
HZPC
Growing with our potatoes

Biochemical blueprint of flavour, health and nutrition in cresses and sprouts

Lecture for the ISGA convention
April 22, 2015, Rotterdam

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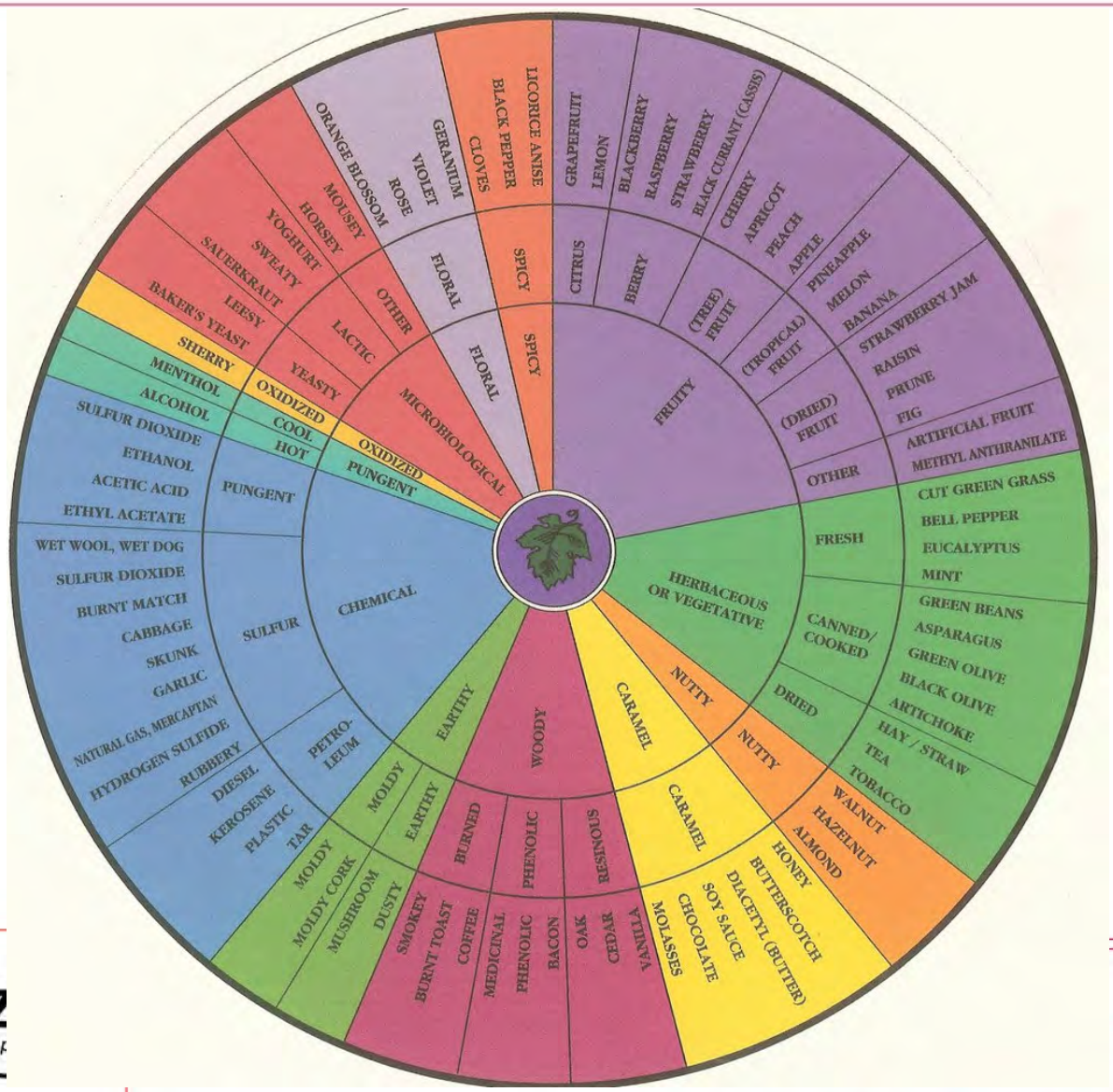
My agenda

- The 5 senses
- The sensorial space
- Basic flavours
- Complex flavours and smells
- Cresses
- Architecture Aromatique = Architecture Biochemique
- Health & nutrition

