

# Terpene

Vortragsteil von Lara Henrichs

- Name: von Friedrich August Kekulé nach dem Terpentin benannt  
Terpentin = leicht flüchtige Flüssigkeit -> aus Nadelbäumen isolierbar
- Vorkommen:
  - als Duft- und Geschmackstoffe in Blumen /Pflanzen -> „Gewürze“
  - ätherische Öle der Bäume -> „Eukalyptus“
  - Insekten: als Pheromone und Botenstoffe der Kommunikation -> Ameisen + Bienen
- Nutzung:
  - Kosmetikindustrie> Seife, Parfum
  - Lebensmittelindustrie -> Geschmackstoffe
  - Polyterpene in der Gummi- / Kunststoffindustrie -> Autoreifen, Dichtungen etc.
- wichtige Forscher:
  - Otto Wallach, Leopold Ruzicka ~ 1870 – 1914
  - Adolf von Bayer
  - Feodor Lynen, Konrad Bloch ~ ab den 1960´ern

# Charakterisierung / Klassifizierung

- wasserunlöslich  
ölig; vollständig verdampfend

↳ Anzahl Isopren-Einheiten  $\approx$  C5

↳ 1887 Otto Wallach: biogenetische Isoprenregel

Name Klasse	Anzahl C-Atome	Anzahl Isopren-Einheiten
Hemi +.	5	1
Mono +.	10	2
Sesqui +.	15	3
Diterpene	20	4
Sester +.	25	5
Triterp.	30	6
Tetrat.	40	8
Polysterp.	5n	n



irreführend !!

↳ griechische Zahlwörter

$$\text{hemi} = \frac{1}{2}$$

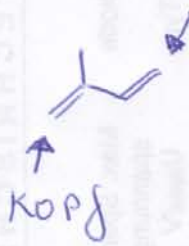
$$\text{mono} = 1 \quad \text{sesqui} = 1\frac{1}{2}$$

$$\text{sester} = 2\frac{1}{2} \quad \dots$$

1 Terpen-Einheit  $\hat{=}$  2 Isopren-Einheiten

↳ auch: 1922 Leopold Ruzicka: Isoprenregel

↳ nach Art der Verknüpfung der Isopreneinheiten



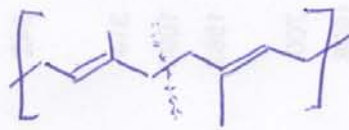
- Kopf-Schwanz-Verkn.



- Schwanz-Schwanz



- Kopf-Kopf



↳ nach Struktur:  
acyclisch | monocyclisch | bicyclisch  
tricyclisch.....

↳ nach funktionellen Gruppen  
↳ Substanzvielfalt

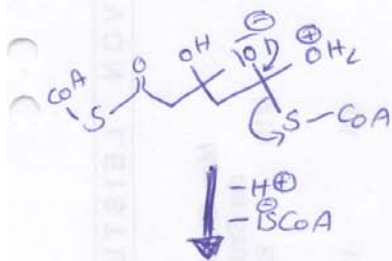
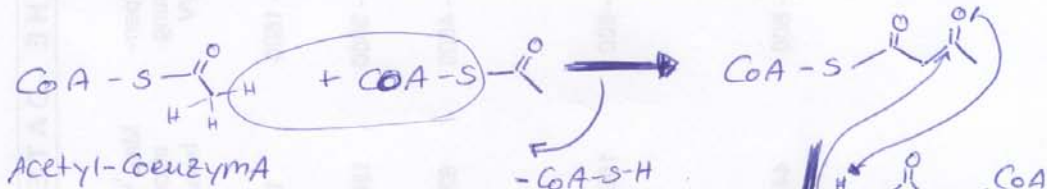
↳ Abbau v. C-At. TERPENOIDE

