The Last Frontier

Odors in the Indoor Environment

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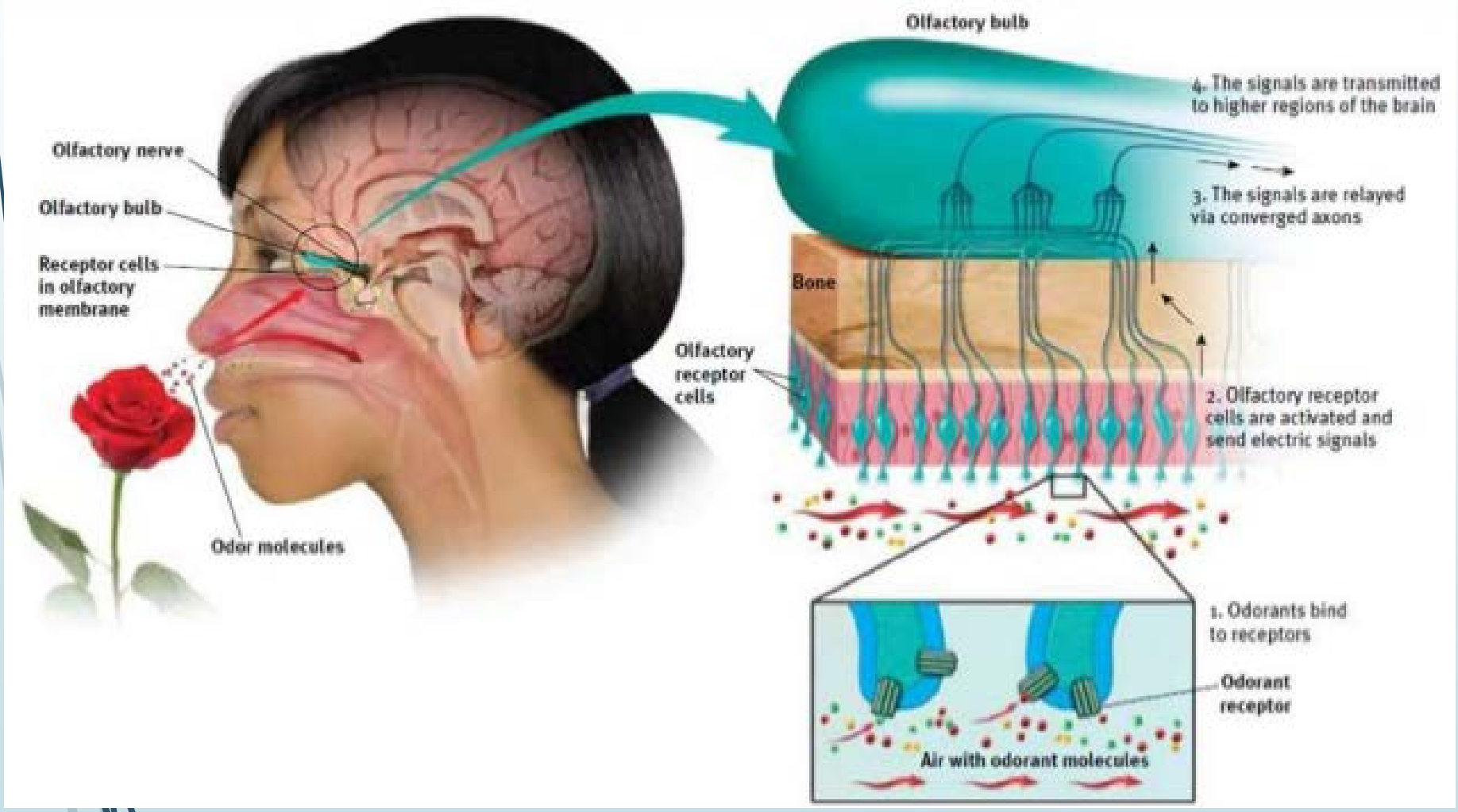
You haven't said what you think of my new perfume.
CARTOONSTOCK .com
Search ID: kmhn469

An Odor Is ...


Olfactory bulb
4. The signals are transmitted to higher regions of the brain
3. The signals are relayed via converged axons
Olfactory nerve
Olfactory bulb
Receptor cells in olfactory membrane
Bone
Olfactory receptor cells
2. Olfactory receptor cells are activated and send electric signals
Odor molecules
1. Odorants bind to receptors
Odorant receptor
Air with odorant molecules

Understand	Explore	Identify
… the basics of volatile organic compounds (VOCs) and odors	… the world of odor characterization	… odor sources based on chemical information

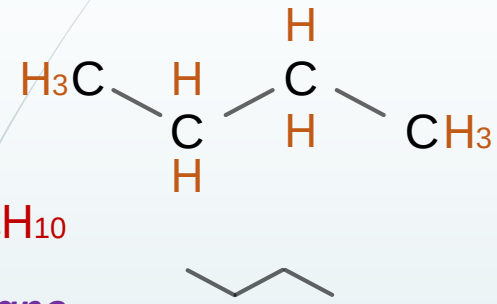
What is a VOC?

Volatile Organic Compounds

- Contains Carbon and Hydrogen
- Size: 6 – 16 Carbons

  OR
- Boiling Point: 50 – 250 °C

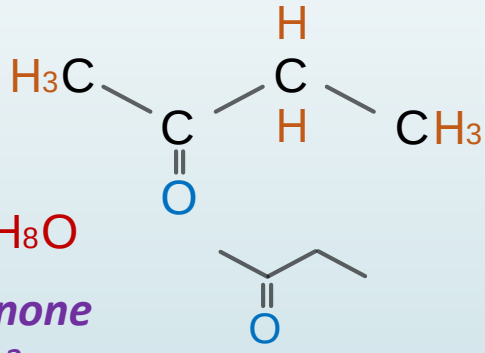
Functional Groups



C_4H_{10}

Butane

Diethyl



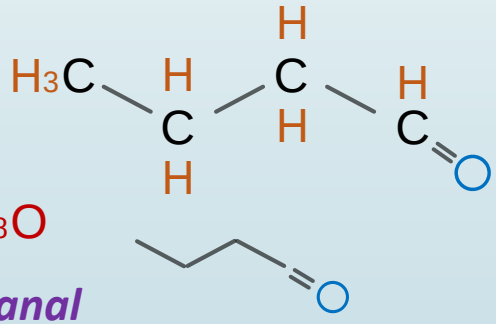
C_4H_8O

Butanone

Butan-2-one

Methyl ethyl ketone (MEK)

Methyl acetone



C_4H_8O

Butanal

Butyraldehyde

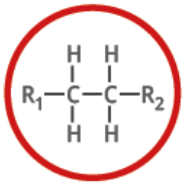
Butaldehyde

n-Butyl aldehyde

FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

FUNCTIONAL GROUPS ARE GROUPS OF ATOMS IN ORGANIC MOLECULES THAT ARE RESPONSIBLE FOR THE CHARACTERISTIC CHEMICAL REACTIONS OF THOSE MOLECULES. IN THE GENERAL FORMULAE SHOWN BELOW FOR EACH FUNCTIONAL GROUP, 'R' REPRESENTS THE REST OF THE MOLECULE, AND 'X' REPRESENTS ANY HALOGEN ATOM.

