ONWUMA CHIBUOGWU OBI

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1)Vitamins are classified as either water -soluble or fat-soluble. In humans there are 13 vitamins: 4 fat-soluble (A, D, E, and K) and 9 water-soluble (8 B vitamins and vitamin C).

Water-soluble vitamins dissolve easily in water and, in general, are readily excreted from the body, to the degree that urinary output is a strong predictor of vitamin consumption. Because they are not as readily stored, more consistent intake is important. Vitamin B complex and Vitamin C are water soluble. They are not stored in the body, therefore are required daily in small amounts. These include the B-vitamins and vitaminC . They are soluble in water and can therefore be excreted in the urine . They share few common properties besides their solubility characteristics Most of these vitamins act as coenzymes Examples include thiamine (Vit B1), Riboflavin (B2), Niacin, Pantothenic acid (Vit B5), Vitamin B6 (Pyridoxine), Biotin, Vitamin B12 (Cobalamin) and folic acid

 Fat-soluble vitamins are absorbed through the intestinal tract with the help of lipids (fats). Vitamins A and D can accumulate in the body, which can result in dangerous hypervitaminosis. Fat-soluble vitamin deficiency due to malabsorption is of particular significance in cystic fibrosis. Fat Soluble Vitamins are oily and hydrophobic compounds, they are stored in the liver and not excreted out of the body. Bile salts and fats are needed for their absorption. Vitamins A,D,E and K are fat soluble.

1b)The biochemical significance of vitamins are:

### i)On fetal growth and childhood development

Vitamins are essential for the normal growth and development of a multicellular organism. Using the genetic blueprint inherited from its parents, a fetus develops from the nutrients it absorbs. It requires certain vitamins and minerals to be present at certain times.These nutrients facilitate the chemical reactions that produce among other things, skin, bone, and muscle. If there is serious deficiency in one or more of these nutrients, a child may develop a deficiency disease. Even minor deficiencies may cause permanent damage.

### ii)On adult health maintenance

Once growth and development are completed, vitamins remain essential nutrients for the healthy maintenance of the cells, tissues, and organs that make up a multicellular organism; they also enable a multicellular life form to efficiently use chemical energy provided by food it eats, and to help process the proteins, carbohydrates, and fats required for cellular respiration.

iii) Vitamin A acts as a regulator of cell and tissue growth and differentiation. Vitamin D provides a hormone-like function, regulating mineral metabolism for bones and other organs.

Iv) The B complex vitamins function as enzyme cofactors (coenzymes) or the precursors for them. Vitamins C and E function as antioxidants.

2) A **coenzyme** is a small, organic, non-protein molecule that carries chemical groups between enzymes. ... In **metabolism**, **coenzymes** play a **role** in group-transfer reactions, such as ATP and **coenzyme** A, and oxidation-reduction reactions, such as NAD+ and **coenzyme** Q10. **Coenzymes** are frequently consumed and recycle

## Energy Production

One primary function of coenzymes is to help with the production of energy. Specifically, the coenzyme ATP is a major player in moving energy within the cell. ATP's structure has three phosphate groups, and when the last one is cleaved off during a process known as hydrolysis, energy is released. ATP is constantly recycled, picking up more phosphate groups that are then broken off once again, replenishing cellular energy.

## b) Redox Reactions

Another primary function of coenzymes is to aid in the loss or gain of electrons in redox reactions. During oxidation, a molecule or atom loses electrons. Reduction occurs when a molecule or atom gains electrons. Oxidative phosphorylation is also a good example of redox as well as an illustration of how coenzymes work in tandem. For NADH to be able to transport the hydrogen atoms, the coenzyme donates two electrons to coenzyme Q. NADH then becomes NAD+, entering an oxidized state because it has lost electrons

Examples of water soluble vitamins that are precursors of coenzymes are: niacin (B3), pantothenic acid (B5).

3)  Nucleosides are components of nucleotidess. Nucleotide is the monomeric unit of nucleic acid, e.g. DNA and RNA. In two-stranded nucleic acids like DNA, the nucleobases are paired. The two nucleobases that are complementary are connected by a hydrogen bond.

### **Characteristics**

A nucleoside is a purine or a pyrimidine nucleobase bound to a pentose sugar ribose or deoxyribose, i.e. nucleoside = nucleobase + ribose or deoxyribose. A nucleoside is a glycoside formed from the hydrolysis of nucleic acid. When a phosphate group is covalently attached to the pentose sugar of a nucleoside, it forms a nucleotide, i.e. nucleotide = nucleoside + phosphate group. In a nucleoside, the anomeric carbon is attached to the N9 of a purine (or to the N1 of a pyrimidine) by a glycosidic bond.