= bei späteren Syntheseschritten wurden C-Atome aus Molekül entfernt

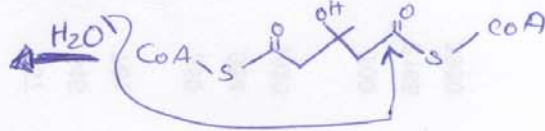
→ C<sub>5</sub>-Regel passt nicht mehr

# BIOSYNTHESE

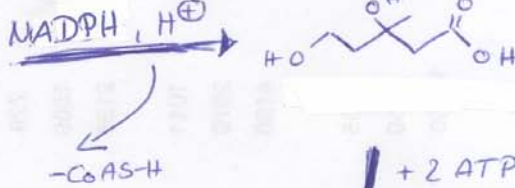
- 1964 erstmals v. Feodor Lynen + Konrad Bloch beschrieben
- MEP (2C-Methyl-D-erythritol-4P)-Pathway  
 Co benannt nach Rohmer - o. Arigoni Pathway



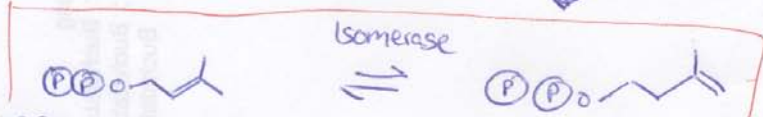
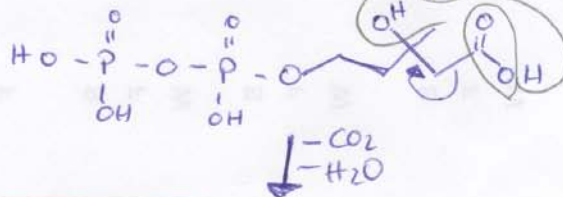
β-Hydroxy-β-methyl-glutaryl-CoA  
- Mevalonsäurederivat



Reduktion



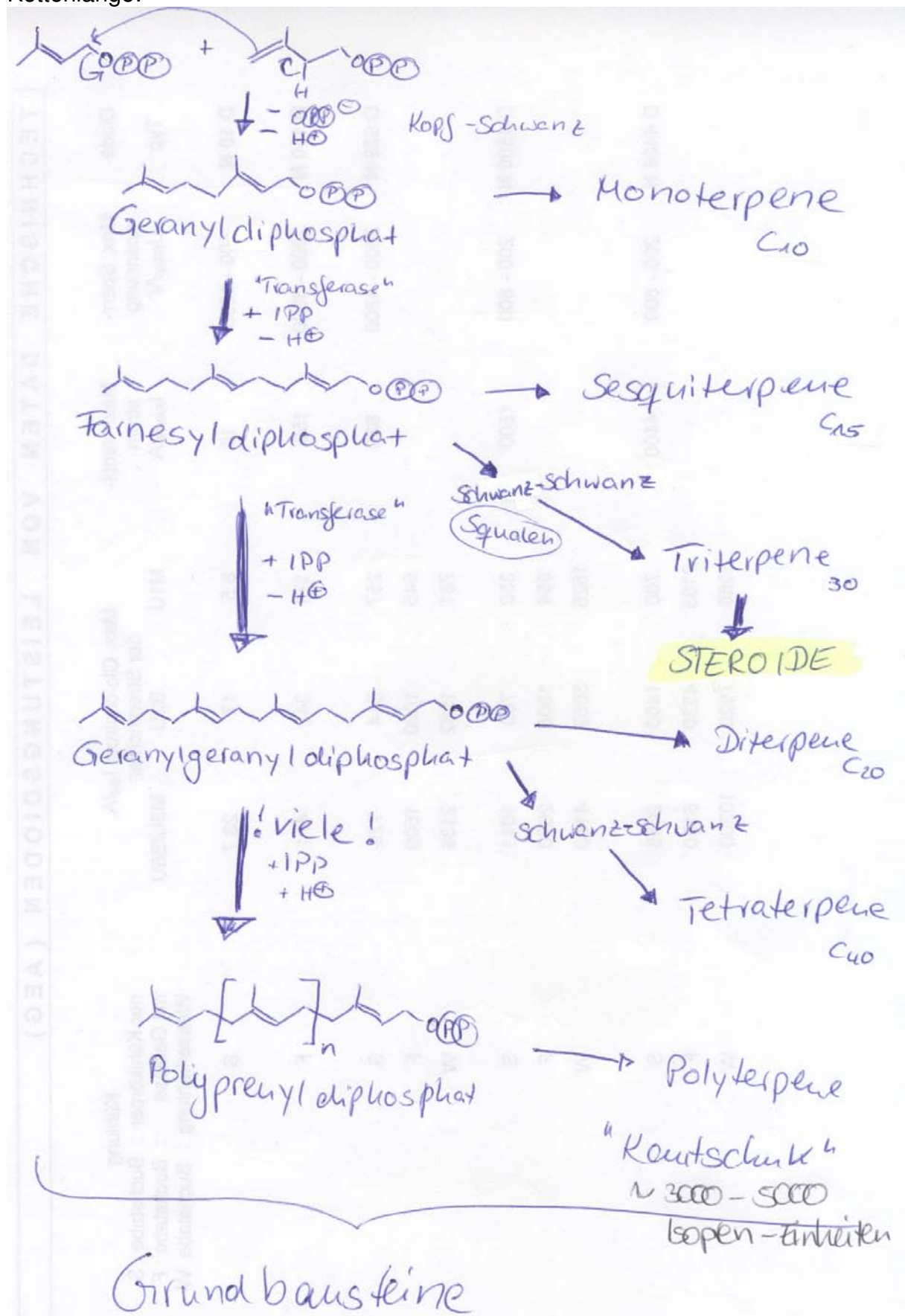
+ 2 ATP } 2.  
+ 2 ADP } P<sub>3</sub>H<sup>⊖</sup>  
Überlager



