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BIOCHEMISTRY: METABOLIC PROCESSES

ASSIGNMENT

TOPIC ⟹ THE CITRIC ACID CYCLE

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Introduction...

* The Citric acid cycle, also known as the krebs Cycle or the tricarboxylic acid (TCA) cycle, is a series of Chemical reactions that produce energy in the form of ATP.

The name we'll primarily use here, the citric acid cycle, refers to the first molecule that forms during the cycle's reactions - citrate, or, in its protonated form, citric acid.

The Cycle takes place in the mitochondrial matrix of eukaryotic cells and in the Cytoplasm of prokaryotic Cells.

The Citric cyle is a Central driver of cellular respiration It takes acetyl CoA - produced by the Oxidation of Pyruvate and originally derived from glucose - as its starting material and, in a series of redox reactions, harvests much of its bond energy in the form of NADH, $FADH_2$ and ATP molecules.

The reduced electron carriers - NADH & $FADH_2$ - generated in the TCA Cycle will pass their electrons into the electron transport chain and, through oxidative phosphorylation, will generate most of the ATP produced in cellular respiration.

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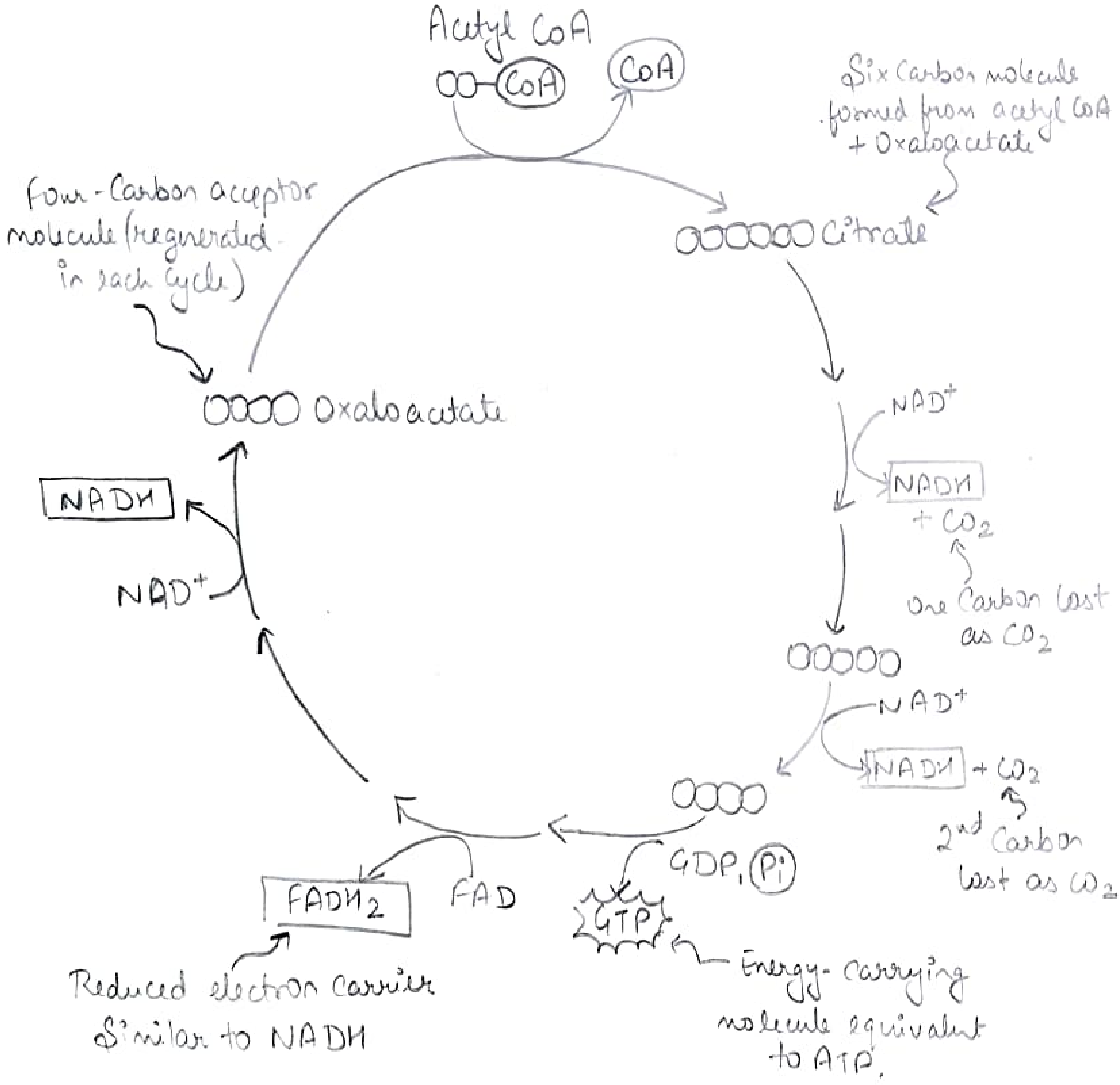
OVERVIEW OF THE CITRIC ACID CYCLE

In eukaryotes, the Citric acid Cycle takes places in the matrix of the mitochondria, just like the Conversion of pyruvate of acetyl CoA.
In prokaryotes, these steps both take place in the cytoplasm.
The Citric acid Cycle is a closed loop; the last part of the pathway reforms the molecule used in the first step. The cycle Includes eight major steps.