### **Types**

Depending on the pentose sugar component, a nucleoside may be a ribonucleoside or a deoxyribonucleoside. A ribonucleoside is a nucleoside with a ribose sugar component. Depending on the nucleobase component, the ribonucleoside may be adenosine, guanosine, cytidine, uridine, . A deoxyribonucleoside is a nucleoside with a deoxyribose sugar. Depending on the nucleobase component, a deoxyribonucleoside may be deoxyadenosine, deoxyguanosine, deoxycytidine, thymidine, or deoxyuridine. Also, depending on the  component, the nucleosides may be

ii) A nucleotide is an organic molecule that is the building block of DNA and RNA. They also have functions related to cell signaling, metabolism, and enzyme reactions. A nucleotide is made up of three parts: a phosphate group, a 5-carbon sugar, and a nitrogenous base. The four nitrogenous bases in DNA are adenine, cytosine, guanine, and thymine. RNA contains uracil, instead of thymine. A nucleotide within a chain makes up the genetic material of all known living things. They also serve a number of function outside of genetic information storage, as messengers and energy moving molecules.

A series of three nucleotides within the DNA is known as a codon, and directs the proteins within the cell to attach a specific protein to a series specified by the rest of the DNA. Special codons even specify to the machinery where to stop and start the process. DNA translation, as it is known, converts the information from DNA into the language of proteins. This chain of amino acids can then be properly folded, and provide one of many functions within the cell.

## Nucleotide Structure

Nucleotide structure is simple, but the structure they can form together is complex. Below is an image of DNA. This molecule consists of two strands which wrap around each other, forming hydrogen bonds in the middle of the structure for support. Each nucleotide within has a specific structure which enables this formation.

### **Nitrogenous base**

The nitrogenous base is the central information carrying part of the nucleotide structure. These molecules, which have different exposed functional groups, have differing abilities to interact with each other. As in the image, the idea arrangement is the maximum amount of hydrogen bonds between nucleotides involved. Because of the structure of the nucleotide, only a certain nucleotide can interact with other. The image above shows thymine bonding to adenine, and guanine bonding to cytosine. This is the proper and typical arrangement.

This even formation causes a twist in the structure, and is smooth if there are no errors. One of the ways proteins are able to repair damaged DNA is that they can bind to uneven spots within the structure. Uneven spots are created when hydrogen bonding does not occur between the opposing nucleotide molecules. The protein will cut out one nucleotide, and replace it with another. The duplicate nature of the genetic strands ensures that errors like this can be corrected with a high degree of accuracy.

### **sugar**

The second portion of the nucleotide is the sugar. Regardless of the nucleotide, the sugar is always the same. The difference is between DNA and RNA. In DNA, the 5-carbon sugar is deoxyribose, while in RNA, the 5-carbon sugar is ribose. This gives genetic molecules their names; the full name of DNA is deoxyribonucleic acid, and RNA is ribonucleic acid.

The sugar, with its exposed oxygen, can bond with the phosphate group of the next molecule. They then form a bond, which becomes the sugar-phosphate backbone. This structure adds rigidity to the structure, as the covalent bonds they form are much stronger than the hydrogen bonds between the two strands. When proteins come to process and transpose the DNA, they do so by separating the strands and reading only one side. When they pass on, the strands of genetic material comes back together, driven by the attraction between the opposing nucleotide bases. The sugar-phosphate backbone stays connected the whole time.

### **Phosphate Group**

The last part of nucleotide structure, the phosphate group, is probably familiar from another important molecule ATP. Adenosine triphosphate, or ATP, is the energy molecule that most life on Earth relies upon to store and transfer energy between reactions. ATP contains three phosphate groups, which can store a lot of energy in their bonds. Unlike ATP, the bonds formed within a nucleotide are known as phosphodiester bonds, because they happen between the phosphate group and the sugar molecule.

During DNA replication, an enzyme known as DNA polymerase assembles the correct nucleotide bases, and begins organizing them against the chain it is reading. Another protein, DNA ligase, finished the job by creating the phosphodiester bond between the sugar molecule of one base and the phosphate group of the next. This creates the backbone of a new genetic molecule, able to be passed to the next generation. DNA and RNA contain all the genetic information necessary for cells to function.

## Nucleotide Examples

### **Adenine**

Adenine is a purine, which is one of two families of nitrogenous bases. Purines have a double-ringed structure. In DNA, adenine bonds with thymine. In RNA, adenine bonds with uracil. Adenosine triphosphate, as discussed earlier, uses the nucleotide adenine as a base. From there, three phosphate groups can be attached. This allows a great deal of energy to be stored in the bonds. For the same reason that the sugar-phosphate backbone is so strong, the bonds in ATP are as well. When combined with special enzymes which have formed to release the energy, it can be transferred to other reactions and molecules.