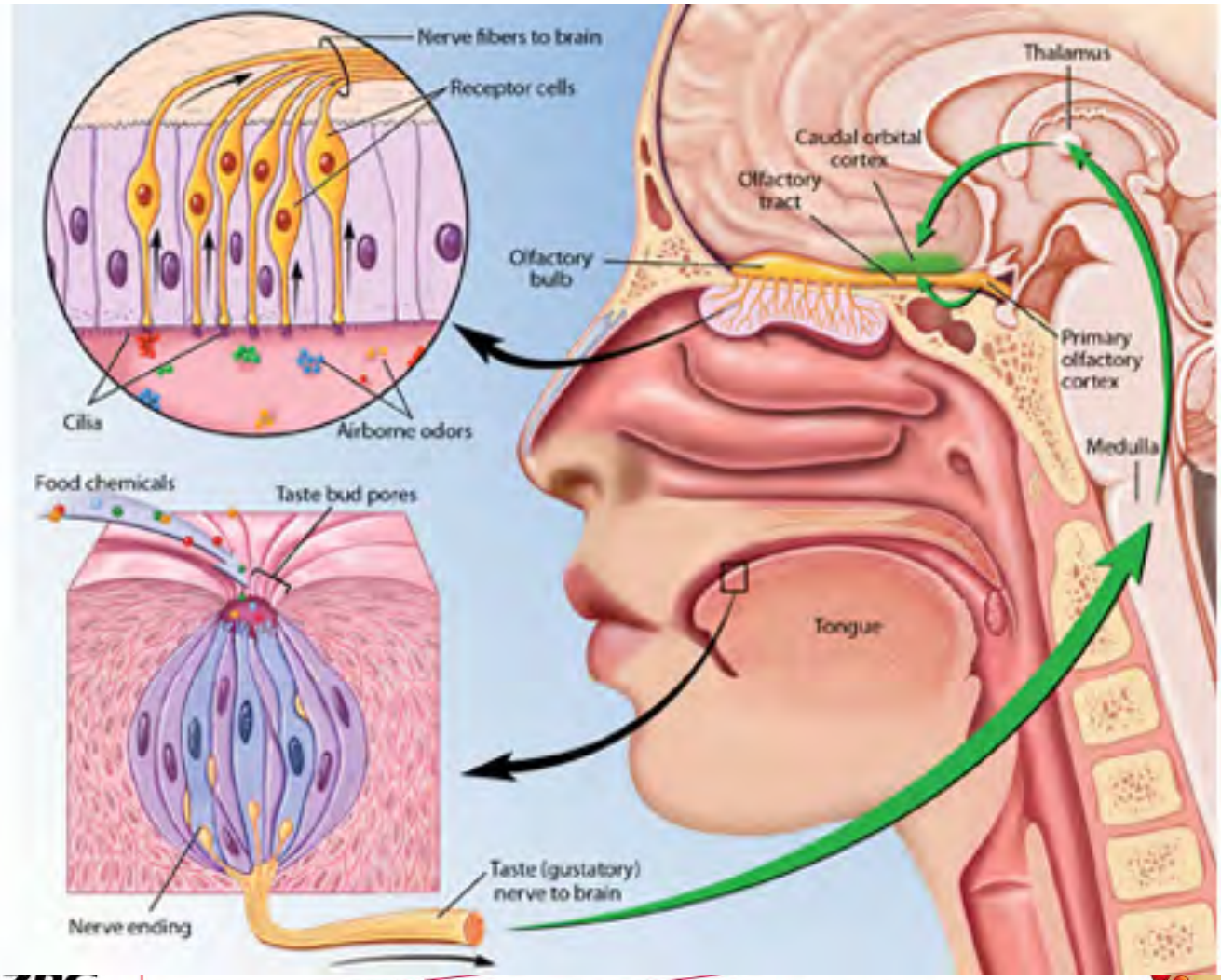
The 5 senses: our toolbox for survival

The sensorial space

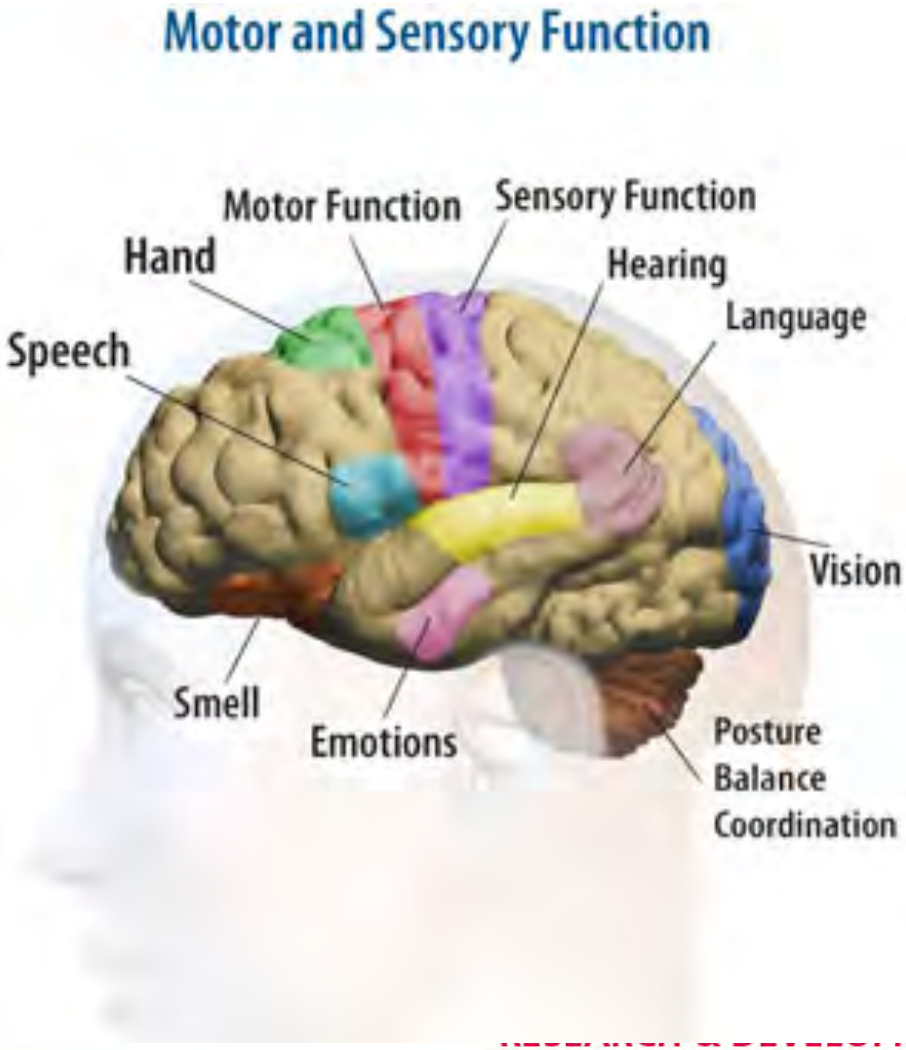


The 5 basic flavours: palette of interactions

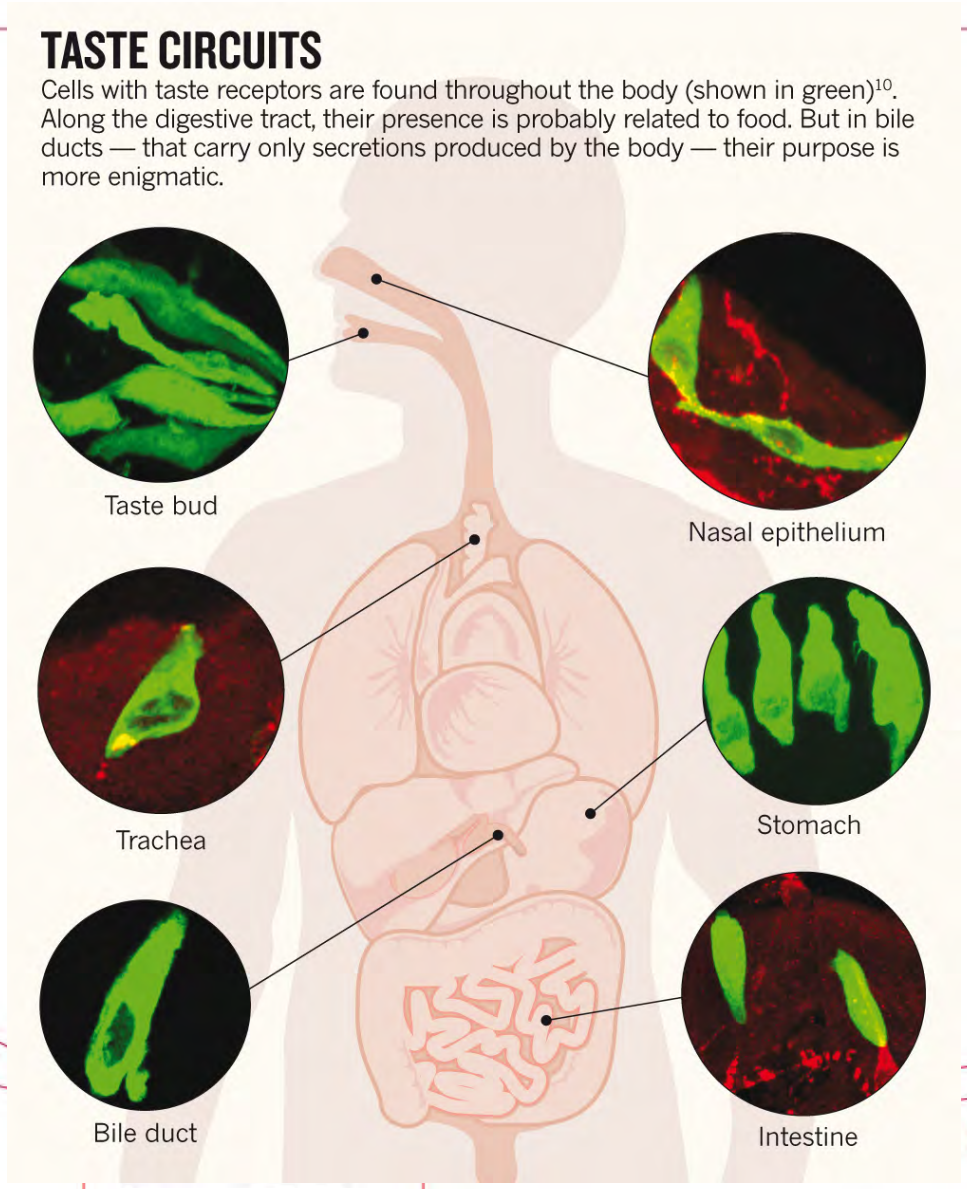
Sensing of aroma's and flavours: tongue vs. nose



Aroma & Flavour = sensorial emotions: imprinted in the memory, new experiences



Taste perception: all along the digestive track!
Malfunctioning in diabetes II patients



Sensing has evolved in time…….

