Biosynthesis of fatty acids

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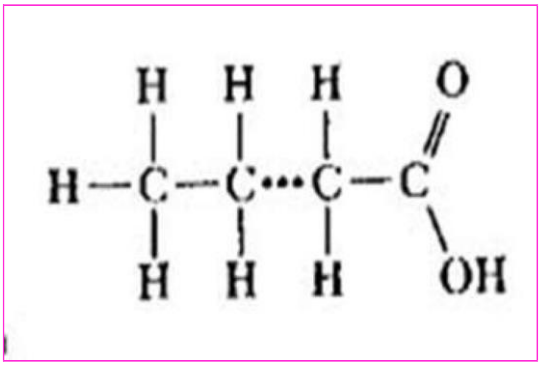
- ✓ Introduction
- ✓ Types
- ✓ Functions
- ✓ Biosynthesis
- ✓ Regulation

Introduction

- Building block of lipids
- C,H,O Element present
- High amount energy other then carbohydrates and proteins
- **Fatty acid** is a carboxylic acid with a long chain hydrocarbon side groups.



- Fatty acid are bind or attach with different group of biomolecule & make complex molecule such as Glycolipids, Phospholipids, Sterols.
- Simple form is Triglycerols.
- Chemically diverse group.
- Common feature is insolubility in water

