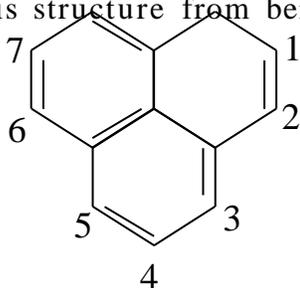
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Phenanthrene ($C_{14} H_{10}$)
m.p. 101 C

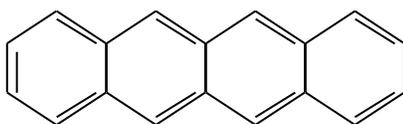
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It is interesting to note that the structure below, $C_{13} H_9$ does not exist in nature. At first glance one would think that because of its tight structure it would be the most stable form of PAH with three rings. But, because of the symmetry of the structure and the fact that each carbon has four bonds, the carbon at site number “9” would need bond to two hydrogen atoms, thereby preventing this structure from being Aromatic.

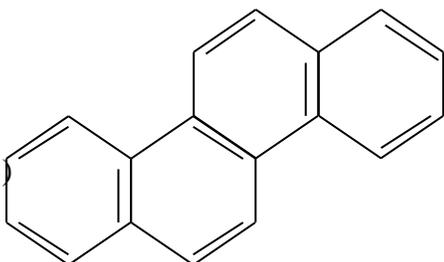


The polycyclic structures with four fused benzene rings takes on three forms: the linear one is called Naphthacene, the tight smallest form is called pyrene (note again due to symmetry this structure is allowed), and the others are called chrysene and triphenylene. Many of these hydrocarbons are available as impurities in coal tars, others can be built up from simpler structures.

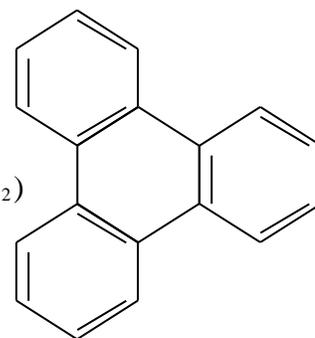
Tetracene ($C_{18} H_{12}$)
m.p. 357 C
ref #. 9262



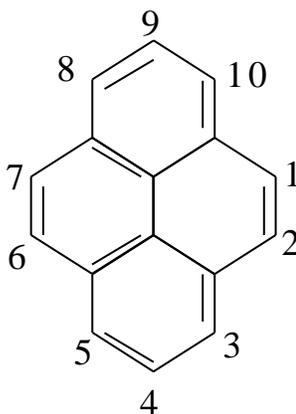
Chrysene ($C_{18} H_{12}$)
m.p. 255- 256 C
ref #. 5047



Triphenylene ($C_{18} H_{12}$)
m.p. 199 C
Ref #. 14535

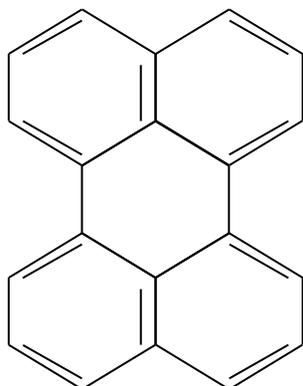


Pyrene ($C_{16}H_{10}$) mp. 156C
Ref #. 12430

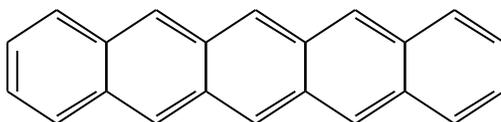


The structure below, containing 5 carbon rings, is called Perylene ($C_{20} H_{12}$).

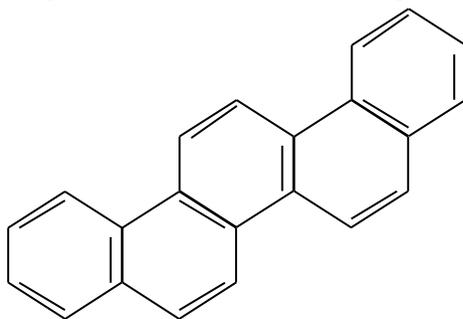
m.p. 277- 279C
ref. # 10640



Pentacene($C_{22} H_{14}$), is a linear structure of 5 carbon rings. Similar linear structures of 6 and 7 rings are called Hexacene and Heptacene respectively.



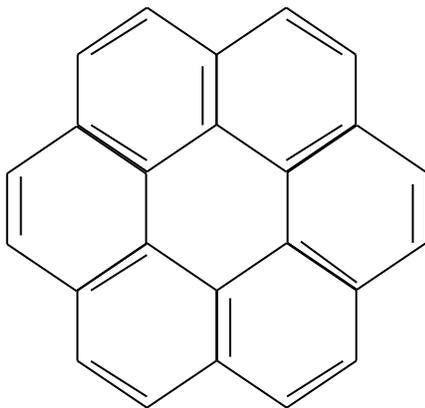
Picene ($C_{22} H_{14}$), is an angular structure of 5 rings. mp. 367- 369 C



Other structures (isomers) containing 5 rings are: pentaphene, (2,3,6,7-Dibenzphenanthrene), Dibenzophenanthrene, 1,2,5,6- Dibenzanthracene, and 3,4- Benzpyrene,

Last we will discuss the structure containing a ring of 6 rings in a macro ring; this has been named coronene. Note this is a 2D structure with 6-fold symmetry. (11)

Coronene $C_{24} H_{12}$
m.p. 438- 440 C
ref. # 5243



Obviously, from the discussion above, there are many different structures containing 6 rings too numerous to mention, and coronene was singled out since it is so symmetric. Polycyclic systems much larger than coronene are also known such as Triaphthylene having 7 rings in a propeller shape similar to Triphenylene. Ovalene is a structure with 10 rings (a tight structure similar to Coronene). All of the above fused ringed structures are planar.

