The biochemical and genetic basis of sickle cell anemia was reviewed as well as the possible means of diagnosis and treatment. Sickle cell anemia as a life threatening and painful disease at molecular level is caused by the inheritance of abnormal gene of hemoglobin that causes red blood cells to become sickle (HbSS) which is in a homozygous form and the mutation of a single amino acid in the polypeptide chain which codes for normal hemoglobin (HbAA or HbA). This changes the amino acid sequence forming an altered form of hemoglobin (HbSS or HbS) responsible for sickle-cell anemia. Individuals that are healthy but have trace of sickle cell anemia in them have Sickle Cell Trait. The examination of the Biochemical and Genetic basis of sickle cell anemia will give a preliminary insight on the causes of sickle cell anemia in humans at molecular level.

**Keywords**: Sickle cell anemia, Sickle Cell Trait, Hemoglobin A, Hemoglobin S, Mutation

**INTRODUCTION**

Sickle Cell Anemia is a disease of hemoglobinopathies (i.e. any group of inherited diseases, in which there is an abnormality in the production of hemoglobin). In the case of sickle cell anemia the abnormality is that of variant hemoglobin S (HbS).

Sickle cell anemia (sickle cell disease) is an autosomal recessive genetic disorder that afflicts American Negroes and the peoples of Mediterranean countries of northern Africa. The highest frequency of sickle cell disease is found in tropical regions, particularly sub-Saharan Africa, India and the Middle-East. It is a hereditary anemia of the hemolytic (blood destruction) variety in which some of the red blood cells, normally disc-shaped, appear under the microscope to be oat-or-sickle-shaped.

Sickle cell anemia is what the Ibos in southeastern Nigeria in those days called ‘Ogbanje’ meaning ‘children who come and go’. The first mention of ‘sickle cell’ came from the explanation in 1910 of the clinical findings of Ernest Edward Trons (1877 – 1959), by James B. Herrick (1861-1954) a Chicago Cardiologist and Professor of Medicine of a ‘peculiar elongated sickle shaped cells’. The blood for this research was obtained from a 20 year old first year dental student suffering from anemia by name Walter Clement Noel from Grenada who later died in 1916 because of pneumonia and is buried in the Catholic cemetery at Sauteurs in the north of Grenada. The term “Sickle Cell Anemia” came from Verne Mason in 1922, then a medical resident at Johns Hopkins Hospital.

Sickle Cell Anemia can be caused by mutation of a single amino acid in the polypeptide chain which codes for normal hemoglobin (HbA) or by inheritance of

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Anemia is a blood condition in which there are too few red blood cells or the red blood cells are deficient in hemoglobin, resulting in poor health.
homozygous gene for sickle cell anemia. The mutation responsible for sickle cell anemia is small - just ONE nucleotide of DNA out of the three billion in each human cell. Yet it is enough to change the chemical properties of hemoglobin, the iron and protein complex that carries oxygen within red blood cells. There are two β globin alleles important for the inheritance of sickle cell anemia: A and S. Individuals with two normal A alleles (AA) have normal hemoglobin, and therefore normal red blood cells. Those with two mutant S alleles (SS) develop sickle cell anemia. Those who are heterozygous for the sickle cell allele (AS) produce both normal and abnormal hemoglobin. Heterozygous individuals are usually healthy, but they may suffer some symptoms of sickle cell anemia under conditions of low blood oxygen, such as high elevation. Heterozygous (AS) individuals are said to be “carriers” of the sickle cell trait. Because both forms of hemoglobin are made in heterozygotes, the A and S alleles are co-dominant. (7) (8)

The sickle cell anemia is marked by the affected individual inheriting the allele for sickle cell hemoglobin from both parents not just one. The erythrocytes of the sufferers are few in number and abnormal in the sense that the erythrocytes otherwise called red blood cells undergoes polymerization in the deoxygenated state making the blood to contain long, thin, crescent-shaped erythrocytes that look like the blade of a sickle. These polymerized cells are what are called ‘sickled cells’ mainly because they look like the cutting blade of sickle – an agriculture tool for cutting grass and grain. The sickled shape of the red blood cells that appears after polymerization in the deoxygenated state of the blood, makes it difficult for the red blood cells to pass through tiny blood vessels; this then leads to more serious consequence that makes the capillaries become blocked by the long, abnormally shaped cells, causing severe pain and interfering with normal organ function – a major factor in the early death of many people with the disease. (7)

People with sickle cell anemia have symptoms such as: Reticulocyte counts elevation showing new red blood cells replacing the rapidly destroyed older cells, White blood cells and platelets counts are elevated – this often leads to vaso-occlusion crises, abdominal and bone pains, delayed growth and puberty, ulcers on the lower legs (in adolescents and adults), yellowing of the eyes and skin (jaundice), skin ulcers, stroke as a result of brain damage and sometimes breathlessness etc. Most of these symptoms are associated with crises i.e. a term used to describe several independent acute conditions occurring in patients with sickle cell disease. The sickle cell crises noted in victims are: vaso-occlusive crises, aplastic crises, hemolytic crises and a splenic sequestration crisis etc and when hemoglobin molecules of a variety characteristic of the disease link together, they cause red blood cells to take on a rigid, sickle shape that prevents them from squeezing through tiny blood vessels, thus depriving tissues of blood.

Sickle Cell Trait (SCT) is a related genetic disorder to sickle cell anemia but in SCT, the red blood cells are normal and the abnormal hemoglobin S (HbS) that brings about sickle cell is present only to the extent of about 30 – 40%, the remaining being normal, (1) but when the erythrocyte is in deoxygenated state only 1% of the erythrocyte becomes sickled (7). People with sickle cell trait do not have symptoms of sickle cell anemia, rate of hospitalization and life expectancies is normal; phenotype is normal and can live completely normal life if they avoid doing vigorous exercise and other related issues that may bring extreme stress to their circulatory system.

Symptoms are very rare to be found in sickle cell trait, but if there should be any, they are usually brought by exercise or what may be called physical exertion. This may be presumably attributed to lactic acid production as the body moves from aerobic to anaerobic production. (9). It have been noted that under unusual circumstances serious morbidity or
mortality can result from complications related to polymerization of deoxy-hemoglobin S. Such problems include: increased urinary tract infection in women, gross hematuria (blood in urine), complications of hyphema, splenic infarction with altitude hypoxia or exercise, and life-threatening complications of exercise, severe low oxygen conditions or severe dehydration, severe physical exercise, urinary tract infections (bladder or kidney infections), pulmonary embolus or deep vein thrombosis (a blood clot in the lung or leg), exertional heat illness (exertional rhabdomyolysis, heat stroke, or renal failure) or idiopathic sudden death. 

Generally, it has been reported that sickle cell anemia can be treated by regular blood transfusion, taking of antibiotics, kidney dialysis or kidney transplant for kidney disease, gallbladder removal in those with gallstone disease, drug rehabilitation and counseling for psychological complications etc. This article reviews the causes of sickle cell disease and that of sickle cell trait at molecular level; in addition, it further reviews the diagnosis, and possible treatment of sickle cell anemia.