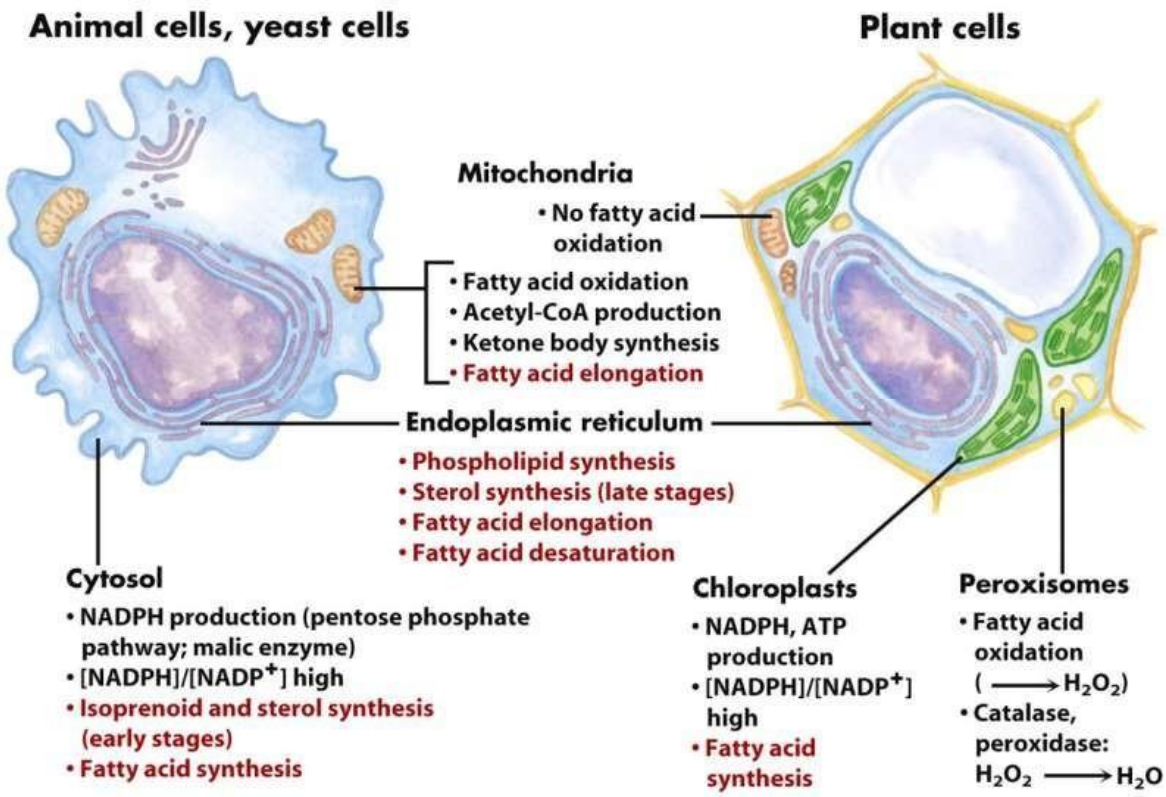
Types

- Based on Carbon bond-
  1) saturated
  2) unsaturated

- Based on Requirement-
  1) Essential
  2) Non essential

- Length of chain-
  1) SCFA
  2) MCFA
  3) LCFA
  4) VLCFA

Localization



Biosynthesis

- In 1945 David Rittenberg and Konrad Bloch demonstrated through isotopic labelling techniques

- In 1950 Sahil Wakil discovered a requirement for bio carbonate in fatty acid biosynthesis and malonyl-CoA was shown to be an intermediate

❖ In vertebrates its happen into cytosol but in plant and bacteria its occur into chloroplast.

❖ The pathway of biosynthesis is not exactly reverse as β oxidation.

❖ Fatty acid breakdown and biosynthesis occur into different compartments of cells, catalysed by different pathways & catalysed by different enzymes