"Hounds used to find things using their sense of smell, but now I use a search tool called Google Nose!"

The cresses and their aroma's & flavours









KOPPERT CRESS
Architecture Aromatique

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RESEARCH & DEVELOPMENT

Cresses of Koppertcress in ‘exotic’ wording

Accla cress	Brocco cress	Mustard cress	Scarlet cress
Affilla cress	Chilli Cress	Persinette cress	Sechuan cress
Asanga cress	Daikon cress	Red Musterd	Shiso green
Atsina cress	Ghoa cress	Rock chives	Shiso Purple
Basil cress	Honny cress	Rucola cress	Tahoon cress
Blinq cress	Kikuna cress	Sakura cress	Garden cress
Borage cress	Limon cress	Salicornia cress	Wheat grass

Clustering of cresses according to flavour principles

Accla cress	Brocco cress	Mustard cress	Scarlet cress
Affilla cress	Chilli Cress	Persinette cress	Sechuan cress
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Cruciferous: glucosinolate containing

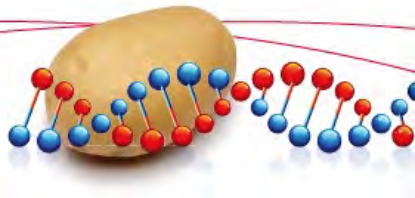
Aromatic: terpenoid flavonoid containing

Green: fatty acid oxidation related

Basic flavours: salt, silt, acid

Sulfur based: S-alkylcysteine-sulfoxide related

KOPPERT CRESS
Architecture Aromatique



Glucosinolate containing cresses

- Are all crucifers
- Belonging to the Brassica's
- Wide variation in flavour
  - Pungent
  - Hot
  - Nutty
  - Bitter
  - Astringent
  - Burning

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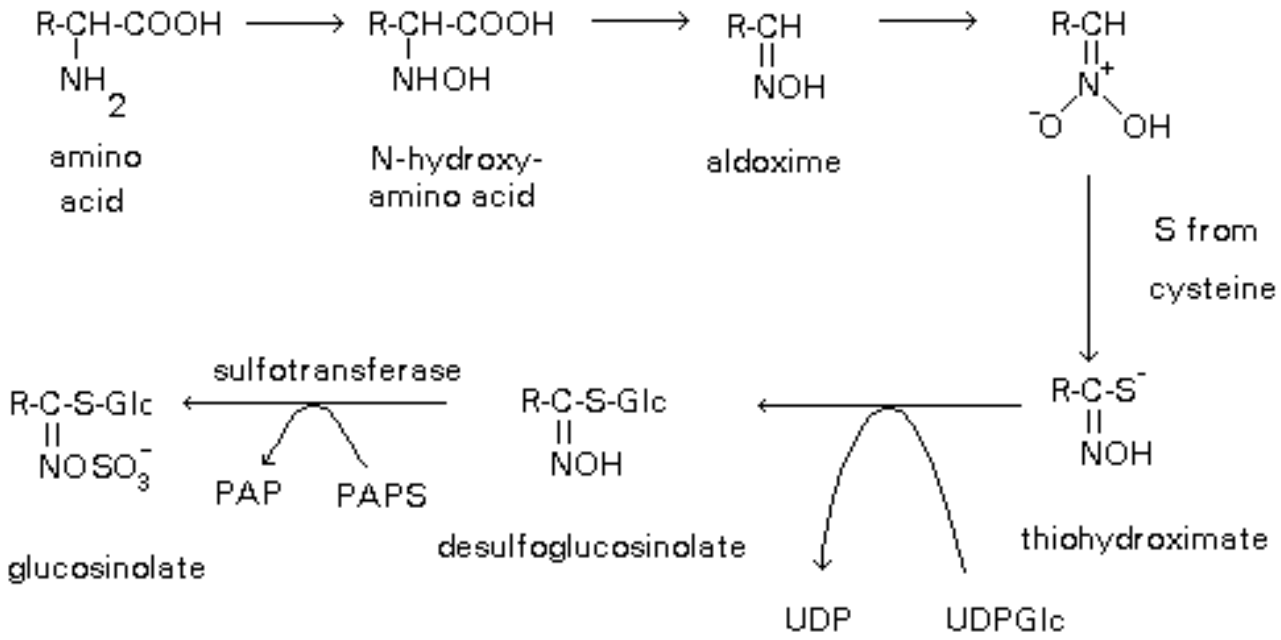
Glucosinolates: complex sulfur-containing sugars

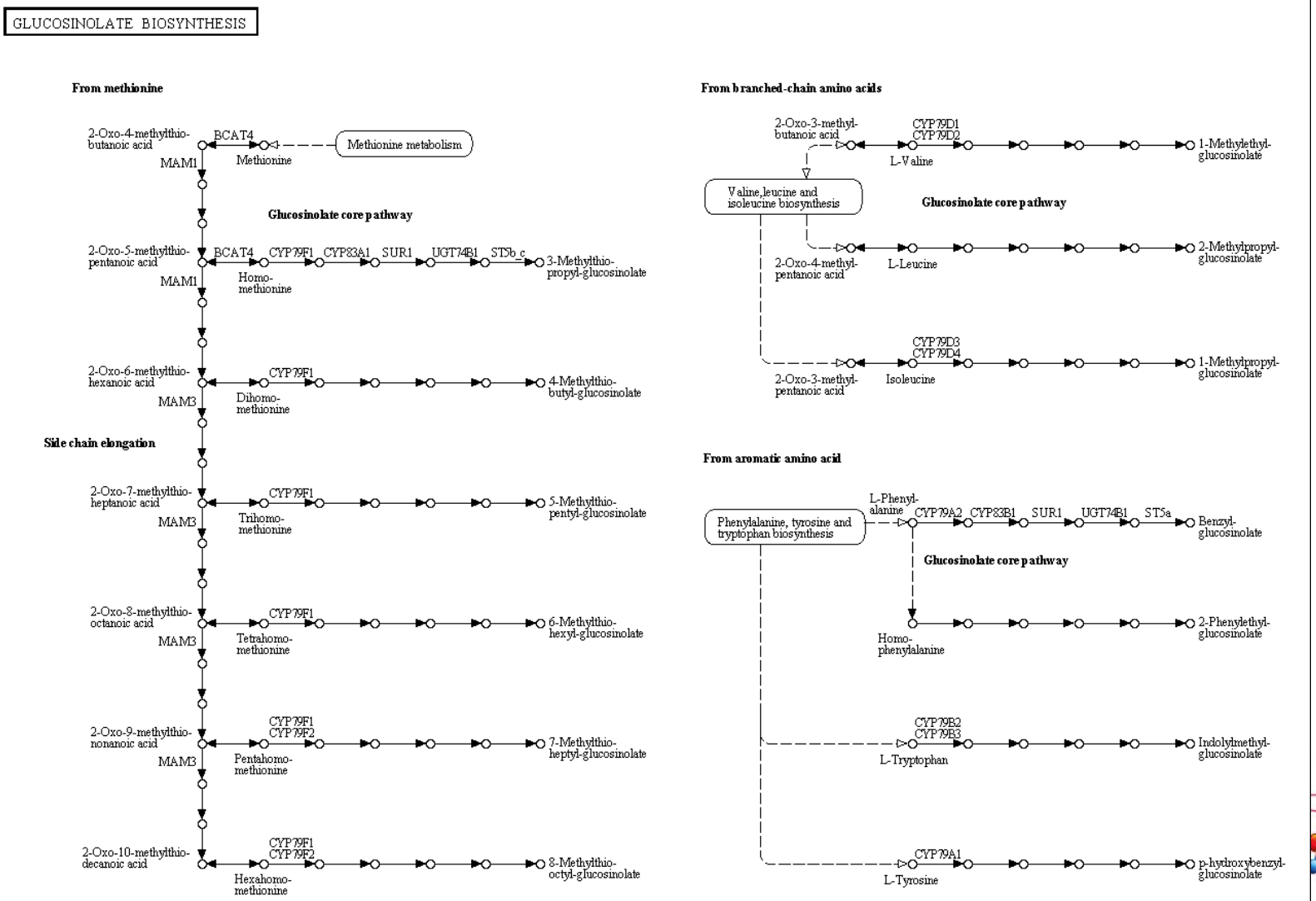
Proposed pathway for the biosynthesis of glucosinolates

