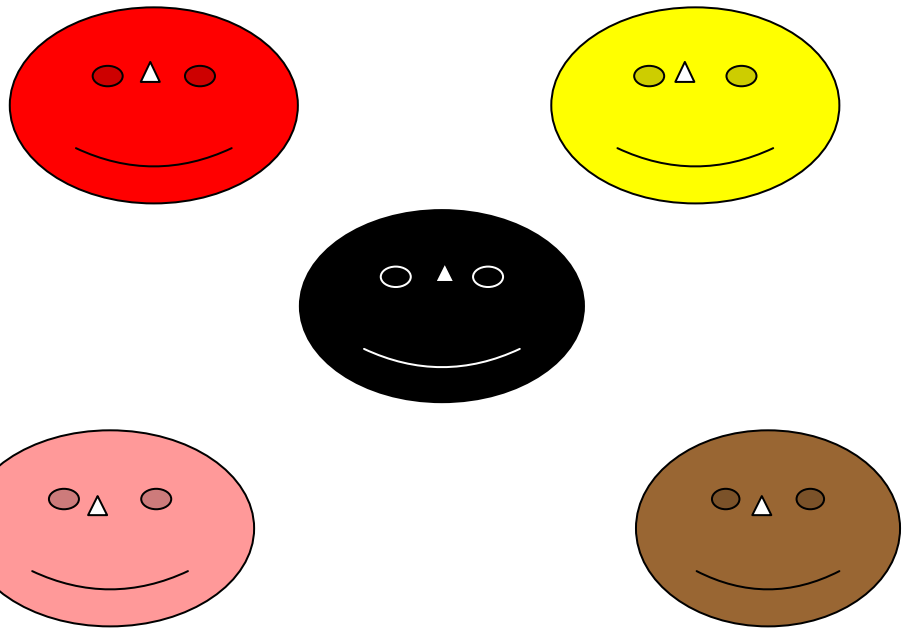
Science and You

A science in context publication for South African schools

Issue 1



education

Department:
Education
REPUBLIC OF SOUTH AFRICA

Foreword

Science in context

Chemistry Focus

The Science and you series aims to draw the attention of learners to the applications of the concepts they learn in school to their everyday lives. Chemistry involves natural processes; the study of chemistry should therefore not be removed from the nature that the subject is trying to explain.

Chemistry affects the lives of all people in this country and elsewhere; whether they study chemistry or not. The materials used in various areas of life all involve chemistry, the foods we all eat, substances that we drink - are all chemical compounds. Cosmetics, from soap to make up all contain chemicals and they react with humans in various ways. Chemicals in the food and environment can cause diseases or good health. Knowledge of the nature of compounds and their reactions are very important to human survival.

It is hoped that when learners are able to see the concepts they learn about in schools demonstrated in the Science and You issues, their interest in chemistry will grow and they will enjoy the subject and understand it better. The learners can then take their rightful place in their societies and make informed decisions for themselves; advise their communities on their well being and with regard to their choice of materials, the food they eat and their relationships with their fellow humans and their environments.

Since chemistry studies natural phenomenon, learners will be able to make links between Indigenous Knowledge Systems and Chemistry. These issues will also show the links between everyday challenges like health, economics, politics, environment, peace, war etc.
Enjoy the reading.

Studying Science is supposed to make you scientifically literate. In this issue, we explore the theories of science that you will study in your high school years and use these theories to explain some of the things you might have been wondering about. In this case, the atomic theory!

Science literacy means you must be able to make informed decisions about what you eat, drink, your environment, what you wear, use based on scientific understanding. The topics in this issue are related to some of the concepts you learn in class and much more.

1. The Chemistry of race - the chemistry of difference

You must be asking yourself, what has chemistry got to do with race? Well, actually, almost everything. The classification of people according to race has throughout history been a cause of conflicts, campaigns, debates and wars. Can you think of another way of classifying people? In this issue we will examine how material chemistry explain race by examining one of the most defining features of race- your hair.

But what is hair made out of? Hair is made up of a compound called a- Keratin. All hair types, no matter how different the hair looks like, is made up of this compound. This compound belongs to a family of compounds known as keratin. This family of keratins is of course made up of atoms arranged in a particular manner. Remember we are all made up of atoms and molecules. Your blood, your organs, your muscles, everything about you has atoms as the basic building blocks.

