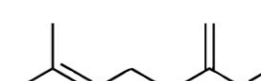
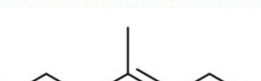
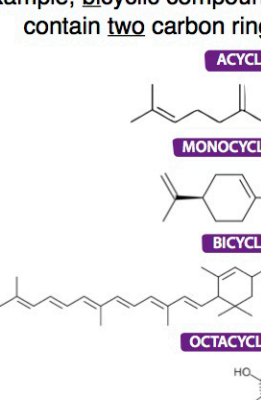
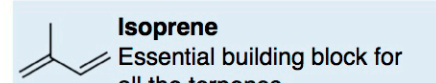
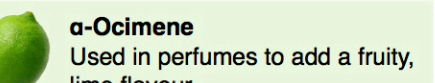
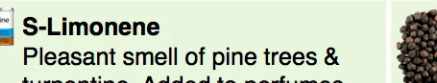
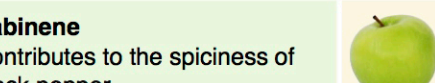
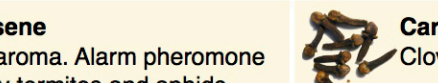

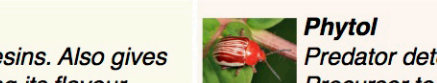

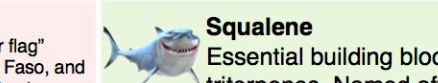
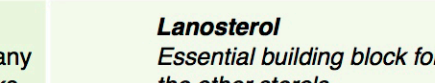
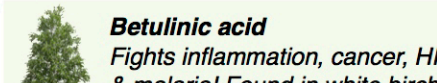
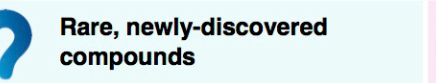
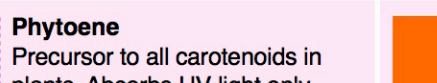
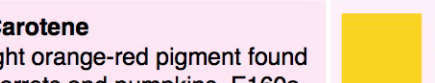
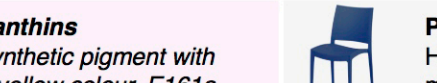
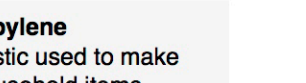


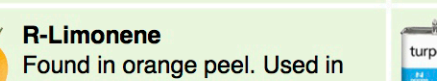
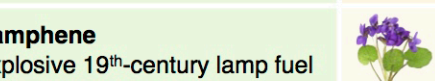
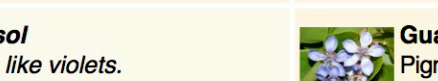
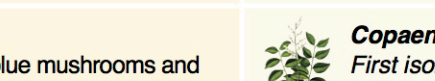


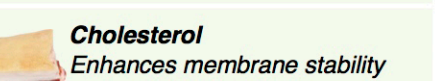
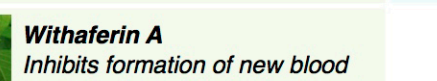
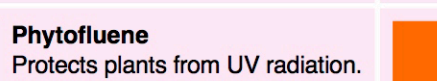
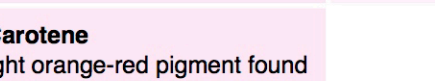

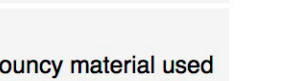
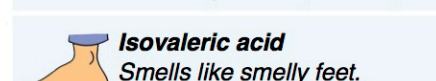
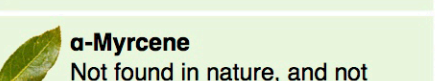
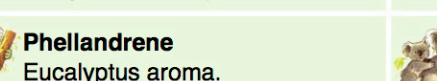
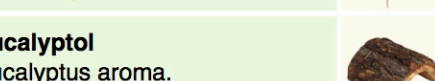
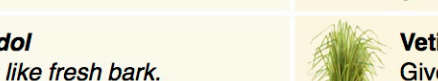



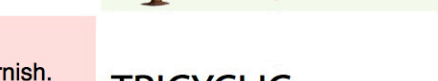
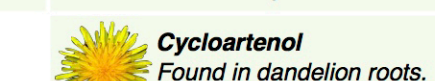
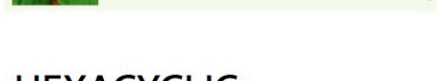

