MICHELE MAGGINI
DIPARTIMENTO DI SCIENZE CHIMICHE
VIA MARZOLO, 1

Ricevimento: MERCOLEDI' ore 16-17

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www.chimica.unipd.it/michele.maggini

Informazioni sul corso, appunti di lezione:
sito Moodle STEM UniPD:
https://stem.elearning.unipd.it/course/index.php
Esami: UNIWEB (https://uniweb.unipd.it)

Chimica Organica 1

SCIENZA DEI MATERIALI

a.a. 2023-2024

27 settembre 2023 - 19 gennaio 2024

64 ore di lezione

Mercoledì: 9.30-11.15

Giovedì: 10.30-11.15

Venerdì: 11.30-13.15

Aula L2, DiSC

2023

settembre

lu	ma	me	gi	ve	sa	do
28	29	30	31	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	1
2	3	4	5	6	7	8

ottobre

lu	ma	me	gi	ve	sa	do
25	26	27	28	29	30	1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	1	2	3	4	5

novembre

lu	ma	me	gi	ve	sa	do
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3
4	5	6	7	8	9	10

dicembre

lu	ma	me	gi	ve	sa	do
27	28	29	30	1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
1	2	3	4	5	6	7

2024

gennaio

lu	ma	me	gi	ve	sa	do
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31	1	2	3	4
5	6	7	8	9	10	11

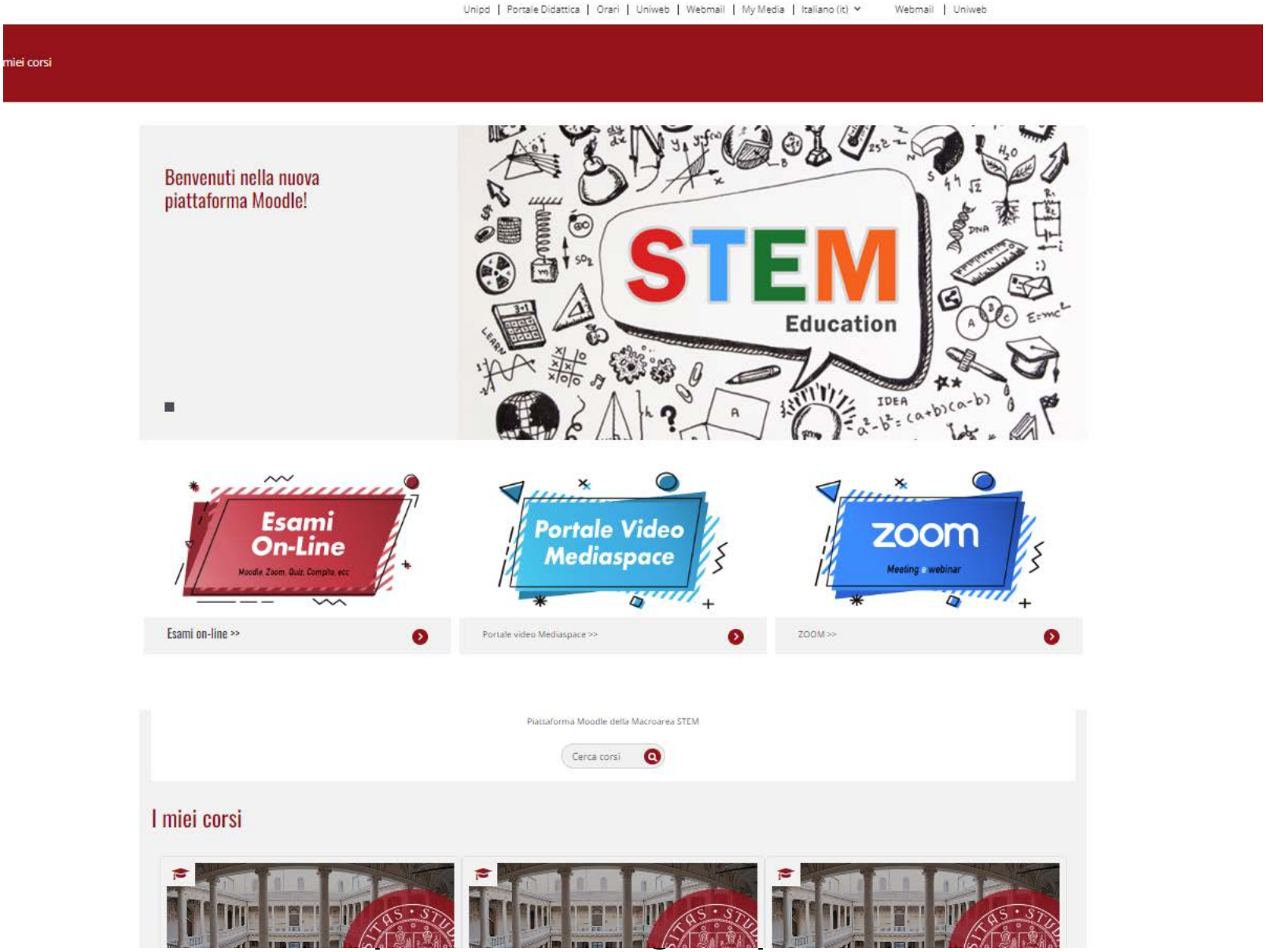
Giallo: vacanza

Arancione: lezione

L’ ESAME DI CHIMICA ORGANICA 1

Sessione INVERNALE:
Sessione ESTIVA:
Sessione DI RECUPERO:

L’esame di CO1 consiste in una prova scritta e un colloquio orale. La prova scritta è costituita da 30 domande a scelta multipla e 5 domande aperte. Per ogni risposta giusta saranno corrisposti 3 punti, zero punti per ogni risposta non data e sarà tolto un punto per ogni risposta sbagliata. Il punteggio ottenuto sarà normalizzato a 30**.**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SCQ2099499 - CHIMICA ORGANICA 1 2023-2024

SCQ2099499 - CHIMICA ORGANICA 1 2023-2024 - PROF. MICHELE MAGGINI

Minimizza tutto

LEZIONI IN PRESENZA - AULA L2 (piano terra DiSC)
LT Scienza dei Materiali
II anno, I semestre - a.a. 2023-2024

mercoledì dalle 9.30 alle 11.15
giovedì dalle 10.30 alle 11.15
venerdì dalle 11.30 alle 13.15
Ricevimento studenti: mercoledì dalle 16 alle 17 su appuntamento (secondo piano, stanza 7, edificio 170)
tel.: 049 8275662
email: michele.maggini@unipd.it

Annunci

Informazioni sull'insegnamento di CO1

Programma del corso

maggini_CO1_2023

Il corso di chimica organica_1 ha lo scopo di fornire i concetti fondamentali sulla struttura, nomenclatura e reazioni di alcuni composti organici monofunzionali. E' necessario aver seguito il corso di chimica generale e inorganica per affrontare e portare a termine proficuamente il corso di introduzione alla chimica organica.

Testi consigliati:

P. Yurkanis Bruice: Chimica Organica, Edises, III edizione - 2017

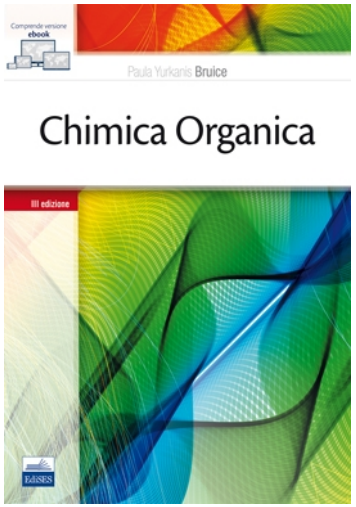
J. Clayden, N. Greeves, S. Warren: Organic Chemistry, 2nd Edition – March 2012 (traduzione italiana, Chimica Organica ed. Piccin, maggio 2023)

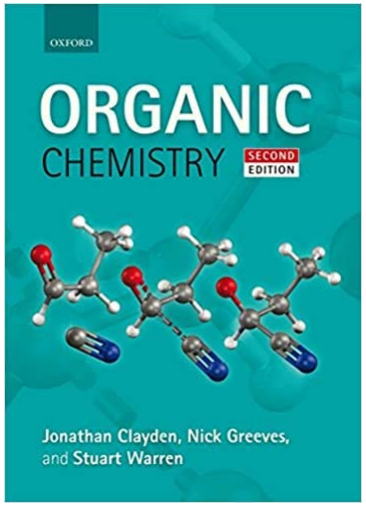
W.H. Brown, B.L. Iverson, E.V. Anslyn, C.S. Foote: Chimica Organica, Edises VI edizione – 2020.

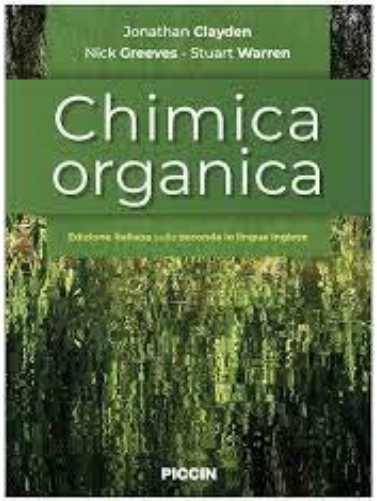
Esercizi

D'Auria, Taglialatela Scafati, Zampella: Guida Ragionata allo Svolgimento di Esercizi di Chimica Organica (ISBN 9788895122519) - V edizione, Loghia Editore

B. L. Iverson, S. Iverson: Guida alla soluzione dei problemi da "Chimica Organica" di Brown, Iverson, Anslyn, Foote, Edises, ISBN: 9788879598965, edizione 4 - 2016

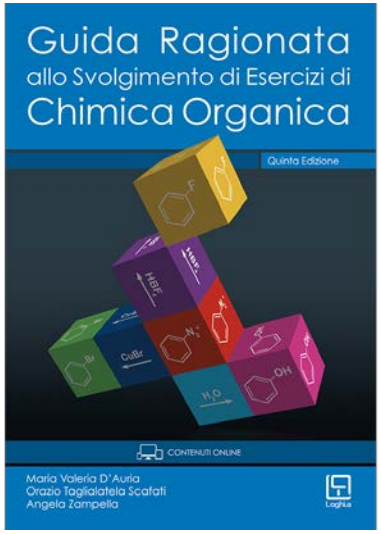

Paula Yurkanis Bruice
Chimica Organica
III edizione


OXFORD
ORGANIC
CHEMISTRY
SECOND EDITION
Jonathan Clayden, Nick Greeves,
and Stuart Warren

