

Meet the Terpenes: a visual intro

Plants* make all these compounds (and thousands more)

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

1 isoprene unit

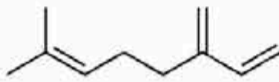
2 isoprene units

HEMITERPENES

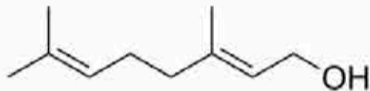
MONOTERPENES & DI

KEY

Terpenes
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.



Terpenoids
Are terpenes that have been modified by the addition of extra atoms (usually oxygen) and are written here in italic text.



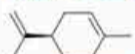
Cyclisation

Forming carbon rings within terpenes (and terpenoids) gives them huge structural diversity. For example, bicyclic compounds contain two carbon rings.

ACYCLIC



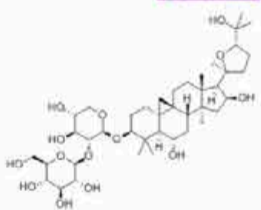
MONOCYCLIC



BICYCLIC



OCTACYCLIC



Now, let's start with isoprene!

ACYCLIC

Isoprene
Essential building block for all the terpenes.

Prenol
Essential building block for many of the terpenoids (in italics)

Isovaleric acid
Smells like smelly feet. Sometimes found in bad wines.

Benzoate
Group of esters, the first two of which smell of ylang-ylang

Prenyl acetate
Ester of isoprene + ethanoic acid Smells fruity, like a pear

ACYCLIC

α-Ocimene
Used in perfumes to add a fruity, lime flavour.

β-Ocimene
Used in perfumes to add a fruity, lime flavour.

α-Myrcene
Not found in nature, and not used in industry. But it exists!

β-Myrcene
Quite unstable in air; used in the production of aroma compounds.

Geraniol
Used in DEET-free mosquito repellent products.

Citronellal
Found in lemon-scented gum & kaffir limes. Repels mosquitoes.

Citronellol
Found in lemongrass. Repels mosquitoes and attracts mites.

Linalool
Group of compounds produced by the mint family (and citruses)

Citral A
Found in Australian lemon myrtle. Used in cosmetics.

Halomon
Produced by red algae. Might be a good anti-cancer drug.

MONOCYCLIC

S-Limonene
Pleasant smell of turpentine. Added to...

R-Limonene
Found in oranges and many household...

Phellandrene
Eucalyptus aroma. Smells like koala...

α-Terpinene
Cardamom aroma. (Also found in m...

Menthol
Strong, cooling, Very mildly anaes...

S-Carvone
Caraway aroma. Chiral enantiom...

R-Carvone
Spearmint aroma. Chiral enantiom...

Safranal
Saffron aroma. Anti-depressant...

Terpineol
Pure pine aroma. souchong tea its...

Thymol
Thyme aroma. Kills fungi.

Carvacrol
Oregano aroma. Pungent taste; k...

Umbellulone
Causes headaches by Californian "f...

Piperitone
Peppermint aroma. converted easily...

Pulegone
Found in pennyroyal spearmint. Caus...

Rose oxide
Typical rose aroma. roses and Germ...

Lactisole
Inhibits sweet taste from Arabica co...

Terpene introduction from isoprene to latex

(and thousands more) from isoprene building blocks.