DMAPP  
Dimethylallyl-pyrophosphat

IPP (isopentylpyrophosphat)  
oder IDP  
Cyx-Dimethylallyldiphosphat

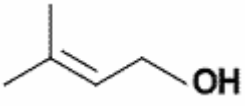
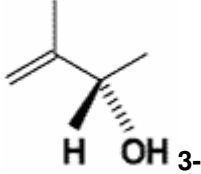
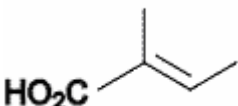
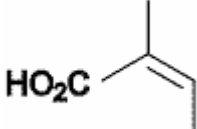
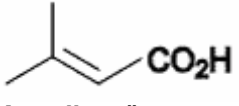
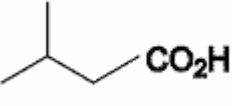
Schematische Darstellung der Entstehung von Terpenen unterschiedlicher Kettenlänge:



# Beispiele:

## Hemiterpene:

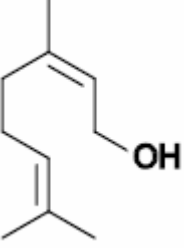
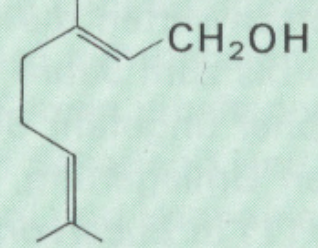
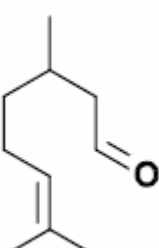
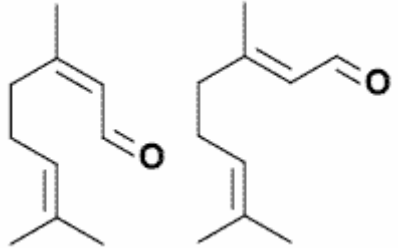
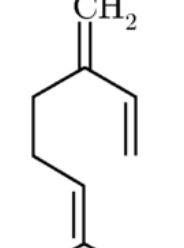
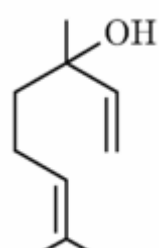
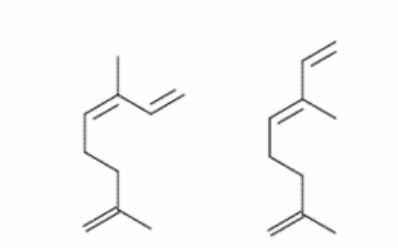
(1 Isopren-Einheit)