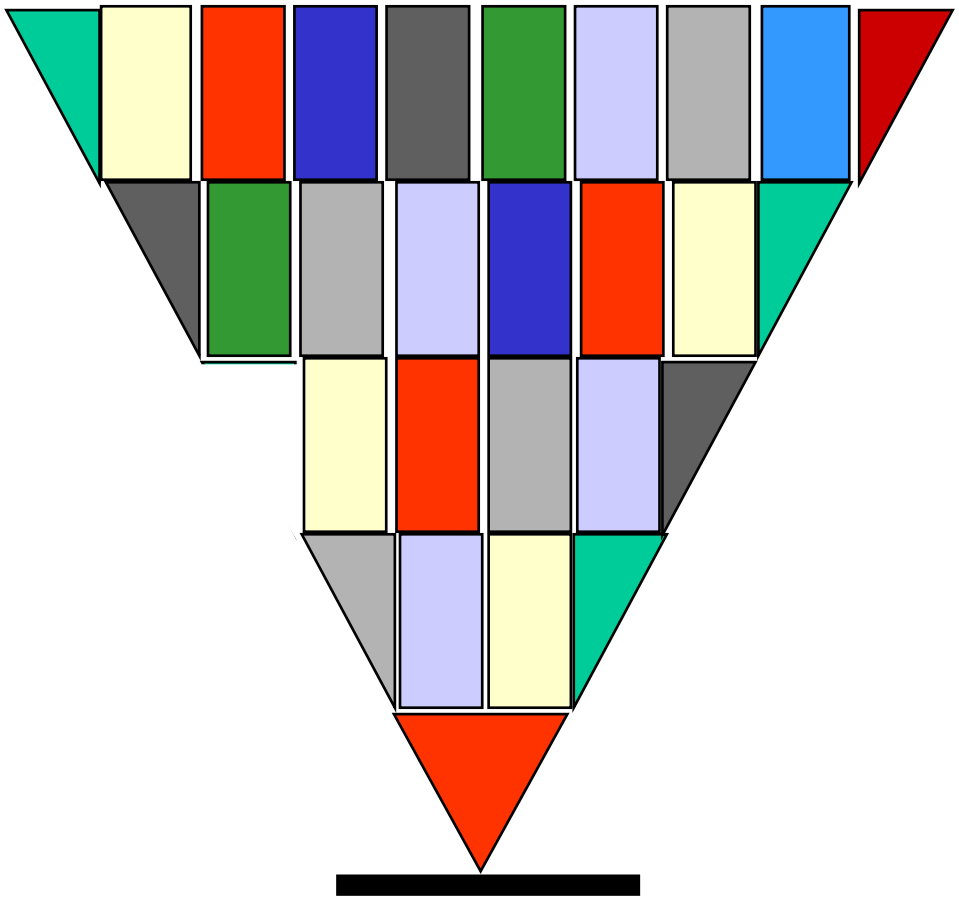

Jonathan Clayden
Nick Greeves - Stuart Warren
Chimica
organica
PICCIN


Brown • Iverson • Anslyn • Foote
Chimica Organica
II edizione


B. L. Iverson • S. Iverson
Guida alla soluzione dei problemi da
Chimica Organica di
Brown, Iverson, Anslyn, Foote

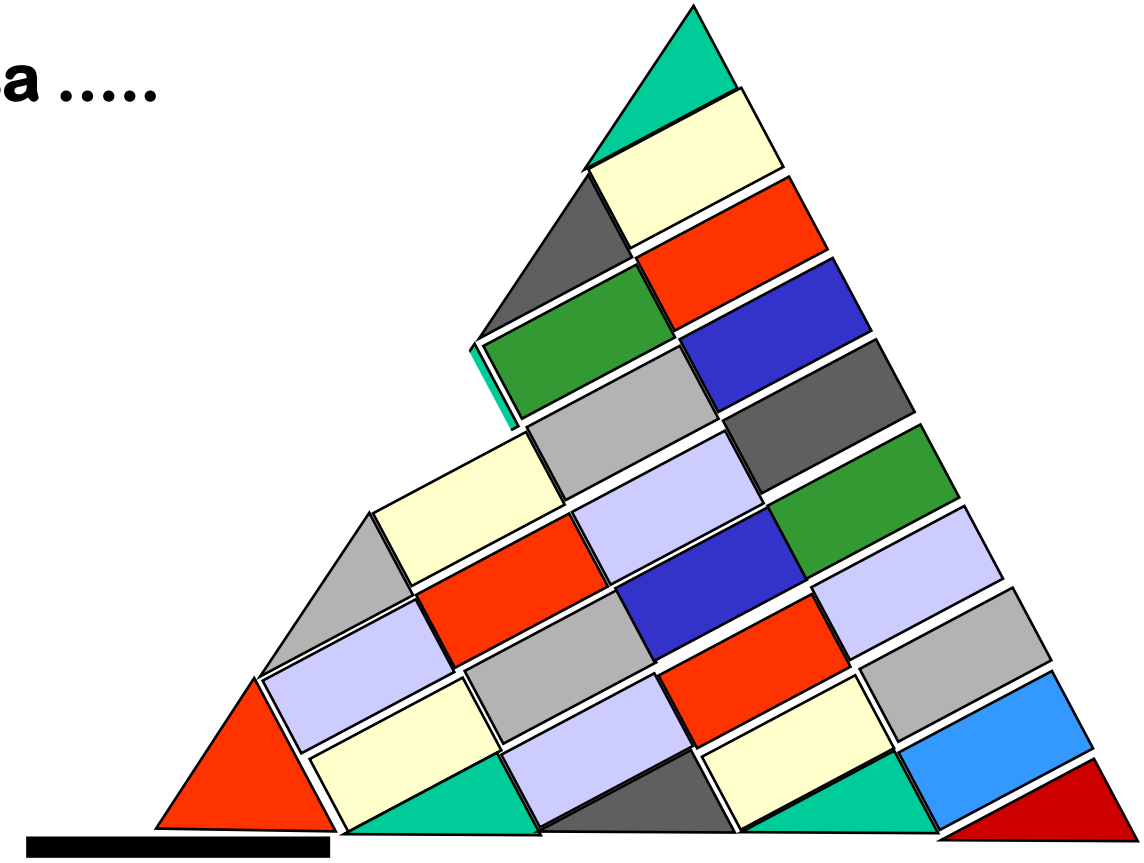

Guida Ragionata
allo Svolgimento di Esercizi di
Chimica Organica
Quinta Edizione
CONTENUTI ONLINE
Maria Valeria D'Auria
Orazio Taglialatela Scafati
Angela Zampella

LA CONOSCENZA IN CHIMICA ORGANICA



Se manca qualcosa …..

L’ intera struttura collassa !!!



NON STARE INDIETRO !

Sebbene il materiale iniziale sia semplice e per molti di voi costituisca un ripasso, esso potrebbe diventare complesso molto velocemente

i contenuti di questo corso sono cumulativi

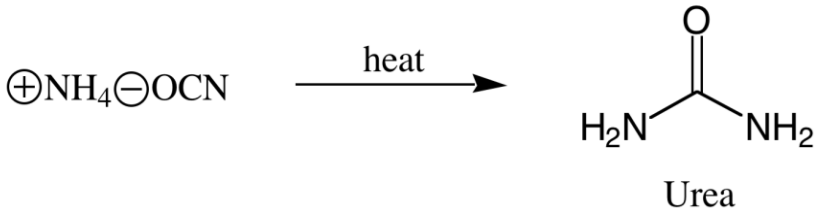
le nuove conoscenze partiranno dai concetti appena appresi

il consiglio è di non lasciare lo studio della chimica organica esclusivamente alla fine del corso

per superare l’esame scritto è necessario saper utilizzare e collegare le conoscenze

Cos’è la chimica organica

- organico: forza speciale negli organismi viventi
- cambio di paradigma: sintesi dell’urea (Wöhler, 1828)

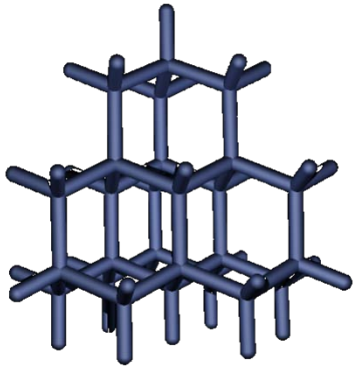


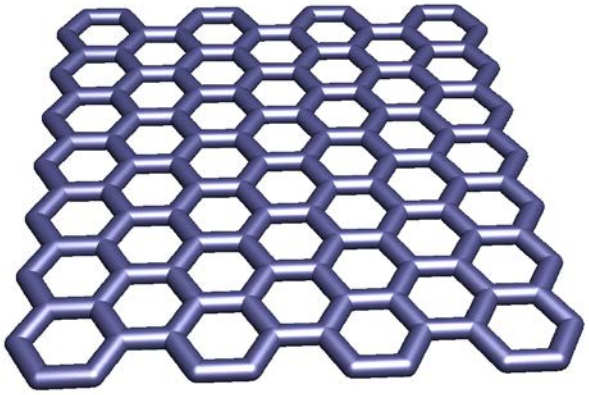
Urea

- chimica organica: chimica del carbonio*

***…ma non solo; ci sono solo poche forme di puro carbonio**

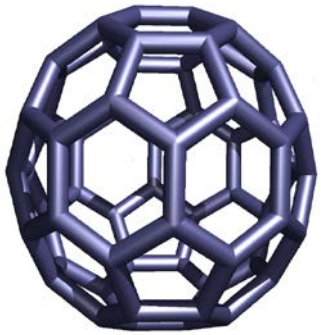
grafene



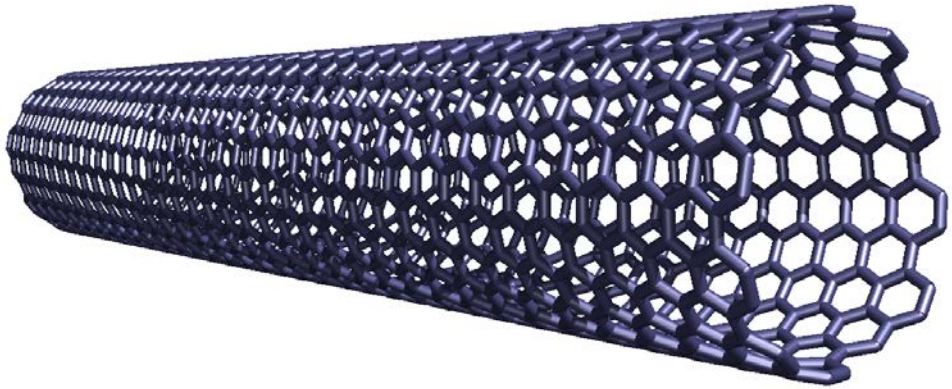


diamante

grafite



fullereni

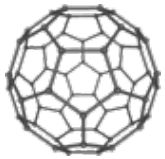


Nanotubi di carbonio

CARBON NANOSTRUCTURES

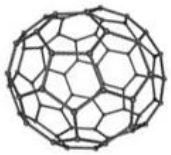
Molecular

C_{60}



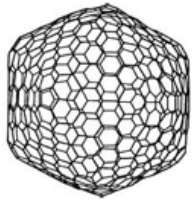
Smalley, R. E. *et al.*
Nature
1985, *318*, 162

C_{70}



Whetten, R. L. *et al.*
J. Phys. Chem.
1990, *94*, 8630

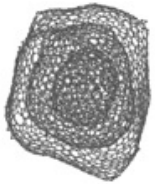
C_{540}



Kroto, H.
Pure Appl. Chem.
1990, *62*, 407

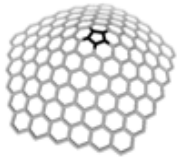
Particellar

Nano-onions



Ugarte, D.
Nature
1992, *359*, 707

Nano-cones



Sattler, K. *et al.*
Chem. Phys. Lett.
1994, *220*, 192

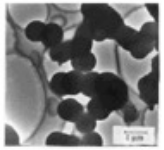
Nano-horns

Iijima, S. *et al.*
Chem. Phys. Lett.
2000, *321*, 514

Nano-diamond

Greiner, N. R. *et al.*
Nature
1990, *343*, 244

Nano-beads



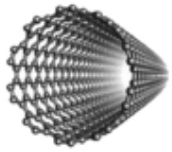
Zhao, X. L. *et al.*
Carbon
1998, *36*, 507

Nano-dots

Scrivens, W. A. *et al.*
J. Am. Chem. Soc.
2004, *126*, 12736

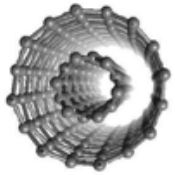
1D

SWCNTs



Ichihashi, T. *et al.*
Nature
1993, *363*, 603

DWCNTs



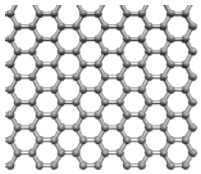
Zakharov, D. N. *et al.*
Carbon
2001, *39*, 761

MWCNTs

Iijima, S.
Nature
1991, *354*, 56

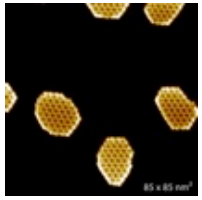
2D

Graphene



Novoselov, K. S. *et al.*
Science
2004, *306*, 666

Graphene nanodots



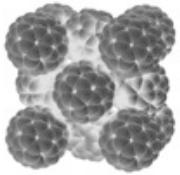
Novoselov, K. S. *et al.*
Science
2008, *320*, 356