2 isoprene units

3 isoprene units

MONOTERPENES & their SMELLS


SESQUITERPENES & the


MONOCYCLIC


BICYCLIC


ACYCLIC

BICYCLIC


 **S-Limonene**
Pleasant smell of pine trees & turpentine. Added to perfumes.


 **Sabinene**
Contributes to the spiciness of black pepper.


 **Farnesene**
Apple aroma. Alarm pheromone used by termites and aphids.


 **Caryophyllene**
Clove aroma, clove flavour.

 **R-Limonene**
Found in orange peel. Used in many household products.


 **Camphene**
Explosive 19th-century lamp fuel with a turpentine smell.


 **Farnesol**
Smells like violets. Kills mites.


 **Guaiol**
Pigment in blue mushroom, guaiacum flowers. Rose-like.

 **Phellandrene**
Eucalyptus aroma. Smells like koala bears (!)

 **Eucalyptol**
Eucalyptus aroma. Smells like koala bears (!)


 **Nerolidol**
Smells like fresh bark.


 **Vetivazulene**
Gives South Indian vetiver its earthy smell. Soothes & calms.


 **alpha-Terpinene**
Cardamom aroma. (Also found in marjoram oils.)


 **Thujene**
Gives Summer Savory its pungent flavour.


MONOCYCLIC


 **Cadinene**
Juniper aroma.


 **Menthol**
Strong, cooling, mint-like aroma. Very mildly anaesthetic.


 **Thujone**
Smells like menthol. Found in cypress trees and in absinthe (the alcoholic drink). Causes muscle spasms and convulsions.