Eventually these large planar structures begin to approach those of a layer of pure carbon atoms shaped into rings. This structure in multiple layers is what we call graphite, an allotrope of carbon that consists of infinite planes of carbon rings, separated by a distance of 3.4 Angstroms in the 'z' direction. (12) Boron Nitride can also form structures similar to graphite with alternating Boron and Nitrogen atoms around the ring forming planar structures (Hexagonal BN). (13) Today we know that boron and carbon can form very complicated 2 dimensional structures called Hyparenes, a family of planer penta- coordinate carbon and boron structures. (14) In addition there are now known to exist very unusual structures such as Propellane, and Prismanes, Helvetane, Israelane, Cubane, Basketane, Churchane, Pagodane, Cyanspolynes, all essentially 2D structures, built into 3-dimensional systems. (15)

Since the length of the single bond is not equal to the length of the double bond, this causes some additional asymmetries that result in differences between isomers of the same structure, yet with the double bonds in different locations. Lets take the simple 3 ring structure of Phenanthrene. There are 5 ways the double bonds can be arranged in this structure. Two of those 5 ways have three double bonds associated with the central ring. If one looks at just the 9th and 10th bond location (top of the central ring), there are 4 ways out of 5 ways that the 9- 10 bond ends up being a double bond. This asymmetry adds additional complexities to these simple 2D structures. (15a)

There are many kinds of chemical bonds. For example ionic bonding involves electron transfers from one atom to another. Covalent bonds involve electron sharing of the different atoms. Covalent bonds can be broken down into single, double, triple, ss, sp, sp², sp³, π , σ , Metallic bonding involves electron mobility. Hydrogen bonding involves electron

orientation. And finally van der Waals bonding involves electron synchronization. (16) The rationale for this exercise is to show that the carbon – carbon bond forms structures that are very strong in the 2D plane and are weakly bound in the third dimension. Looking at graphite, or the macro properties of graphite, how would one have guessed the structure at the atomic level of how these structures work? Yet the structures we use today in modern organic chemistry would not have been found in August Kekule's famous 1861 textbook on chemistry. Kekule did not believe these structures could be flat (2D) as first suggested by Joseph Loschmidt. In fact Kekule's first text on chemistry proposed that organic bonds took the form of sausages, and his theory depicts the carbon atom as a linear, lumped sausage. (17)

Joseph Loschmidt was a Physicist / Chemist born in 1821 in what is now the Czech Republic. (18) Loschmidt made the first suggestion about how triple and double bonds formed certain organic compounds and suggested that benzene was a ring structure in two dimensions while still teaching in a secondary High School (somewhat reminiscent of Einstein who did some of his greatest works while tutoring students in physics and working at the Patent office). Also he was the first person to use the kinetic theory of gasses to obtain a reasonably good value for the size of the molecule. Later in his life, at age 51, he was recognized for his works and was made full professor. To add irony to this story, later August Kekule' claimed that the idea of a benzene ring had come to him (independently) in a dream, yet this claim is still being debated even today, since it is likely that August knew of Loschmidt's 1861 booklet (Chemische Studien).

Today we know the sausage theory of binding organic chemistry is wrong, but it does lead us into a discussion of linear organic structures, which are known to be correct. Many organic chemicals exhibit linear structures. They go by the class of molecules called polymers. Polyethylene is one of the most basic of these structures being just a long chain of CH₂ segments. The chains can grow to enormous lengths, perhaps thousands of units long. (19)

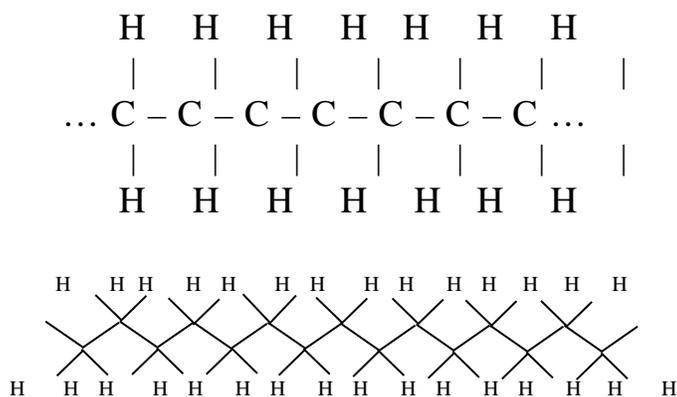


Figure 2.

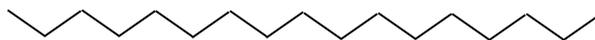
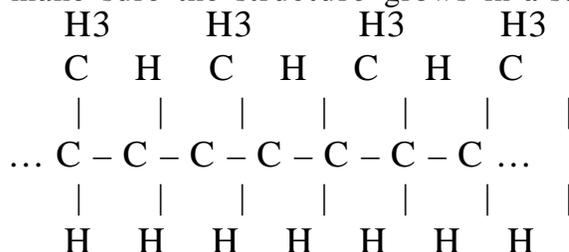
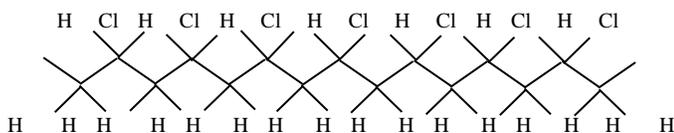


Figure 2 shows 3 representations of the polyethylene molecule.