In the first step of the cycle, acetyl CoA Combines with a four-Carbon acceptor molecule, oxoloacetate. to form a six-carbon molecule releases two of its Carbons as carbon dioxide molecules in a pair of similar reactions, producing a molecule of NADH each time.
The enzyme that Catalyze these reactions are key regulators of the Citric acid cycle, speeding it up or slowing it down based on the Cell's energy needs.

The remaining four-carbon molecule undergoes a series of additional reactions, first making an ATP molecule - or, in some cells, a similar molecule Called GTP - then reducing the electron carrier FAD to $FADH_2$, and finally generating another NADH.



The Citric acid Cycle

OVERVIEW

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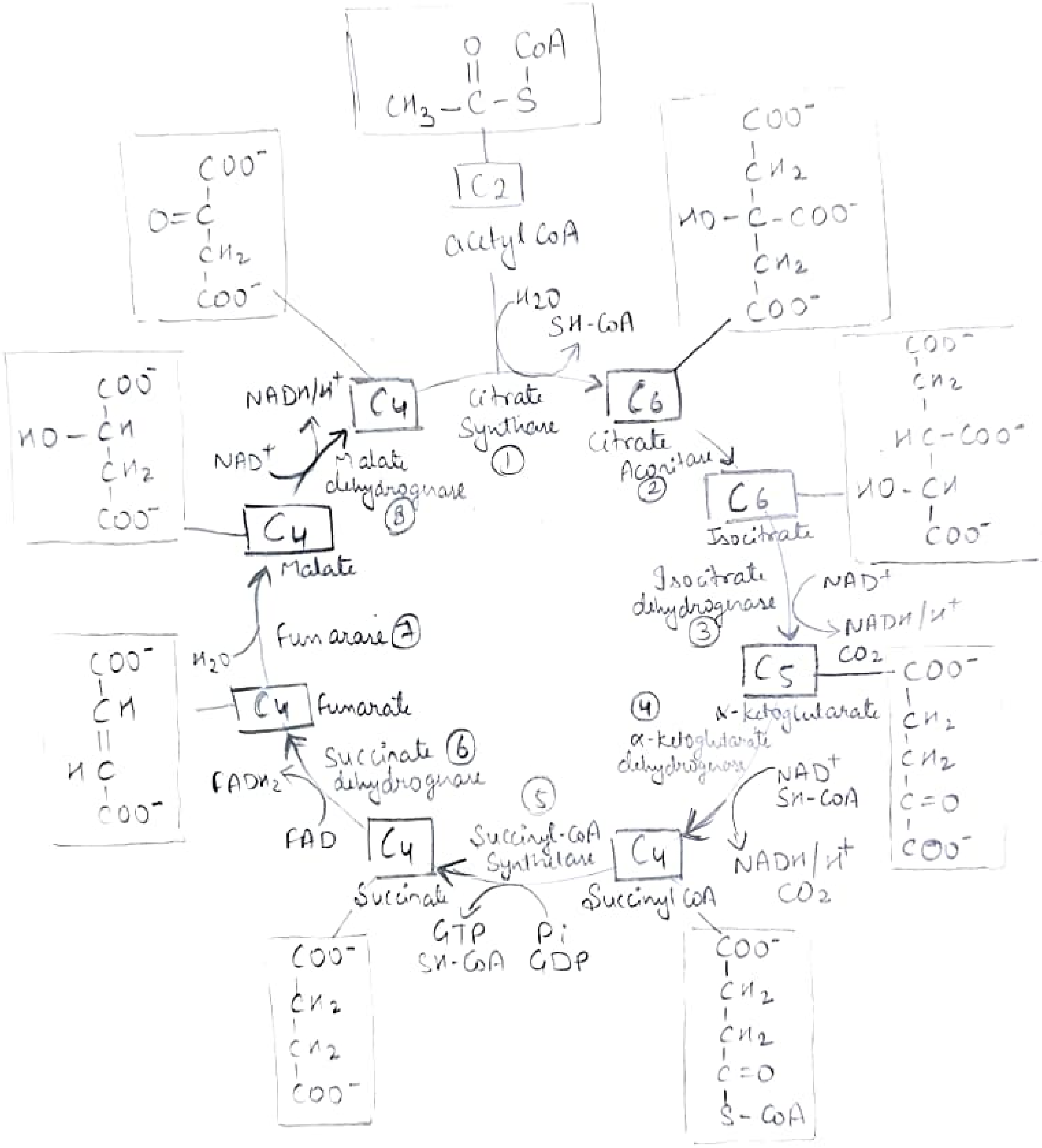
iii) STEP 3 :→ In the third Step, isocitrate is oxidized and releases a molecule of Carbon dioxide, leaving behind a five-carbon molecule – α-Ketoglutarate. During the Step, NAD^+ is reduced to form NADH.
The enzyme Catalyzing this step, isocitrate dehydrogenase, is important in regulating the Speed of the Citric acid Cycle.