These atoms are part of the original creation, they have been through many life processes. They have existed as elements, compounds, particles in genes, organs, tissues, and they have belonged to different species of animal, plants, and human beings since creation. So, in your body from your hair to your toenail, you have atoms that have belonged to many plants, people, animals, minerals and the soil. The atoms, and compounds, get 'recycled' through the ages to give the world 'the beautiful you'.

This an extract from a book entitled: Genes for Teens:

'Have you ever wondered why we all look different? Some people have very curly hair, others have dead-straight hair, and there are all sorts of wavy variations in between. Then there's hair colour- from jet black to red, many shades of brown, and gold to almost white blonde. While most obvious, of course are all shades of skin colour in the world.

Have you also noticed that people from the same continent tend to look the same? I say 'tend to because, especially over the last 400 years, there's been a lot of migration or movement of people from one country to another. South Africa and the United States of America are good examples of countries with people who migrated there from many other countries. Look at Indians, Africans and people from far North countries: have you noticed the differences between these groups, and that people from certain countries tend to be tall, or short, or have eyes of a particular shape?
*What I notice the most about other people is their hair and skin colour. What about you? But are people with similar hair or skin colour really the same? Is it correct to say that Japanese people behave like this or Indian people behave like that? How did these differences come about anyway?' Extract from 'Genes for Teens', Author Khumalo N: Yigugu Publishers (October 10, 2008). New York, Cape Town*Permission to print this section kindly given to the Department of Basic Education by Prof Nonhlanhla P Khumalo, the author is a dermatologist at the Grooteschuur Hospital and the Red Cross Children's Hospital, Cape Town.

The following is a periodic table. Every compound that you know or will know in the future is a product of the atoms on this periodic table, naturally occurring or formed from some chemical reaction.

http://en.wikipedia.org/wiki/File:Periodic_table.svg

Only two things make compounds different from each other, these are:

1. The types of atoms contained in the compounds; look at the periodic table above and imagine the number of permutations! This explains the many different types of compounds found in nature and this is further increased by the possibilities of new synthetic (man made) compounds.
2. The type of bonding found in these compounds. (Discussed in hair and carbon compounds in diamonds, graphite and fullerenes below)

1.2 How are genes related to atoms?

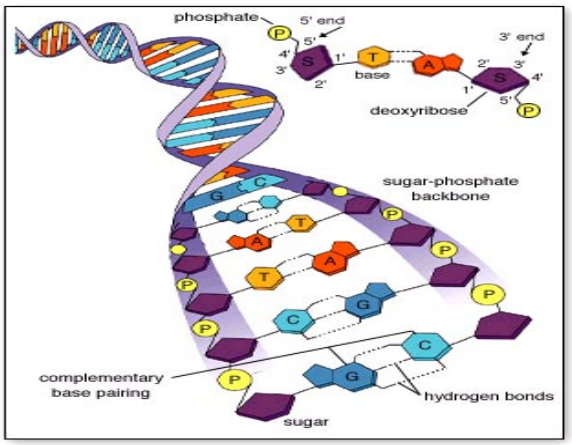
Genes are sections or segments of DNA that are carried on the chromosomes and determine specific human characteristics, for example your complexion, height or hair color or texture etc. Each parent gives you one chromosome in each pair, you now have two of every gene (except for some of the genes on the X and Y chromosomes in boys because boys have only one of each).

Some characteristics come from a single gene, whereas others come from gene combinations. Because every person has from 25,000 to 35,000 different genes, there are an almost endless number of possible characteristics! This is why children born of the same set of parents have distinguished differences. http://kidshealth.org/teen/your_body/health_basics/genes_genetic_disorders.html#

These characteristics are determined by the arrangement of atoms in compounds called DNA!