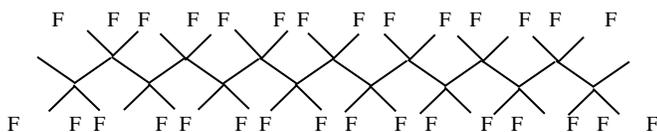
Polypropylene is a structure of $[\text{CH}(\text{CH}_3)\text{CH}_2]_n$. The polypropylene molecule is an ethylene molecule in which a $-\text{CH}_3$ group has replaced one (of the two) hydrogen atom connected to the carbon backbone. Like polyethylene, polypropylene can exist in extremely long chains. Catalysts can be used to make sure the structure grows in a straight orientation.



By replacing one hydrogen atom with a chlorine atom in the ethylene molecule you end up with the linear molecule known as Polyvinyl Chloride.



If you replace all 4 atoms of hydrogen of ethylene with fluorine you get the building block for Poly tetrafluoroethylene (PTFE), commonly known as Teflon.



Again this structure is linear and exists as a long chain. (20) It is not just the man-made compounds that form linear structures. Nature also makes linear structures: examples (21) Stearic Acid $\text{C}_{18}\text{H}_{36}\text{O}_2$, is an example of one fatty acid. Also Cellulose has the structure of a long flat ribbon like chains that are supported by hydrogen bonds between neighboring units. (22) These flat ribbons pack together, and the hydrogen bonds between them

stabilize the structure into a solid rigid mass. “The difference between starch, the fuel for the body and cellulose, the scaffolding of plants is a simple twist of a link, which shows nature at its most brilliant.” With any quick perusal of the book, “Molecules,” one begins to understand how complex and yet how simple nature really is. The structures of these molecules are all based upon hydrogen and carbon bonding, which is essentially an electromagnetic force.

In 1943 Erwin Schrödinger gave a series of lectures in Dublin later published (1945) under the title “What is Life?” (subtitle “The Physical Aspects of Living Cell”). Schrödinger, who had already received his Nobel Prize in Physics for contributing to Quantum Mechanics, was emboldened to set off into an area he knew little about and challenged the leading thinkers of that time on this subject (Neils Bohr {the Light of Life lecture of 1932} and Max Delbrück). He proposed that genes were very small and perhaps used a code analogous to the Morse code in which dots and dashes formed in groups of 5 to generate 32 words or in groups of 10 genes to form over 1000 words. This theory was in line with what Schrödinger called “The Delbrück Model” of the gene. The essence of what is called the Delbrück Model was published in 1935 by Max Delbrück, Timoféeff- Ressovsky and K.G. Zimmer entitled “About the Nature of the Gene Mutation and the Gene Structure” was read by almost no one, since it was published by *Nachrichten der gelehrten Gesellschaften der Wissenschaften in Göttingen*. As luck would have it, a reprint of this paper was given to Schrödinger and he popularized the Delbrück Model in his lectures and in his book, “What is Life”. This far out reach (some would call it speculations) influence two young minds, James Watson and Francis Crick (as they would later claim having read “What is Life”) to discover the real structure of DNA. (23)

The structure of DNA is now known to be just as Schrödinger / Delbrück had predicted although it is not coded with dots and dashes, but instead with base pairs: one purine base pair such as Adenine (A) or Guanine (G) and one pyrimidine base of either thymine (T) or cytosine (C) connected at each step of the ladder by multiple hydrogen bonds and each base pair a two dimensional structure. This is the well-known structure called the Double Helix. (24) The simplicity of nature comes out again.

Max Delbrück’s work was influenced by the work of Gregor Johann Mendel an Austrian monk the father of genetics. Most textbooks do not tell the whole story of Mendel’s life and trials. Many probably do not know that (like Copernicus before him) his work was not recognized in his lifetime. Johann Mendel was born to a poor peasant farmer in Heinzdorf Austria (a very small town, now called Hynčice in the Czech Republic) in 1822. In his early years Johann worked with his father keeping bees, tending the fruit trees, and gardening. Johann loved science and his family went to great

efforts to send him to high school and the Gymnasium (junior college), the Philosophical Institute in Olmütz (now Olomouc). When his family could no longer support him and his father asked that Johann take over the farm, Johann instead elected to go into the monastery, where he could continue his studies, without the worry about finances. His bother- in- law ended up taking over the farm. He entered the Augustinian Monastery at Bruenn (now called Brno in the Czeck Republic, not far from Prague). He became a monk at age 24 and took the name Gregor. He taught himself science with the vast library at the Monastery. His major love was physics. One of his mentors was the famous Christian Johann Doppler (discover of the Doppler effect). At age 29 the Abbot sent him to the University of Vienna to study Physics, Chemistry, Mathematics, Zoology and Botany. He never received his formal degree as lecturer (PhD) since he failed the exam because of his poor score in Zoology. His tests papers in Zoology have been preserved and scholars find it hard to understand why his paper failed to meet the standards. In 1854 he returned to the Monastery to perform what would become revolutionary experiments in genetics. He studied the genetics of tall and short pea plants. After about 8 years of work and experimentation (1856- 1864), at age 43, he came up with the three laws of genetics that still hold true today. (1) The law of Uniformity (2) The law of Segregation and (3) The law of Independent Assortment. He is most know for his work on pea plants but during these 8 years he worked on many other different plants and animals (such as the bee). Mendel had his big day in February 1865 in Bruenn, where before 40 distinguished scientists of the Society of Natural Sciences he gave a one-hour presentation on his theories. A month later a second follow up lecture to even more distinguished scientists was held also in Bruenn. A year later Mendel would publish his one and only paper “Experiments with Plant Hybrids”. Yet all this effort did not result in any recognition. He would subsequently send his paper to famous Swiss Botanist Karl Wilhem von Näegeli (then in Munich). After a number of exchanges of discouraging letters with Näegeli, Mendel would give up. Two years later he was elected Abbot of the Monastery where perhaps other duties took up his time. Mendel died in 1884 without any recognition of what he had accomplished. 16 years later his work would be rediscovered by Hugo De Vries (Amsterdam), Carl Erich Correns (Germany) and Erick Tschermak von Seysenegg (Vienna). It is interesting that some reference consider him Russian, others consider him German, while most consider him Austrian, yet his home town is now part of the Czech Republic. At one point no one would recognize him, now everyone wants to claim him as their own. One reference indicates that the Abbot that took over after Mendel’s death had his works taken out and burned. What a tragic ending to such a revolutionary set of ideas. Eventually as we all know now, Mendel’s “time did come” as he had predicted, too bad he was not alive to see it, nor could he have perceived how far the development of Biology has come. (25)