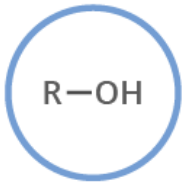
HYDROCARBONS | SIMPLE OXYGEN HETEROATOMICS | HALOGEN HETEROATOMICS | CARBONYL COMPOUNDS | NITROGEN-BASED | SULFUR-BASED | AROMATIC



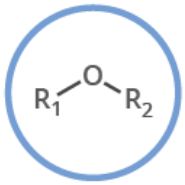
ALKANE
Naming: -ane
e.g. ethane

ALKENE
Naming: -ene
e.g. ethene

ALKYNE
Naming: -yne
e.g. ethyne



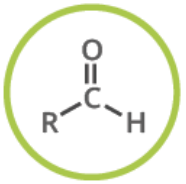
ALCOHOL
Naming: -ol
e.g. ethanol



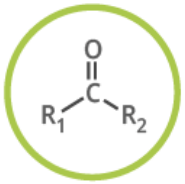
ETHER
Naming: -oxy -ane
e.g. methoxyethane

EPOXIDE
Naming: -ene oxide
e.g. ethene oxide

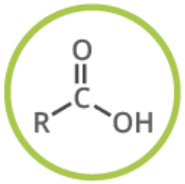
HALOALKANE
Naming: halo-
e.g. chloroethane



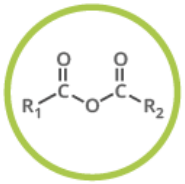
ALDEHYDE
Naming: -al
e.g. ethanal



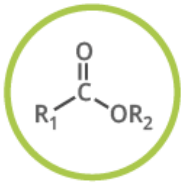
KETONE
Naming: -one
e.g. propanone



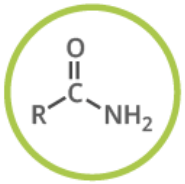
CARBOXYLIC ACID
Naming: -oic acid
e.g. ethanoic acid



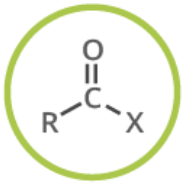
ACID ANHYDRIDE
Naming: -oic anhydride
e.g. ethanoic anhydride



ESTER
Naming: -yl -oate
e.g. ethyl ethanoate



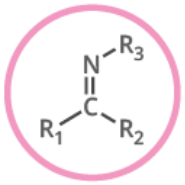
AMIDE
Naming: -amide
e.g. ethanamide



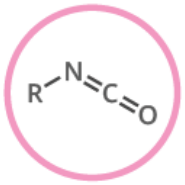
ACYL HALIDE
Naming: -oyl halide
e.g. ethanoyl chloride

AMINE
Naming: -amine
e.g. ethanamine

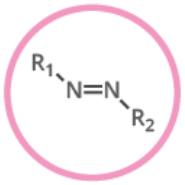
NITRILE
Naming: -nitrile
e.g. ethanenitrile



IMINE
Naming: -imine
e.g. ethanimine

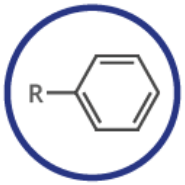


ISOCYANATE
Naming: -yl isocyanate
e.g. ethyl isocyanate



AZO COMPOUND
Naming: azo-
e.g. azoethane

THIOL
Naming: -thiol
e.g. methanethiol



ARENE
Naming: -yl benzene
e.g. ethyl benzene

chocolate
coffee
old
wood
burnt
burning
cocoa
smoke
hot
vanilla
clothes
victorian
cadbury
farm
biscuits
beans
smell
books
garments
socks
ash
moth
incense
musty
latte
work
coal
dusty
sweets
room
for
fire
items
metal
chocolatey
seasoning
sticks
factories
aromatic
clothing
industry
furniture
cream