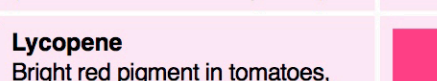
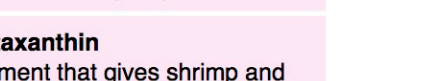

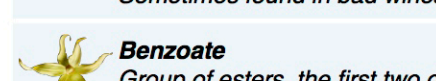
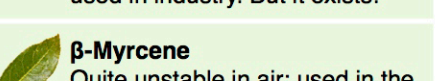

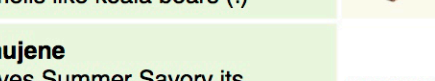
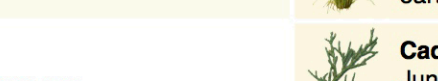




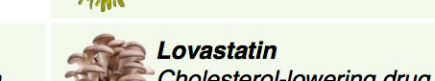
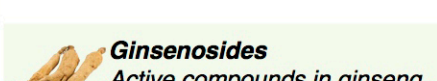

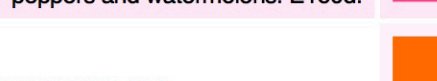
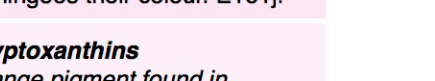

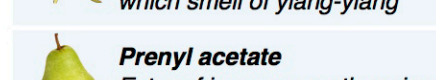
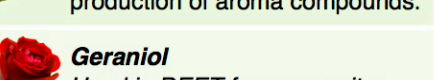
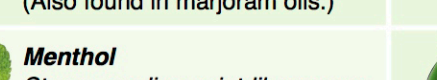

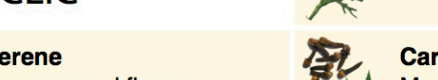
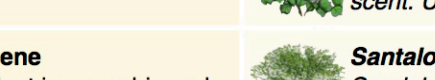



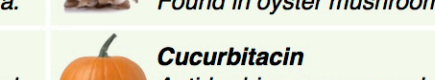
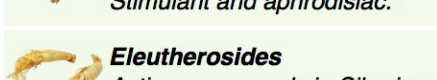

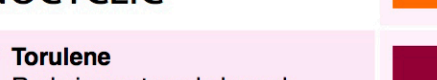
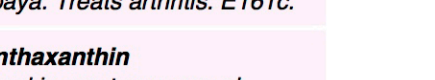



# Meet the Terpenes: a visual introduction from isoprene to latex

Plants\* make all these compounds (and thousands more) from isoprene building blocks.

\*Animals, fungi and algae make some of them, too.