From planar (2D) PAH structures and the linear (1D) polymer structures we progress to the shell 2D structures. The most beautiful Molecule of all has to be the Buckyball, C_{60} . The discovery of C_{60} is well worth reading. (26) The formation of C_{60} still seems somewhat a mystery. Recently a rational for the chemical synthesis of C_{60} has been proposed. (27) Subsequent discovery of Buckyball structures include C_{70} , C_{58} , C_{56} , C_{32} (Ref. 26, page 107), C_{44} , C_{48} (Ref. 26, page 110), C_{240} , C_{540} , (Ref. 26, page 121). The additional discovery that doped C_{60} , and undoped single crystal C_{70} show properties of superconduction at temperatures ranging from 7K to 40K is remarkable, although this result has recently come under scrutiny. (28)

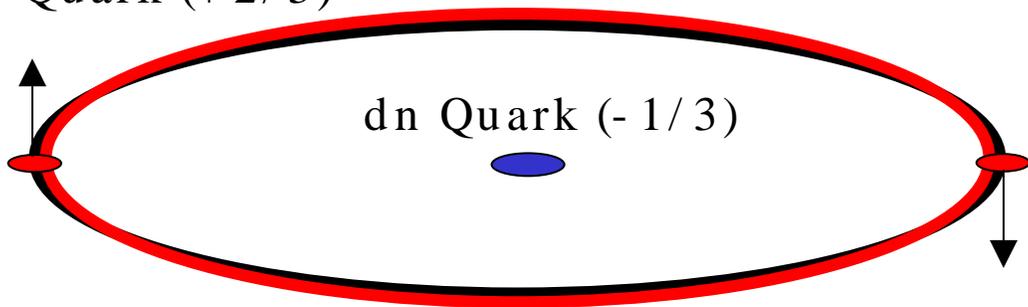
In some respects the structure of the nucleus as proposed in the Checker Board Model (CBM) has many things in common with the way benzene forms PAH structures. In the checkerboard model the He nucleus plays the role of the benzene ring. In similar fashion the He nucleus forms the basic unit cell from which all other stable nuclei are formed. The same variety of structures as seen in the PAH structures above is perceived possible with a nucleus in the CBM theory.

Why should the nucleus be spherical? It has long been assumed that since the nucleus must be held together with a "strong" nuclear force, one that can overcome the repulsion of the protons, it must produce a spherical body. At first glance this logic seems reasonable. Where does this common sense come from? It comes from our experience with nature, for example the water drop. A water drop is held together by Van der Waals forces, a form of surface tension. This force is not very strong, but it shapes our thinking so that we assume that materials form spherical bodies. In fact one of the models of the nucleus is called the water drop model. But how realistic is this when dealing with structures the size of the nucleus? Today nuclear physicists no longer believe that all nuclei are spherical. Some nuclei they believe are distorted like footballs with aspect ratios of 2:1 (super deformed) or even in the extreme 3:1 (hyper deformed). Other nuclei they believe are flattened spheres or "pancake shaped" having similar aspect ratios. In reality we do not know the nature of the strong nuclear force. We know it has short nearest neighbor attraction and therefore exhibits the so-called saturation effect. We know from binding energy that the strong nuclear force is limited in range to only a few nearest neighbors, which has been estimated to be no more than 4 to 6 nucleons.

We know the protons and neutrons are composed of quarks. Protons and neutrons, and all the rest of the universe we see are composed of just 2 types of quarks: the up quarks and the down (dn) quarks. Add to these two particles the electron and the electron antineutrino and we can make everything in the universe. So how should we try to combine three quarks (two up and one down) into a structure that makes sense for the proton?

A key is that the neutron (a zero charge particle) has a negative magnetic moment. If we assume that the two up quarks revolve about the down quark in the center of the proton, then we can use simple relativistic physics to come up with some basic properties of the proton. Assuming that the neutron is built the same way, only the mirror image (two down quarks revolving about the up quark in the center) we can do some additional calculations to determine what those properties are. Since this paper is not intended to go into the mathematics of this structure, I refer you to another paper for those calculations. (29)