Odor Sources

Plants

Animals

Furniture

Food

Building Materials

Trash

50% of …

Thresholds

Detection

Detect Odor without characterizing it

Odor

Respond to Odor

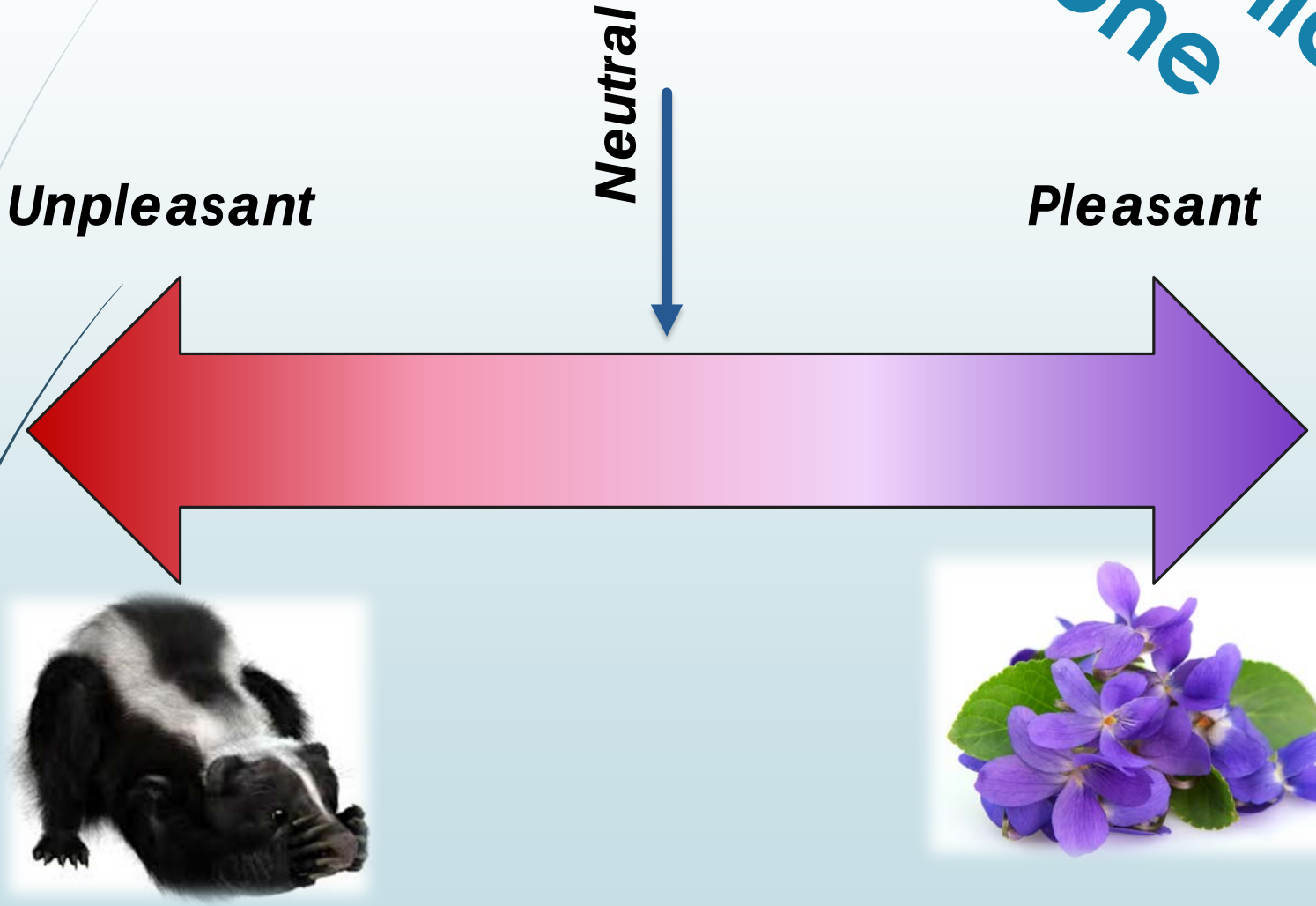
Recognition

Identify Specific Odor

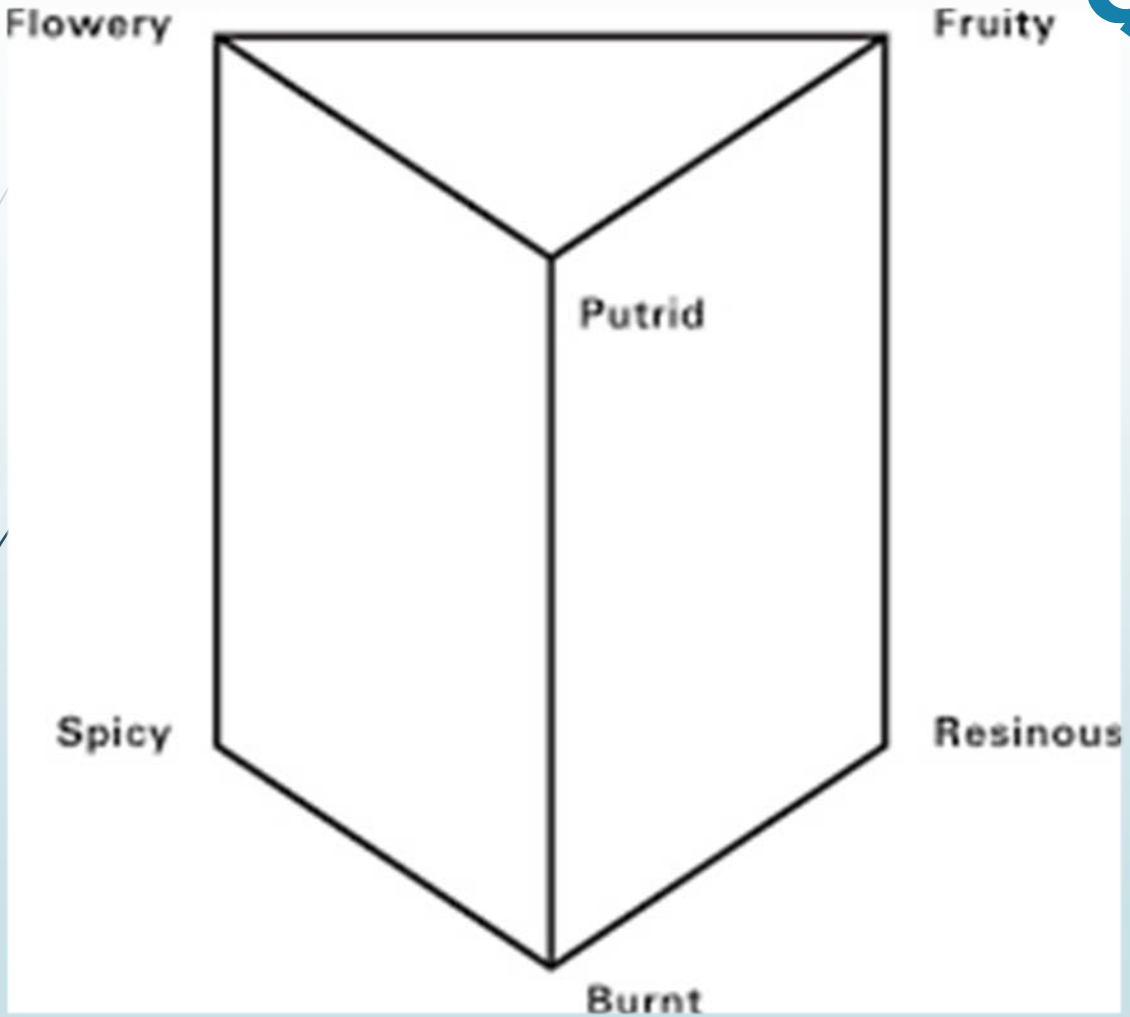
Intensity

0 – No Odor
1 – Very Weak (Threshold)
2 – Weak
3 – Distinct
4 – Strong
5 – Very Strong
6 – Intolerable