1.3 What is DNA

Most living organisms are made up of cells that contain a substance called deoxyribonucleic acid (DNA). A DNA molecule is composed of two chains of nucleotides that wind about each other to resemble a twisted ladder. The sides of the ladder are made up of sugars and phosphates, and the rungs are formed by bonded pairs of nitrogenous bases. These bases are adenine (A), guanine (G),



cytosine (C), and thymine (T). Picture of DNA courtesy of Wiki

An A on one chain bonds to a T on the other (thus forming an A–T ladder rung); similarly, a C on one chain bonds to a G on the other. If the bonds between the bases are broken, the two chains unwind, and free nucleotides within the cell attach themselves to the exposed bases of the now-separated chains. The free nucleotides line up along each chain according to the base-pairing rule—A bonds to T, C bonds to G. This process results in the creation of two identical DNA molecules from one original and is the method by which hereditary information is passed from one generation of cells to the next.

I think by now you can already see that what biologists call cells, DNA etc are actually chemical compounds, made up of atoms. You also know where these atoms come from! As we explained in the first paragraph, these atoms are part of the original creation of the earth. You do not get new atoms with a new body. The atoms in all our bodies have been part of the earth for millennia. Do you see now why you are connected to everything and everybody?

But what really makes people different or think they are different? Well, all people are different, even identical twins are different, their chemical composition is different! The answer lies in the genetic makeup which in turn depends on the different chemicals making it up.

1.4 Genes and culture

Culture

What about culture? My culture is different from my friend's culture! Well culture is a human invention, Genes are nature at work!. You are a human being first and then you create a culture. Different people choose particular values or ways of behaving based on various circumstances and perhaps their worldview[1]! Culture is dynamic, therefore generations continue with the culture they were born in or change it to suit their new circumstances. Culture extends beyond ethnicity to microcosms in societies. For example; the culture at your school is probably different from the culture at another school. The same goes for homes of people within the same ethnic grouping. Some cultures are good, others are bad, some cultures embrace kindness, others war, some theft, others generosity, respect or disrespect, tolerance or intolerance, pride or humility the list goes on.

Gangsters have their own different cultures, the values they uphold define their culture; based on their culture, they are different from their rivals. What values does your culture promote? What values does the culture of your school promote? Culture has nothing to do with the genetic makeup. People with particular genetic disposition and environmental as well as sociological circumstances have adopted particular cultures; this makes them different from others. Culture serves particular purposes at particular times; and culture being dynamic, changes from generation to generation, depending on the needs and circumstances of people in the particular culture.

[1] ***world·view***

a. The overall perspective from which one sees and interprets the world.

b. A collection of beliefs about life and the universe held by an individual or a group- http://www.thefreedictionary.com/worldview

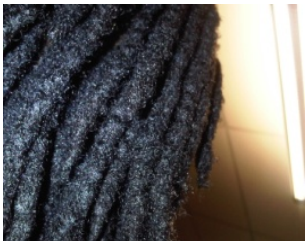
2. Your hair and chemistry

2.1 Hair Types

2.2

(Atoms, compounds and the beauty of chemical bonds)

Long hair, short hair, curly hair, straight hair and every type in between……. Hair! Hair! Hair!



African hair in dreadlocks

Indian hair

African hair

White hair

Hair is one of the most distinguishing features in human beings. In apartheid South Africa, hair texture was used to classify people as black, coloured or white in what was called the 'pencil test.'

The Population Registration Act of 1950 required the classification of South Africans into racial groups based on physical and socio-economic characteristics. Since a person's racial heritage was not always clear, a variety of tests were devised to help authorities classify people. One such test was the pencil test.
The pencil test involved sliding a pencil or pen in the hair of a person whose racial group was uncertain. If the pencil fell to the floor, the person "passed" and was considered "white". If it stuck, the person's hair was

considered too kinky to be white and the person was classified as "coloured" (of mixed racial heritage). The classification as coloured allowed a person more rights than one considered "black," but fewer rights than a person considered white.
An alternate version of the pencil test was available for blacks who wished to be reclassified as coloured. In this version, the applicant was asked to put a pencil in their hair and shake their head. If the pencil fell out as a result of the shaking, the person could be reclassified. If it stayed in place, they remained classified as black.[3]
http://en.wikipedia.org/wiki/Apartheid_Pencil_Test

This method of classification of people was obviously very unscientific, considering what we know now about humans and atomic combinations. A movie entitled SKIN, which demonstrated a phenomenon called a 'throw back' proved that classification of human being is complex!!! And maybe even unnecessary. Human beings are just that- human beings!