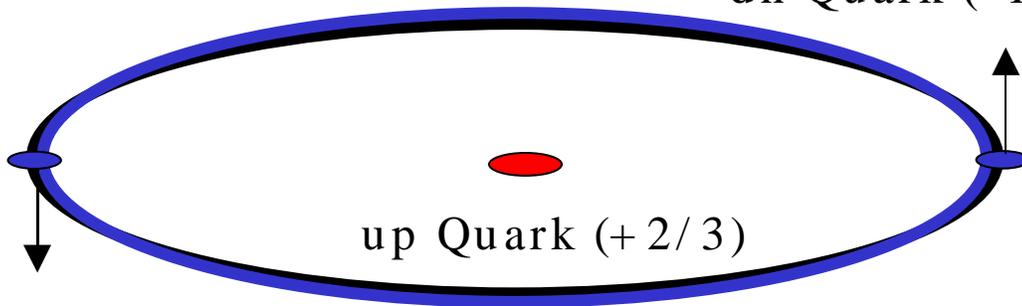
up Quark (+ 2/3)



up Quark (+ 2/3)

Proton

dn Quark (- 1/3)



dn Quark (- 1/3)

Neutron

Note that both of these particles have a *reason* to have a magnetic moment, i.e. revolving charged quarks, and this structure explains why a zero charged particle (the neutron) can have a magnetic moment just like the proton. This calculation also explains quite well the sizes of both the proton and neutron and the charge distribution inside the neutron.

The purpose of this exercise is to look at symmetry of nature over the different size scales. The structure that the CBM presumed was a two dimensional structure of the proton and neutron. Where in nature have two- dimensional structures come up before? Benzene, PAHs, Graphite,

structure of the solar systems (which is planar, except for the orbit of Pluto, now believed not to be one of the original planets), structure of the Milky Way and many other spiral galaxies, the original Bohr model of the hydrogen atom to name just a few. The CBM theory has more symmetry than the current theory, “quark bag model” of the nucleons, where the quarks move inside the bag in chaotic random patterns. In the quark bag model, at any point in time the three quarks inside the bag form a 2D plane where the quarks are connected to each other by three gluons, where the random motions of the quarks fill in the space of a spherical nucleon. Recent interpretations of experiments at the Jefferson Lab have indicated that the proton is not spherical, but instead oblate, casting some doubt on the bag Model. How can the bag model of the nucleon be extended to predict an oblate proton? In the CBM model the revolving quarks form a 2D plane (a naturally oblate structure), but the quark at the center has no motion and the two quarks at the perimeter are revolving in the same direction at opposite sides of the nucleon. This revolving motion of the charged quarks leads naturally to the magnetic moment of the nucleons. It just seems more symmetric, and therefore more reasonable, and more consistent with an oblate nucleon. This theory does not require a 4th force, the Strong Force to explain the stability of the nucleus. Remember Occam’s razor. William of Occam (or Ockham) lectured at Oxford from 1315 to 1319. Occam is best known for his maxim, “It is vain to do with more what can be done with fewer”. Ref: (page 172 and 173 of Milton A. Rothman’s *A Physicist’s guide to Skepticism*). If nature is truly simple and strives for simplicity, then this is the structure nature would have chosen. And more impressively it accounts for some of the basic properties of nucleons: magnetic moments, masses, charge distributions and sizes. It also gives a simple explanation for the strong nuclear force, i.e. a combination of electrostatic forces for stationary quarks at the center of the nucleons, synchronized electrostatic forces from rotating quarks, and electromagnetic forces (flux coupling) caused by those rotating quarks all contributing to a short range strong nuclear force. This theory also eliminates the need for an extra “strong” force with very strange properties (such as repulsion below 0.5 Fermi). Without the need for a “strong” force to hold the nucleus together we are left with just gravity and the electroweak force, which is what Occam’s razor would suggest as the best theory.

Even though the Bohr model did well explaining the electronic energy level of hydrogen, it did not do as well with helium and the higher mass atoms. Arnold Sommerfeld proposed highly elliptical orbits to help explain the energy levels of atoms heavier than helium. In late 1915 Sommerfeld (and W. Wilson independently) generalized Niels Bohr’s quantization conditions to systems of more than one degree of freedom. The agreement between the Sommerfeld prediction and the observations taken by Friedrich Paschen, made with fantastic precision, were in such good agreement, that

it impressed Einstein and many others. With reduced mass corrections it withstood the assaults of even more precision measurements up until 1947, when Willis Lamb and R.C. Retherford discovered (at Columbia U., N.Y.) the minute splitting between the 2S and 2p states of hydrogen subsequently explained by radiative corrections, which eventually led to the theory of QED (Quantum Electro Dynamics). (30)

QED is believed to be the most precise theory in Physics. The agreement between theory and experiment is remarkable. Agreement between the predicted and experimentally verified anomalous magnetic moment of the electron agree to 9th and 10th place accuracy. Key contributors to QED are Richard Feynman, Julian Schwinger, and S. Tomonaga (Tokyo University, Japan). In 1948, Julian Schwinger, a young professor at Harvard, a student of Oppenheimer, gave an 8 hour presentation on his calculations of the radiative correction factors of the anomalous magnetic moment of the electron at a meeting held in a Pocono Mts. resort. (31) This was a masterpiece of mathematical calculations. Few at this meeting even understood those calculations. Five years earlier Tomonaga, without the benefit of the Columbia discovery, had essentially developed the same calculations as Schwinger in a work entitled "On a Relativeistically Invariant Formulation of the Quantum Theory of Wave Fields". The calculation that Schwinger and Tomonaga had discovered was an equation that expressed the anomalous magnetic moment of the electron as an infinite series of terms each with a higher power of the fine structure constant over π . Each term has a coefficient that must be evaluated by calculating the effects of the interactions due to the higher order loops of the Feynman diagrams. For example, the C2 (squared term) contains 15 Feynman loop diagrams, and the C3 (the cubic term) requires the evaluation of 72 contributing Feynman diagrams consisting of three loops. This analysis has been taken out to the fourth term (containing many hundreds of four loop diagrams) by Kinoshita and Lindquist resulting in this phenomenal agreement between theory and experiment. So far no one has taken QED to five loop corrections to see if the agreement can be made even better. (32)

