Hello students, welcome to module number 17 on anabolism: biosynthesis of saturated fatty acids, Part 2 from Unit 3 chemoheterotrophic lipid metabolism. Outline is elongation of fatty acid biosynthesis and stoichiometry of fatty acid biosynthesis. Learning outcomes the student will be able to explain fatty acid biosynthesis and explain stoichiometry of Fatty acid biosynthesis.

In the previous module, we saw how the Acetyl CoA is converted into a malonyl ACP and how Acetyl CoA is converted into Acetyl ACP. This ACP stands for the Acyl Carrier Protein. It is made up of 77 residues and all the intermediates which are formed in the fatty acid biosynthesis, they are bound to this Acyl Carrier Protein. ACP has a propantheline group with a sulfhydryl group, to which these intermediates are attached. Fatty acids with an even number of carbon atoms, start with the Acetyl CoA whereas the fatty acids with an odd number of carbon atoms they begin with the Propionyl CoA.

Let's see now what is the elongation of fatty acid synthesis. Elongation requires four steps. First is condensation, 2nd is the reduction, third is hydration and 4th is reduction. The first step, is condensation, which is actually a step 4, three carbon Malonyl ACP condenses with the two carbon Acetyl ACP to form a four-carbon compound that is acetoacetyl ACP. One carbon is lost in the form of carbon dioxide and one molecule of ACP is released in this reaction.

The second step is the reduction reaction. In this, the keto group, which is present at the C3 position in acetoacetyl ACP, gets reduced to form a D-3-hydroxybutyryl ACP. This Reduction reaction utilizes NADPH as a reducing compound.

In the step 6, D-3-hydroxy butyryl ACP undergoes dehydration to form a crotonyl ACP. The water molecule is removed from the C3 position. In Step 7, the crotonyl ACP undergoes reduction to form a butyryl ACP. So here the reduction occurs at the C2 and C3 positions, eliminating the double bond present in the crotonyl ACP.

This is the final product of the first step, i.e., butyryl ACP. So this butyryl ACP in the second cycle combines with the Malonyl ACP and undergoes the same steps i.e. step four, step five, Step 6 and step 7 to form an acyl ACP which contains additional 2 carbons that are 6 carbons. Now, this particular 6 carbon acyl ACP undergoes a cycle three to form 8 carbon acyl ACP. Like that this particular cycle goes on continuing till the acyl ACP of the desired carbon number is formed. Once the acyl ACP is formed it undergoes a hydrolysis reaction by an enzyme called a thioesterase to form a 16 carbon palmitic acid. ACP is released which can be used for the next reaction.

So coming to the stoichiometry or fatty acid biosynthesis to understand this particular concept, I would recommend you to sit with the pathway and try to understand it. So for simplicity we will take the example of a palmitate. Now palmitate is a fatty acid which contains the 16 carbon atoms. OK, so first we'll have to see how many times the cycles have to be repeated in order to form the 16 carbon compound. To find out that one can use the formula which is mentioned that is (the number of carbon atoms in fatty acids divided by 2) - 1. So now here in our case the number of carbon atoms is 16, so 16 / 2 comes eight. 8 -- 1 is 7. So that means Acetyl CoA will have to undergo seven different cycles in order to form a 16 carbon palmitate.

So now we know how many number of carbons are present. We know how many number of cycles are present. We can now calculate stoichiometry. Stoichiometry can be divided into 2 parts that are activation, and elongation and then these two parts can be combined into a net reaction. We will start with the activation. Activation is the first step in which first 2 steps in which the Acetyl CoA leads to the formation of malonyl CoA. Now, remember here the cycle is repeating 7 times, so that's why I have multiplied all the reactants and products seven times. So, in the activation 7 Acetyl CoA are consumed, 7 carbon dioxide are consumed. 1 ATP, 7 water consumed in order to form 7 Malonyl Co A and seven ADP molecules. The next is the elongation step. So, the elongation step also involves the Acetal CoA. So, this Acetyl CoA comes in step four which is used for the condensation reaction. Since Malonyl CoA also undergoes seven different cycles so seven malonyl CoA. Please recall the elongation step utilizes two NADH molecules since the 7th cycle that's why I multiplied 7 into 2, giving rise to 14 NADPH. In the end, we get the one molecule of palmitate, which is written in the product. Also, we get the 7 carbon dioxide molecules, 14 NADP molecules and six water molecules. Now 6 water molecules are written because actually, in the dehydration reaction during the seven cycles, 7 water molecules are formed, but in the last reaction, which is catalyzed by thioesterase, one water molecule is consumed. That is why I have taken your 6 water molecules. Now once you get the calculations for activation and elongation you can combine these two reactions to get the net reactions. So, if we combine what we get is 7 + 1 eight Acetyl CoA molecules then we get the seven ATP because both the side reactions ATP is present only in the activation. So, it can be written as it is. Then NADPH OK it's coming to the NADPH. It is utilized only in elongation, so it can be used as it is. Then the water molecule I'll come back to this water molecule. Then coming to the product, the palmitate can be taken as it is from the elongation step, then seven ADP as it is from activation and 14 NADP from the elongation step. Now here I have not written carbon dioxide anyway because as you can see in the case of activation 7, CO_2 are utilized whereas in elongation or 7 seven CO_2 are produced so it gets nullified. The same thing goes for the water in case of activation 7 water molecules are consumed whereas 6 water molecules are produced. So, 7 - 6. So only in the net reaction, you will write only one water molecule. So that means in order to form one Palmitate molecule cell has to utilize 8 acetyl CoA molecules, 7 ATP molecules, 14 NADPH molecules and one water molecule. Then you get a formation of 1 palmitate. So palmitate is a really energy-consuming process. These are my references, thank you.