Graphene nanoribbons

Dresselhaus, M. S. *et al.*
Phys. Rev. B
1996, *54*, 17954

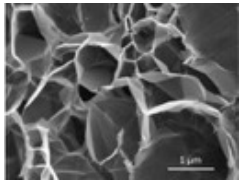
3D

Fullerite



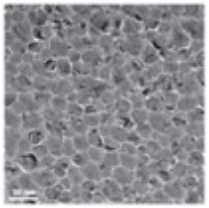
Thiel, F. A. *et al.*
Nature
1991, *351*, 380

Graphene nanoplatelets



Thiel, F. A. *et al.*
Nature
1991, *351*, 380

Nanocristalline diamond films



Gruen, D. M. *et al.*
Annu. Rev. Mater. Sci.
1999, *29*, 211

1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Uun								

58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Numero atomico

6

C

Carbonio

12,011

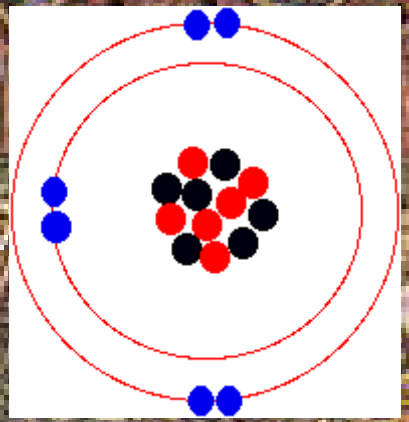
$[He]\ 2s^2\ 2p^2$

Simbolo atomico

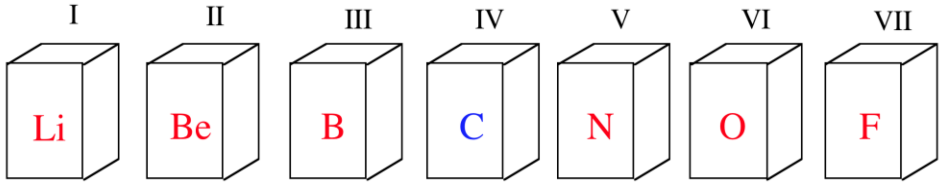
Nome dell'elemento

Peso atomico

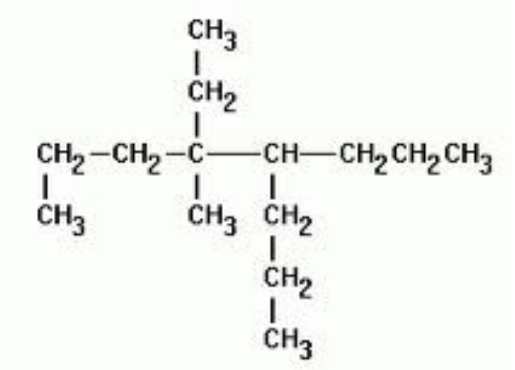
Configurazione elettronica

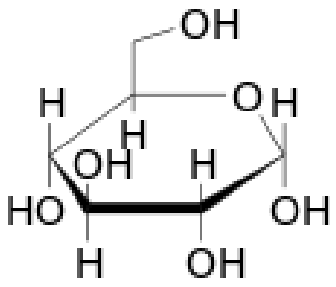


- la posizione del C nel mezzo del II periodo della TP permette di condividere elettroni con molti elementi e fare legami (**ci interessa molto cosa fanno gli elettroni e come si comportano**)



- il C è uno dei pochi elementi che forma **catene**; può formare **sistemi ramificati** e **anelli**





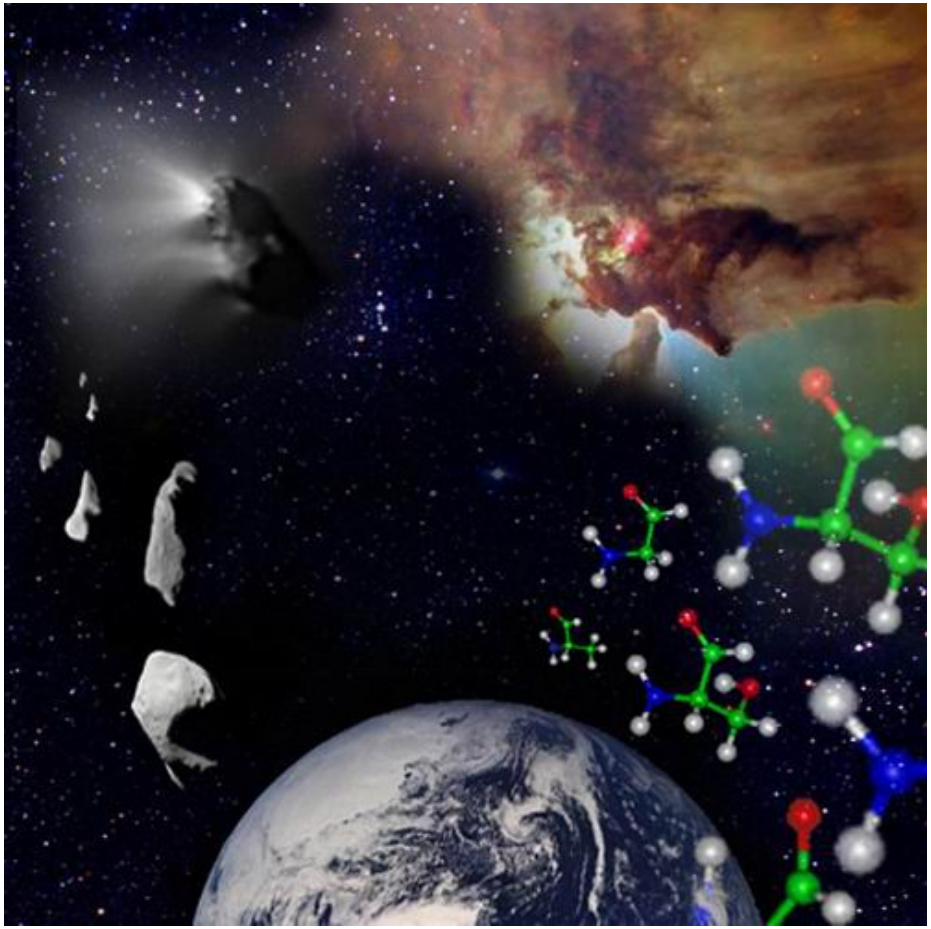
LA GRANDE VARIETA' DEL CARBONIO

Per il fatto che il C può concatenarsi e ramificare esistono MILIONI di composti a base di carbonio

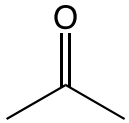
La grande varietà e molteplicità dei derivati rende il carbonio un elemento su cui basare complicati sistemi viventi.

Si possono identificare molecole specifiche per codificare ogni processo biochimico

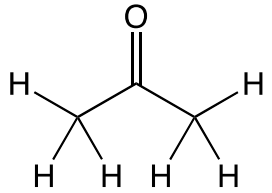
spazio chimico : 10^{60} composti



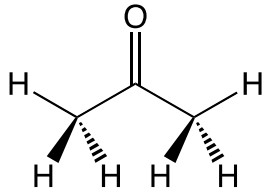
comprendere la chimica organica attraverso la conoscenza dei legami tra gli atomi nelle molecole e la loro disposizione spaziale, e del movimento degli elettroni che li formano.



Shorthand drawing

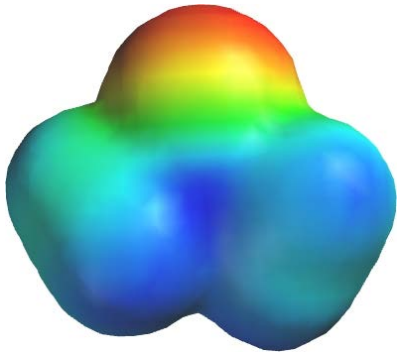


All atoms indicated



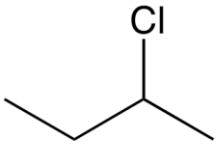
3-dimensional drawing

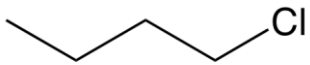
wedge and dash lines have meaning



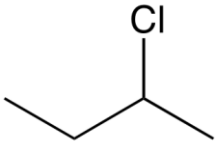
Electron density plot

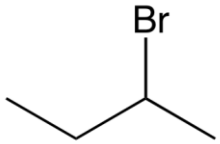
le reazioni organiche si possono anticipare attraverso la comprensione della disposizione e della natura dei legami che si rompono e si formano nelle molecole interagenti



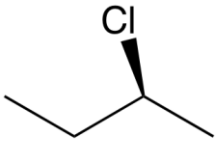


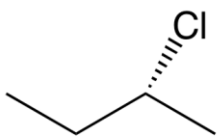
stessa formula C_4H_9Cl ma reattività differente





cambia l’alogeno, cambia la reattività

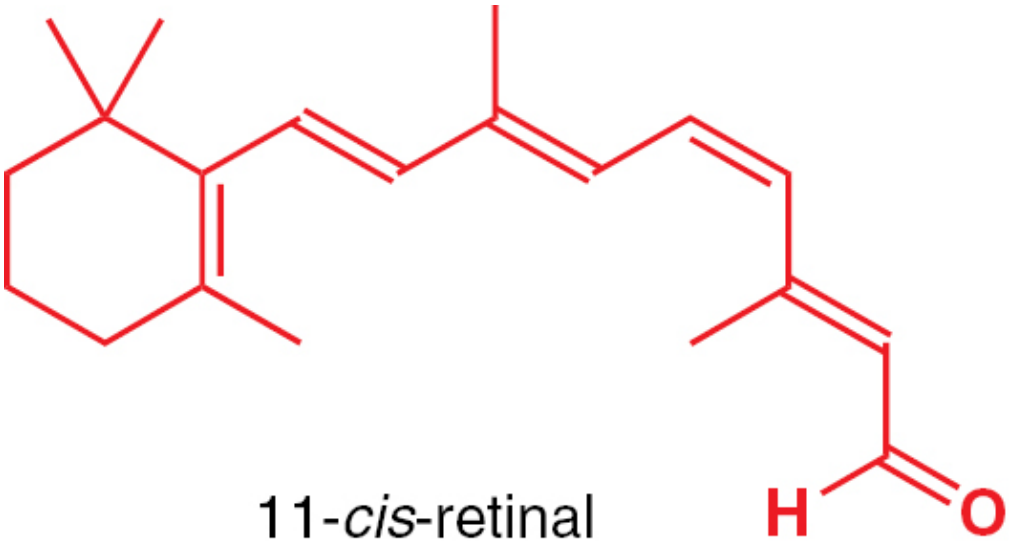




stessa struttura ma differente disposizione spaziale dell’alogeno (stereochimica)

Cos’è la chimica organica

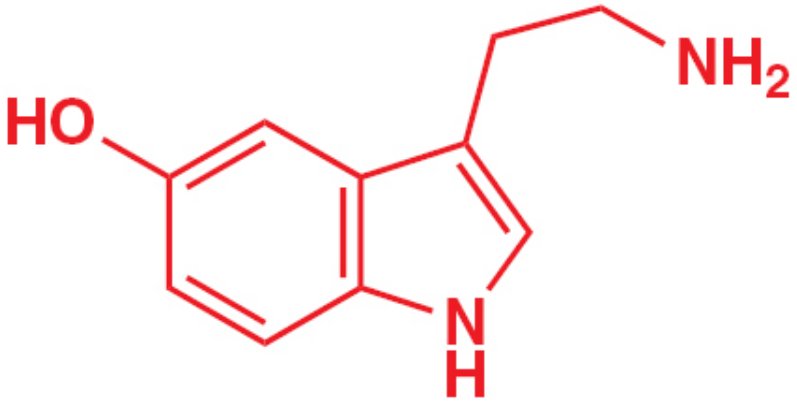
siamo tutti chimici organici



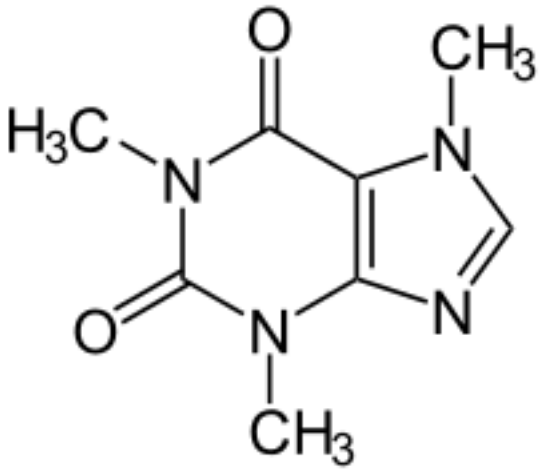
11-*cis*-retinal
absorbs light and allows vision

Nonostante la grande biocomplessità, alla base della natura umana ci sono meccanismi di fondo relativamente semplici. Il flusso di informazioni tra l'inconscio (il corpo) e il conscio (il cervello) è portato avanti da interruttori molecolari regolati da **interazioni deboli** e **variazioni conformazionali**.