Today though, there is a new debate on this subject. Even though the traditional interpretation of quantum theory does not accept that electrons looping around the nucleus in elliptical orbits as Sommerfeld proposed, some observations obtained within the past 10 years suggest that atoms can exhibit binding energies that traditional QM cannot explain. Recently Pascal Salieres and colleagues at the French Atomic Energy Commission and Gerhard Paulus and colleagues at Max Planck Institute for Quantum Optics in Garching Germany, have shown by using a model first suggested by R. Feynman, that the electrons ("loopy electrons") can be treated as ordinary point particles that circle the nucleus, and thereby they explain

the phenomenon of superionized atoms for the first time, which Q.M. cannot explain. (33, 34)

So, the proton is a quantum vortex as proposed by the CBM theory. The neutron is the mirror image of the proton. This structure explains of the charge distribution of the neutron, the size of the proton, the magnetic moments of both the protons and neutrons, and the justification for the strong nuclear force that holds the nucleus together. Belief in this theory hinges upon the quantum vortex structure of the proton.

Other areas of physics have dealt with the concept of quantum theory, quantum mechanics for many years now. The first major discovery that the world contained quantum mechanical phenomenon was the discovery by Niels Bohr that the electron circled the proton in quantum orbitals. A quantum vortex is based upon the findings that a particle of given mass and velocity (i.e. momentum) has the correct wavelength consistent with the circumference of the orbit of the particle. Neil Bohr found the first quantum vortex when he discovered that the electron was circulating the proton at an orbital radius of $0.52 \cdot 10^{-10}$ meters (0.52 Angstroms). The orbital speed of the electrons was determined to be 1/137 the speed of light, where 137 happens to be the inverse of the fine structure constant. It is interesting that the CBM predicts that the proton is almost exactly 5 orders of magnitude smaller than the ground state of the Hydrogen atom.

The He 4 nucleus is made of spin up and spin down protons and neutrons. The strong nuclear force results from the magnetic flux produced by the adjacent protons and neutrons in the He nucleus, along with the close proximity approach of the rotating quarks at the perimeter at the nucleons. This theory predicts the mass of the up and dn (down) quarks and the mass of the protons and neutrons. Mirror nuclei exist because when you exchange all the protons for neutrons and vice versa you get nuclei of very similar properties and energy levels. From this fact it may be reasonably assumed that the proton and the neutron are mirror images of each other. Another reason for believing that the proton and neutron are mirror images of each other is that if you exchange the two up quarks for two down quarks and one dn quark for one up quark; you end up changing a proton into a neutron. Therefore one would expect that the up and dn quarks play the same roll in the nucleons as protons and neutrons in the nuclei.

The shape of the binding of the He 4

up = Up Quark
dn = Down Quark

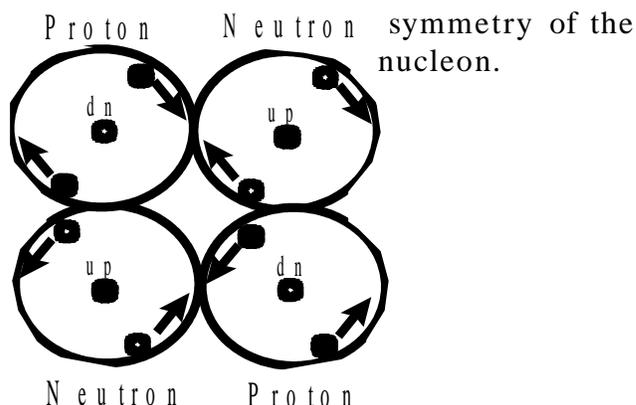


Figure 3.

Structure of the helium nucleus

Yet if we take this one step further we can develop patterns for the masses of all the

Sub atomic particles (quarks and leptons in the other generations). (36)

The justification of these numbers appears in that reference, and will not be covered in detail here.

I believe we lose track of the fact that 73% of all nuclei in the universe are hydrogen nuclei (protons) and 25% are Helium nuclei (alpha particles). This leaves only 2% for all the rest of the nuclei in the universe, and half of the rest (1%) are the nuclei of Carbon and Oxygen (very symmetric structures in the CBM theory). Large parts of the rest of the 1% are nuclei like Si, Mg, Ca, Fe, which are either squares or diamond shaped (in the CBM theory). Therefore a handful of very symmetric nuclei make up 99.5% of the universe.

Why should the proton be a spinning quantum vortex? Well many structures in the universe itself are forms of spinning vortices: A few examples are: whirlpools in a turbulent river, hurricanes, tornadoes, Jupiter's red spot, the rapidly rotating neutron star at the center of the Crab Nebula, and galaxies themselves. Our Milky Way is a very flat structure; the thin disk is thought to be 2000 light- years thick and 120,000 light- years across with a very massive spinning black hole at its center . (37)

Checkerboard structures in Superconducting materials.

Is there any basis for supporting checkerboard structures in nature?