All types of hair are made up of the a-keratin. Keratin is a highly durable protein that provides structure to several types of living tissues. It is a major component of mammalian hair and hooves, mammalian and reptilian nails and horns, reptile and fish scales, bird feathers, bird beaks, and the outermost layer of skin in most animals. Keratin provides a tough, fibrous **matrix** to these tissues. An important quality of keratin is its ability to flex in multiple directions without tearing.

The molecules of this protein twist into coils called alpha helices and contain many disulfide bonds (bonds between pairs of sulfur ions). When human hair is straightened or curled in a beauty salon, special

chemicals must be used to break the disulfide bonds. The breaking and subsequent reconfiguration of these bonds allows the hair to change shape. The final shape depends on the relative positions of the sulfur ions in the new bonds. This is the impact that the disulphide bonds have on our hair.

2.2 Why do people have different types of hair: curly hair, straight hair?

The shape of your hair reflects the shape of the molecules of which it is made. These molecules are long keratin molecules (a type of protein) that resemble a long spring, with several 'springs' wrapped around each other like a twisted rope. The strands are held together by strong chemical bonds called disulphide bonds, while the coiling of the individual molecules is maintained by much weaker **hydrogen bonds**.

Hair is curly or straight, depending upon the number of disulfide bonds between hair proteins found in the hair shaft. The greater the number of links, the curlier the hair, and the fewer the number of links, the straighter the hair. This of course is caused by the types of atoms making the DNA molecule of the hair. Some hair will have more disulphide bonds, thereby more inclined to curl and other types fewer therefore more straight.

2.3 What makes hair go curly when it's wet?

The disulphide bonds can only be broken with heat (as happens in 'permanent waving' hair treatment), but hydrogen bonds are affected by water, so the individual molecules can change their

shape temporarily when wet. http://sciencefocus.com/qa/what-makes-hair-go-curly-when-its-wet

The amount of humidity in the air not only makes for what some label a "bad hair day," but alters the degree of curliness or of straightness of hair. This occurs when high humidity forces water back into the hair fibre, acts on its protein structure, and forces the hair shaft to return to its original structure.

People can temporarily alter their hair to force it into a straight state, or a curly state, but only on a temporary, not on a permanent, basis. When a straight-haired person gets a "permanent wave," known as a "perm," he or she is chemically forcing the making of strong disulfide bonds. The wave does not stay permanently, because new hair, which is straight, grows in as the "perm" grows out. People with curly hair may chemically alter their hair to give it a straighter appearance, but this, too, is also a temporary solution to a permanent "problem," with the same end result. **http://sciencefocus.com/qa/what-makes-hair-go-curly-when-its-wetAaron Billson, Cannock**

2.4 Other bonds in your hair

2.4.1. Hydrogen Bonds

Like most chemical bonds, the bindings on our hairs are actually invisible to the naked eye. The first kind of binding are the hydrogen bonds. Why do we need hydrogen for healthy hair? First, hydrogen provides the hair a means to be as flexible as it can. Without hydrogen, our hair would be as stiff as twigs. You know what this means: the hair will break easier.

2.4.2. Salt Bonds

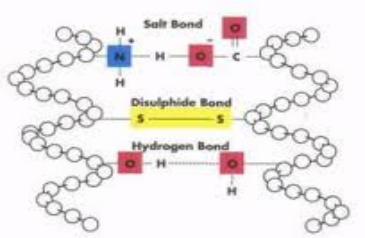
The second type of binding are called the salt bonds. True to its name, salt bonds are dependent on specific pH environments. These

bindings are the most easily disposed of. Since the hair is continually under 'assault' from different chemicals, salt bonds are progressively weakened on a daily basis. If you wish to maintain your salt bonds, simply purchase a chemical normalizing solution for your hair. Or do not use shampoos containing harsh chemicals that might change the PH of your hair (Read the labels on the shampoo!).