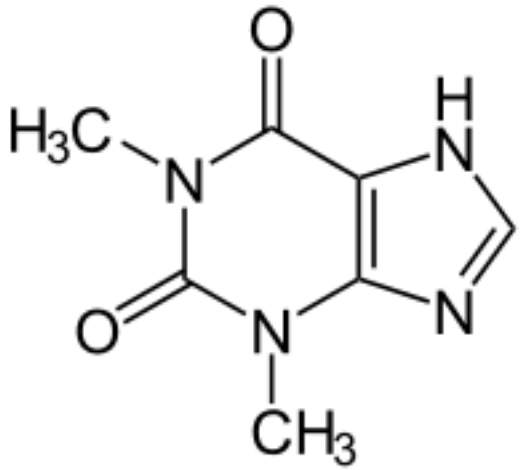
L'intero sistema **EMOZIONALE-SENSORIO-INTELLETTUALE** che noi definiamo umano ha una **base molecolare**.



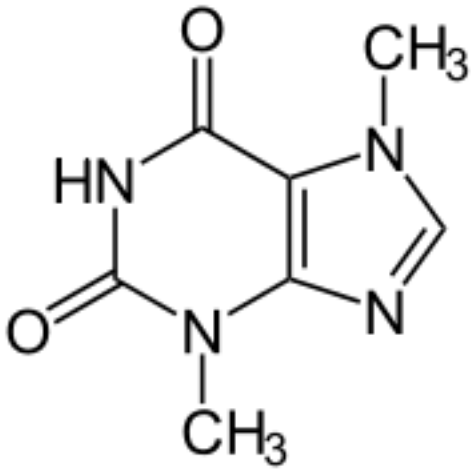
serotonin
human neurotransmitter



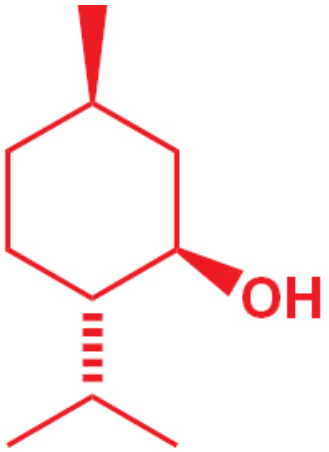
Caffeina



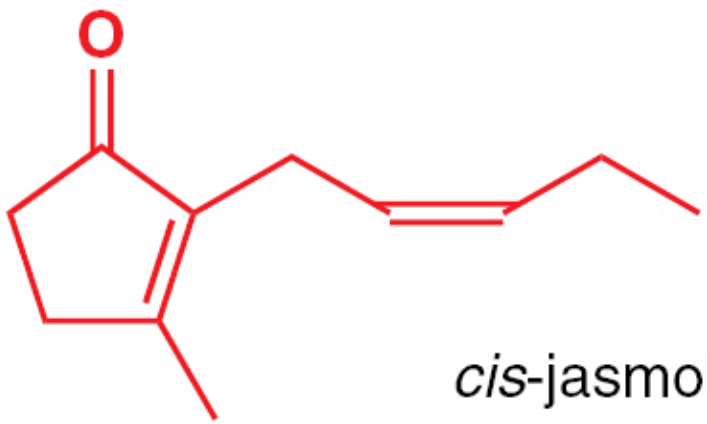
Teofillina



Teobromina

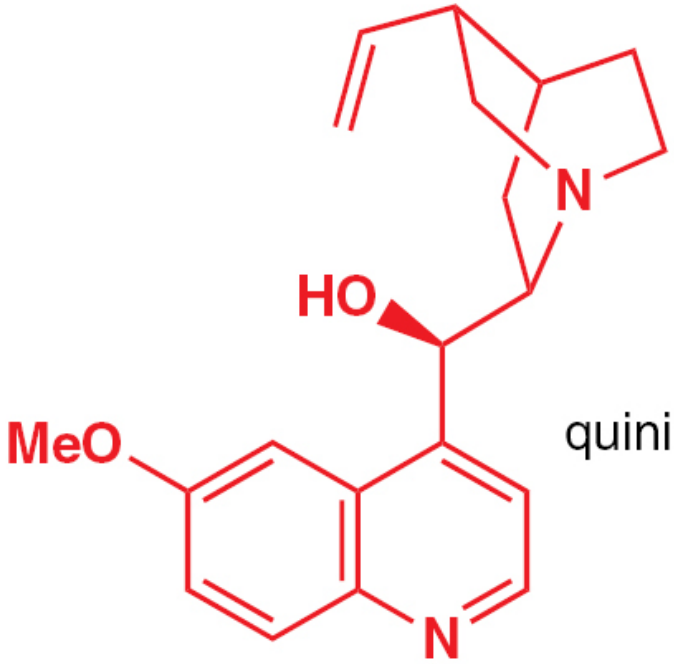


menthol



cis-jasmone

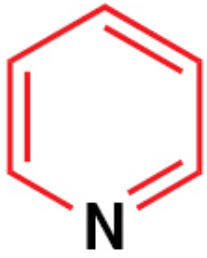
composti organici
di origine naturale



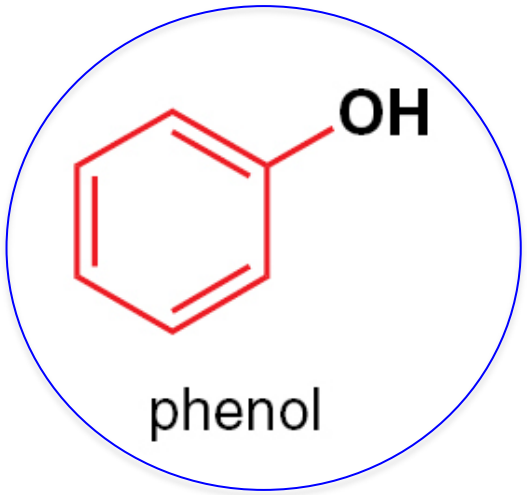
quinine

Residui della distillazione del carbone (litantrace)

