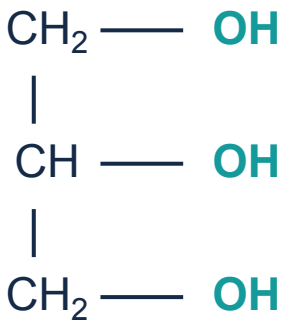
One glycerol, three fatty acids

A triglyceride, also called a triacylglycerol, is a lipid assembled from glycerol and three fatty acids. It is not a polymer of many repeating monomers.

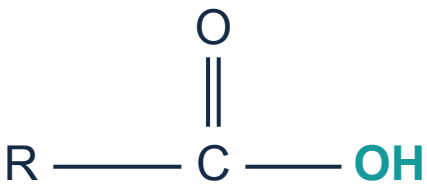
THE STARTING MOLECULES

GLYCEROL



three hydroxyl groups

A FATTY ACID



R = hydrocarbon chain

C(=O)OH = carboxyl group

1. GLYCEROL PROVIDES THREE ATTACHMENT SITES

Glycerol is a three-carbon alcohol with three hydroxyl (-OH) groups, one on each carbon. Each hydroxyl group can react with the carboxyl group of a fatty acid.

2. FATTY ACIDS PROVIDE THE HYDROCARBON CHAINS

A fatty acid contains a carboxyl (-COOH) group attached to a hydrocarbon chain. Chain lengths can differ, and carbon-carbon double bonds may be present. The three fatty acids in a triglyceride need not be identical.

Count the ingredients carefully: one glycerol + three fatty acids. Glycerol is not itself a fatty acid, and a triglyceride is not made from glucose or amino acids.

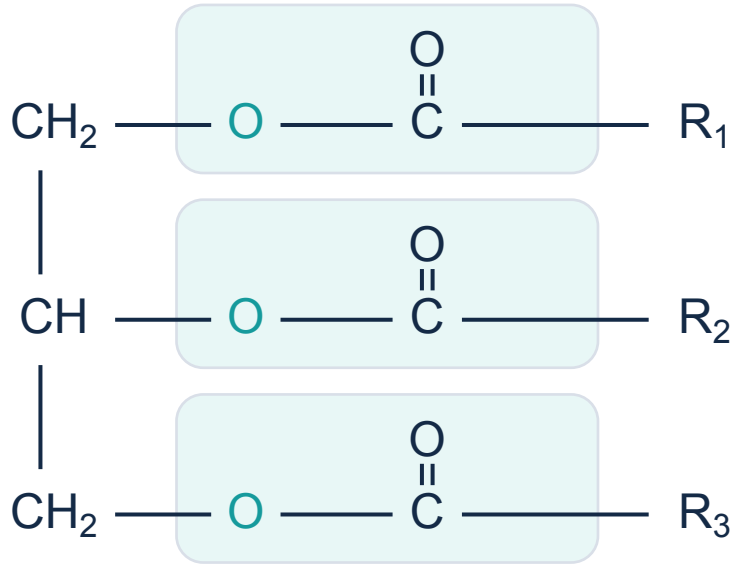
Supporting reading: OpenStax Biology 2e, 3.3 Lipids.

Scope: Cambridge Biology 9700 syllabus, section 2.2, outcome 9, p. 18.

Three ester links, three waters

The net condensation reaction joins each glycerol hydroxyl group to a fatty acid carboxyl group. One molecule of water is released for each ester linkage formed.

TRIGLYCERIDE: THE THREE ESTER GROUPS



Shaded region in each row: -O-C(=O)-, an ester group.

R_1, R_2 and R_3 represent hydrocarbon chains. The vertical three-carbon skeleton comes from glycerol; each carbonyl group comes from a fatty acid.

glycerol + 3 fatty acids → triglyceride + 3 H_2O

Three ester linkages are formed in the complete net reaction.

TRACK THE ATOMS, NOT JUST THE SHAPES

For each linkage, the fatty acid supplies the OH lost from its carboxyl group and glycerol supplies an H from a hydroxyl group. These form water. The glycerol oxygen remains in the ester. This is a net structural account, not the full cellular synthesis pathway.

Check your drawing: three ester groups, three chains, no free glycerol OH groups left. Complete hydrolysis reverses the net change and uses three waters.

Supporting reading: OpenStax Biology 2e, 3.3 Lipids.

Scope: Cambridge Biology 9700 syllabus, section 2.2, outcome 9, p. 18.

Read the carbon-carbon bonds

Saturation describes the fatty acid hydrocarbon chain. Every fatty acid has a carbonyl C=O bond in its carboxyl group; that bond does not make the chain unsaturated.

SATURATED CHAIN

$$...\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}...$$

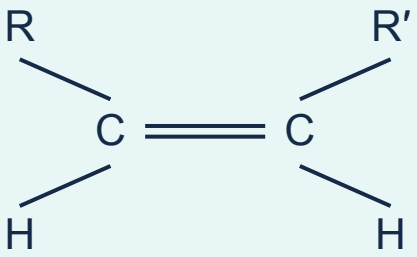
No C=C bonds in the hydrocarbon chain; the carbon skeleton carries the maximum number of hydrogen atoms.

UNSATURATED CHAIN

$$...\text{-}CH_2\text{-}CH{=}CH\text{-}CH_2\text{-}...$$

One C=C bond: monounsaturated. Two or more: polyunsaturated. Each C=C replaces a C-C bond and two attached hydrogen atoms in the corresponding saturated chain.

CIS GEOMETRY AT A DOUBLE BOND



Both H atoms lie on the same side of the C=C. A cis double bond introduces a kink and reduces close packing.

R and R′ are the rest of the chain. Trans geometry does not produce the same kink.

WHY THE WHOLE TRIGLYCERIDE IS HYDROPHOBIC

Long hydrocarbon regions dominate the molecule, so triglycerides are classed as non-polar and do not dissolve readily in water. Ester groups contain polar bonds, but do not give the molecule a large water-attracting head. Do not confuse triglycerides with membrane phospholipids.

Supporting reading: OpenStax Biology 2e, 3.3 Lipids.

Scope: Cambridge Biology 9700 syllabus, section 2.2, outcome 9, p. 18.