2.4.3. Disulfide Bonds

The third type of binding are called the disulfide bonds. What makes disulfide bonds special and more important than the other two bonds mentioned before? Disulfide bonds are actually the reason why the hair is intrinsically resistant to stresses. The hair shaft will go back to its original curled nature after being pulled. This is also the reason why plain old water can't break hair that easily.**http://www.articlesbase.com/medicine-articles/what-are-the-chemicals-bond-in-hair-912987.html**

The disulfide bonds join one sulfur atom on one polypeptide chain to another sulfur atom on different polypeptide chain. Perms use reducing agents called thiol compounds, which break the disulfide bonds by adding a hydrogen atom to each of the sulfur atoms in the disulfide bonds. With the disulfide bonds broken, the polypeptide chains are able to slip into their new shape.



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3. The Beauty of bonds

3.1 Some examples of the roles of chemical bonds in everyday life

In the section above, we have seen how chemical bonds have been use to classify people. Bonds are very important in nature because they give us a variety of compounds. In the home for instance, cooking generally breaks or rearranges the bonds of substances we are cooking to give a cooked meal.

Meat for example contains some 75 per cent water, 20 per cent protein and five per cent fat and carbohydrates. The proteins in the raw meat are coiled and held together by bonds. On heating, the bonds break and the proteins unravel in a process known as denaturation. This makes the meat tender. Most everyday foods contain many compounds which react with other compounds within the food and form new compounds which give us new flavours and new tastes. These compounds break old bonds and form new bonds to give us what eventually is cooked food. Application of heat makes all this possible.

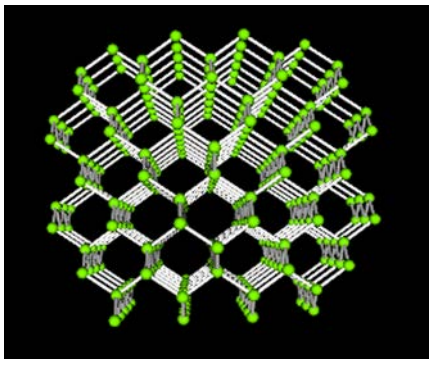
Different bonds could be formed when applying either high or low heat- that is why temperatures are specified for most reactions.

3.2 The element carbon

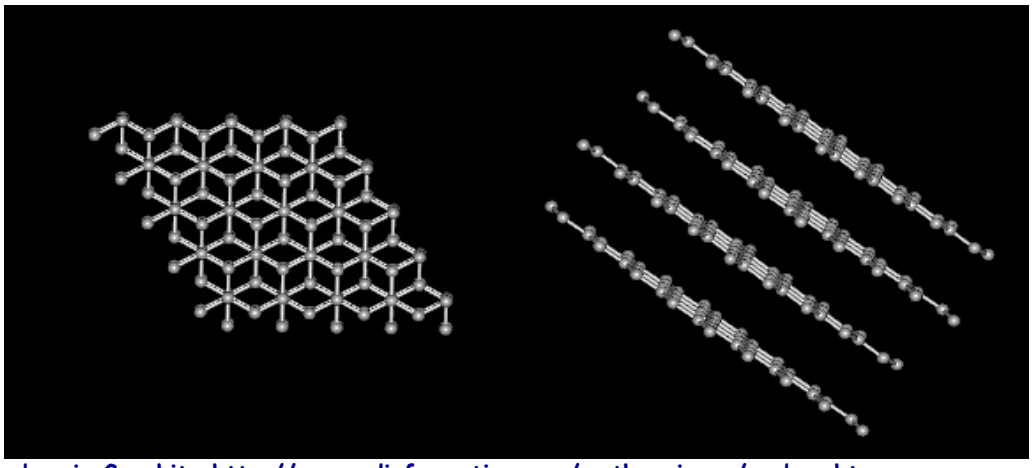
Carbon is found in many different compounds. It is in the food you eat, the clothes you wear, the cosmetics you use and the petrol in your car. In addition, carbon is a very special element because it plays a dominant role in the chemistry of life.

Carbon has four electrons in its valence shell (outer shell). Since this energy shell can hold eight electrons, each carbon atom can share electrons with up to four different atoms. Carbon can combine with other elements as well as with itself. This allows carbon to form many different compounds of varying size and shape.

Carbon alone forms the familiar substances graphite and diamond. Both are made only of carbon atoms. Graphite is very soft and slippery. Diamond is the hardest substance known to man. If both are made only of carbon what gives them different properties? The answer lies in the way the carbon atoms form bonds with each other.