 **Zingiberene**
Ginger aroma and flavour.


 **Caryophyllene**
Most abundant in cannabinoids. Found in West African pepper. Eucalyptus-like.


 **S-Carvone**
Caraway aroma. Chiral enantiomer.

 **Pinene**
Bronchodilator, anti-inflammatory, and broad-spectrum antibiotic.


 **Humulene**
Hops aroma. Gives beer its "hoppy" taste.


 **Cuparane**
Gives Japanese liverwort its characteristic aroma.


 **R-Carvone**
Spearmint aroma. Chiral enantiomer.


 **Nepetalactone**
Active ingredient in catnip. Gets cats extremely high.


 **Bisabolane**
Fragrant. Currently being tested as an alternative to diesel.


 **Laurane**
Found in marine red algae.


 **Safranal**
Saffron aroma. Anti-depressant and anti-oxidant.


 **Ascaridole**
Poisonous, explosive compound with a funny-looking structure.


 **Bisabolene**
Balsamic aroma.


 **Oppositane**
Found in the Zimbabwean evergreen tree, Teclea nana.


 **Terpineol**
Pure pine aroma. Gives lapsang souchong tea its distinctive taste.

 **Borneol**
Active ingredient in Chinese moxibustion therapy: 冰片.


 **Elemol**
Gives Filipino "pili tree" resin its spicy-citrus aroma.


 **Mutislanthol**
Moderate anti-tumor activity. Found in Mutisia flowers.


 **Thymol**
Thyme aroma. Kills fungi.

 **Verbenone**
Spanish verbena aroma. Signature fragrance of L'Occitane.


 **Limonene**
Common terpene found in citrus fruits.


 **Thapsane**
Active ingredient in "villainous" deadly carrot. Makes you see things.


 **Carvacrol**
Oregano aroma. Pungent taste; kills bacteria.

 **Camphor**
Camphor laurel tree aroma. Repels insects and is used in sweets.


 **Limonene**
Common terpene found in citrus fruits.


 **Lepidozanes**
Group of compounds found in liverworts.

 **Umbellulone**
Causes headaches. Produced by Californian "headache trees".

 **Ethyl fenchol**
Smells pleasant, like damp soil. Made by Actinobacteria in lakes.


 **Limonene**
Common terpene found in citrus fruits.


 **Chiloscyphane**
Group of compounds found in liverworts.


 **Piperitone**
Peppermint aroma. Can be converted easily into menthol.

TRICYCLIC


 **Limonene**
Common terpene found in citrus fruits.


 **Pinguisanes**
Group of compounds found in liverworts.

 **Pulegone**
Found in pennyroyal. Smells like spearmint. Causes abortions.


 **Cyclosantene**
Rare. Has a musty odour.


 **Limonene**
Common terpene found in citrus fruits.

 **Herbertanes**
Group of compounds found in liverworts.


 **Rose oxide**
Typical rose aroma found in roses and German wine grapes.

 **Limonene**
Common terpene found in citrus fruits.

 **Botrydial**
Toxic to plants. Produced by Botrytis cinerea fungus.

 **Lactisole**
Inhibits sweet tastes! Extracted from Arabica coffee beans.

 **Limonene**
Common terpene found in citrus fruits.

 **Ngaione**
Toxin produced by New Zealand Ngaio trees.

Smells are pictured

3 isoprene units

4 isoprene units

5 isoprene units

TRITERPENES & their SMELLS

DITERPENES


SESTERTERPENES


BICYCLIC


TRICYCLIC


ACYCLIC


TETRACYCLIC


 **Caryophyllene**
Clove aroma, clove flavour.

 **Longifolene**
Found in pine resins. Also gives lapsang souchong its flavour.

 **Phytol**
Predator deterrent for insects.
Precursor to vitamins E and K1.


 **Geranylarnesol**
Found in Central African "alligator trees", which are eaten in Burkina Faso. Also used elsewhere to make perfume.


 **Guaiaol**
Pigment in blue mushrooms and guaiacum flowers. Rose-like smell.


 **Copaene**
First isolated in Copaiba trees. Attracts Mediterranean fruit flies.


MONOCYCLIC

PENTACYCLIC


 **Vetivazulene**
Gives South Indian vetiver its earthy smell. Soothes & relaxes.


 **Patchoulol**
Gives patchouli its characteristic scent. Used widely in perfumes.

 **Cembrene A**
Colourless oil with a waxy odour. Also a termite "trail" pheromone.


 **Amyrin**
Resin used in ink and varnish. Also a herbal bronchitis treatment.


 **Cadinene**
Juniper aroma.

 **Norpatchoulol**
Gives patchouli its characteristic scent. Used widely in perfumes.

 **Retinol (Vitamin A)**
Helps with night vision. Works wonders on skin.

 **Caryophyllene**
Most abundant in cannabis and in West African pepper. Earthy.


 **Santalol** 🎅
Sandalwood aroma. Used in Hindu, Buddhist & Muslim rituals.


 **Retinal (Vitamin A aldehyde)**
Detects light in the eyes and allows us to see in colour.


 **Cuparane**
Gives Japanese liverwort its characteristic aroma.


TETRACYCLIC


BICYCLIC

 **Laurane**
Found in marine red algae.

 **Cortisol**
Human stress hormone. Increases blood sugar levels.


 **Labdane**
Has antibacterial, anti-fungal and anti-inflammatory properties.


 **Oppositane**
Found in the Zimbabwean evergreen tree, *Teclea nobilis*.


 **Progesterone**
Prepares the female reproductive system for pregnancy.


TRICYCLIC


 **Mutisianthol**
Moderate anti-tumor activity. Found in *Mutisia* flowers.


 **Oestrogen**
Promotes female secondary characteristics (like breasts).

 **Abietic acid**
Irritant in pine resin. Rubbed on musical instrument bows for grip.


 **Thapsane**
Active ingredient in "villous deadly carrot". Makes you sick.


 **Testosterone**
Increases muscle and bone mass. Increases body hair growth.


 **Ferruginol**
Tumor-suppressant extracted from needles of redwood trees.


 **Lepidozanes**
Group of compounds found in liverworts.

 **11-Ketotestosterone**
Testosterone for fish.


 **Tetrahydrocannabinol, Δ⁹-THC**
Active ingredient in cannabis. Relaxes; relieves pain & anxiety.


 **Chiloscyphane**
Group of compounds found in liverworts.


 **Forskolin**
Weight-loss aid extracted from Indian *Coleus* trees.


 **Pinguisanes**
Group of compounds found in liverworts.


PENTACYCLIC

 **Herbertanes**
Group of compounds found in liverworts.

 **Cafestol**
Found in coffee. Protects against cancer and Parkinson's Disease.

 **Botrydial**
Toxic to plants. Produced by *Botrytis cinerea* fungus.

 **Gibberellins**
Important plant hormones that influence growth & development.

 **Ngaione**
Toxin produced by New Zealand *Ngaio* trees.

5 isoprene units

6 isoprene units

SESTERTERPINES


TRITERPENES & their USES


TETRACYCLIC

ACYCLIC


TETRACYCLIC

PENTACYCLIC

 **Geranyl farnesol**
Found in Central African "alligator flag" trees, which are eaten in Burkina Faso, and are used elsewhere to make packaging.