 Prenol	 Methyl-3-buten-2-ol	 Tiglicsäure	 Seneciosäure	 Angelicasäure	 Isovaleriansäure
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Nur ca. 25 bekannt, sehr selten in Natur.

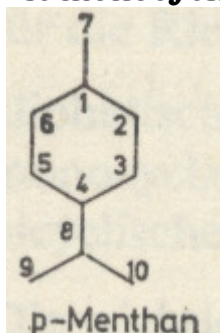
## Monoterpene:

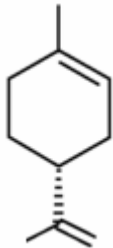
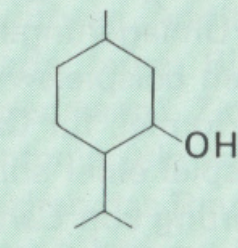
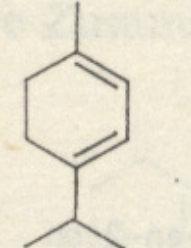
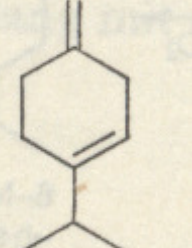
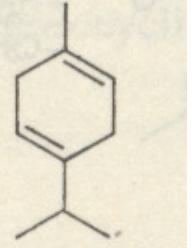
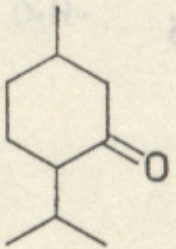
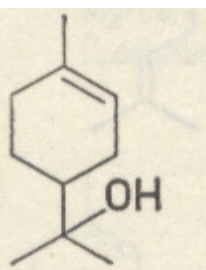
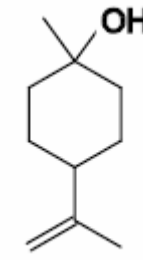
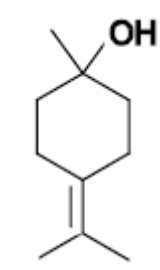
### a) acyclisch:

 Nerol in Lavende-Rosenöl, Orangenblüten	 Geraniol: in Koreander, Lorbeer, Muskat, in der Rose	 Citronellal: in Zitrusfrüchten z.B. Limette, auch Wachholder	 Neral + Geranial Citral A + Citral B (im Lemonengrasöl, im Rosenöl)
 Myrcen: in Lorber, rKümmel, Fenchel, Estragon, Dill, Hopfen sowie Hanfölen	 Linalool: : In Linaloeöl, Lavendel, Koriander, Muskat, Ingwer, Bohnenkraut, Zimt, Basilikum, Majoran, Thymian, Oregano		 cis-a-Ocimen trans-a-Ocimen in Lavendel, Basilienkraut