Hedonic Tone

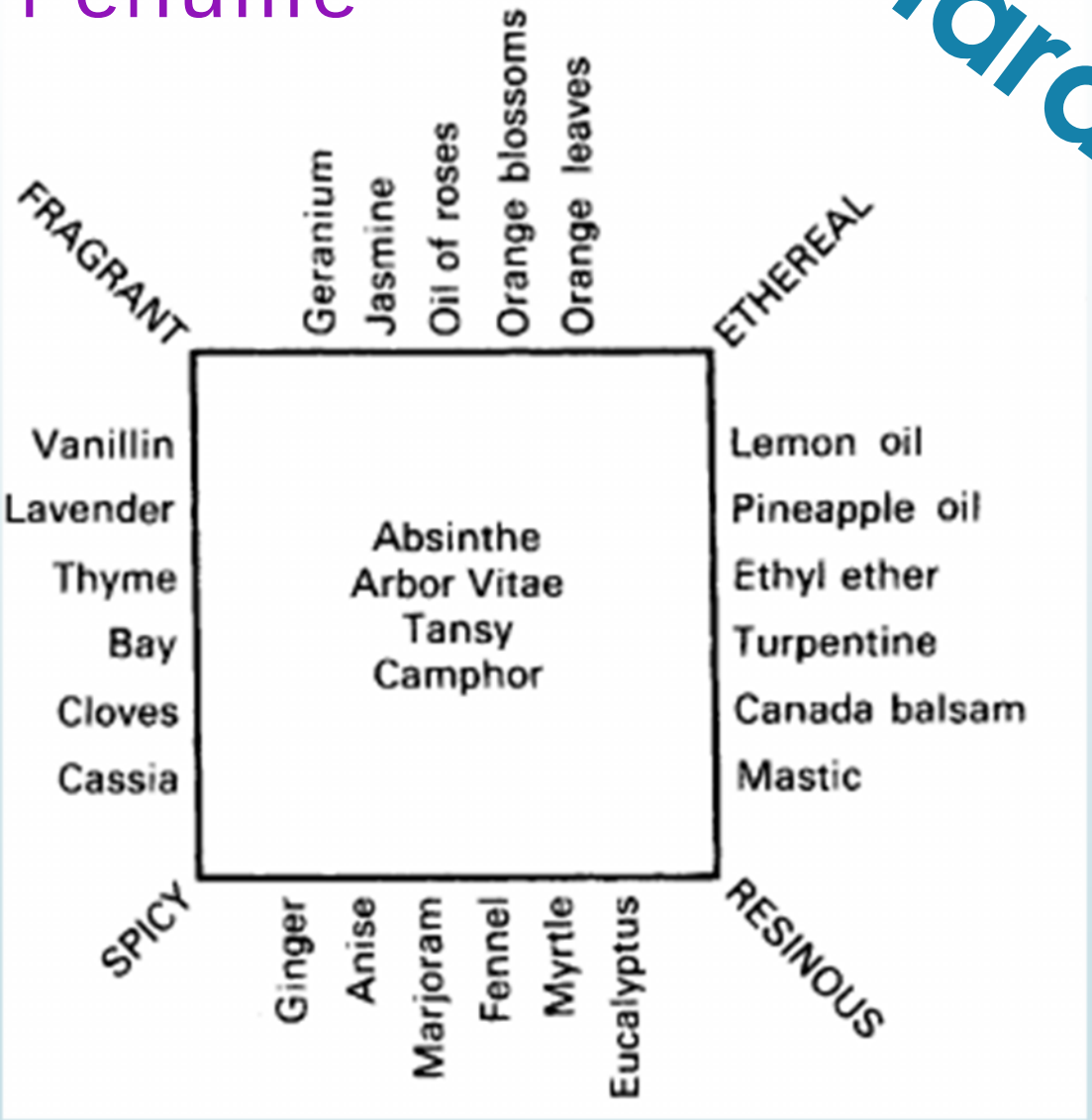


Henning Character

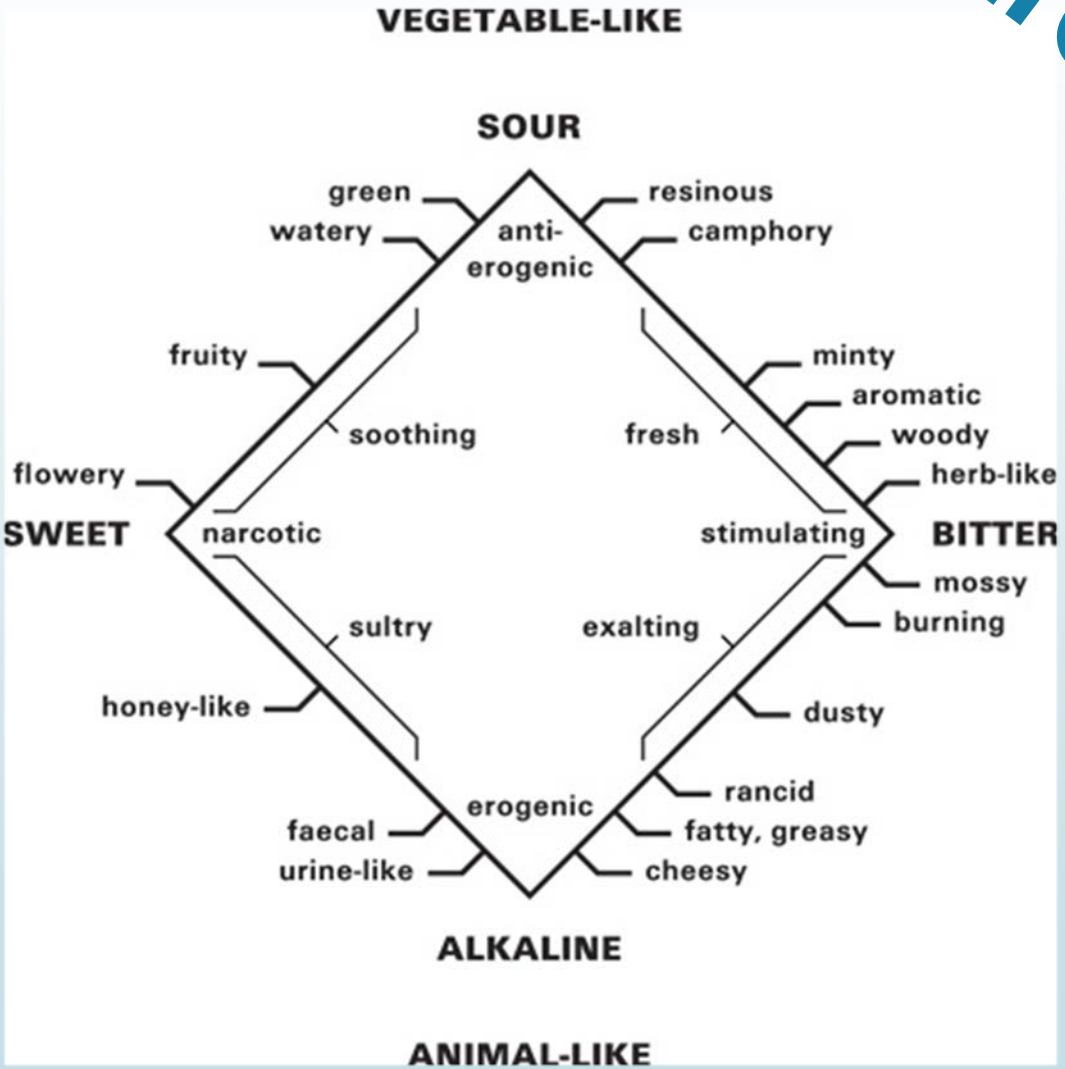


Perfume

Character



Perfume Character



Concentration (ppb)	Character	Compound
9 *	--	Sulfur dioxide
0.47	Rotten eggs	Hydrogen sulfide
210	Sulfide	Carbon disulfide
210	Green/sweet	Acetaldehyde
1000	Pungent	Formaldehyde
2.1	Pungent	Methyl mercaptan
47	Medicinal	Phenol
0.21	Fishy, pungent	Trimethyl amine
210	Burnt sweet	Acrolein

* All concentrations are in parts per billion (ppb)
G. Leonardos (Odor Threshold Determinations of 53 Odorant Chemicals)


Coffee & Cake
YUM. THAT COFFEE SHOP SMELLS SO GOOD.
I LIVE ABOVE IT AND I THINK IT STINKS!

Odor vs Chemical

- Odors are perception of the physiological process
- Chemicals (VOCs) are what starts that process
- Odors and physical symptoms are both effects
- Odor compound may or may not be responsible for physical symptoms; there is no specific relationship linking the odor to other effects

What Causes Release of Chemicals

Damage

- Cut
- Decomposition/decay/death

Chemical conversion

(e.g., photosynthesis, plant respiration)

Stress

Attract or Repel

- Pheromones

Organic Chemistry

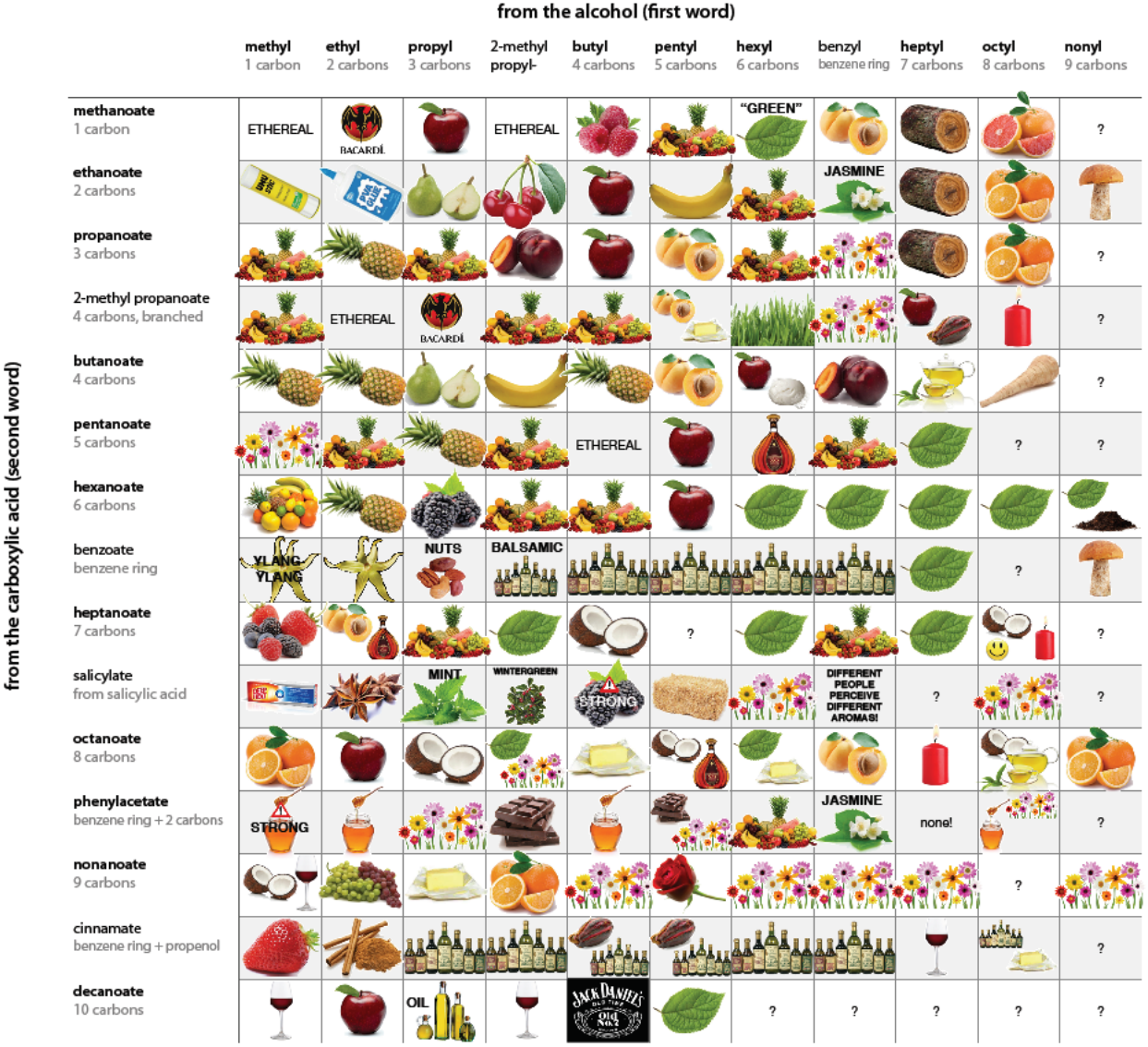
Table of organic compounds and their smells