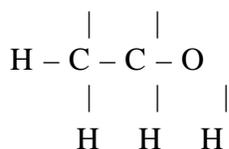
Recent studies of the vortices found in high temperature Copper- Oxide superconductors suggest that the inner structure of an individual vortex is made up of a checkerboard pattern of ordered stripes of spin and charge regions, or the so called staggered flux phase. In 1997, Shou- Cheng Zhang of Stanford University suggested this structure for insulating antiferromagnetic states. (38) (39) (40) Two- dimensional structures of Copper, Oxygen, and Carbon were discovered to have superconducting properties at Tc of 38 K in 1986 and raised the hopes that even higher temperatures could be reached. Today Cuprate ladder structures first

observed in 1996 are being shown to have superconductivity properties at Tc of 13K. (41)

The CBM is unique because it predicts that the structure of the proton is a quantum vortex, (the smallest yet proposed Q.V.) When Bohr's model of the hydrogen atom predicted that the electron orbitals of the hydrogen atom explained the Balmer series of the Hydrogen spectrum, he knew he had solved the problem of the H atom. For the same reasons this theory calculates the mass of the up quarks and their velocity to be consistent with the known size of the proton, and the De Broglie wavelength of the circulating quarks around the circumference of the proton exactly match the prescribed circumference of the proton, and in addition the theory explains the proton's mass and magnetic moment. Thus this theory predicts the proton is a quantum vortex.

Quantum Vortices have recently been discovered in Bose Einstein condensates when these super fluids have been imparted rotational momentum. Interesting pictures of the structures of these rotational momentum structures now exist. Wolfgang Ketterle presented an excellent overview of this subject at the 2001 APS conference. I need not say much about BEC because much has been reported. Last year Eric Cornell and Carl Wieman (who made the first BEC) and Wolfgang Ketterle got the Nobel Prize in physics for their efforts in this field. What some may not know is that these structures resemble periodic 2-dimensional checkerboard structures. (42, 43, 44)

Critics will say that the structures proposed by CBM are too simple to explain the variety of gamma ray spectrum and spin states of the nuclei and their excited states. The gamma ray spectrum of the nuclei is analogous to the optical spectrum of atoms or the infrared spectrum of molecules. Let's use a simple molecule as an example: ethanol (ethyl alcohol). Formula $\text{CH}_3\text{CH}_2\text{OH}$.



In spite of the simplicity of this molecule it has many stretching and deformation modes of oscillation, which results in a very complicated infrared spectrum. (45, 46, 47) On the other hand a molecule of C60 contains many more atoms, yet because all carbon atoms form essentially the same type of relative bond with its neighbor and it is spherical (dodecahedron), it results in a very simple one peak infrared spectrum. Yet a structure similar to C60, namely C70 with just a little more asymmetry has 5 peaks in its IR spectrum. (48) Therefore it is difficult

from just studying the gamma spectrum of nuclei to determine how complicated the underlying structure may be.

In the early phases of the CBM theory attempts were made to rationalize the shell levels of the nucleus by trying to duplicate the magic numbers with certain patterns of 2D structures. Those magic numbers are: 2, 8, 20, 28, 50, 82, and 126. At one point in time in the early years of nuclear theory 14 was also considered magic. In addition to the magic numbers there are sub-magic numbers like 64 and others. Early attempts in CBM to generate structures that would explain the nuclear magic numbers looked like the structures in figures 4-9. Even though these structures did not explain exactly the nuclear magic numbers of the larger shells they did give enough encouragement to continue working on other structures, many of which have been developed much further and have predicted real nuclear phenomenon like “halo nuclei” ${}^{11}\text{Li}$.

Molecular Fragmentation

Just like the predictions of nuclear cluster model fragmentation, molecules undergo fragmentation when hit by electrons with energy sufficient to cause bond breakage. Where these bonds break and why is the subject of mass spectrum analysis of molecular fragmentation. “When there is a branch point in a molecular chain, an unusually large amount of fragmentations occurs there because a more stable carbo-cation results”. (49) The Fragmentation of n-dodecane (Polyethylene with 10 segments plus 2 CH₃ end terminations) is an example worth looking at. Refer to figure 10 for this structure. You will notice from this mass fragmentation spectrum that the C3 bond location is the most likely bond to break, leading to an intensity peak at 43 AMUs. Figure 10 shows this peak to be normalized to 100% intensity. Note this figure is a simplification of the real spectrum, since only Hydrogen 1 and Carbon 12 were plotted. If deuterium and Carbon 13 were considered there would be a few extra peaks. It is interesting to note that this linear structure does not break in the middle, like a stick would break if broken by hand. Also note the structure almost never breaks at the very end at the C1 position, as it would be difficult to break a stick at the very end by hand. In molecular fragmentation the peak intensities are determined by contributions by secondary and tertiary bond breaking. This structure is somewhat reminiscent of that produced during nuclear fragmentation caused by the breakup of the nucleus under high spin states, which are also evenly spaced in energy (analogous to mass in molecular fragmentation). Also the declining peak intensity with higher energy is also reminiscent of the nuclear gamma ray spectrums. Based upon structures predicted the CBM, it was suggested that the gamma ray evenly spaced spectrum was related to the periodic nature of the structures predicted by the CBM. Therefore here is a case where a known linear 1D periodic structure has a very similar spectrum to the gamma ray spectrum of heavy nuclei.