benzene



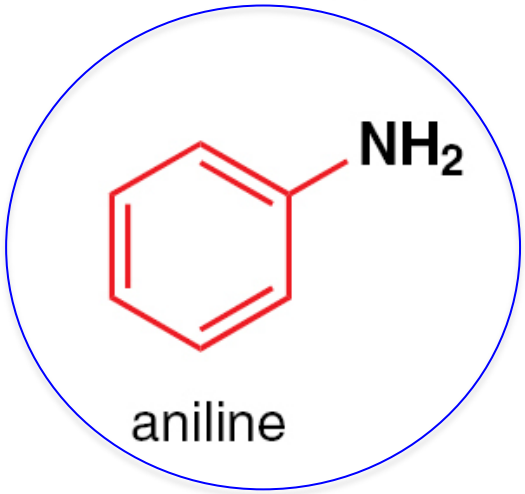
pyridine



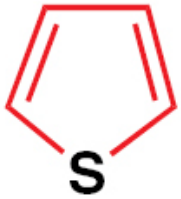
phenol

disinfettante

coloranti organici

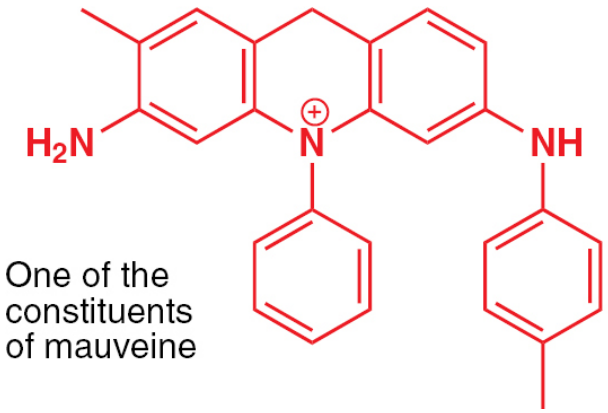


aniline

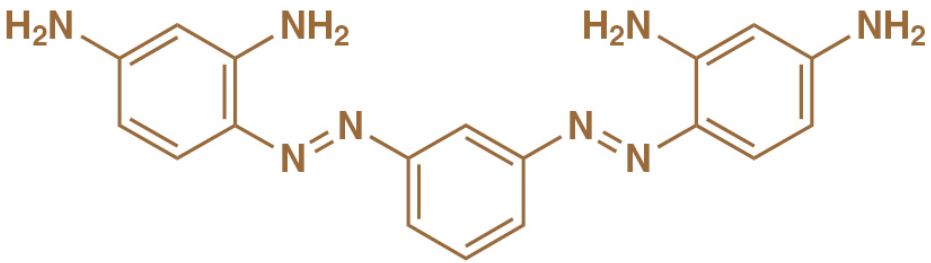


thiophene

composti organici non naturali

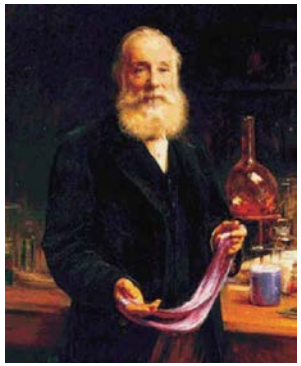


One of the constituents of mauveine



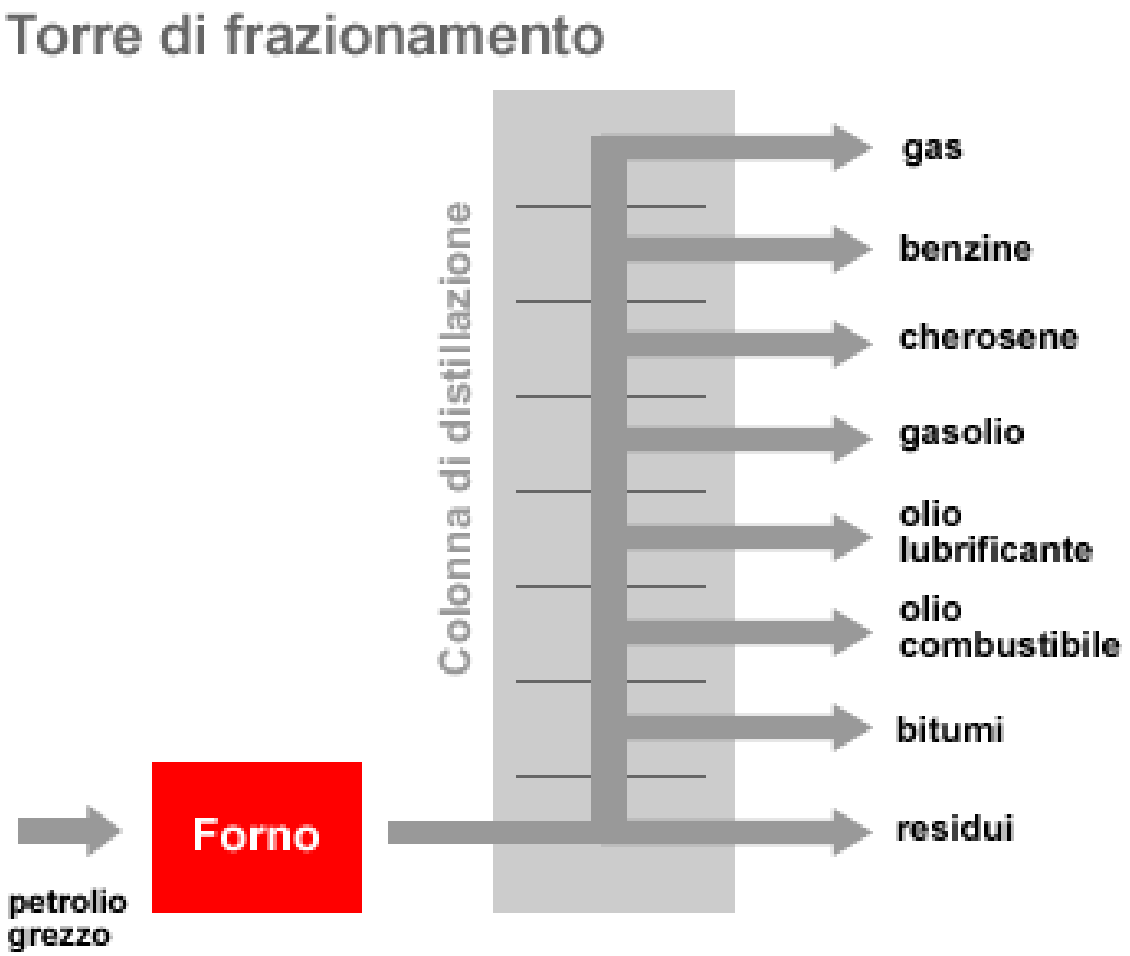
Bismarck Brown Y

primo colorante sintetico

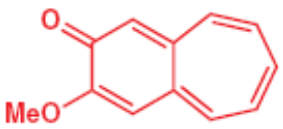
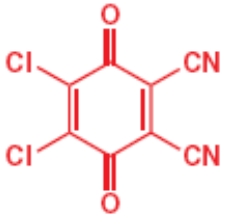
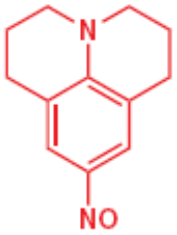
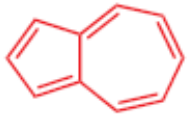
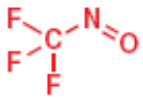


mauveina, porpora di anilina

petrolio

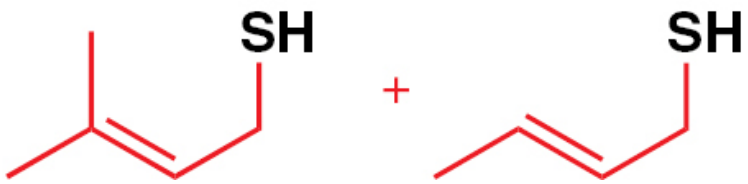

Torre di frazionamento
Colonna di distillazione
gas
benzine
cherosene
gasolio
olio lubrificante
olio combustibile
bitumi
residui
Forno
petrolio grezzo

Colore

Colour	Description	Compound	Structure
red	dark red hexagonal plates	3-methoxybenzocycloheptatriene-2-one	
orange	amber needles	dichlorodicyanoquinone (DDQ)	
yellow	toxic yellow explosive gas	diazomethane	
green	green prisms with a steel-blue lustre	9-nitrosojulolidine	
blue	deep blue liquid with a peppery smell	azulene	
purple	deep blue gas condensing to a purple solid	nitrosotrifluoromethane	

Odore

skunk spray contains:

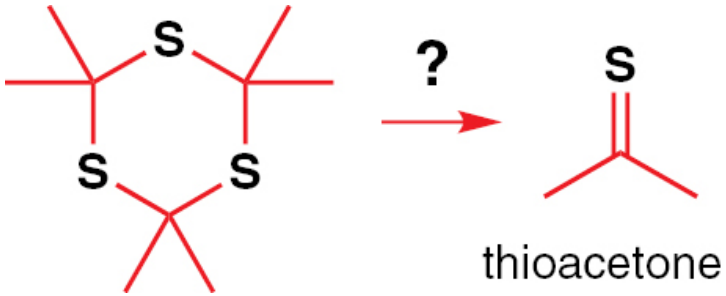


the scent of the black truffle

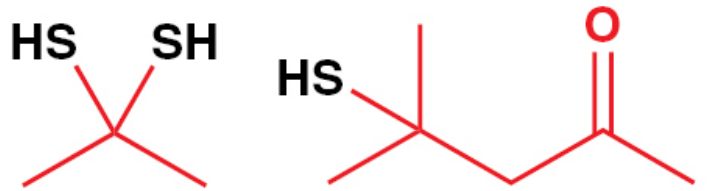
***t*butil tiolo**

1 parte su
50 000 000 000
di gas naturale

odore e diluizione



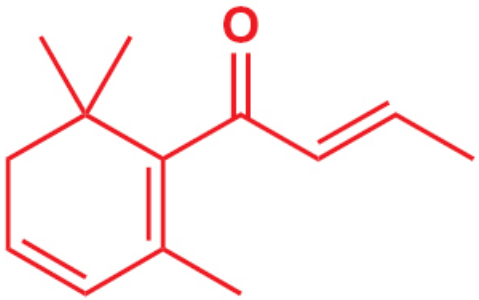
thioacetone



propane-dithiol

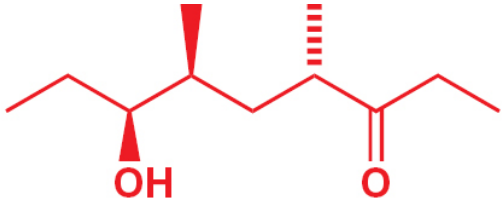
4-methyl-4-sulfanylpentan-2-one

two candidates for
the worst smell in the world
(no-one wants to find the winner)

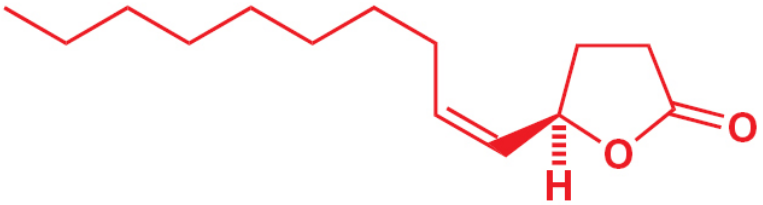


damascenone—the smell of roses

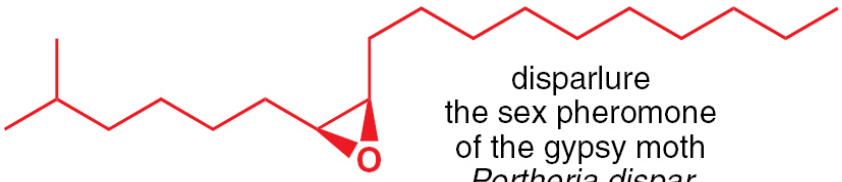
Insetti e trappole chimiche



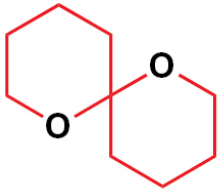
serricornin
the sex pheromone of the cigarette beetle
Lasioderma serricorne



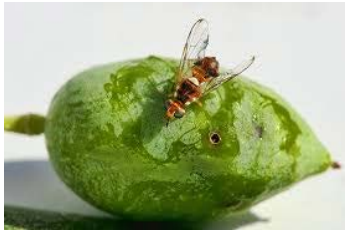
japonilure
the sex pheromone of the Japanese beetle
Popilia japonica



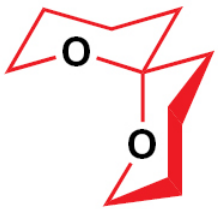
disparlure
the sex pheromone
of the gypsy moth
Portheria dispar



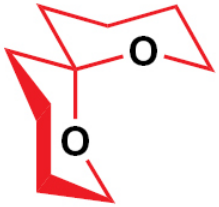
olean
sex pheromone
of the olive fly
Bacrocera oleae



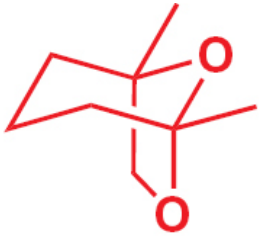
Simmetria e feromoni



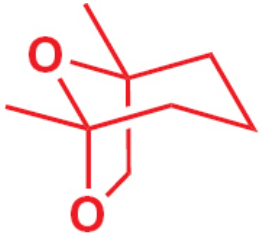
this mirror image isomer attracts male olive flies



this mirror image isomer attracts female olive flies



this mirror image isomer smells of young male elephant*

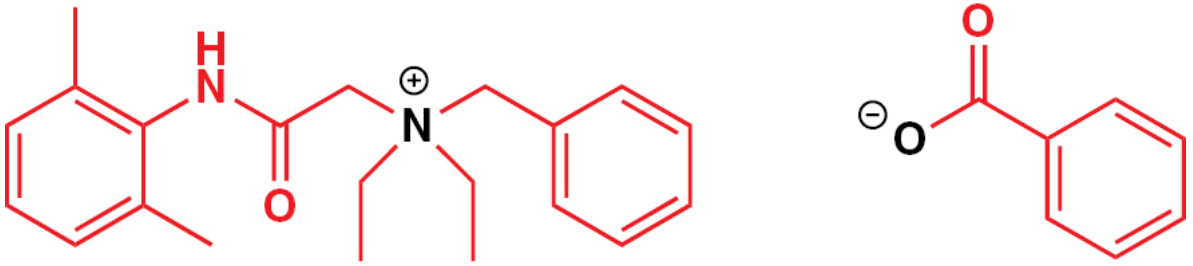


this mirror image isomer smells of old male elephant*

*if you are a female elephant

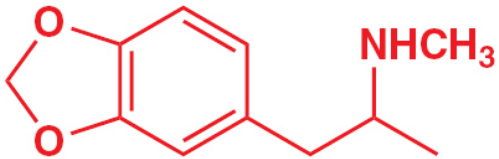
Nature. 2005 Dec 22;438(7071):1097-8.

gusto

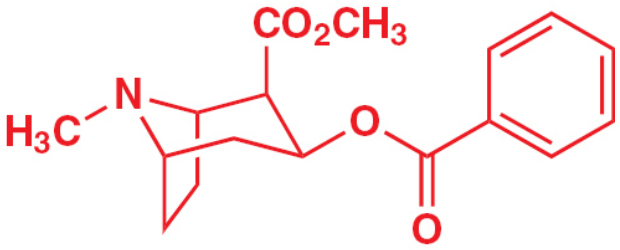


'denatonium benzoate', marked as Bitrex
benzyldiethyl[(2,6-xylylcarbamoyl)methyl]ammonium benzoate

alcohol
(ethanol)

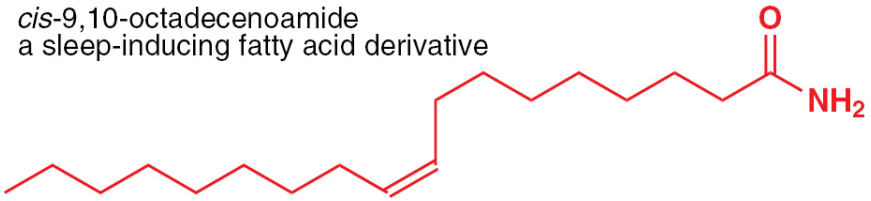


MDMA
(ecstasy)