Enzymes & co factors

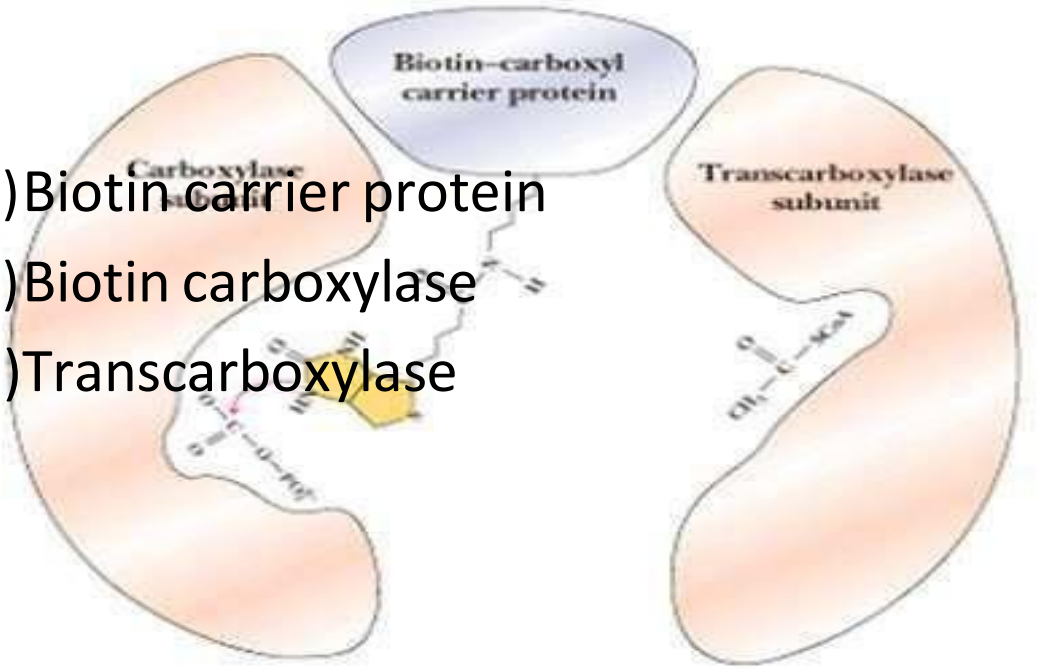
- Two main enzyms-

✓ 1)acetyl CoA carboxylase
✓ 2)fatty acid synthase

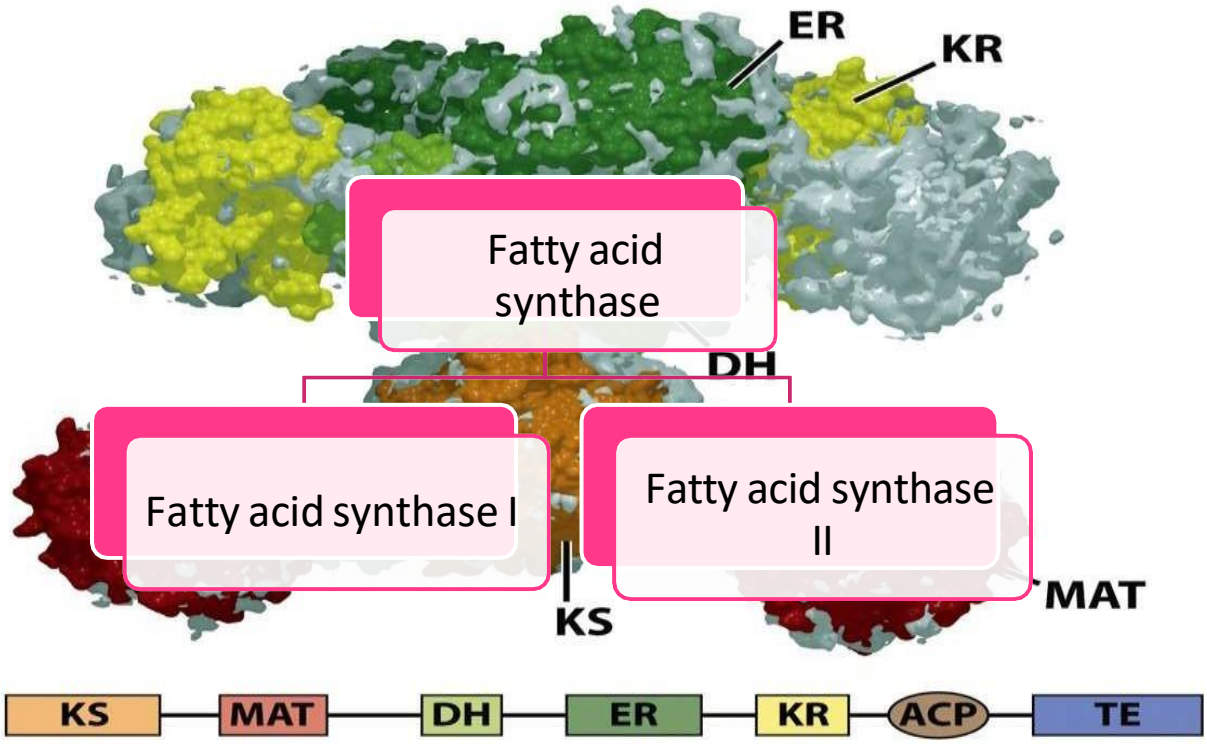
- Co factors-

✓ 1)Biotin
✓ 2)NADH
✓ 3)Mg†

Acetyl CoA carboxylase

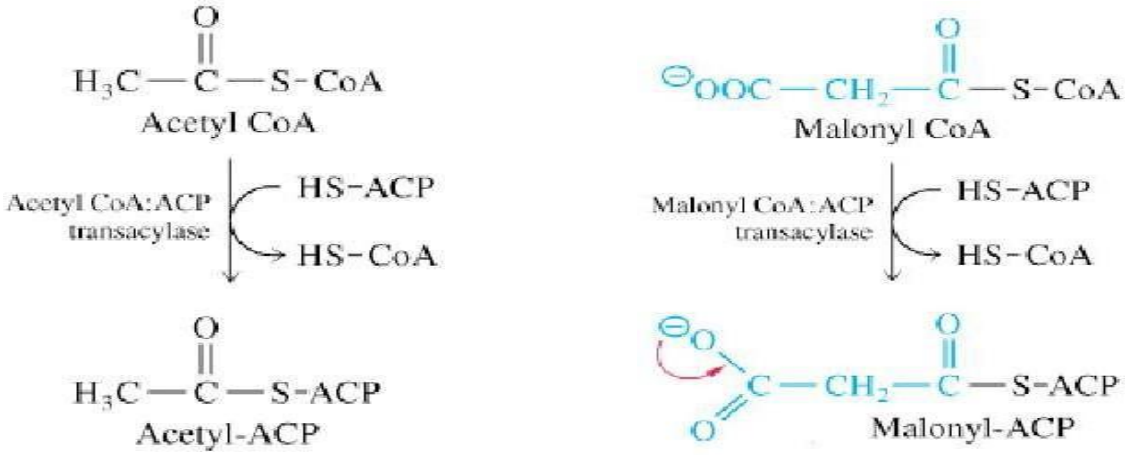


1) Biotin carrier protein
2) Biotin carboxylase
3) Transcarboxylase



Activation

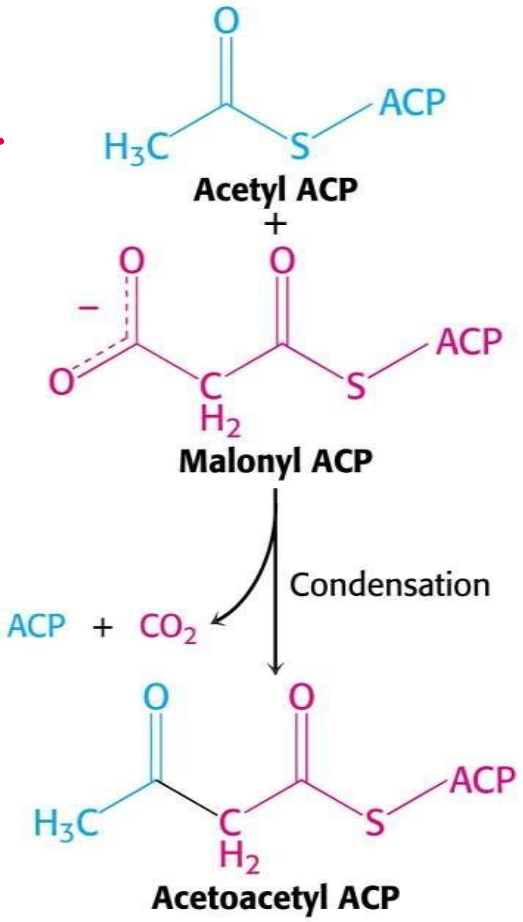
- ✓ Fatty acid synthesis starts with the formation of acetyl ACP and malonyl ACP.