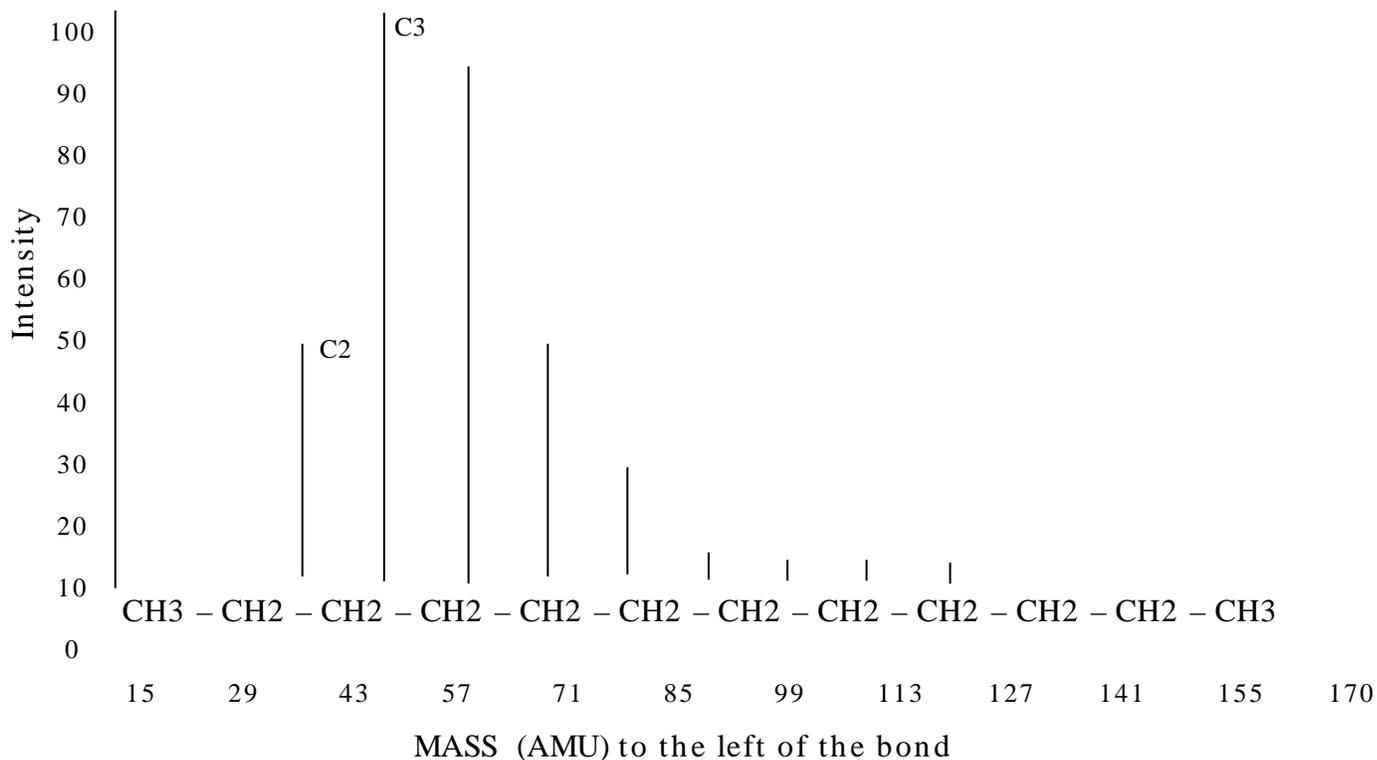


Figure 10.

By now you should see the points being made. 2D structures are not that uncommon in nature. The 2D Checker Board Structure (C B S) should not be considered out of the question as a possible structure for the nucleus. Structures that are spherical such as the the earth, the sun, the planets, and water drops are the result of the weaker forces of nature such as gravity and surface tension, not strong forces.

Acknowledgement

I would like to acknowledge Felix T. Smith who took the time to explain to me (at my poster session in Washington D.C. 2001) how the nuclear structures of the CBM theory were similar to the structures of PAH structures which led my research in this direction and this paper.

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$$3 \times 2 = 6$$

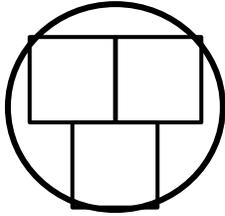


Figure 4



He Nucleus

$$4 \times 2 = 8$$

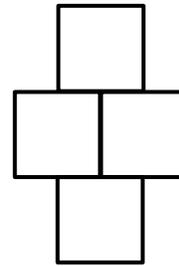


Figure 5

$$7 \times 2 = 14$$

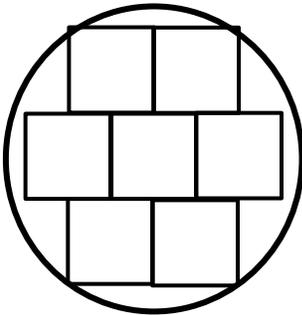


Figure 6

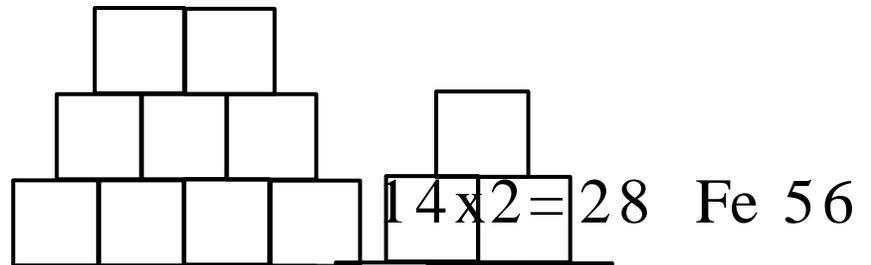
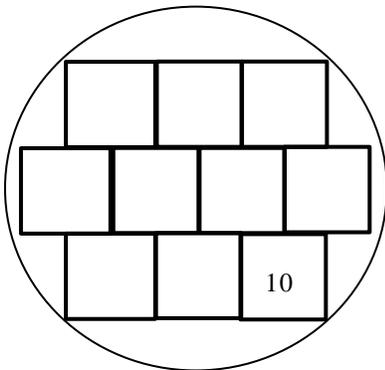


Figure 7



$$10 \times 2 = 20$$

14 x 2 = 28 Fe 56

Figure 8

$$25 \times 2 = 50$$

2 3
4 5 6

Figure 9

25