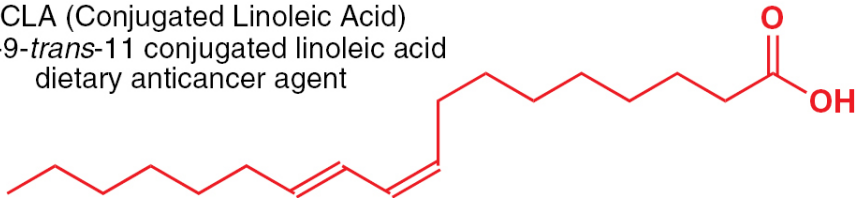


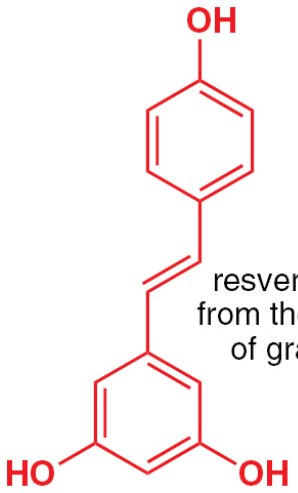
cocaine—an addictive alkaloid

cis-9,10-octadecenoamide
a sleep-inducing fatty acid derivative



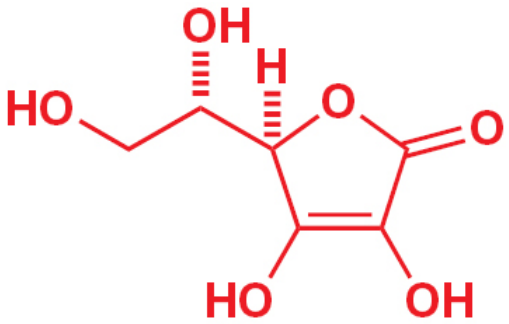
CLA (Conjugated Linoleic Acid)
cis-9-*trans*-11 conjugated linoleic acid
dietary anticancer agent





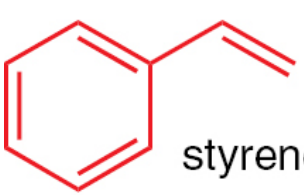
resveratrole
from the skins
of grapes

chimica organica e industria

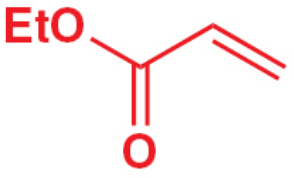


vitamin C (ascorbic acid)

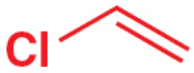
monomers for polymer manufacture



styrene

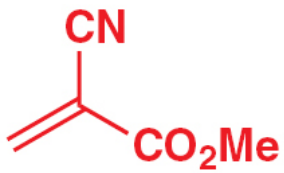


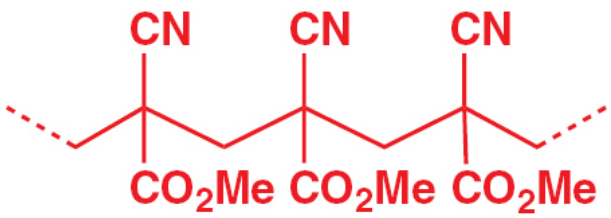
ethyl acrylate



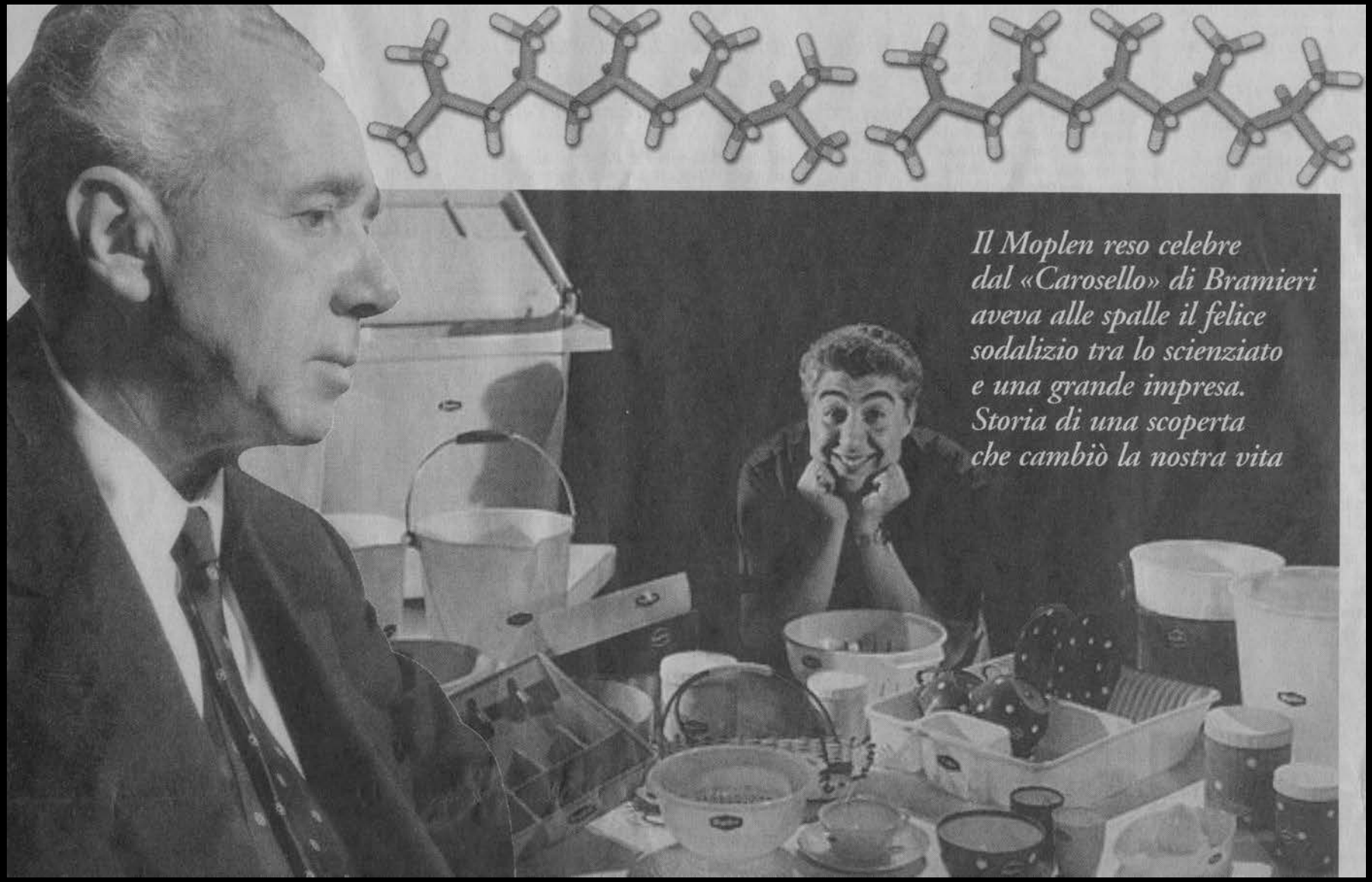
vinyl chloride

methyl cyanoacrylate ('superglue')



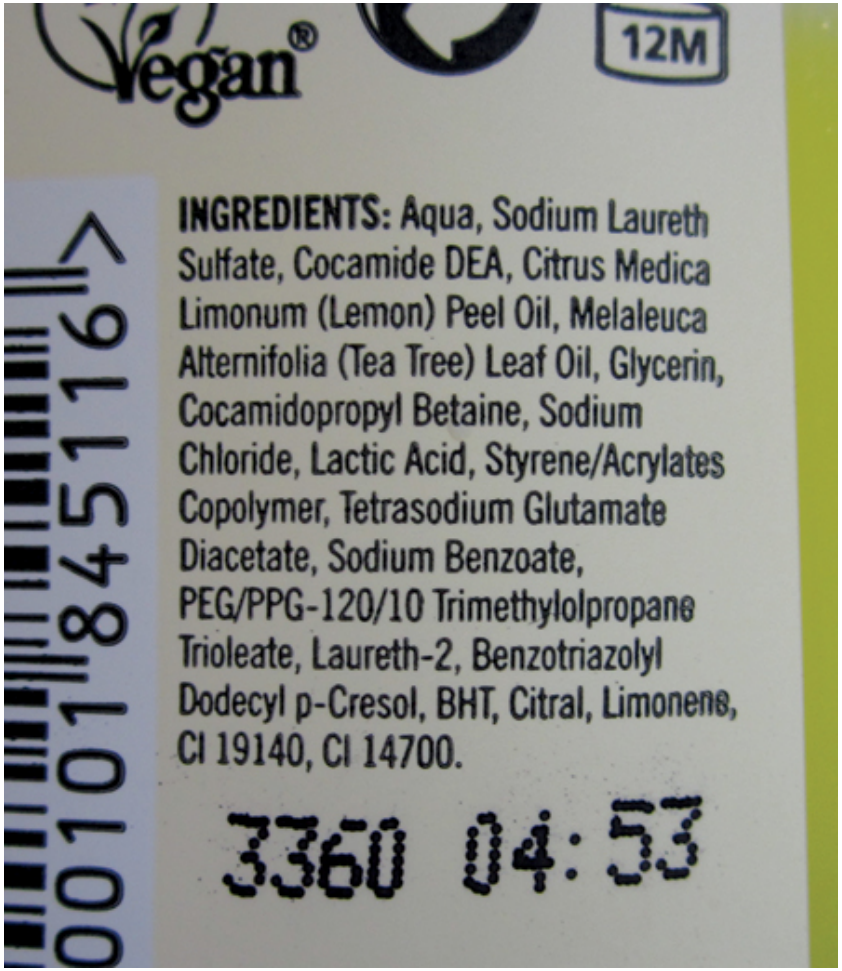


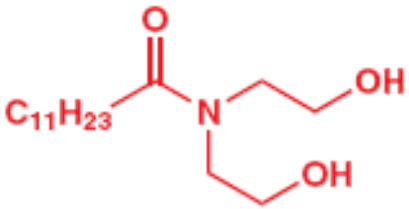
premio Nobel per la chimica 1963

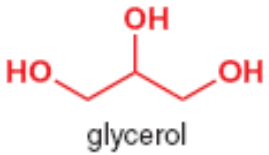
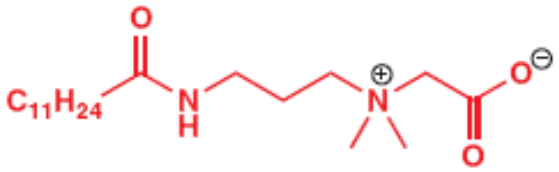
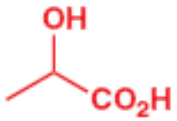
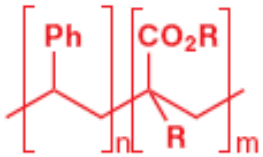
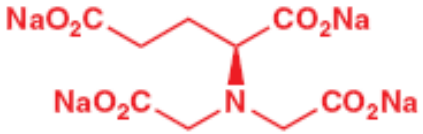
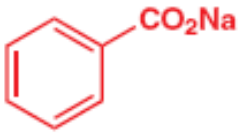


Giulio Natta e il polipropilene (1903-1979)