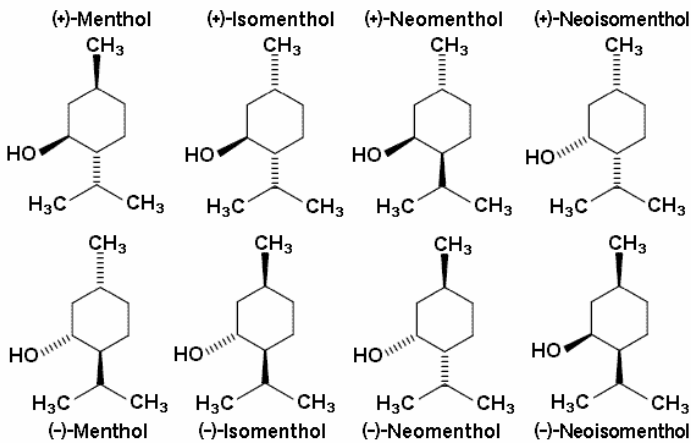
### b) monocyclisch:

Die monocyclischen Monoterpene leiten sich vom p-Menthan ab:

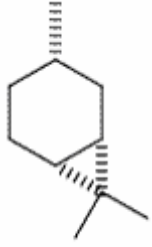
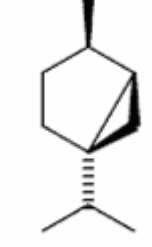




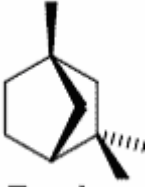
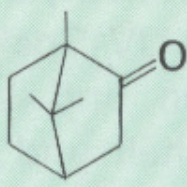
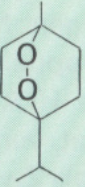
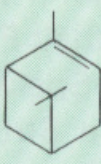
 <p><b>Limonen:</b> in Kümmelöl, Dillöl, Korianderöl, Zitronenöl, Orangenöl, Edeltannen- und in Pfefferminzöl, Muskatnussöl</p>	 <p><b>Menthol</b> (Pfefferminze)</p> <p>*</p>	 <p><math>\alpha</math>-Terpinen</p> <p><b>Terpinen:</b> In Bohnenkraut und Majoran, Dill, Fenchel, Johanniskraut, Muskatnuss, Teebaumöl, Wacholder, Weihrauch</p>	 <p><math>\beta</math>-Terpinen</p>	 <p><math>\gamma</math>-Terpinen</p>
 <p><b>Menthon</b></p> <p>im Fruchtlöl des Baumes <i>Eucalyptus</i> <i>globulus</i></p>	 <p><math>\alpha</math>-Terpineol</p>	 <p><math>\beta</math>-Terpineol</p>	 <p><math>\gamma</math>-Terpineol</p>	<p><b>Terpineol:</b> in Lorbeer, Rosmarin, Anis, Majoran, Salbei oder Wacholder</p>

**\* (das war nur die halbe Wahrheit ☺)**



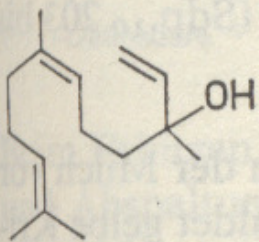
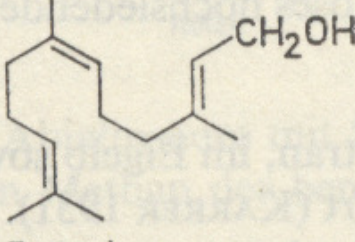
**c) bicyclisch:**

 <p><b>Caran</b></p>	 <p><b>(trans-)Thujan</b></p>	 <p><b>Pinan</b></p>	 <p><b>Camphan</b></p>
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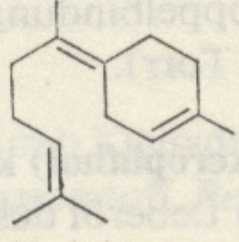
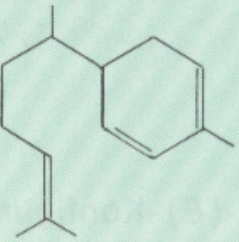
 <p><b>Fenchan</b></p>	 <p><b>Campher</b></p>	 <p>Ascaridol (wurmtreibendes Mittel aus Chenopodiumöl)</p>	 <p><b><math>\alpha</math>-Pinen</b> (Terpentinöl) in Fichtennadeln, Dill, Fenchel, Koriander und Kümmel</p>
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**Sesquiterpene:**