 **Squalene**
Essential building block for many triterpenes. Named after sharks.


Lanosterol
Essential building block for all the other sterols.


 **Betulinic acid**
Fights inflammation, cancer & malaria! Found in white birch bark.

PENTACYCLIC


 **Sapelenins**
Group of compounds found in the tropical African Sapele tree.

 **Cholesterol**
Enhances membrane stability and mobility in animals.


 **Withaferin A**
Inhibits formation of new blood vessels. Found in winter cherry.


 **Amyrin**
Resin used in ink and varnish. Also a herbal bronchitis remedy.


TRICYCLIC


 **Cycloartenol**
Found in dandelion roots.


HEXACYCLIC


 **Tangshenoside I**
Active ingredient in Dangshen. Boosts energy. Treats anorexia.


 **Lovastatin**
Cholesterol-lowering drug. Found in oyster mushrooms.


 **Ginsenosides**
Active compounds in ginseng. Stimulant and aphrodisiac.

 **Cholecalciferol**
Vitamin D₃. Enhances intestinal absorption of Ca²⁺ and PO₄³⁻.


 **Cucurbitacin**
Anti-herbivory compound produced by pumpkins & friends.


 **Eleutherosides**
Active compounds in Siberian ginseng. Stimulant.


 **Dihydrotachysterol**
Synthetic vitamin D analogue.


 **20-Hydroxyecdysone**
Arthropod moulting hormone that bodybuilders use as a steroid.


HEPTACYCLIC

 **Campesterol**
Lowers cholesterol but also lowers vitamin E levels.


 **Astragalosides**
Protects cardiovascular, immune & digestive systems. Found in astragalus.


 **Stigmasterol**
Cholesterol-like plant compound easily converted into steroids.


 **Bacoside A**
Active ingredient in Indian ginseng. Has neuroprotective effects.


 **Ergosterol**
Provitamin D₂ found in Claviceps fungi, rye and alfalfa.

OCTACYCLIC

 **Bile acids**
Group of compounds that promote digestion of dietary fats.

 **Araloside A**
Anti-ulcer agent found in Japanese angelica trees.

 **Ziziphin**
Inhibits sweet tastes & soothes sore throats. Found in 红枣 (jujube).

 **Gymnemic acids**
Inhibits sweet taste. Makes syrups taste like water! Found in gymnema.

7 isoprene units

8 isoprene units

SESQUITERPENES SESQUARTERPENES TETRATERPENES & their derivatives

PENTACYCLIC

PENTACYCLIC

ACYCLIC

BICYCLIC



Betulinic acid
Fights inflammation, cancer, HIV & malaria! Found in white birch.



Rare, newly-discovered compounds



Phytoene
Precursor to all carotenoids in plants. Absorbs UV light only.



α-Carotene
Bright orange-red pigment found in carrots and pumpkins.



Withaferin A
Inhibits formation of new blood vessels. Found in winter cherry.



Phytofluene
Protects plants from UV radiation. (Natural sunscreen for plants.)



β-Carotene
Bright orange-red pigment found in carrots and pumpkins.

HEXACYCLIC



Lycopene
Bright red pigment in tomatoes, peppers and watermelons. E160d.



Astaxanthin
Pigment that gives shrimp and flamingoes their colour.



Ginsenosides
Active compounds in ginseng. Stimulant and aphrodisiac.

MONOCYCLIC



Cryptoxanthins
Orange pigment found in papaya. Treats arthritis.



Eleutherosides
Active compounds in Siberian ginseng. Stimulant.



Torulene
Red pigment made by red mushrooms and red pea aphids.



Canthaxanthin
Found in crustaceans and tanning pills. Dark red.

HEPTACYCLIC



γ-Carotene
Bright orange-red pigment totally useless to carnivores.