1 isoprene unit	2 isoprene units		3 isoprene units			4 isoprene units	5 isoprene units	6 isoprene units		7 isoprene units	8 isoprene units			many isoprene units			
HEMITERPENES	MONOTERPENES & their SMELLS		SESQUITERPENES & their SMELLS			DITERPENES	SESTERTERPINES	TRITERPENES & their USES		SESQUARTERPENES	TETRATERPENES & their COLOURS			POLYTERPENES			
ACYCLIC	ACYCLIC	MONOCYCLIC	BICYCLIC	ACYCLIC	BICYCLIC	TRICYCLIC	ACYCLIC	TETRACYCLIC	ACYCLIC	TETRACYCLIC	PENTACYCLIC	PENTACYCLIC	ACYCLIC	BICYCLIC	TRICYCLIC	ACYCLIC	
<p><b>Terpenes</b> Are made from isoprene units (see right). Isoprene units can be pieced together in different combinations to produce thousands of terpene compounds. Terpenes contain only C and H atoms, and are written here in normal text.</p> 	<p><b>Terpenoids</b> Are terpenes that have been modified by the addition of extra atoms (usually oxygen) and are written here in italic text.</p> 		<p><b>Cyclisation</b> Forming carbon rings within terpenes (and terpenoids) gives them huge structural diversity. For example, bicyclic compounds contain two carbon rings.</p> 			<p>Now, let's start with isoprene!</p>											
<p><b>Isoprene</b> Essential building block for all the terpenes.</p> 	<p><b>α-Ocimene</b> Used in perfumes to add a fruity, lime flavour.</p> 	<p><b>S-Limonene</b> Pleasant smell of pine trees &amp; turpentine. Added to perfumes.</p> 	<p><b>Sabinene</b> Contributes to the spiciness of black pepper.</p> 	<p><b>Farnesene</b> Apple aroma. Alarm pheromone used by termites and aphids.</p> 	<p><b>Caryophyllene</b> Clove aroma, clove flavour.</p> 	<p><b>Longifolene</b> Found in pine resins. Also gives lapsing souchong its flavour.</p> 	<p><b>Phytol</b> Predator deterrent for insects. Precursor to vitamins E and K.</p> 	<p><b>Geranylarnesol</b> Found in Central African "alligator flag" trees, which are eaten in Burkina Faso, and are used elsewhere to make packaging.</p> 	<p><b>Squalene</b> Essential building block for many triterpenes. Named after sharks.</p> 	<p><b>Lanosterol</b> Essential building block for all the other sterols.</p> 	<p><b>Betulinic acid</b> Fights inflammation, cancer, HIV &amp; malaria! Found in white birch.</p> 	<p><b>?</b> Rare, newly-discovered compounds</p>	<p><b>Phytoene</b> Precursor to all carotenoids in plants. Absorbs UV light only.</p> 	<p><b>α-Carotene</b> Bright orange-red pigment found in carrots and pumpkins. E160a.</p> 	<p><b>β-Carotene</b> Bright orange-red pigment found in carrots and pumpkins. E160a.</p> 	<p><b>Flavoxanthins</b> Photosynthetic pigment with golden-yellow colour. E161a.</p> 	<p><b>Polypropylene</b> Hard plastic used to make many household items.</p>
<p><b>Prenol</b> Essential building block for many of the terpenoids (in italics)</p> 	<p><b>β-Ocimene</b> Used in perfumes to add a fruity, lime flavour.</p> 	<p><b>R-Limonene</b> Found in orange peel. Used in many household products.</p> 	<p><b>Camphene</b> Explosive 19<sup>th</sup>-century lamp fuel with a turpentine smell.</p> 	<p><b>Farnesol</b> Smells like violets. Kills mites.</p> 	<p><b>Guaio</b> Pigment in blue mushrooms and guaiacum flowers. Rose-like smell.</p> 	<p><b>Copaene</b> First isolated in Copaiba trees. Attracts Mediterranean fruit flies.</p> 	<p><b>MONOCYCLIC</b></p>	<p><b>PENTACYCLIC</b></p>	<p><b>Sapelenins</b> Group of compounds found in the tropical African Sapele tree.</p> 	<p><b>Cholesterol</b> Enhances membrane stability and mobility in animals.</p> 	<p><b>Withaferin A</b> Inhibits formation of new blood vessels. Found in winter cherry.</p> 	<p><b>?</b></p>	<p><b>Phytofluene</b> Protects plants from UV radiation. (Natural sunscreen for plants.)</p> 	<p><b>β-Carotene</b> Bright orange-red pigment found in carrots and pumpkins. E160a.</p> 	<p><b>Astaxanthin</b> Pigment that gives shrimp and flamingoes their colour. E161j.</p> 	<p><b>Rubber</b> Strong, bouncy material used in tyres and conveyor belts.</p> 	