From : Glendening and Poulton 1990. Upon tissue disruption the enzyme myrosinase initiates the rapid degradation of glucosinolates to isothiocyanates, nitriles and thiocyanates which contribute to the distinctive flavor and odor characteristics of the family Brassicaceae.

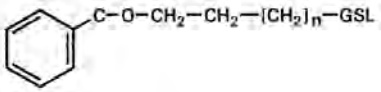
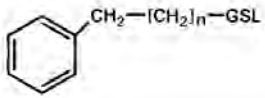


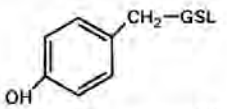
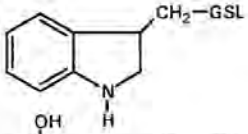
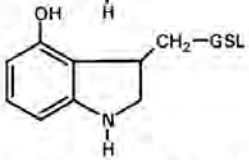
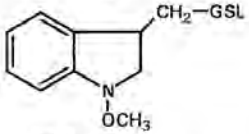
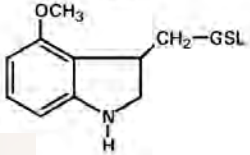
Glendening TM, Poulton JE 1990 Partial purification and characterization of a 3'-phospho-adenosine 5'-phosphosulfate: desulfoglucosinolate sulfotransferase from cress (Lepidium sativum). Plant Physiol 94:811-818. (High activity of this enzyme in Arabidopsis).

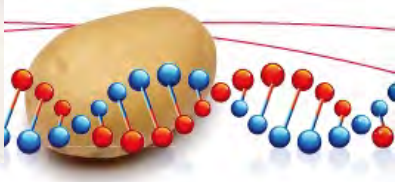
Glucosinolates: complex & differentiated flavours in crucifers



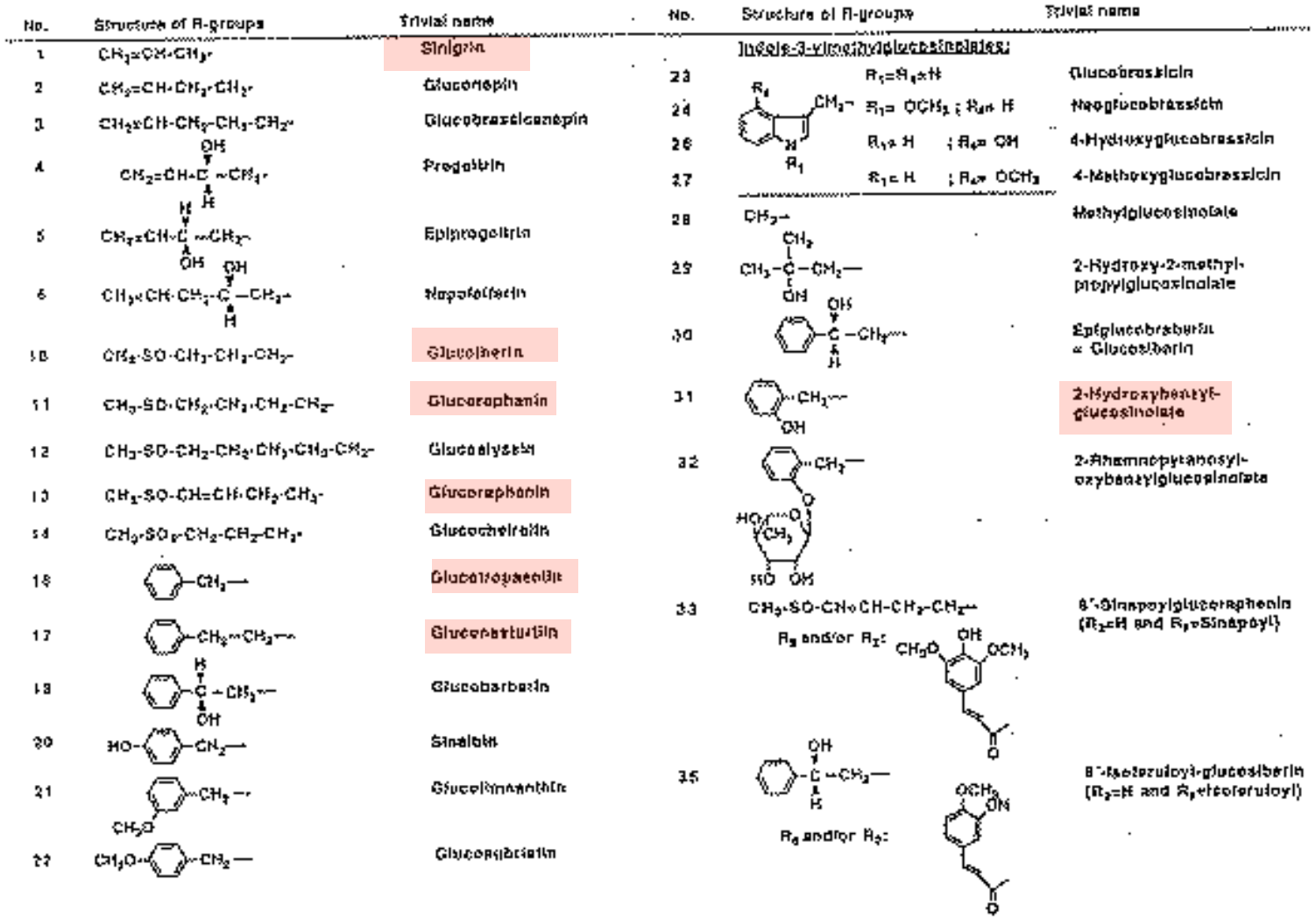
Glucosinolates: tailored chemistry for attraction and repellence

Amino acid precursor	Glucosinolate structure	Amino acid chain elongation
Methionine	Methylthioalkyl	$CH_3-S-CH_2-CH_2-[CH_2]_n-GSL$	n = 1 - 8
	Methylsulphinylalkyl	$CH_3-SO-CH_2-CH_2-[CH_2]_n-GSL$	n = 1 - 9
	Methylsulphonylalkyl	$CH_3-SO_2-CH_2-CH_2-[CH_2]_n-GSL$	n = 1, 2, 6
	4-Methylsulphinyl-3-butenyl	$CH_3-SO-CH=CH-[CH_2]_2-GSL$	
	Alkenyl	$CH_2=CH-[CH_2]_n-GSL$	n = 1, 2, 3
	2-Hydroxy-3-butenyl	$CH_2=CH-\underset{OH}{CH}-CH_2-GSL$	
	2-Hydroxy-4-pentenyl	$CH_2=CH-CH_2-\underset{OH}{CH}-CH_2-GSL$	
	Hydroxalkyl	$\underset{OH}{CH_2}-CH_2-[CH_2]_n-GSL$	n = 1, 2, 3
	Benzoyloxyalkyl		n = 1 - 4
Valine		$\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!CH-[CH_2]_n-GSL$	n = 0 - 2
Isoleucine		$CH_3-CH_2-\underset{CH_3}{CH}-[CH_2]_n-GSL$	n = 0, 1
Phenylalanine	Phenylalkyl		n = 0 - 4