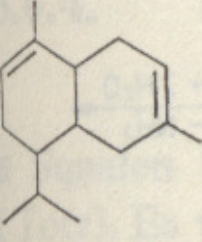
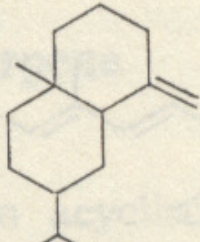
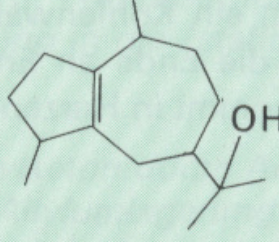
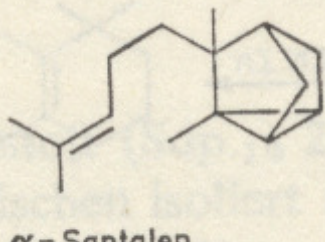
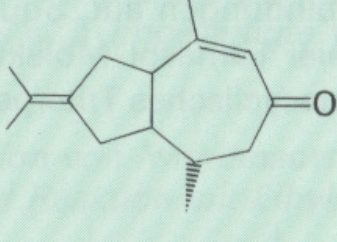
**a) acyclisch**

 <p>Nerolidol (Capreuvaöl)</p>	 <p>Farnesol (Kamillenblütenöl) + Maiglöckchen</p>
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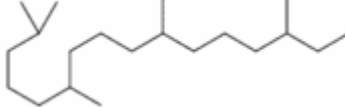
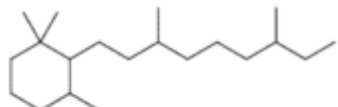
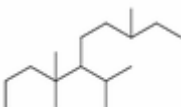
**b) monocyclisch:**

 <p>Bisabolen (Citronenöl) in Kubebenpfeffer, Zitrone und Oregano</p>	 <p>Zingiberen (Ingwer)</p>
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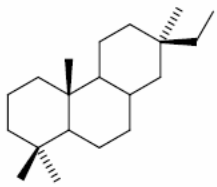
**c) bicyclisch:**

 <p>Cadinen (Cadeöl)</p>	 <p><math>\beta</math>-Selinen (Sellerieöl)</p>	 <p>Guajol (Guajakharz)</p>	 <p><math>\alpha</math>-Santalen (Sandelholzöl)</p>	 <p>Vetivon (Vetiveröl)</p>
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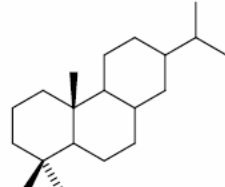
**Diterpene:**

 <p>Phytan</p>	 <p>10,16-Cyclophytan</p>	 <p>Labdan</p>
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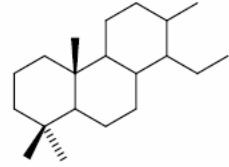




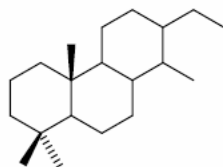
Primaran



Abletan

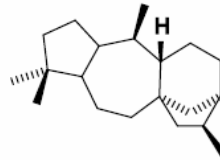


Cleistanthan

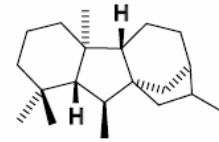


Cassan

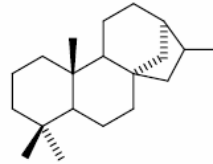
Wichtige Stammverbindungen der Tricyclicophytane