Carbon in Diamond
http://www.edinformatics.com/math_science/carbon.htm



Carbon in Graphite http://www.edinformatics.com/math_science/carbon.htm

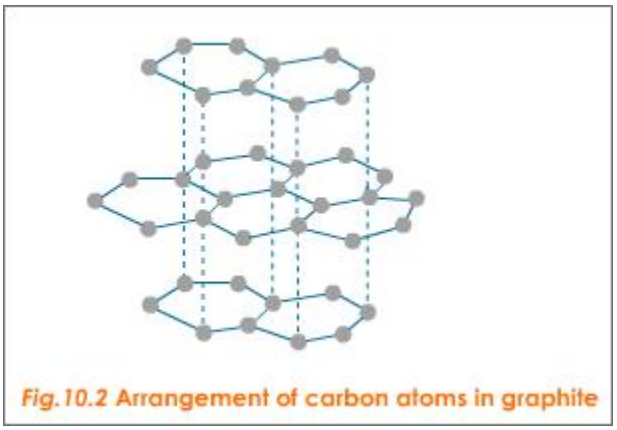
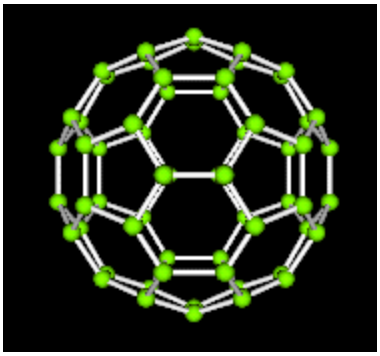
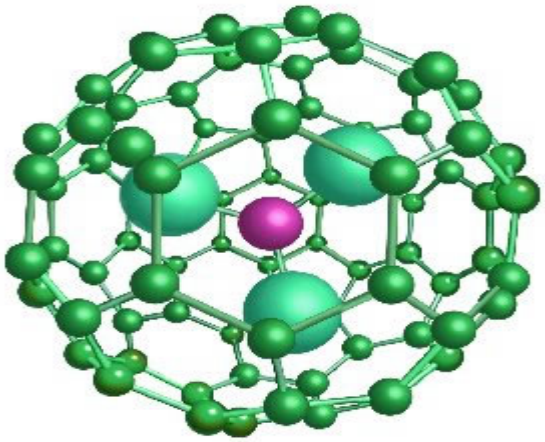


Fig. 10.2 Arrangement of carbon atoms in graphite

http://www.tutorvista.com/content/chemistry/chemistry-i/carbon/graphite.php

A third class of carbon compounds has recently been discovered. They are called fullerenes. The figure shown on the left is one form composed of 60 carbons. Notice the geometric patterns of pentagons and hexagons that form the familiar icosohedron.





Fullerenes[2]

http://www.edinformatics.com/math_science/carbon.htm

Can you see how bonds affect the physical properties; do these molecules have similar chemical properties? Can you see how carbon bonded in different ways give us completely different products. Bond structure changed through cooking or heating an also give compounds with different physical and chemical properties.

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2 A **fullerene** is any molecule composed entirely of carbon, in the form of a hollow sphere, ellipsoid or tube. One ring could contain 60 carbon atoms. Spherical fullerenes are also called **buckyballs**, and they resemble the balls used in association football. Cylindrical ones are called carbon nanotubes or buckytubes. Fullerenes are similar in structure to graphite, which is composed of stacked graphene sheets of linked hexagonal rings; but they may also contain pentagonal (or sometimes heptagonal) rings.

Bonds give us structure

Bonds give us strength

Bonds give us character

We are all atoms and bonds

IMAGINE A WORLD WITHOUT BONDS; EVERYTHING WOULD BE PILED UP ON THE GROUND WITHOUT FORM, STRENGTH, STRUCTURE OR DIFFERENCE!

4. Chemicals and your hair (Acids and Bases)

Acids and Bases - Hair relaxing Hair relaxing is a common phenomenon amongst many people. People relax their hair for a variety of reasons. The chemicals commonly used in relaxing hair are discussed below. Acids and bases are commonly used as catalysed in organic chemistry.