Amino acid precursor	Glucosinolate structure
Tyrosine	*p*-Hydroxybenzyl	
Tryprophan	3-Indolylmethyl	
	4-Hydroxy-3-indolylmethyl	
	1-Methoxy-3-indolylmethyl	
	4-Methoxy-3-indolylmethyl	



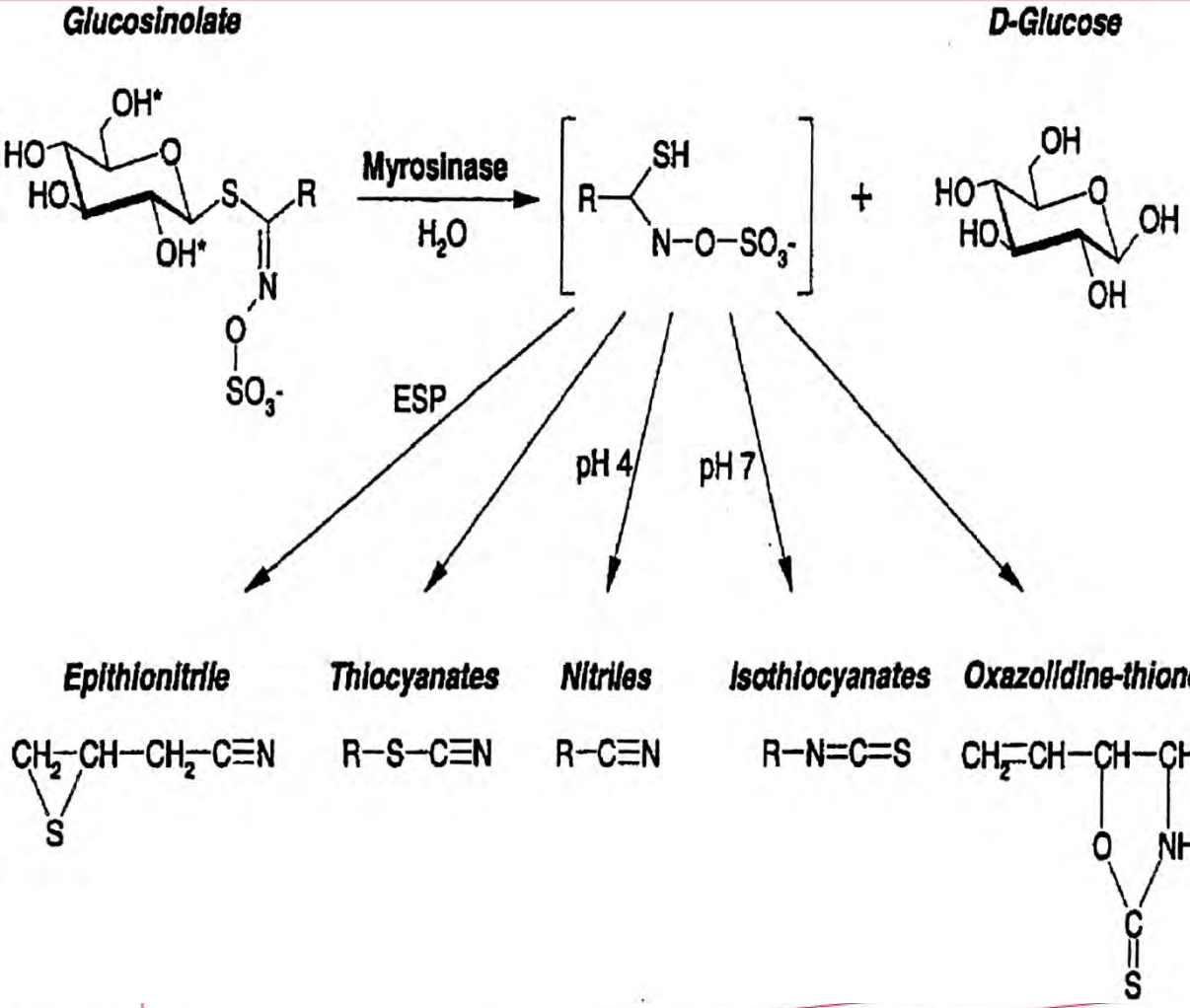
Glucosinolates: precursors for flavour and aroma in cresses



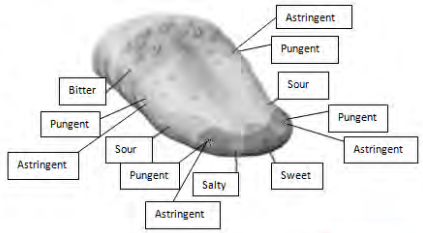
No.	Structure of R-groups	Trivial name
1	$CH_2{=}CH{-}CH_2{-}$	Sinigrin
2	$CH_2{=}CH{-}CH_2{-}CH_2{-}$	Gluconapin
3	$CH_2{=}CH{-}CH_2{-}CH_2{-}CH_2{-}$	Glucobrassicanapin
4	$CH_2{=}CH{-}C(OH)(H){-}CH_3$	Progoitrin
5	$CH_2{=}CH{-}C(H)(OH){-}CH_2{-}$	Epiprogoitrin
6	$CH_3{-}CH{=}CH{-}CH_2{-}C(H)(OH){-}CH_2{-}$	Napoleiferin
10	$CH_3{-}SO{-}CH_2{-}CH_2{-}CH_2{-}$	Glucoiberin
11	$CH_3{-}SO{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}$	Glucoraphanin
12	$CH_3{-}SO{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}CH_2{-}$	Glucoalyssin
13	$CH_3{-}SO{-}CH{=}CH{-}CH_2{-}CH_2{-}$	Glucoerysolin
14	$CH_3{-}SO_2{-}CH_2{-}CH_2{-}CH_2{-}$	Glucocheirolin
16	$C_6H_5{-}CH_2{-}$	Glucotropaeolin
17	$C_6H_5{-}CH_2{-}CH_2{-}$	Gluconasturtiin
18	$C_6H_5{-}C(H)(OH){-}CH_2{-}$	Glucobarbarin
20	$HO{-}C_6H_4{-}CH_2{-}$	Sinalbin
21	$CH_3O{-}C_6H_3(CH_2O){-}CH_2{-}$	Glucolimnanthin
22	$CH_3O{-}C_6H_4{-}CH_2{-}$	Glucoaubrietin