### **Guanine**

Like adenine, guanine is a purine nucleotide; it has a double ring. It bonds with cytosine in both DNA and RNA. Guanine binds to cytosine through three hydrogen bonds. This makes the cytosine-guanine bond slightly stronger than the thymine-adenine bond, which only forms two hydrogen bonds.

iii)NUCLEIC ACID

**Nucleic acids** are the biopolymers, or large biomolecules, essential to all known forms of life. The term *nucleic acid* is the overall name for DNA and RNA. They are composed of nucleotides, which are the monomers made of three components: a 5-carbon sugar, a phosphate group and a nitrogenous base. If the sugar is a compound ribose, the polymer is RNA (ribonucleic acid); if the sugar is derived from ribose as deoxyribose, the polymer is DNA (deoxyribonucleic acid).

Nucleic acids are the most important of all biomolecules. These are found in abundance in all living things, where they function to create and encode and then store information of every living cell of every life-form organism on Earth. In turn, they function to transmit and express that information inside and outside the cell nucleus—to the interior operations of the cell and ultimately to the next generation of each living organism. The encoded information is contained and conveyed via the nucleic acid sequence, which provides the 'ladder-step' ordering of nucleotides within the molecules of RNA and DNA.

4) Vitamin A (all-trans-retinol) is a precursor to the formation of the photopigment rhodopsin, which is located in the rods.  In order for rhodopsin to be formed, vitamin A must be converted to 11-cis-retinal.  This can occur in one of two ways.  Vitamin A (all-trans-retinol) can be converted to 11-cis-retinol by isomerase.  This 11-cis-retinol can then be converted to 11-cis-retinal. Alternatively, vitamin A (all-trans-retinol) can be converted to all-trans-retinal which can then be converted to 11-cis-retinal.  Now that 11-cis-retinal has been formed by either method, it can combine with scotopsin to form the rhodopsin.  As rhodopsin absorbs light in the rods, a conformational change occurs in 11-cis-retinal to become all-trans-retinal.  A conformational change also occurs in the opsin fragment to form metarhodopsin II, which is the activated form of rhodopsin.  The metarhodopsin II then stimulates transducin, a G-coupled protein found on the surface of the disk within the outer membrane in the rod cell.  This activation of transducin causes an activation in cGMP phosphodiesterase, which will remove the cGMP mediated activation of cGMP-gated channels that are letting Na+ ions leak into the rod cytoplasm resulting in a hyperpolarization of that rod cell.  Thus, in the presence of light, the blockage of Na+ movement into the rod cell will result in a hyperpolarization of that rod cell which then allows messages about light being seen during night vision to be sent to the brain for final interpretation.

5) ability to see is dependent on two main photoreceptors that sit in the posterior aspect of the eye, the rods and cones (with the rods outnumbering the cones by a ratio of 20:1).1  To be able to see, light must first enter into and pass through the lens of the eye and then travel through the posterior segment (vitreous chamber).  Next, light must travel through ten layers of the neural retina to get to the rods and cones.  The rods and cones are made up of an inner segment that contains the nucleus and an outer segment that is made up of discs that contain light-absorbing photopigments.1  When comparing the two photoreceptors, the rods are useful for night vision and the cones are useful for day vision.  Vitamin A is one of the required precursors for the formation of rhodopsin, the photopigment found in rods.  Rhodopsin helps us to see at night and without vitamin A, rhodopsin cannot form and night blindness occurs

6) During exposure to sunlight, ultraviolet radiation penetrates into the epidermis and photolyzes provitamin D3 to previtamin D3. Previtamin D3 can either isomerize to vitamin D3 or be photolyzed to lymisterol and tachysterol. Vitamin D is also sensitive to sunlight and is photolyzed to 5,6-transvitamin D3, suprasterol I, and suprasterol II. In Boston, solar irradiation only produces previtamin D3 in the skin between the months of March and October. Aging, sunscreens, and melanin all diminish the capacity of the skin to produce previtamin D3. Once formed, vitamin D3 enters the circulation and is sequentially metabolized to 25-hydroxyvitamin D3 and 1,25-dihydroxyvitamin D3 (1,25-[OH]2-D3). The epidermis possesses receptors for 1,25-(OH)2-D3. 1,25-(OH)2-D3 inhibits the proliferation of cultured keratinocytes and induces them to terminally differentiate.