<p><b>Isovaleric acid</b> Smells like smelly feet. Sometimes found in bad wines.</p> 	<p><b>α-Myrcene</b> Not found in nature, and not used in industry. But it exists!</p> 	<p><b>Phellandrene</b> Eucalyptus aroma. Smells like koala bears (!)</p> 	<p><b>Eucalyptol</b> Eucalyptus aroma. Smells like koala bears (!)</p> 	<p><b>Nerolidol</b> Smells like fresh bark.</p> 	<p><b>Vetivazulene</b> Gives South Indian vetiver its earthy smell. Soothes &amp; relaxes.</p> 	<p><b>Patchoulol</b> Gives patchouli its characteristic scent. Used widely in perfumes.</p> 	<p><b>Cembrene A</b> Colourless oil with a waxy odour. Also a termite "trail" pheromone.</p> 	<p><b>Amyrin</b> Resin used in ink and varnish. Also a herbal bronchitis remedy.</p> 	<p><b>TRICYCLIC</b></p>	<p><b>Cycloartenol</b> Found in dandelion roots.</p> 	<p><b>Hexacosanol</b> Cholesterol-lowering drug. Found in oyster mushrooms.</p> 	<p><b>Ginsenosides</b> Active compounds in ginseng. Stimulant and aphrodisiac.</p> 	<p><b>Lycopene</b> Bright red pigment in tomatoes, peppers and watermelons. E160d.</p> 	<p><b>Astaxanthin</b> Pigment that gives shrimp and flamingoes their colour. E161j.</p> 	<p><b>Latex</b> Used to make tight clothing such as laboratory gloves.</p> 		
<p><b>Benzoate</b> Group of esters, the first two of which smell of ylang-ylang</p> 	<p><b>β-Myrcene</b> Quite unstable in air; used in the production of aroma compounds.</p> 	<p><b>α-Terpinene</b> Cardamom aroma. (Also found in marjoram oils.)</p> 	<p><b>Thujene</b> Gives Summer Savory its pungent flavour.</p> 	<p><b>MONOCYCLIC</b></p>	<p><b>Cadinene</b> Juniper aroma.</p> 	<p><b>Norpatchoulol</b> Gives patchouli its characteristic scent. Used widely in perfumes.</p> 	<p><b>Retinol (Vitamin A)</b> Gives patchouli its characteristic scent. Works wonders on skin.</p> 	<p><b>Retinal (Vitamin A aldehyde)</b> Detects light in the eyes and allows us to see in colour.</p> 	<p><b>TANGSHENOSIDE I</b> Active ingredient in Dangshen. Boosts energy. Treats anorexia.</p> 	<p><b>Lovastatin</b> Cholesterol-lowering drug. Found in oyster mushrooms.</p> 	<p><b>Eleutherosides</b> Active compounds in Siberian ginseng. Stimulant.</p> 	<p><b>Torulene</b> Red pigment made by red mushrooms and red pea aphids.</p> 	<p><b>γ-Carotene</b> Bright orange-red pigment totally useless to carnivores.</p> 	<p><b>Canthaxanthin</b> Found in crustaceans and tanning pills. Dark red. E161g.</p> 	<p><b>Cryptoxanthins</b> Orange pigment found in papaya. Treats arthritis. E161c.</p> 		
<p><b>Prenyl acetate</b> Ester of isoprene + ethanoic acid Smells fruity, like a pear</p> 	<p><b>Geraniol</b> Used in DEET-free mosquito repellent products.</p> 	<p><b>Menthol</b> Strong, cooling, mint-like aroma. Very mildly anaesthetic.</p> 	<p><b>Thujone</b> Smells like menthol. Found in cypress trees and in absinthe (the alcoholic drink). Causes muscle spasms and convulsions.</p> 	<p><b>Zingiberene</b> Ginger aroma and flavour.</p> 	<p><b>Humulene</b> Smells like menthol. Found in cypress trees and in absinthe (the alcoholic drink). Causes muscle spasms and convulsions.</p> 	<p><b>Cuparane</b> Gives Japanese liverwort its characteristic aroma.</p> 	<p><b>Labdane</b> Has antibacterial, anti-fungal and anti-inflammatory properties.</p> 	<p><b>Abietic acid</b> Irritant in pine resin. Rubbed on musical instrument bows for grip.</p> 	<p><b>TRICYCLIC</b></p>	<p><b>20-Hydroxyecdysone</b> Arthropod moulting hormone that bodybuilders use as a steroid.</p> 	<p><b>Campesterol</b> Lowers cholesterol but also lowers vitamin E levels.</p> 	<p><b>Astragalosides</b> Protects cardiovascular, immune &amp; digestive systems. Found in 黄芪.</p> 	<p><b>γ-Carotene</b> Temporary intermediate in plants between lycopene &amp; α-carotene.</p> 	<p><b>Violaxanthin</b> Used by plants to protect against excessive light. E161e.</p> 	<p><b>Antheraxanthin</b> Yellow pigment first extracted from Euglenozoa protozoa.</p> 		
<p><b>ACYCLIC</b></p>	<p><b>MONOCYCLIC</b></p>	<p><b>BICYCLIC</b></p>	<p><b>TRICYCLIC</b></p>	<p><b>TETRACYCLIC</b></p>	<p><b>PENTACYCLIC</b></p>	<p><b>TRICYCLIC</b></p>	<p><b>BICYCLIC</b></p>	<p><b>TRICYCLIC</b></p>	<p><b>TRICYCLIC</b></p>	<p><b>TETRACYCLIC</b></p>	<p><b>PENTACYCLIC</b></p>	<p><b>HEPTACYCLIC</b></p>	<p><b>HEPTACYCLIC</b></p>	<p><b>OCTACYCLIC</b></p>	<p><b>OCTACYCLIC</b></p>	<p><b>OCTACYCLIC</b></p>	
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