	ALKANES		ALKENES	ALCOHOLS		ALDEHYDES				KETONES		CARBOXYLIC ACIDS		HALOALKANES			THIOLS	AMINES		NITRILES	LACTONES
	-ane	cyclo -ane	-ene	-anol	-an-2-ol	-anal	2-methyl -anal	3-(4-t-butylphenyl) -anal	-enal	-an-2-one	methyl -an-2-one	-anoic acid	-enoic acid	chloro -ane	bromo -ane	iodo -ane	-anethiol	-anamine	diamino -ane	-anenitrile	-anolide
meth- 1 carbon	none	doesn't exist	carbene is too unstable to smell	ABSOLUT VODKA	doesn't exist	DANGER FORMALDEHYDE CANCER HAZARD	doesn't exist	doesn't exist	doesn't exist	doesn't exist	doesn't exist	PUNGENT & PENETRATING	doesn't exist	TOXIC & MILDLY SWEET	LIKE CHLOROFORM	SWEET, ACRID			?		doesn't exist
eth- 2 carbons	none	doesn't exist		ABSOLUT VODKA	doesn't exist	FRUITY, ETHEREAL	doesn't exist	doesn't exist	doesn't exist	doesn't exist	doesn't exist	VINEGAR	doesn't exist	MILDLY SWEET	SWEET, ACRID	ETHEREAL	SKUNK			ETHEREAL	doesn't exist
prop- 3 carbons	none			ABSOLUT VODKA	RUBBING ALCOHOL	IRRITATING GREEN COFFEE	WET CEREAL	ATTRACTS SPERM	BURNED GREASE	NAIL VARNISH REMOVER	doesn't exist	SLIGHTLY RANCID	SHARP	MILDLY SWEET	SWEET	SHARP, UNIQUE				ETHEREAL	none
but- 4 carbons	none				WINE	PUNGENT BANANA		LILY	PUNGENT & SUFFOCATING	BUTTERSCOTCH	LIKE NAIL VARNISH REMOVER	RANCID BUTTER	BROWN SUGAR	SHARP	PLEASANT, SWEET	SHARP, UNIQUE			DEAD ANIMALS	SUFFOCATING	
pent- 5 carbons	STARTING FLUID	PLEASANT		STRONG SWEET	(S)- and (R)- enantiomers	PUNGENT NUTS & CHOCOLATE	FRESHLY CUT GRASS	?		&	MINT (4-methyl-)	DISGUSTING		MILD	PLEASANT, SWEET		ROASTED GARLIC		DEAD ANIMALS & URINE		HERBAL
hex- 6 carbons	STARTING FLUID	SWEET		FRESHLY CUT GRASS		FRESHLY CUT GRASS	FRESHLY CUT GRASS	?		ATTRACTS MICE	(3-methyl-)	GOATS	ARMPITS (WHEN 3-METHYL-ATED)	AROMATIC	SLIGHTLY SWEET	?	BURNED		ROTTING FISH		&
benzene different naming system is used	n/a	n/a	Benzene	SICKENINGLY SWEET AND TARRY Phenol	doesn't exist			?	doesn't exist	doesn't exist	Acetophenone	BALSAMIC	doesn't exist		AROMATIC			Aniline	TOXIC, AROMATIC	Benzonitrile	doesn't exist
hept- 7 carbons				FRESHLY CUT GRASS	(S)- and (R)- enantiomers	STRONG, FRUITY COGNAC	(2,6-dimethyl-heptanal)	?	ALMOND BUTTER	&	BAD (6-methyl-)	RANCID	ARMPITS (WHEN 3-METHYL-ATED)	none	SLIGHTLY SWEET	none	&				CARAMEL &
oct- 8 carbons	PETROL			PENETRATING, SWEET	(S)- and (R)- enantiomers	STRONG, CITRUS-LIKE	?	?		-2-one petrol -3-one herb butter	?	&	ARMPITS	none		SEAWEED	STENCH				
non- 9 carbons	DIESEL			CITRUS		ATTRACTS MOSQUITOES		?	OLD PEOPLE	MILK	?	RANCID	ARMPITS	none	none	none	OBNOXIOUS				
dec- 10 carbons	JET FUEL			CITRUS FLOWERS	?	BUCKWHEAT		?	ATORA TALLOW	?	?		ARMPITS	none	none	none	OBNOXIOUS				
undec- 11 carbons	NEW JET FUEL ALSO ANT 'PANIC' PHEROMONE	?		CITRUS FLOWERS	?	MAKES SPERM UNABLE TO FIND THE EGG	KUMQUATS	?	&	ALGERIAN OIL OF RUE	?	WAXY	PUNGENT & PENETRATING	UNIQUE & UNPLEASANT	none	MOUSE PHEROMONE	OBNOXIOUS				&
dodec- 12 carbons		MUSTY		FLOWERS	?		?	?	&	?	?	BAY OIL	FATTY	UNIQUE & UNPLEASANT	none	?	OBNOXIOUS				&
tridec- 13 carbons	STINK BUG PHEROMONE	UNIQUE; FOUND IN ROSES		PLEASANT	?	GRAPEFRUIT PEEL	ROASTED	?	?	WAXY	?		?	UNIQUE & UNPLEASANT	none	?	OBNOXIOUS		none		ANGELICA ROOT
tetradec- 14 carbons	KAPOK BUSH FLOWERS	none			?		?	?	?	?	?	WAX & NUTMEG	?	UNIQUE & UNPLEASANT	none	?	OBNOXIOUS		none		CEDAR WOOD
pentadec- 15 carbons	TAMARIND (ANT-CALMING PHEROMONE)	?		ABSOLUT VODKA	?	FRESH	?	?	CORIANDER	CELERY	?	BIOMARKER FOR DAIRY CONSUMPTION (No smell)	?	UNIQUE & UNPLEASANT	none	?	OBNOXIOUS		none		MUSK

Version 1.2 Produced by James at jameskennedymonash.wordpress.com. Visit website for more infographics. Free to use!

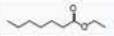
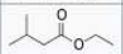
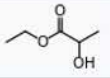
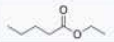
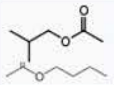
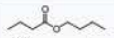
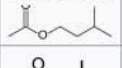
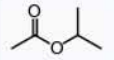
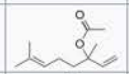
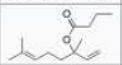
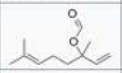
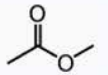
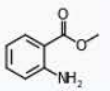
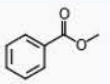
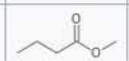
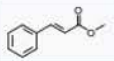
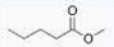
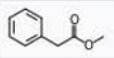
Esters

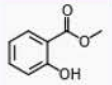
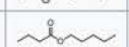
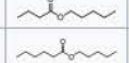
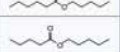
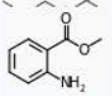
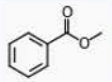
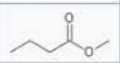
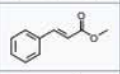
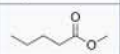
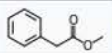
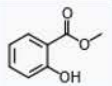
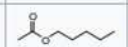
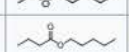
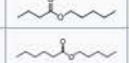
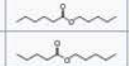
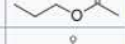
Table of esters and their smells



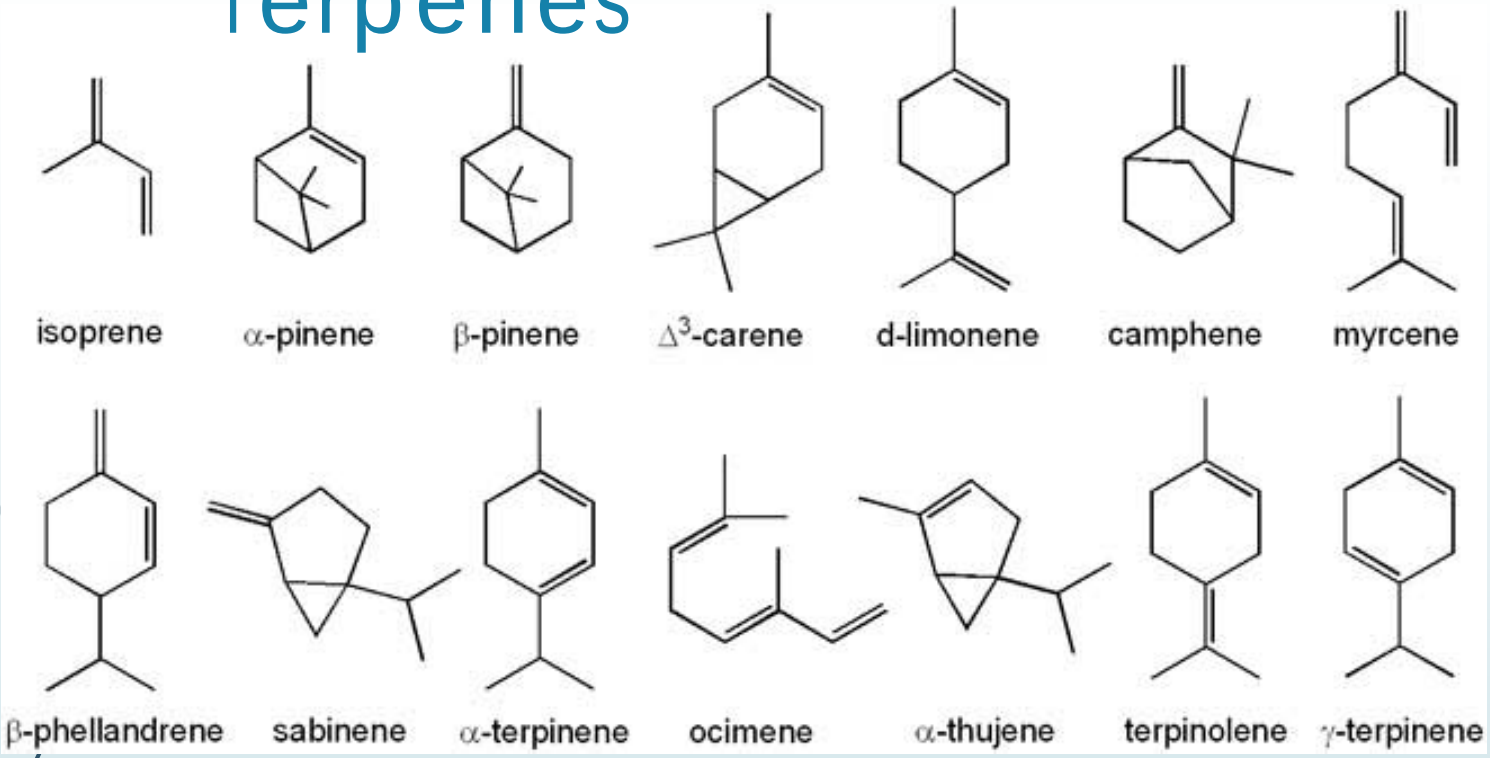
Produced by James at jameskennedymonash.wordpress.com. Visit website for more infographics. Free to use!