- ✓ ***Acetyl transacylase*** and ***malonyl transacylase*** catalyze these reactions.
- ✓ **Acetyl CoA + ACP ⇌ acetyl ACP + CoA**
  Malonyl CoA + ACP ⇌ malonyl ACP + CoA



Condensation reaction-

Acetyl ACP and malonyl ACP react to form acetoacetyl ACP.

Enzyme - ***acyl-malonyl ACP condensing enzyme.***

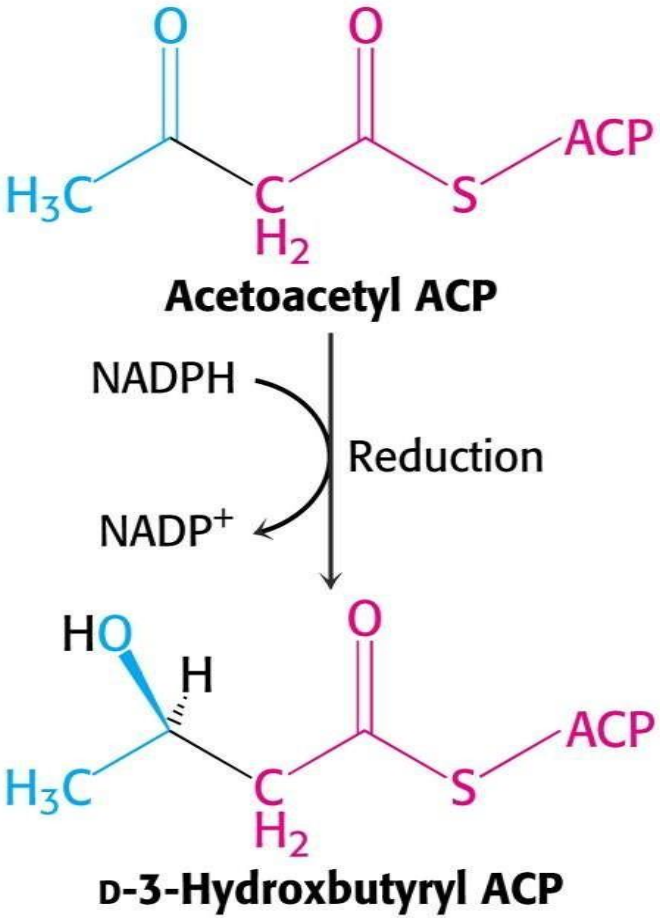


Reduction Reaction-

Acetoacetyl ACP is reduced to D-3-hydroxybutyryl ACP.