Violaxanthin
Used by plants to protect themselves from excessive light. E161e.



Astragalosides
Protects cardiovascular, immune & digestive systems. Found in 黄芪.



δ-Carotene
Temporary intermediate in plants between lycopene & α-carotene.



Antheraxanthin
Yellow pigment first extracted from Euglenozoa protozoa.



Bacoside A
Active ingredient in Indian brahmi plants. Has neuroprotective activity.



Citranaxanthin
Violet plant pigment. Makes chicken fat more yellow. E161i.



Zeaxanthin
Gives egg yolks their yellow colour. E161h.

OCTACYCLIC



Rubixanthin
Orange-red pigment found in rose hips. E161d.



Lutein
Gives chicken skin its yellow colour. Good for eyes. E161j.



Araloside A
Anti-ulcer agent found in Japanese angelica trees.



Diadinoxanthin
Used by algae to protect themselves from excessive light.



Ziziphin
Inhibits sweet tastes & soothes throats. Found in 红枣 (jujube).



Diatoxanthin
Used by algae to protect themselves from excessive light.



Gymnemic acids
Inhibits sweet. Makes syrup taste like water! Found in gymnema.



Neoxanthin
Yellow pigment found in algae.



Fucoxanthins
Accessory pigment found in brown algae. Olive-green.

8 isoprene units

many isoprene units

TETRATERPENES & their COLOURS

POLYTERPENES

BICYCLIC

TRICYCLIC

ACYCLIC

β-Carotene
Precursor to all carotenoids in plants. Absorbs UV light only.



α-Carotene
Bright orange-red pigment found in carrots and pumpkins. E160a.

Fluorocyclohexene
Protects plants from UV radiation. (Natural sunscreen for plants.)



β-Carotene
Bright orange-red pigment found in carrots and pumpkins. E160a.

Lycopene
Bright red pigment in tomatoes, watermelons and pumpkins. E160d.



Astaxanthin
Pigment that gives shrimp and flamingoes their colour. E161j.

ACYCLIC

β-Carotene
Pigment made by red algae and red pea aphids.



Canthaxanthin
Found in crustaceans and tanning pills. Dark red. E161g.

β-Carotene
Bright orange-red pigment totally essential to carnivores.



Violaxanthin
Used by plants to protect against excessive light. E161e.

β-Carotene
Precursor intermediate in plants between lycopene & α-carotene.



Antheraxanthin
Yellow pigment first extracted from Euglenozoa protozoa.

β-Carotene
Most common plant pigment. Makes egg yolks more yellow. E161i.



Zeaxanthin
Gives egg yolks their yellow colour. E161h.

β-Carotene
Bright orange-red pigment found in pumpkins. E161d.



Lutein
Gives chicken skin its yellowish colour. Good for eyes. E161b.

β-Carotene
Used by algae to protect against excessive light.



Diadinoxanthin
Used by algae to protect against excessive light.

β-Carotene
Used by algae to protect against excessive light.



Diatoxanthin
Used by algae to protect against excessive light.

β-Carotene
Yellow pigment found in spinach.



Neoxanthin
Yellow pigment found in spinach.

β-Carotene
Accessory pigment found in brown algae. Olive-green colour.



Fucoxanthins
Accessory pigment found in brown algae. Olive-green colour.



Flavoxanthins
Photosynthetic pigment with golden-yellow colour. E161a.



Polypropylene
Hard plastic used to make many household items.



Rubber
Strong, bouncy material used in tyres and conveyor belts.



Latex
Used to make tight clothing such as laboratory gloves.



Xanthophyll cycle
Plants constantly alter the concentrations of these compounds to regulate the amount of sunlight they receive: not too much, and not too little.



Xanthophyll cycle
These xanthophylls are mostly found in algae, where they also regulate the amount of sunlight that is received.

Made by James at jameskennedymonash.wordpress.com

Version 1. Visit website for more science posters. Free to use.

Colours are pictured

Materials