Esters

Ethyl heptanoate		apricot, cherry, grape, raspberry
Ethyl isovalerate		apple
Ethyl lactate		butter, cream
Ethyl nonanoate		grape
Ethyl pentanoate		apple
Geranyl acetate		geranium
Geranyl butyrate		cherry
Geranyl pentanoate		apple
Isobutyl acetate		cherry, raspberry, strawberry
Butyl acetate		apple, honey
Butyl butyrate		pineapple
Isoamyl acetate		pear, banana (flavoring in Pear drops)
Isopropyl acetate		fruity
Linalyl acetate		lavender, sage
Linalyl butyrate		peach
Linalyl formate		apple, peach
Methyl acetate		glue
Methyl anthranilate		grape, jasmine
Methyl benzoate		fruity, ylang ylang, feijoa
Methyl butyrate (methyl butanoate)		pineapple, apple, strawberry
Methyl cinnamate		strawberry
Methyl pentanoate (methyl valerate)		flowery
Methyl phenylacetate		honey

Methyl salicylate (oil of wintergreen)		Modern root beer, wintergreen, Germolene and Ralgex ointments (UK)
Nonyl caprylate		orange
Octyl acetate		fruity-orange
Octyl butyrate		parsnip
Amyl acetate (pentyl acetate)		apple, banana
Pentyl butyrate (amyl butyrate)		apricot, pear, pineapple
Pentyl hexanoate (amyl caproate)		apple, pineapple
Pentyl pentanoate (amyl valerate)		apple
Propyl acetate		pear
Methyl anthranilate		grape, jasmine
Methyl benzoate		fruity, ylang ylang, feijoa
Methyl butyrate (methyl butanoate)		pineapple, apple, strawberry
Methyl cinnamate		strawberry
Methyl pentanoate (methyl valerate)		flowery
Methyl phenylacetate		honey
Methyl salicylate (oil of wintergreen)		Modern root beer, wintergreen, Germolene and Ralgex ointments (UK)
Nonyl caprylate		orange
Octyl acetate		fruity-orange
Octyl butyrate		parsnip
Amyl acetate (pentyl acetate)		apple, banana
Pentyl butyrate (amyl butyrate)		apricot, pear, pineapple
Pentyl hexanoate (amyl caproate)		apple, pineapple
Pentyl pentanoate (amyl valerate)		apple
Propyl acetate		pear
Propyl hexanoate		blackberry, pineapple, cheese, wine

Terpenes


isoprene
α-pinene
β-pinene
Δ3-carene
d-limonene
camphene
myrcene
β-phellandrene
sabinene
α-terpinene
ocimene
α-thujene
terpinolene
γ-terpinene

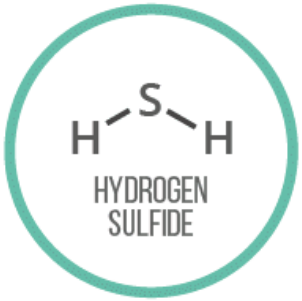

LINALOOL
CARYOPHYLLENE
TERPINENE
EUCALYPTOL
PINENE
LIMONENE
MYRCENE

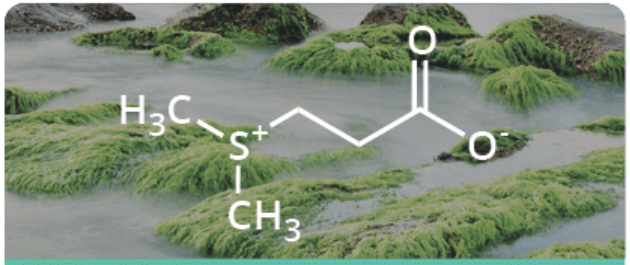
Odor Chemistry – Seaside

The characteristic smell of the seaside stems from volatile organic compounds that contain sulfur. Some of these compounds are emitted by algae in the sea, as a result of enzymatic activity or bacterial action, whilst others can be emitted by decomposing seaweed on the beach itself.

COMPOUNDS FROM BACTERIA

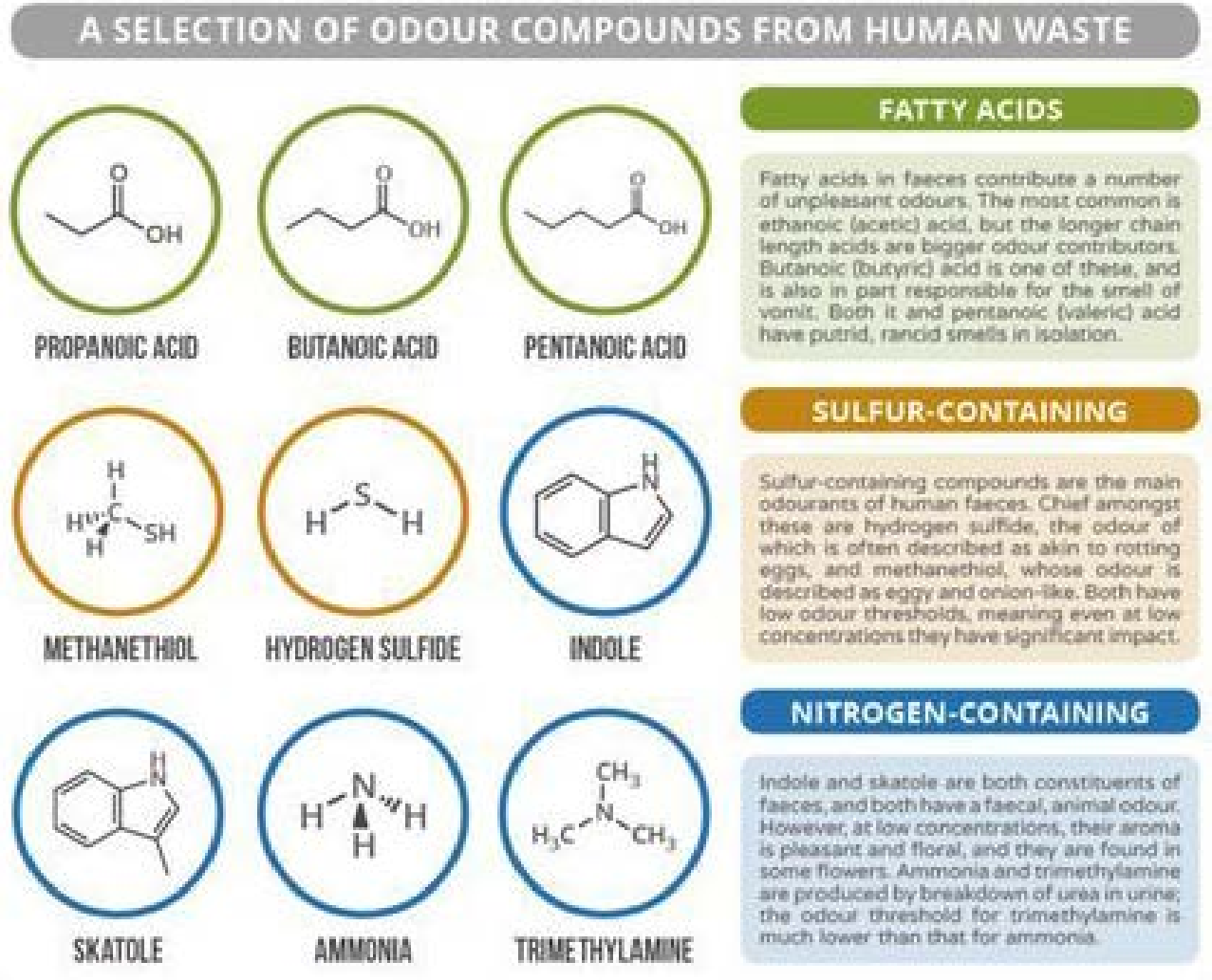
Hydrogen sulfide gas is produced by decomposing seaweed; the anaerobic breakdown of sulfates in the seaweed leads to the production of the gas. It is toxic in high concentrations, but as it is produced naturally in the body, humans have mechanisms to break it down, so can tolerate low concentrations.