No.	Structure of R-groups	Trivial name
	Indole-3-ylmethylglucosinolates:	
23	$R_1{=}R_4{=}H$	Glucobrassicin
24	$R_1{=}OCH_3$; $R_4{=}H$	Neoglucobrassicin
26	$R_1{=}H$; $R_4{=}OH$	4-Hydroxyglucobrassicin
27	$R_1{=}H$; $R_4{=}OCH_3$	4-Methoxyglucobrassicin
28	$CH_3{-}$	Methylglucosinolate
29	$CH_3{-}C(CH_3)(OH){-}CH_2{-}$	2-Hydroxy-2-methylpropylglucosinolate
30	$C_6H_5{-}C(H)(OH){-}CH_2{-}$	Epiglucobrabarin = Glucosiberin
31	$HO{-}C_6H_4{-}CH_2{-}$	2-Hydroxybenzyl-glucosinolate
32	$C_6H_4(OH){-}CH_2{-}$ + Rhamnopyranosyl	2-Rhamnopyranosyloxybenzylglucosinolate
33	$CH_3{-}SO{-}CH_2{-}CH(OR_3){-}CH_2{-}CH_2{-}$	6'-Sinapoylglucoraphenin (R_3=H and R_4=Sinapoyl)
35	$C_6H_5{-}C(H)(OH){-}CH_2{-}$	6'-Feruloyl-glucosiberin (R_3=H and R_4=feruloyl)

Enzymatic release of flavours and aroma's from glucosinolates



bitter



The tongue

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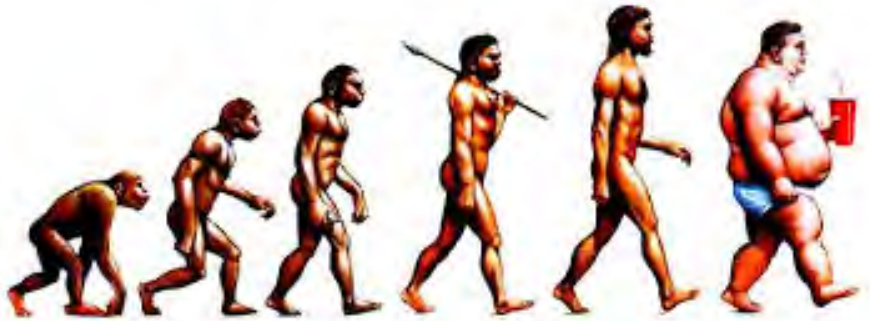
RESEARCH & DEVELOPMEN

Specialists
Love it

Generalists
Avoid it

Consumers
(Dis)like it



Terpenes as flavour makers in many herbs and spices

- Trichomes as flavour bombs on leaf surface
- Widespread biochemistry over species
- Well-recognized aroma's and flavours
- Pretty & positive
- Low odour threshold
- Attractants and repellants

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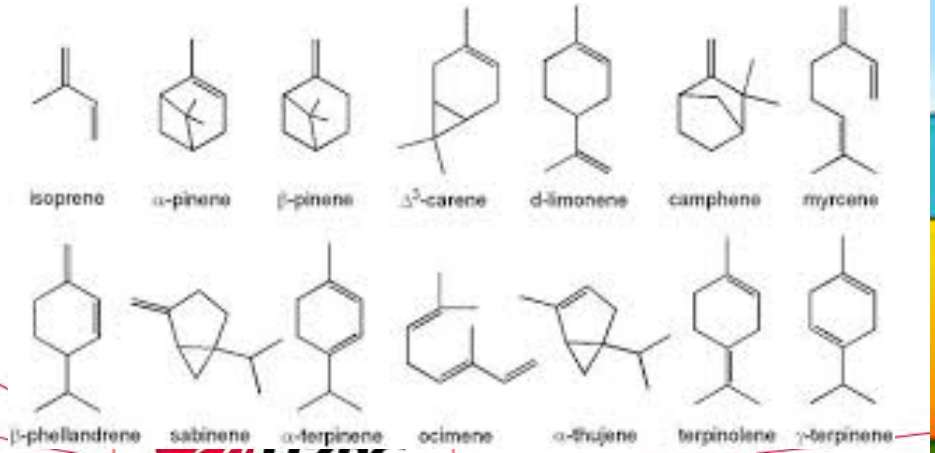

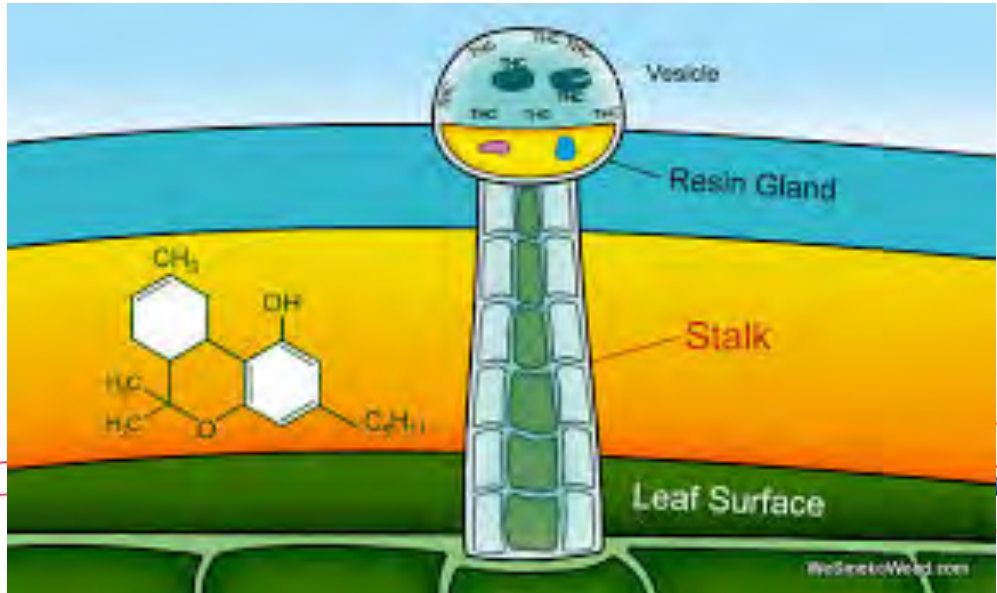

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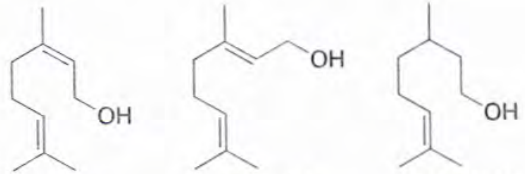
Biodiversity of terpenes in plant species

Table 1 A heat map of the most abundant foliar terpenes in all species of Myrtaceae