7) The hydroxide ion concentration and pH have a direct correlation, meaning the higher the pH, the higher the hydroxide concentration. Likewise, the lower the hydrogen ion concentration falls. At high pH, then, the solution is rich in hydroxide ions, and these negatively-charged ions can pull hydrogen ions off of molecules like the base pairs in DNA. This process disrupts the hydrogen bonding that holds the two DNA strands together, causing them to separate. Considering the effect of alkali to the genomic DNA:  
1. If DNA is exposed to low concentration of alkali:  
Low concentration of alkali will not be too harmful to the nucleic acid though some damage is obviously incurred like for instance denaturation of some binding proteins or breakage of a few hydrogen bonds of the base pairing,etc.  
2. If DNA is exposed to moderate concentration of alkali:  
Moderate concentrate of alkali causes deprotonation and the hydrogen bonding between the base pairs is disrupted causing the DNA to denature.  
3. If DNA is exposed to high concentration of alkali:  
High concentration of base will induce a hydrolysis of the phosphodiester bonds of the DNA and the DNA will be cleaved into smaller fragments.  
Alkali treatment is often used for isolation of plasmid DNA or any other extra chromosomal material so as to ensure the degradation of genomic DNA to avoid contamination of it into the desired product.  
  
·  Considering the effect of Acid on Genomic DNA:  
1.If DNA is exposed to low pH conditions:  
At low pH i.e. acidic conditions, the DNA is deprived of the purines. This causes DNA melting. Also since A+G content is lost 50% of the sequence of the DNA is lost.  
2.If DNA is exposed to extremely low pH conditions (pH<3)  
At extremely low pH i.e. high acidic conditions the phosphodiester bonding of the DNA is disrupted which cleaves the DNA into nucleosides and nucleotides.  
The effect of acid on DNA is the reason as to why the pH in the stomach is low. Since the pH is nearing 2.0 most of the bacterial load is reduced prior to digestion and decontaminated food is passed further.

8) **Deoxyribonucleic Acid** (**DNA**) is a **double-stranded, helical molecule**. It consists of two **sugar-phosphate backbones** on the outside, held together by **hydrogen bonds** between pairs of **nitrogenous bases** on the inside. The bases are of four types (**A**, **C**, **G**, & **T**): pairing always occurs between **A**&**T**, and **C**&**G.** **James Watson**  and **Francis Crick**  realized that these pairing rules meant that either strand contained all the **information**necessary to make a new copy of the entire molecule, and that the **aperiodic**order of bases might provide a **"genetic code"**.

    Watson and Crick shared the **Nobel prize** for their discovery, along with **Maurice Wilkins** (1916 - 2004), who had continued research to provide a large body of crystallographic data supporting the model. Working in the same lab, **Rosalind Franklin** (1920 - 1958) had earlier produced the first clear crystallographic evidence for a helical structure. Crick went on to do fundamental work in molecular biology and neurobiology. Watson become Director of the Cold Spring Harbor Laboratory, and headed up the **Human Genome Project** in the 1990s.

9) DNA contains the sugar deoxyribose, while RNA contains the sugar ribose. The only difference between ribose and deoxyribose is that ribose has one more -OH group than deoxyribose, which has -H attached to the second (2') carbon in the ring.

ii)DNA is a double-stranded molecule, while RNA is a single-stranded molecule.

iii)DNA is stable under alkaline conditions, while RNA is not stable.

iv)DNA and RNA perform different functions in humans. DNA is responsible for storing and transferring [genetic information](https://www.thoughtco.com/genetic-code-373449), while RNA directly codes [for amino acids](https://www.thoughtco.com/definition-of-amino-acid-605822) and acts as a messenger between DNA and ribosomes to make proteins.

v)[DNA and RNA](https://www.thoughtco.com/rna-facts-ribonucleic-acid-608189) base pairing is slightly different since DNA uses the bases adenine, thymine, cytosine, and guanine; RNA uses adenine, uracil, cytosine, and guanine. Uracil differs from thymine in that it lacks [a methyl group](https://www.thoughtco.com/functional-groups-in-organic-chemistry-4054178) on its ring.

10)functions of nucleotides are:

ecursors of DNA and RNA.

        Activated intermediates in many biosyntheses: e.g UDP-glucose  glycogen, CDP-diacylglycerol  phosphoglycerides, S-adenosylmathionine as methyl donor, etc.

        Nucleotside triphosphates, especially ATP, as the universal currency of energy in biological systems.

        Adenine nucleotides are components of the coenzymes, NAD(P)+, FAD, and CoA.

        Metabolic regulators:  **(a)** c-AMP is the mediator of hormonal actions; **(b)** ATP-dependent protein phosphorylation - activates phosphorylase and inactivates glycogen synthase; **(c)** adenylation of a Tyr of bacterial glutamine synthetase - more sensitive to feedback inhibition and less active; **(d)** allosteric regulator - glycogen phosphorylase activated by ATP and inactivated by AMP.