iv) STEP 4 :→ The fourth Step is similar to the third. In this Case, it's α-Ketoglutarate that's oxidized, reducing NAD^+ to NADH and releasing a molecule of Carbon dioxide in the process. The remaining four-carbon molecule picks up Coenzyme A, forming the unstable Compound succinyl CoA.
The enzyme Catalyzing this step, α-ketoglutarate dehydrogenase, it is also important in regulation of the Citric acid Cycle.

v) STEP 5 :→ In Step five, the CoA of succinyl CoA is replaced by a phosphate group, which is then transferred to ADP to make ATP.
In Some Cells, GDP – guanosine diphosphate – is used instead of ADP, forming GTP – guanosine triphosphate – as a product.
The four-Carbon molecule produced in this Step is Called Succinate.



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vi) STEP 6 :→ In Step six, succinate is oxidized, forming another four-carbon molecule called fumarate. In this reaction, two hydrogen atom - with their rea electrons - are transferred to FAD, producing $FADH_2$. The enzyme that carries out this step is embedded in the inner membrane of the mitochondrion so $FADH_2$ can transfer its electrons directly into the electron transport chain.

vii) STEP 7 :→ In Step Seven, water is added to the four-carbon molecule fumarate, converting it into another four-carbon molecule called malate.

viii) STEP 8 :→ In the last Step of the citric acid cycle, oxaloacetate - the starting four-carbon compound - is regenerated by oxidation of malate. Another molecule of NAD^+ is reduced to NADH in the process.

PRODUCTS OF THE CITRIC ACID CYCLE

In a Single turn of the Cycle,

- two Carbons enter from acetyl CoA, and two molecules of Carbondioxide are released;
three molecules of NADH and one molecule of $FADH_2$ are generated; and
One molecule of ATP or GTP is produced.

These figures are for one turn of the cycle, corresponding to one molecule of acetyl CoA.

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Each glucose produces two acetyl CoA molecules, so we need to multiply these numbers by 2 if we want the per-glucose yield.

Two Carbons - from acetyl CoA - enter the citric acid cycle in each turn, and two Carbon dioxide molecules are released.
However, the Carbon dioxide molecules don't actually contain Carbon atoms from the acetyl CoA that just entered the Cycle. Instead, the Carbons from acetyl CoA are initially incorporated into the intermediates of the Cycle and are released as Carbon dioxide only during later turns. After enough turns, all the Carbon atoms from the acetyl group of acetyl CoA will be released as Carbon dioxide.

REGULATION OF THE CITRIC ACID CYCLE ⇒

→ The Citric acid cycle is regulated by a number of factors, including the availability of substrates and products, the energy needs the Cell, and the pH of the mitochondrial matrix.

- SUBSTRATES AND PRODUCTS ⇒ The availability of acetyl-CoA, oxaloacetate, NAD+, FAD and ADP can all affect the rate of the Citric acid Cycle. For example, if there is a high Concentration of acetyl-CoA, the Cycle will Speed up in Order to oxidize the acetyl-CoA.
- ENERGY NEEDS OF THE CELL ⇒ The energy needs of the Cell also regulate the Citric acid Cycle. If the Cell needs more energy, the Cycle will Speed up in order to produce more ATP.

* pH of the mitochondrial matrix → The pH of the mitochondrial matrix can also affect the rate of the Citric acid cycle. The enzymes involved in the Cycle are most active at a pH of around 7.4.

* SIGNIFICANCE OF THE CITRIC ACID CYCLE →

The Citric acid cycle is a central metabolic pathway that is essential for life. It is the final Step in the complete oxidation of glucose, yielding 32 ATP molecules per molecule of glucose. The citric acid cycle also produces NADH and $FADH_2$, which are electron carriers that transfer electrons to the electron transport chain, where they are used to produce ATP.

In addition to its role in energy production, the Citric acid Cycle also plays a role in other metabolic processes, such as the synthesis of amino acids, fatty acids, and nucleic acids. The citric acid Cycle is also involved in the detoxification of certain compounds.