Tribe	Genuses	Samples	E-hex-2-enal	methyl cinnamate	geraniol	geranial	geranyl acetate	citronellol	citronellal	neral	isoamyl isovalerate	linalool	E-β-ocimene	β-myrcene	α-pinene	trans-pinocarveol	pinocarvone	β-pinene	myrtenal	methyl myrtenate	limonene	carvone	1,8-cineole	α-terpineol	α-terpinyl acetate	cryptone	terpinolene
Carbocation			0	0	1	1	1	1	1	1	1	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4
P450			+	+	-	+	-	-	+	-	+	-	-	-	-	-	+	-	+	-	-	+	-	-	-	+	-
Xanthosternoneae	2	7	-	-	-	-	-	-	-	-	-	-	12.5	-	25.0	-	-	-	-	-	-	-	-	-	-	-	-
Melaleuceae	3	404	-	0.5	-	0.9	0.0	0.2	0.3	0.5	-	4.5	0.2	0.2	37.3	3.5	0.0	4.9	0.6	0.2	9.2	-	58.9	6.7	0.2	-	2.0
Syncarpieae	1	4	-	-	-	-	-	-	-	-	-	-	-	-	120.0	-	-	-	-	-	-	-	-	-	-	-	-
Eucalypteae	3	797	-	0.1	0.2	0.3	0.4	0.1	0.3	-	0.4	0.2	0.3	0.1	37.5	2.9	0.3	3.7	0.1	-	3.2	0.3	50.2	3.3	0.4	0.6	0.1
Leptospermeaea	4	77	-	1.3	1.3	0.6	1.5	-	0.2	0.3	-	1.3	0.6	0.6	40.3	0.3	-	10.9	1.3	-	3.2	-	15.6	0.6	-	-	-
Chamelaucieae	5	13	-	-	-	-	-	-	14.3	-	-	7.1	-	-	92.9	3.6	-	-	-	21.4	21.4	-	35.7	-	-	-	-
Lindsayomyrteae	1	1	-	-	-	-	-	-	-	-	-	-	25.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Myrteae	35	355	1.8	-	0.7	0.6	-	-	-	0.6	-	2.6	1.4	2.0	24.8	0.6	-	5.2	0.1	-	9.0	0.1	9.8	1.7	0.6	-	0.4
Kanieae	5	12	-	-	-	-	-	-	-	-	-	-	-	15.4	76.9	-	-	15.4	-	-	23.1	-	-	-	-	-	7.7
Tristanieae	2	2	-	-	-	-	-	-	-	-	-	-	-	-	75.0	-	-	-	-	-	-	-	-	-	-	-	-
Backhousieae	1	3	-	-	-	33.3	-	-	33.3	16.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Syzygieae	4	15	-	6.7	-	-	0.8	-	-	3.3	-	1.7	-	-	15.0	-	-	10.0	-	-	-	-	-	7.5	-	-	-
Metrosidereae	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

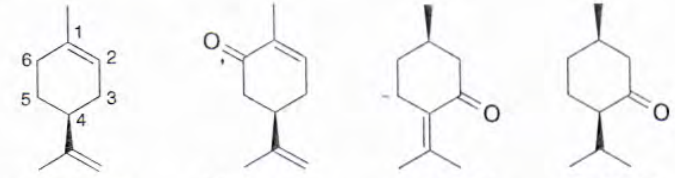
Terpenes: very diverse, exotic in perception

Acyclic

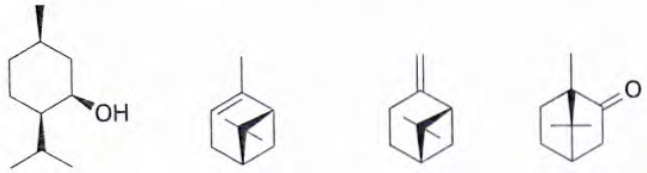


Nerol Geraniol Citronellol

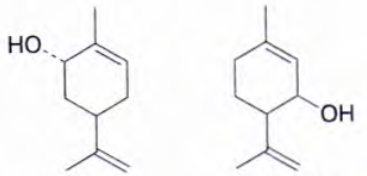
Cyclohexanoid



(–)-Limonene (–)-Carvone Pulegone Menthone



Menthol α-Pinene β-Pinene Camphor



Carveol Isopiperitenol

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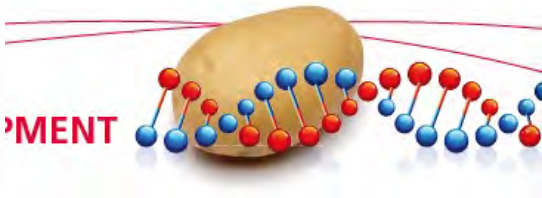
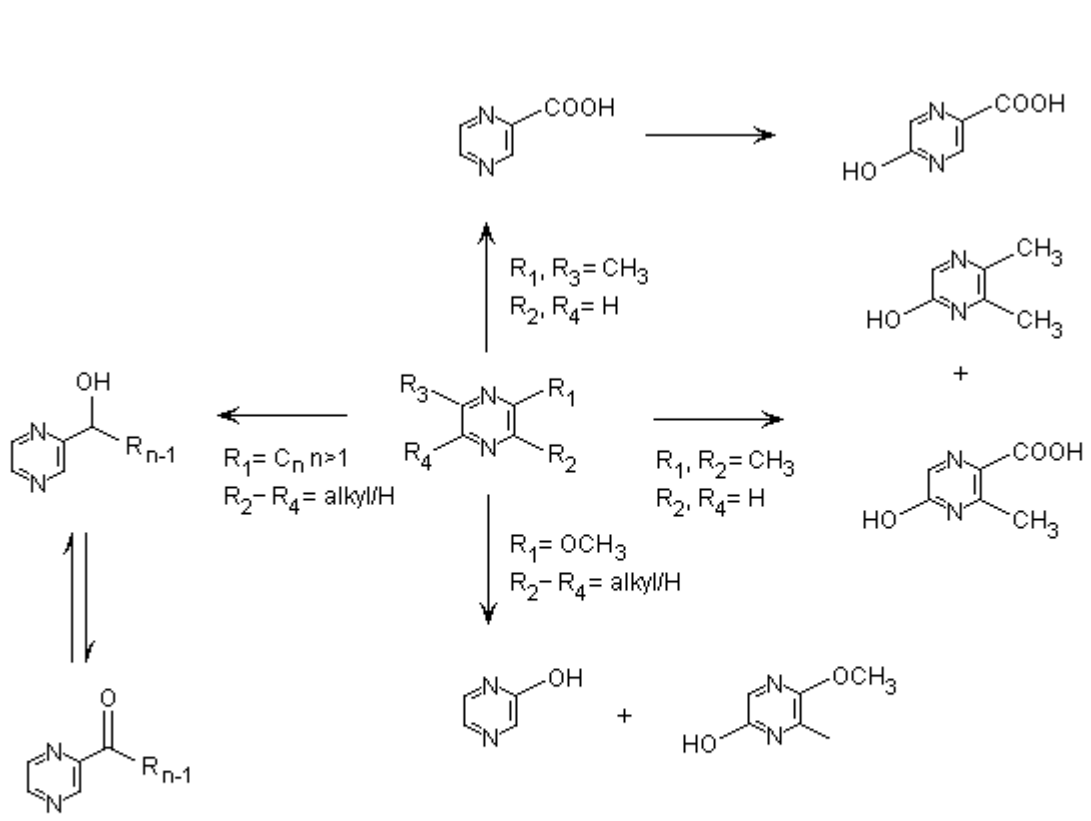
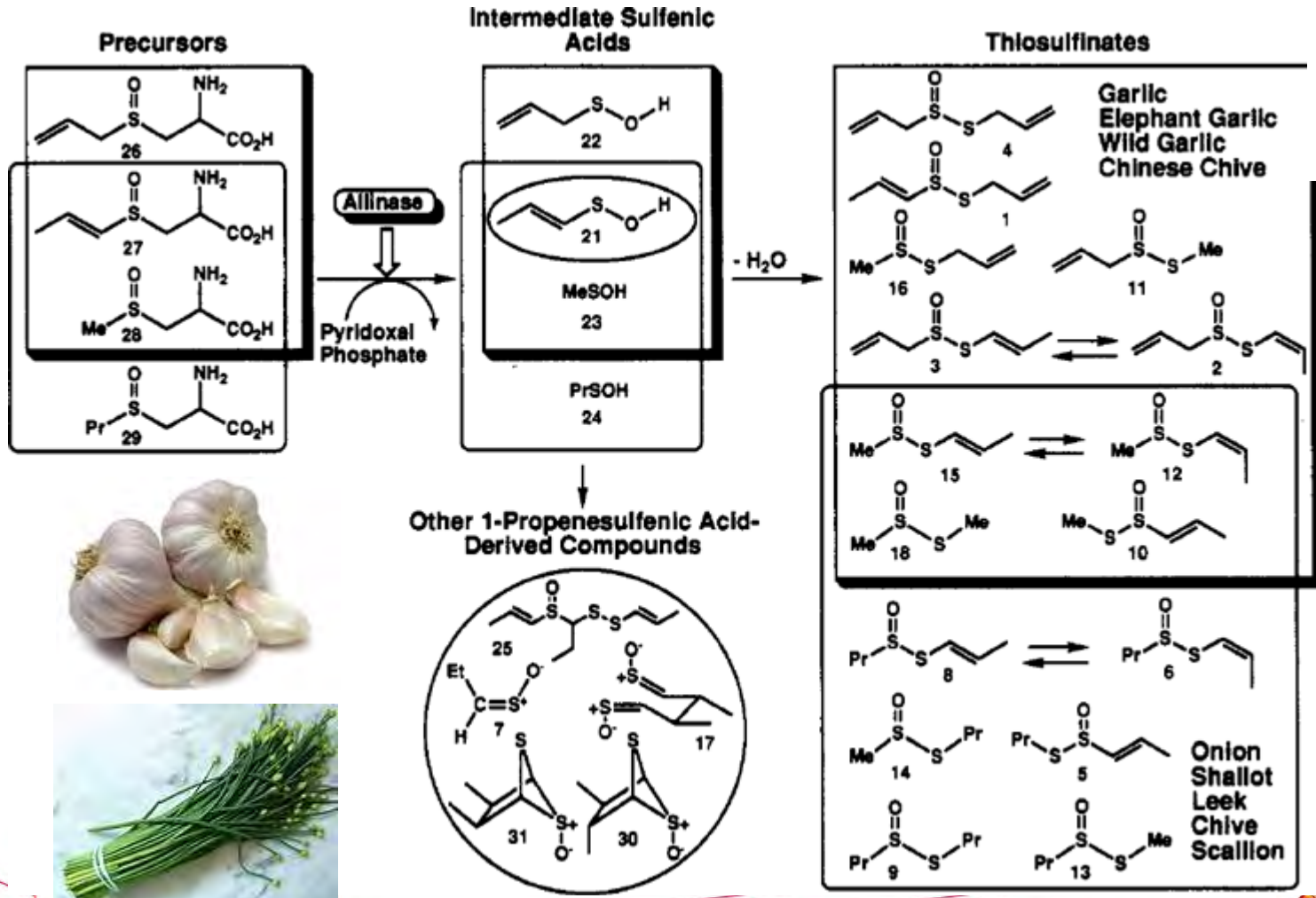
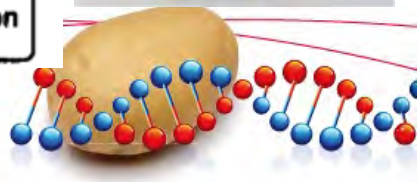