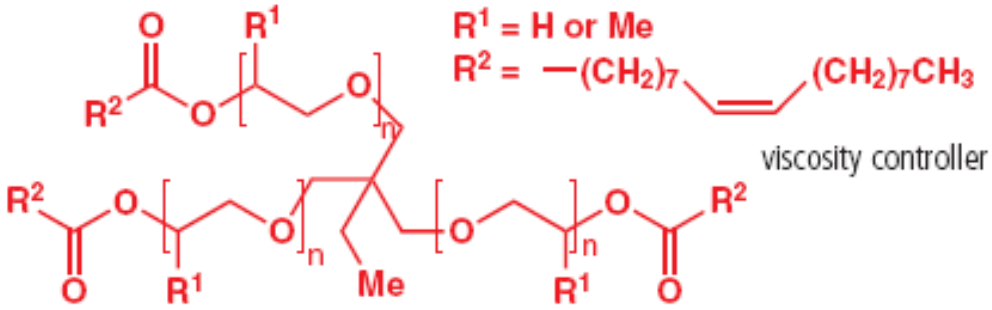
doccia gel


Vegan®
12M
INGREDIENTS: Aqua, Sodium Laureth Sulfate, Cocamide DEA, Citrus Medica Limonum (Lemon) Peel Oil, Melaleuca Alternifolia (Tea Tree) Leaf Oil, Glycerin, Cocamidopropyl Betaine, Sodium Chloride, Lactic Acid, Styrene/Acrylates Copolymer, Tetrasodium Glutamate Diacetate, Sodium Benzoate, PEG/PPG-120/10 Trimethylolpropane Trioleate, Laureth-2, Benzotriazolyl Dodecyl p-Cresol, BHT, Citral, Limonene, CI 19140, CI 14700.
3360 04:53
00101845116

Ingredient	Chemical meaning	Purpose
aqua	 water	solvent
sodium laureth sulfate	 typically $n = 3$	detergent
cocamide DEA		foaming agent
Citrus medica limonum peel oil	mainly  α-pinene	scent, appeal to customer
Melaleuca alternifolia leaf oil	mainly  terpinen-4-ol	scent, appeal to customer, possibly antiseptic

glycerin	 glycerol	cosolvent; moisturizer; ensures smoothness
cocamidopropyl betaine		detergent and anti-electrostatic
sodium chloride	NaCl	control solubility of Na^+-based detergents
lactic acid		acidifier
styrene acrylates copolymer	 R = Me or H	film former
tetrasodium glutamate diacetate		chelator, to prevent formation of insoluble scum in hard water
sodium benzoate		preservative

PEG/PPG -120/10 trimethylolpropane trioleate

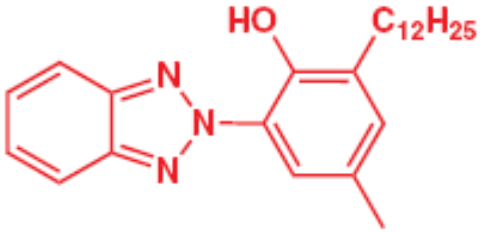


viscosity controller

laureth-2

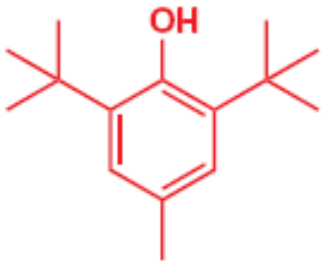
emulsifier

benzotriazolyl dodecyl *p*-cresol



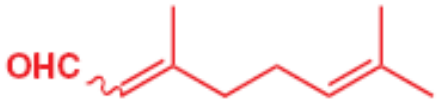
absorbs UV light

BHT



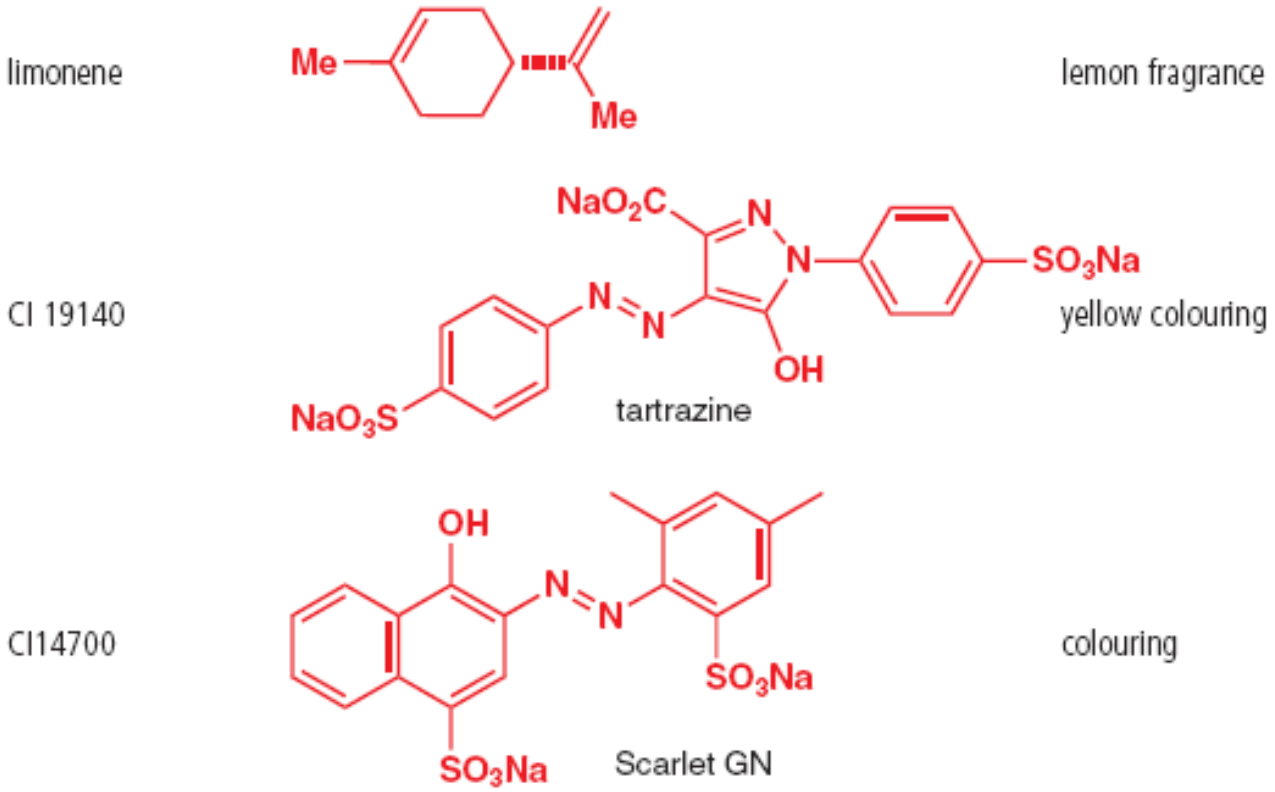
antioxidant

citral



mixture of isomers

lemon fragrance



l'etichetta dei docciaschiuma nella maggioranza dei casi evoca prodotti naturali e fragranze dalla natura…. in effetti è vero se pensiamo che le fonti naturali da cui derivano le molecole usate per preparare il docciaschiuma provengono dalle foreste carbonifere decomposte e intrappolate nel sottosuolo…

dentifrici

acqua (1), **carbonato di calcio (2)**, **cloruro di sodio (3)**, **glicerina (4)**, **silice idrata (5)**, aroma (**6**), **idrossietilcellulosa (7)**, **lauramide propil betaina (8)**, **saccarina (9)**, **triclosan (10)**, **eugenolo (11)**, **limonene (12)**, CI 77891 **(13)**, CI 73015 (**14**).

acqua, silice, glicerina, carbonato: ca 70-80%

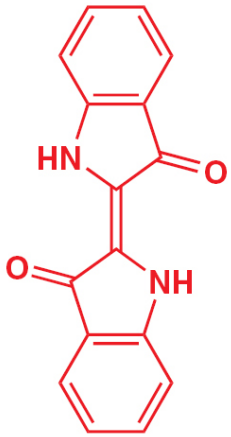
egizi

si lavavano i denti spalmando su di essi, con le dita, una miscela composta di ceneri polverizzate di zoccoli di bue, mirra, gusci d'uova polverizzati e bruciati

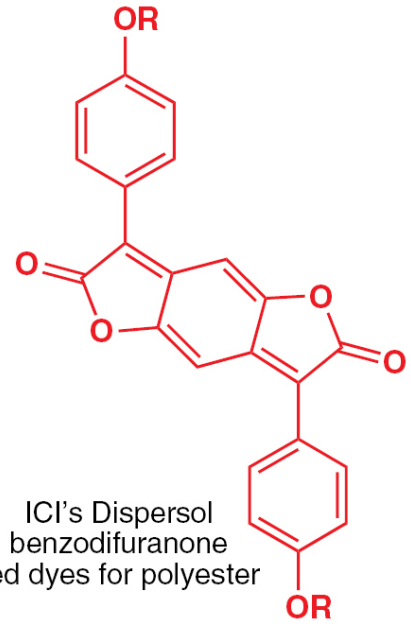
da fine 1800 ad oggi

molte sostanze sono state aggiunte: disinfettanti, tensioattivi, addensanti, dolcificanti, coloranti per migliorare il sapore della pasta dentifricia e fornire additivi come disinfettanti, dolcificanti e coloranti che servono ad aumentare l'accettabilità del prodotto da parte del cliente.

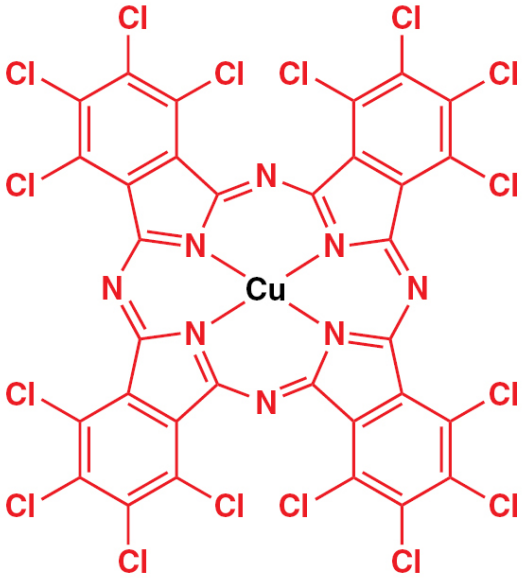
coloranti industriali



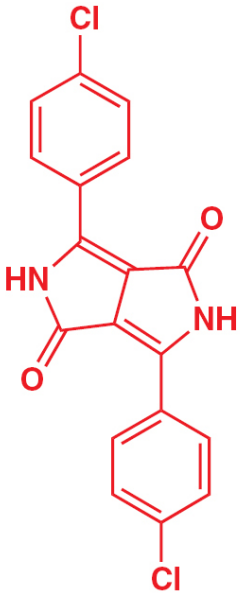
indigo
the colour of blue jeans



ICI's Dispersol
benzodifuranone
red dyes for polyester

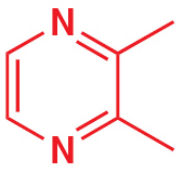


ICI's Monastral Green GNA
a green for plastic objects

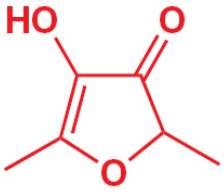


Ciba-Geigy's Pigment Red 254
an intense DPP pigment

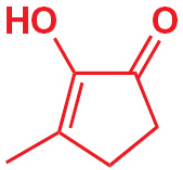
sapori e fragranze



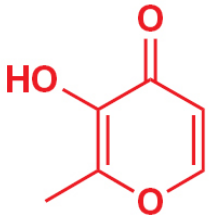
an alkyl pyrazine
from coffee and
roast meat