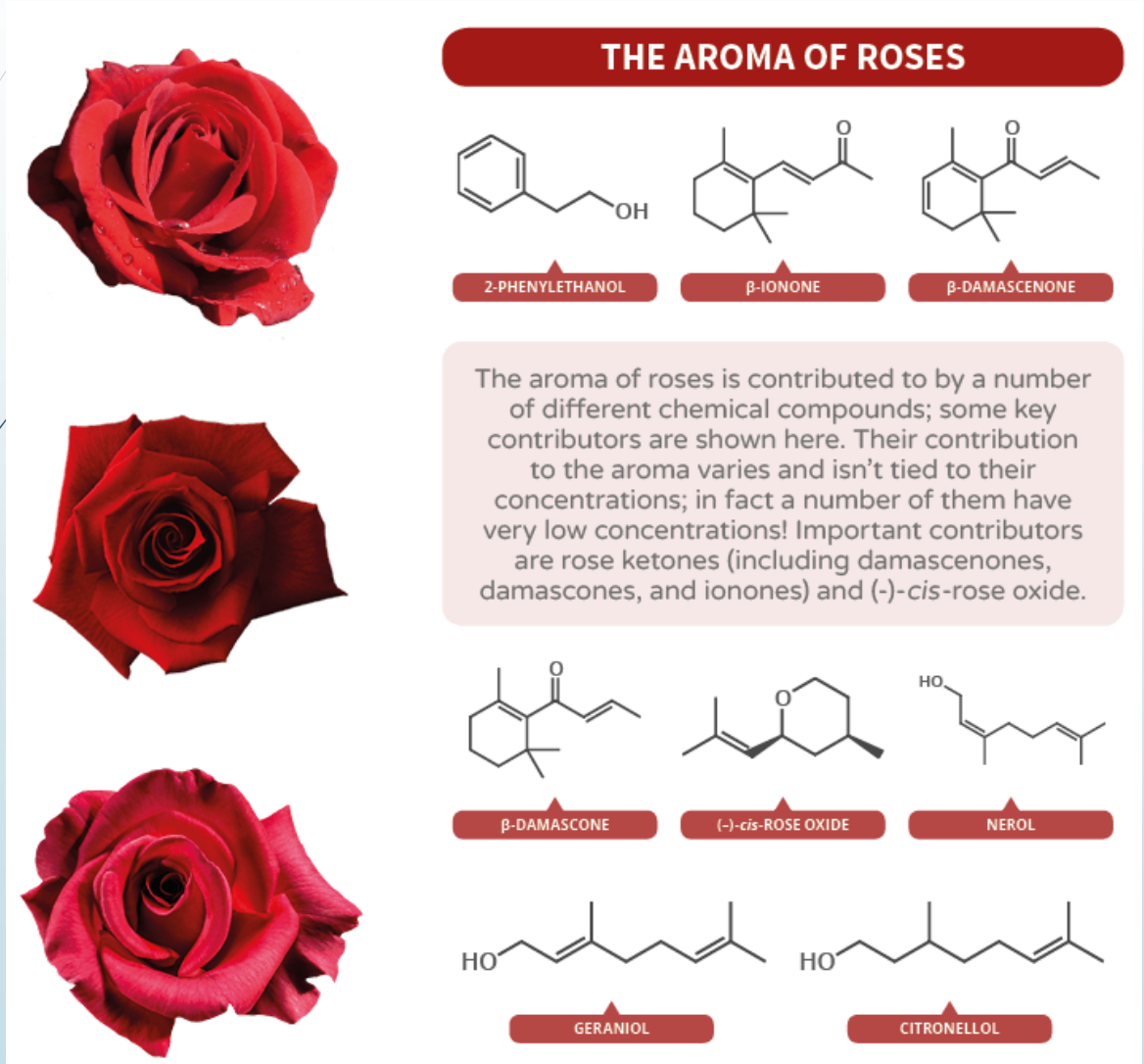


Dimethylsulfoniopropionate (DMSP) is a compound found in algae cells, which acts as an osmolyte (maintains cell volume and water levels). This compound can be broken down by both enzymes and bacteria, and this can produce dimethylsulfide (DMS). DMS is considered a major component of the smell of the sea.

Odor Chemistry – Waste

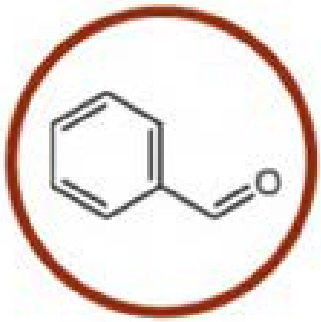


Odor Chemistry – Roses

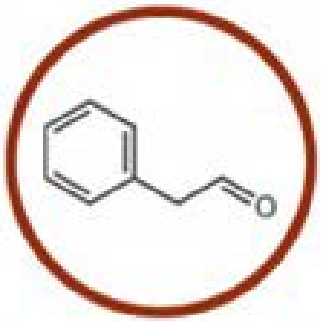


Odor Chemistry – Wet Dog

The smell of dogs is complex: multiple chemical compounds contribute which individually do not have odours associated with dog smell, but produce it in combination. A pilot study found emitted concentrations of some compounds increased when dog hair was wet. Those shown on the top row below showed greater increases than those on the second row.