Pyrazins: the most potent odours



Alkylsulfoxides: the allium flavour profile





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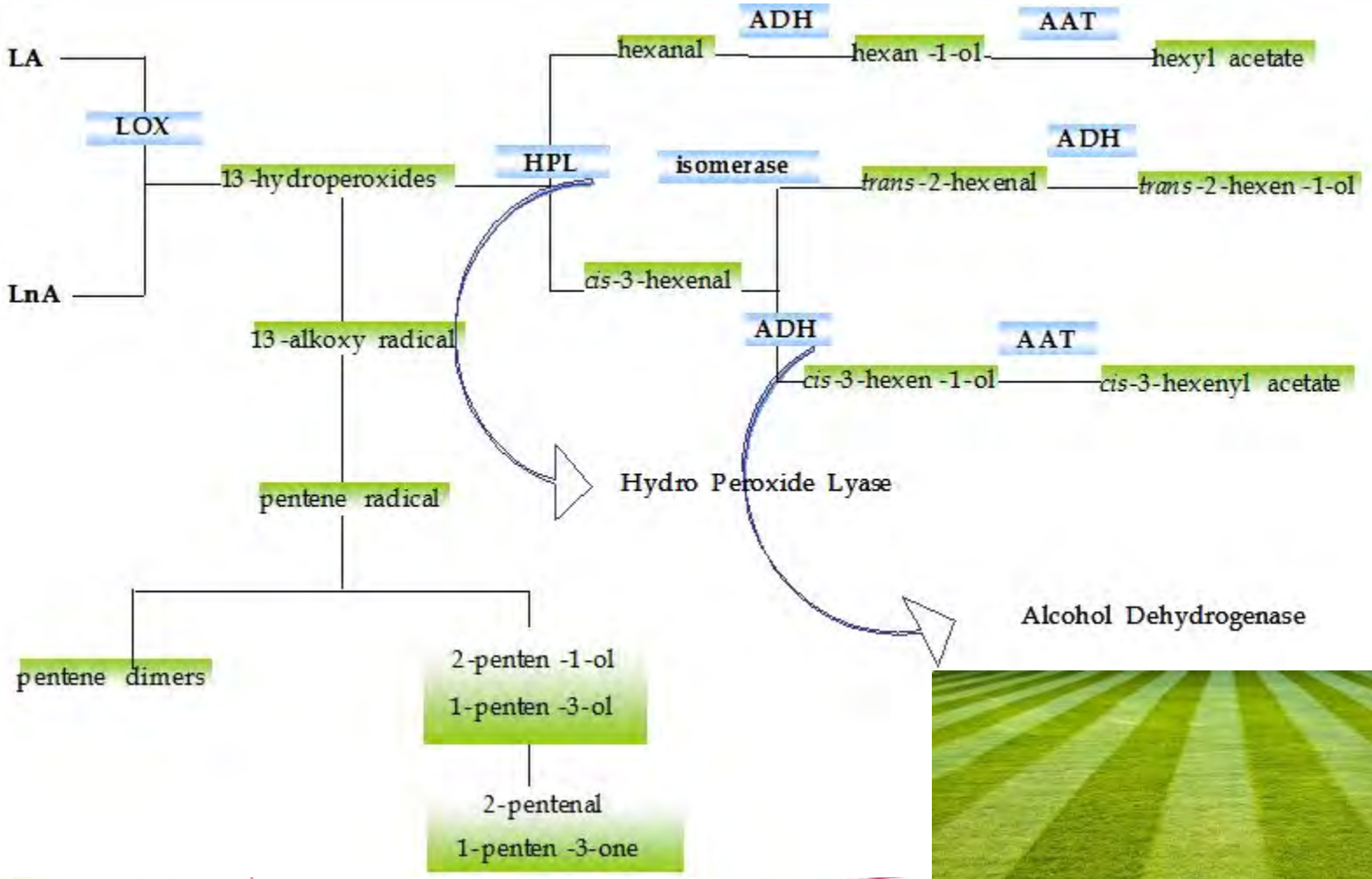
‘Green’ chemistry: fresh flavours from fatty acids



Architecture Aromatique = Architecture Biochemique

- Flavours & aroma's have a complex blueprint:
  - Often long biosynthesis routes
  - Many enzymatic steps involved
  - Release often upon disruption or damaging of tissues
  - Liberation very often by an enzymatic step
  - Multicomponent mixtures in various compositions
  - Diversity has a genetic basis and can be selected and bred for
  - Genomics of flavour & aroma's in cresses and sprouts is (still) in an early stage of development

Health & nutrition of cresses

- Not addressed in this presentation, however….
- Cresses and sprouts have clear potential
- Most component groups discussed are active
- Health aspects of cresses in lecture of Prof. Roel Vonk on 2nd symposium day

Thanks for your attention

Questions???

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