NADPH is the reducing agent

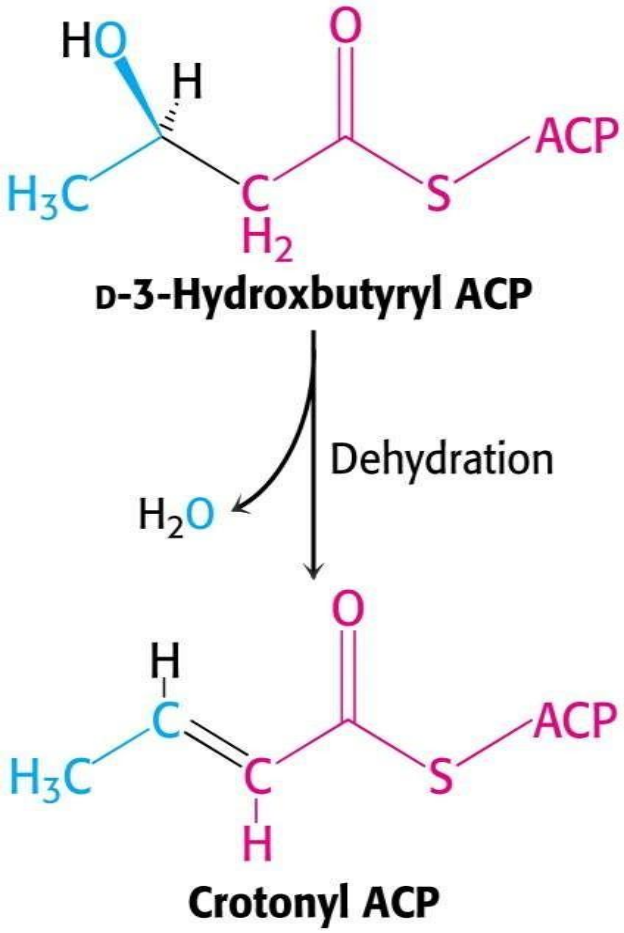
Enzyme: ***β-ketoacyl ACP reductase***



Dehydration Reaction-

D-3-hydroxybutyryl ACP is *dehydrated* to form crotonyl ACP (trans-Δ^2-enoyl ACP).