4.1 Lye Relaxers

Lye is a very strong alkaline solution that is also used in a huge variety of cleaning products like laundry detergent, pool cleaning supplies and drain de-cloggers. Some formulas are so strong that one can basically dissolve anything in its way. You will recall that the presence of acids or bases makes many reactions possible.

Basically a lye hair relaxer is made up of the same strong corrosive alkaline solution known as Sodium Hydroxide (NaOH) that is mixed with water, petroleum jelly and other ingredients. Upon application, the lye relaxer floods through the protein structure of your hair and breaks the disulphide bonds causing the hair to loosen up for reshaping. http://www.surviving-hairloss.com/Hair_Relaxers.html

4.2 No-Lye Relaxers

As the name says it, No-lye denotes the absence of Sodium Hydroxide but instead replaces with a slightly milder kind of chemical agent like

- Potassium Hydroxide
- Lithium Hydroxide
- Guanidine Hydroxide

All of the above chemicals share the same method of action like lye but they are just milder and supposedly to be less damaging compared to lye relaxers.

No matter what kind of chemical relaxers you use, whether lye or no-lye, the basic mechanism is the same. To permanently shape your hair, chemicals must enter into your hair to break or modify your hair structure for reshaping. Therefore, excessive or unsupervised using of these relaxers can and cause problems to your hair and scalp like:

- Scalp irritation
- Dry, brittle and damaged hair

- Burns if chemical contacts with the skin
- Potentially toxic fumes from the chemicals
- Chemical induced hair loss (Anagen Effluvium)

Read about the effect of relaxing and braiding on **http://www.uct.ac.za/usr/press/2010/Khumalo.pdf**

Hydroxide relaxers break the disulfide bonds in the hair by removing one atom of sulfur from the disulfide bond and thereby converting it into a lanthionine bond. This process is called lanthionization. When a hydroxide relaxer breaks a disulfide bond the bond is permanently broken and can never be reformed.

Hydroxide relaxers leave the hair extremely alkaline even after rinsing. To restore the pH balance of the hair an acid-balanced shampoo or normalizing lotion neutralizes any remaining hydroxide ions to lower the pH of the hair and scalp. Some neutralizing shampoos intended for use after hydroxide relaxers have a built-in color-change indicator to show when the hair's pH has returned to normal.

Make sure that next time you visit the hair salon, the indicator is completely washed out and the pH has returned to normal.

The Back Page

Ancient Civilizations from Africa- Architecture

Zimbwabwe

Great Zimbabwe Ruins

The Great Zimbabwe Ruins are one of the most important archaeological sites in Africa, giving testimony to the lost civilisation of the Shona. .

A great city existed here from the 11th century on, with over 10.000 inhabitants. Great Zimbabwe ("stone houses") was a main regional trading center, its wealth associated with (Arab) gold trading. There were also trade links with East Africa (Kilwa), and fragments of Persian and Chinese pottery has been found at the site.
The ruins nowadays are spread out over three main areas: the Hill Ruins, the Great Enclosure and the Valley Ruins. The **Ruins** of Great **Zimbabwe**
www.places.co.za/html/greatzim.html

Ethiopia

Axum Obelisk and Piazza di Porta Capena (Porta Capena Square)

This Axum Obelisk (Obelisco di Axum) was moved here from a saint Ethiopian city (Axum) in 1937 as a trophy of the colonial company of Italy in Eastern Africa, during the time when Italy was trying to colonize Ethiopia. It dates from the 4th century and is 24 meters high. This architectural marvel was one of many that graced the Ethiopian landscape many years ago.

It was taken to Italy as part of the loot from Africa. It was erected in the middle of the square in Italy. In 1947, in the peace treaty between post-war Italy and Ethiopia, it was agreed that all the spoils of war were to be returned within 18 months. However, in Italy this obligation was never taken seriously. In breach of all contracts, the pillar remained in Rome until 2005 on the Piazza di Porta Capena, where ironically the World Food Organisation WFO is situated.

The obelisk is actually a **huge funerary stela** that was sent to Rome in 1937 as war booty from Axum, the ancient religious capital of Ethiopia. The stela is considered one of the most important monuments of the ancient Ethiopian culture. After its removal it achieved even greater status as a symbol of Ethiopian independence and nationhood. Wiki

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Email to: masemula.m@dbe.gov.za