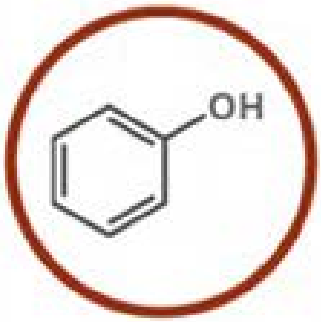


BENZALDEHYDE
almond-like

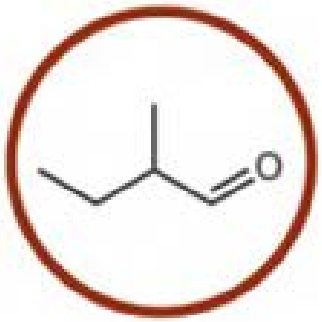


PHENYLACETALDEHYDE
honey/floral

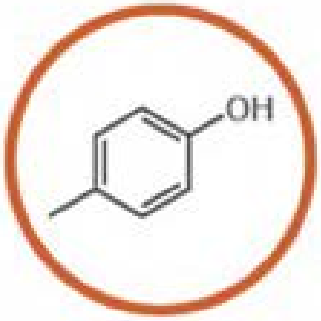
ACETALDEHYDE
fruity/musty



PHENOL
medicinal

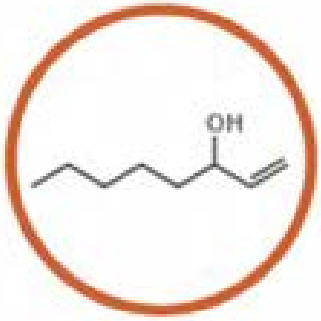


2-METHYLBUTANAL
musty/nutty



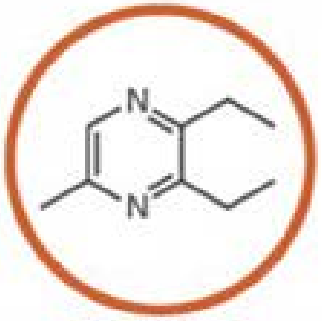
p-CRESOL
~~faecal~~

DIMETHYL TRISULFIDE
sulfurous



1-OCTEN-3-OL
mushroom-like

2-NONANONE
fruity

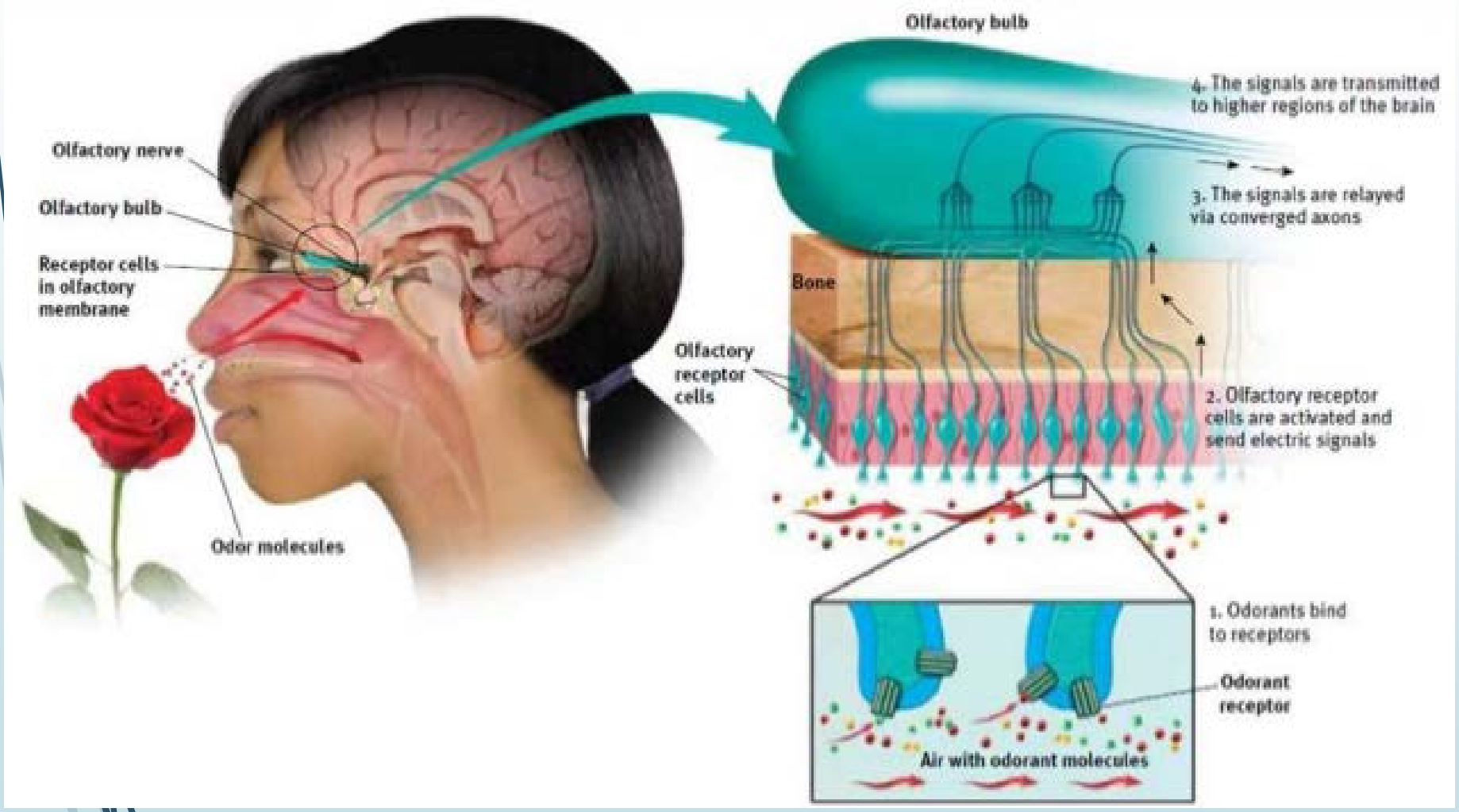


2,3-DIETHYL-5-METHYLPYRAZINE
earthy

Good Smells vs Bad Smells

Understand	Explore	Identify
… the basics of volatile organic compounds (VOCs) and odors	… the world of odor characterization and measurement	… odor sources based on chemical information

Sense of Smell



Facets

- Sources
- Thresholds
- Intensity
- Tone
- Character

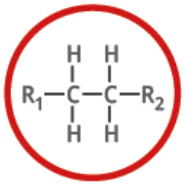
VOCs

- C and H
- Volatility
  - Temperature
  - Humidity
- Functional Groups
  - Specific Order

FUNCTIONAL GROUPS IN ORGANIC CHEMISTRY

FUNCTIONAL GROUPS ARE GROUPS OF ATOMS IN ORGANIC MOLECULES THAT ARE RESPONSIBLE FOR THE CHARACTERISTIC CHEMICAL REACTIONS OF THOSE MOLECULES. IN THE GENERAL FORMULAE SHOWN BELOW FOR EACH FUNCTIONAL GROUP, 'R' REPRESENTS THE REST OF THE MOLECULE, AND 'X' REPRESENTS ANY HALOGEN ATOM.

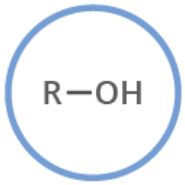
HYDROCARBONS | SIMPLE OXYGEN HETEROATOMICS | HALOGEN HETEROATOMICS | CARBONYL COMPOUNDS | NITROGEN-BASED | SULFUR-BASED | AROMATIC



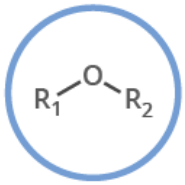
ALKANE
Naming: -ane
e.g. ethane

ALKENE
Naming: -ene
e.g. ethene

ALKYNE
Naming: -yne
e.g. ethyne



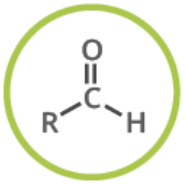
ALCOHOL
Naming: -ol
e.g. ethanol



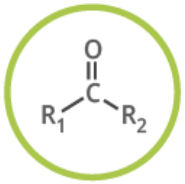
ETHER
Naming: -oxy -ane
e.g. methoxyethane

EPOXIDE
Naming: -ene oxide
e.g. ethene oxide

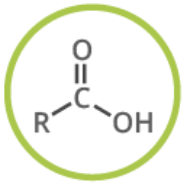
HALOALKANE
Naming: halo-
e.g. chloroethane



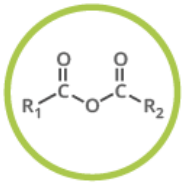
ALDEHYDE
Naming: -al
e.g. ethanal



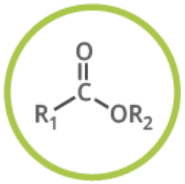
KETONE
Naming: -one
e.g. propanone



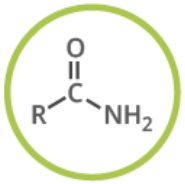
CARBOXYLIC ACID
Naming: -oic acid
e.g. ethanoic acid



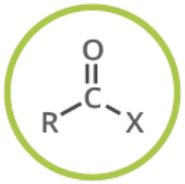
ACID ANHYDRIDE
Naming: -oic anhydride
e.g. ethanoic anhydride



ESTER
Naming: -yl -oate
e.g. ethyl ethanoate



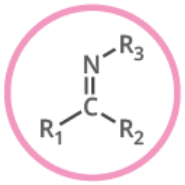
AMIDE
Naming: -amide
e.g. ethanamide



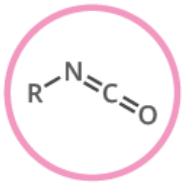
ACYL HALIDE
Naming: -oyl halide
e.g. ethanoyl chloride

AMINE
Naming: -amine
e.g. ethanamine

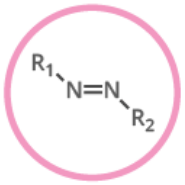
NITRILE
Naming: -nitrile
e.g. ethanenitrile



IMINE
Naming: -imine
e.g. ethanimine

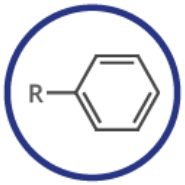


ISOCYANATE
Naming: -yl isocyanate
e.g. ethyl isocyanate



AZO COMPOUND
Naming: azo-
e.g. azoethane

THIOL
Naming: -thiol
e.g. methanethiol



ARENE
Naming: -yl benzene
e.g. ethyl benzene

Terms

Odorant – substance capable of eliciting an olfactory response

Odor – sensation resulting from stimulation of the olfactory organs

Detection Threshold – 50% can identify presence of odor or odorant without characterizing it (smell something but can't say what it is)

Odor Threshold – concentration at which 50% of the individuals exposed to the odorant respond

Recognition Threshold – 50% identify odorant or odor

Odor Adaptation – process by which one becomes accustomed to odor

Odor Fatigue – total adaptation occurred through prolonged exposure

Odor Tenacity – persistence; time odor remains perceptible

References

3M Respirator Selection Guide

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