Enzyme:
3-hydroxyacyl ACP dehydratase



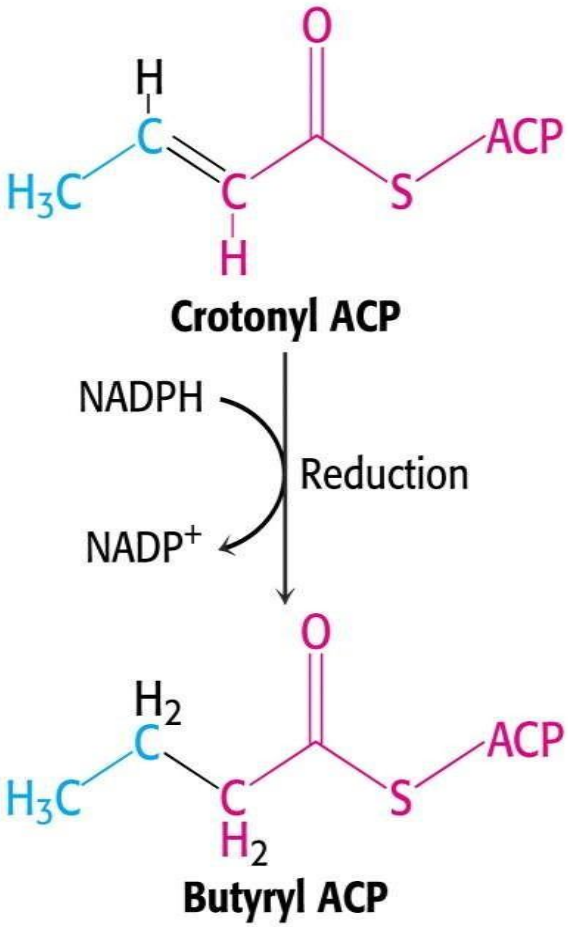
Reduction Reaction-

The final step in the cycle reduces crotonyl ACP to **butyryl ACP.**

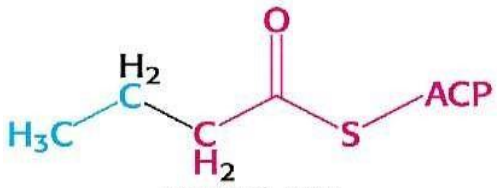
NADPH is reductant.

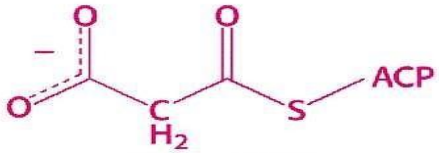
Enzyme - ***enoyl ACP reductase.***

This is the end of first elongation cycle (first round).

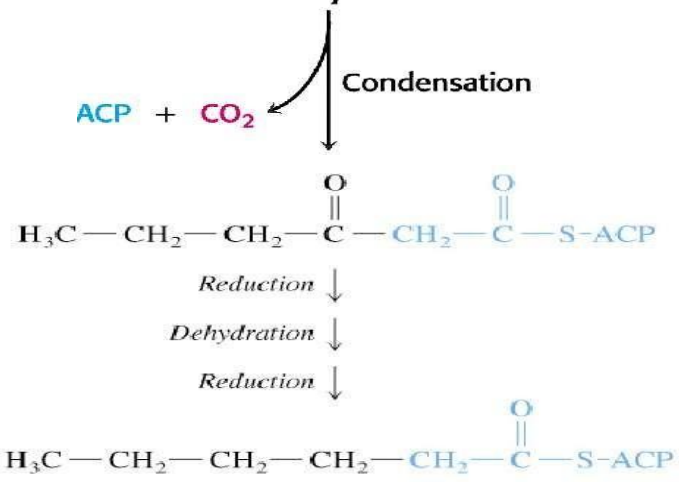


In the second round butyryl ACP condenses with malonyl ACP to form a C_6-β-ketoacyl ACP.





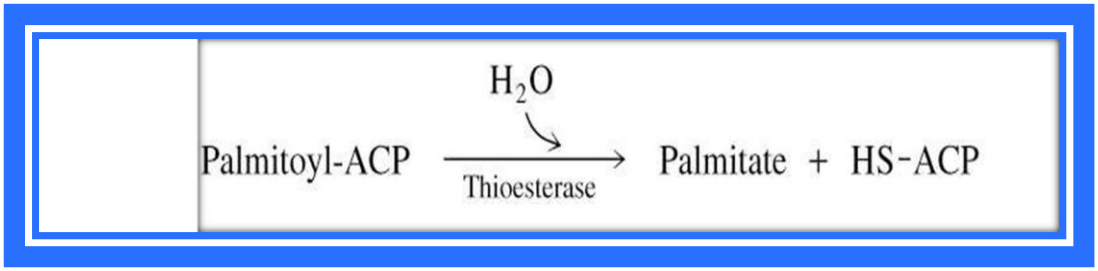
Reduction, dehydration, and a second reduction convert the C_6-β-ketoacyl ACP into a C_6-acyl ACP, which is ready for a third round of elongation.