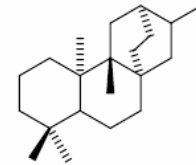
Grayanotoxin



Giberellan



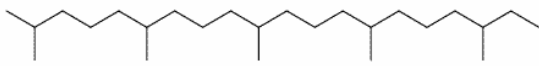
Kauran



Atisan

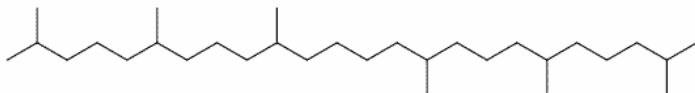
Wichtige Stammverbindungen der Tetracyclicophytane

### Sesterterpen:

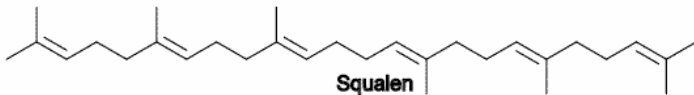


3,7,11,15,19-Pentamethylicosan

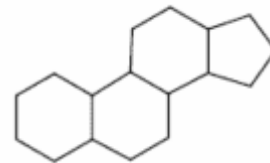
### Triterpene:



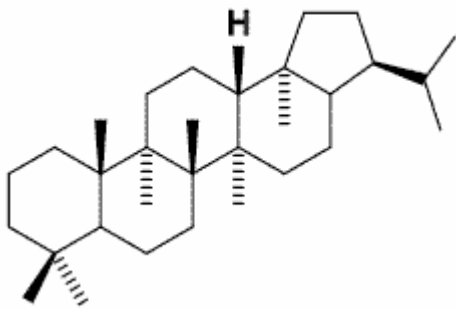
Squalan



Squalen



Gonan

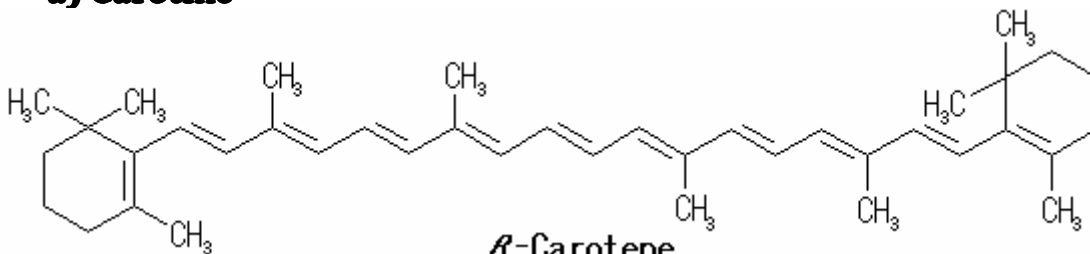


Hopan

### Tetraterpene:

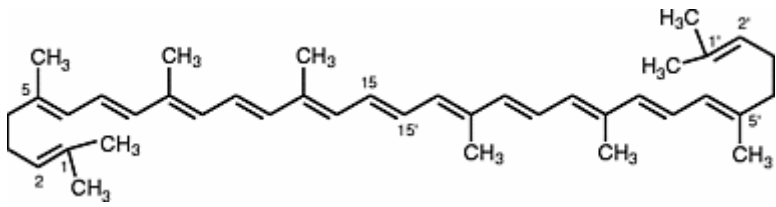
→ Carotinoide :

a) Carotine



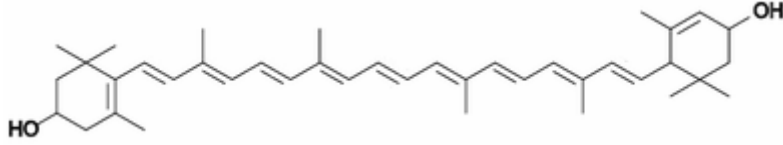
*β*-Carotene

-> orange der Möhre



Lycopin (Lycopen) -> Rot der Tomate

**b) Xanthophylle: (sauerstoffhaltige Derivate der Carotine)**



Lutein -> gelb-orange

**Polyterpene:**