Termination

- Rounds of synthesis continue until a C_{16} palmitoyl group is formed

- Palmitoyl-ACP is hydrolyzed by a ***thioesterase***



Net Production

- **Net reaction-**

$$8\,\text{acetyl-CoA} + 14\,\text{NADPH} + 7\,\text{ATP} \rightarrow \text{palmitate} + 14\,\text{NADP}^+ + 8\,\text{CoA} + 7\,\text{ADP} + 7\,\text{P}_i$$

- **Over all Net Reaction-**

$$\text{acetyl-CoA} + 7\,\text{malonyl-CoA} + 14\,\text{NADPH} \rightarrow \text{palmitate} + 7\,\text{CO}_2 + 14\,\text{NADP}^+ + 8\,\text{CoA}$$

Regulation

Acetyl CoA carboxylase- rate limiting step

In vertebrate

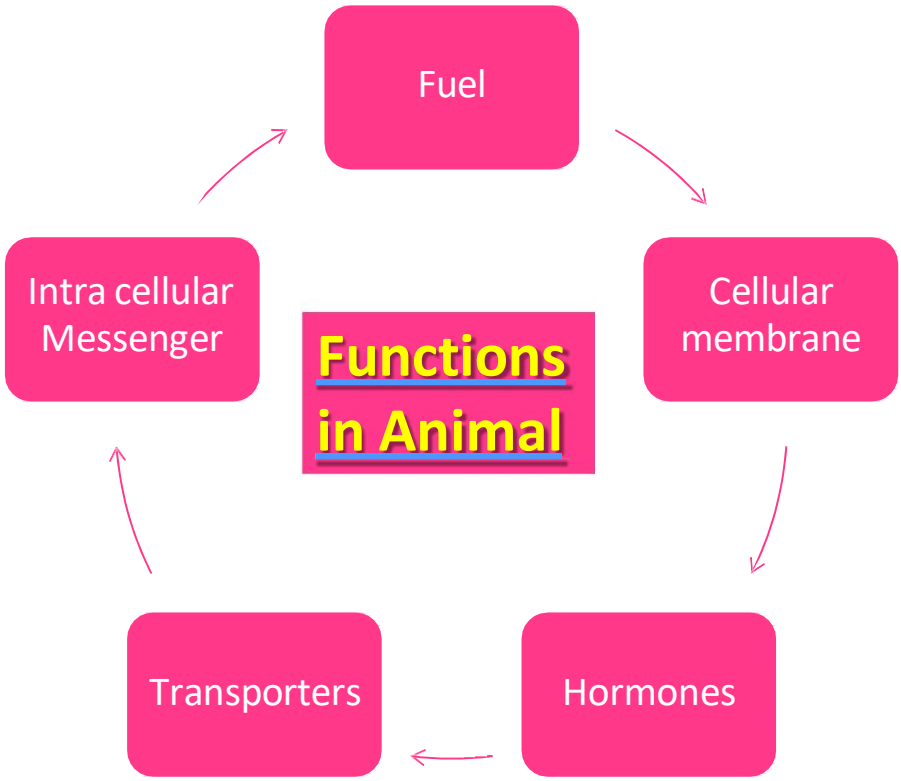
- ✓ Feedback inhibitor- palmitate
- ✓ Allosteric activator- citrate
- ✓ Covalent modification- glucagon & epinephrine

In plants

- ✓ Not citrate
- ✓ Not Hormonal
- ✓ pH
- ✓ [Mg+]
- ✓ At gene level

Difference

Difference	Biosynthesis	oxidation
Location	Chloroplast	Peroxisome
Carrier	Acyl carrier protien	CoA
Isomer	D	L
Activation of Co_2	Require	Not
Carbon chain	Add 2 Carbon	Remove 2 Carbon
NADH	Require	Generate
Enzyme	Multi complex	Independent



Functions in Plants

- Photosyntthesis- eg.Chlorophyll
- Electrone transport chain- eg.ubiquinone
- Photoprotection- eg.Caretenoids
- Coloration- eg.Pigments
- Cellular membrane- eg.Galactolipid
- Transporters
- Communication

Summery

- Fatty acid biosynthesis in plant occure into chloroplast.
- Not reverse as Oxidation process.
- Four steps- condensation, reduction, dehydration and reduction.
- Regulation is different then animals.
- Important role as a structural and biological functions in plants

Reference

- ✓1) Biochemistry- Lehninger
- ✓2)Biochemistry & molecular biology of plants- Buchanan