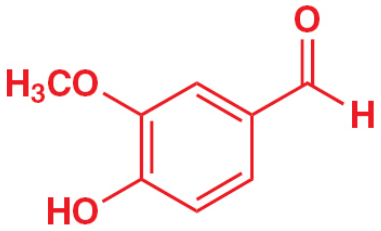
furonol
roast meat



corylone
caramel
roasted taste

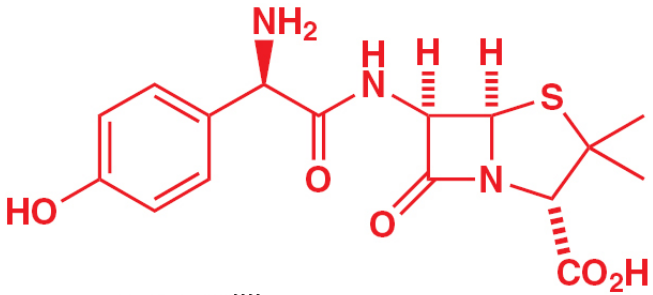


maltol
E-636 for cakes
and biscuits

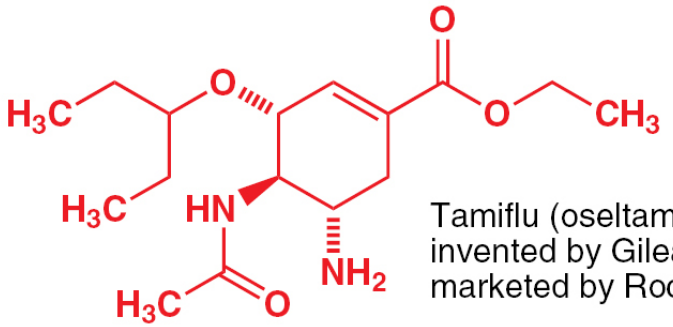


vanillin
found in vanilla pods;
manufactured on a large scale

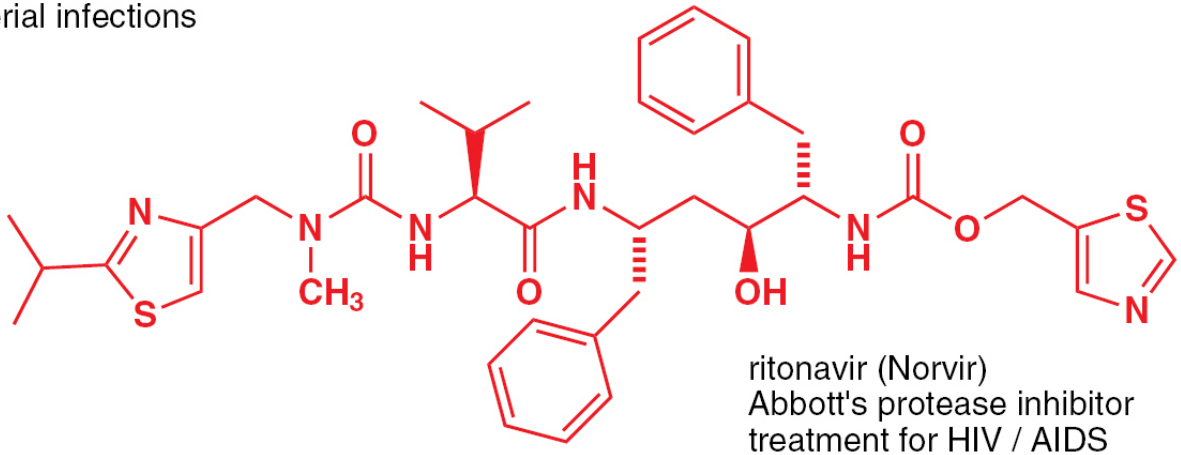
principi attivi farmaceutici



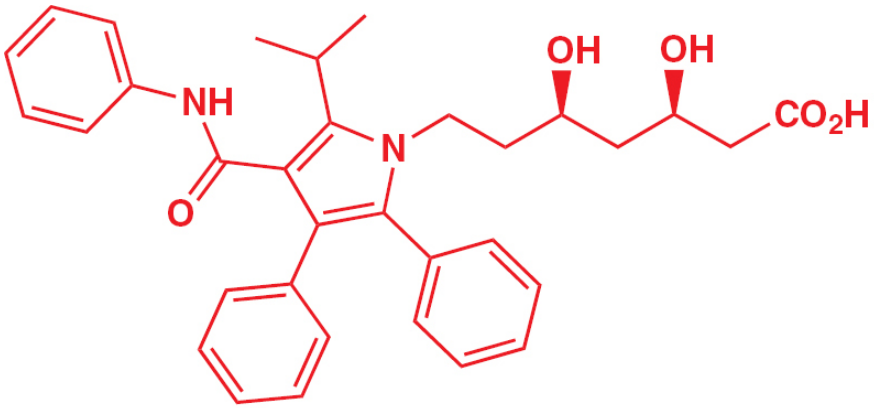
amoxycillin
developed by SmithKline Beecham
β-lactam antibiotic treatment of
bacterial infections



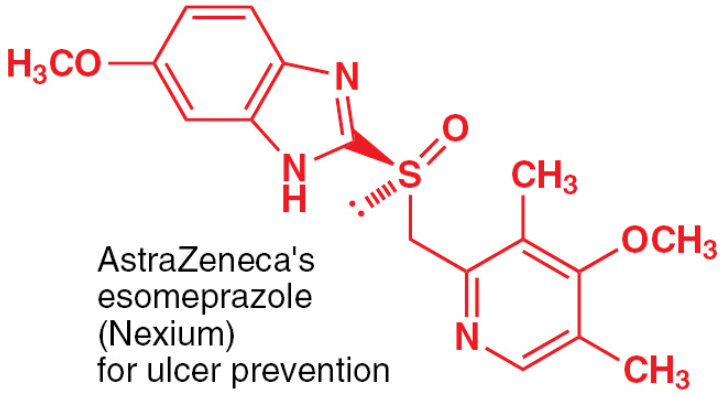
Tamiflu (oseltamivir)
invented by Gilead Sciences
marketed by Roche



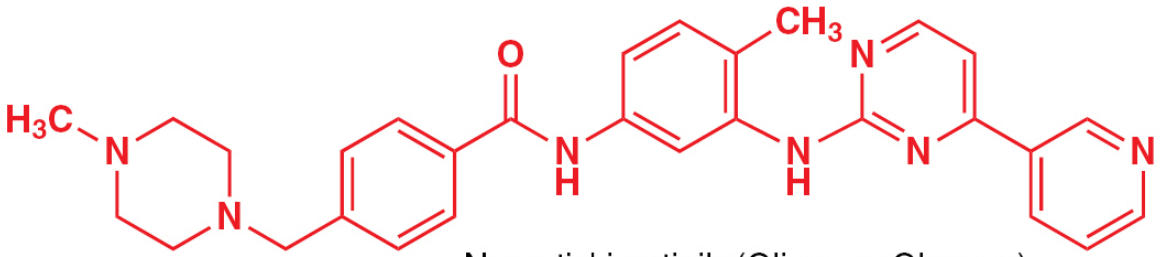
ritonavir (Norvir)
Abbott's protease inhibitor
treatment for HIV / AIDS



Pfizer's atorvastatin (Lipitor)
cholesterol-lowering drug

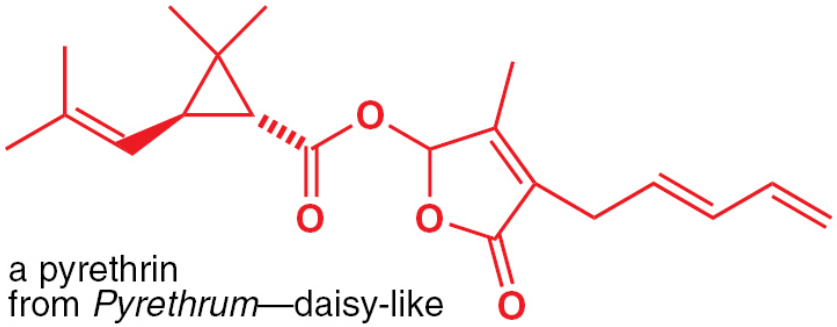


AstraZeneca's
esomeprazole
(Nexium)
for ulcer prevention

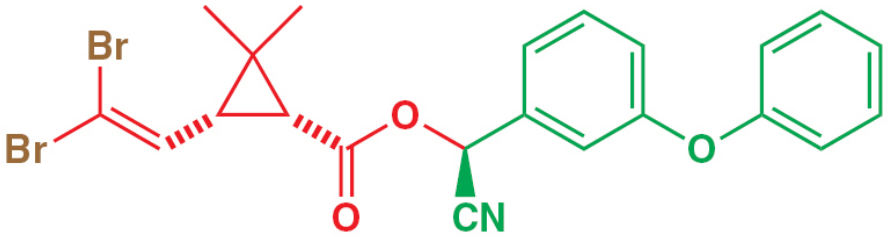


Novartis' imatinib (Glivec or Gleevec)
treatment for cancers such as leukaemia

erbicidi, fungicidi, insetticidi



a pyrethrin
from *Pyrethrum*—daisy-like
flowers from East Africa



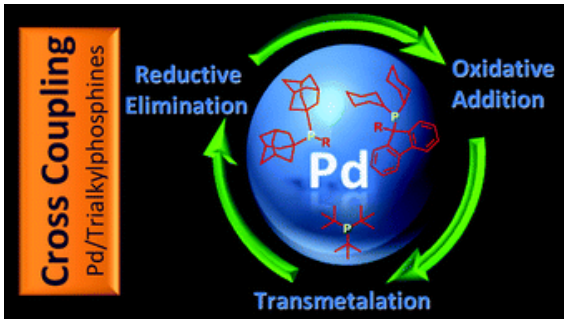
decamethrin

a modified pyrethrin—more active and stable in sunlight

la tavola periodica della chimica organica

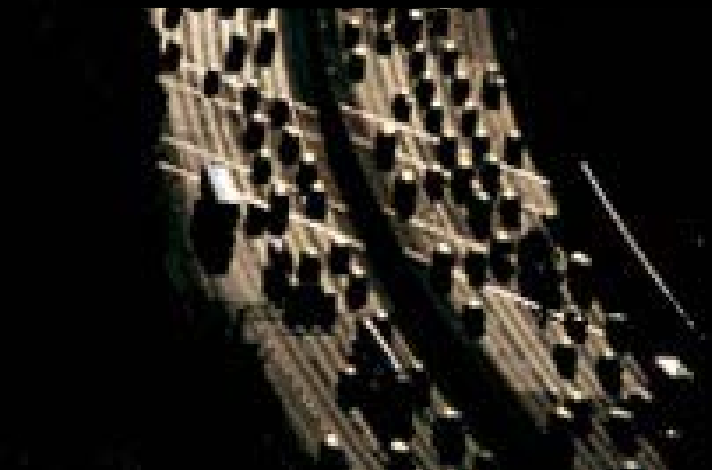
the organic chemist's periodic table

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
H																	
Li												B	C	N	O	F	
Na	Mg											Al	Si	P	S	Cl	
K			Ti		Cr		Fe			Cu	Zn				Se	Br	
							Ru		Pd	Ag			Sn			I	
							Os			Au	Hg						
	Sm																



Think gas is expensive now?
Just wait.
You've heard it before,
but this time it's for real:
We're at the beginning of
the end of
cheap
Oil

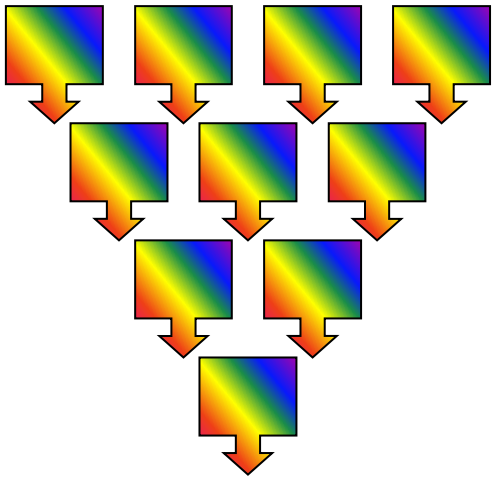
"…The world is not running out of oil - at least not yet. What our society does face, and soon, is the end of the abundant and cheap oil…"



la fotosintesi clorofilliana

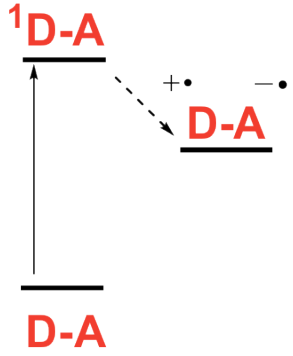
$$6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$$

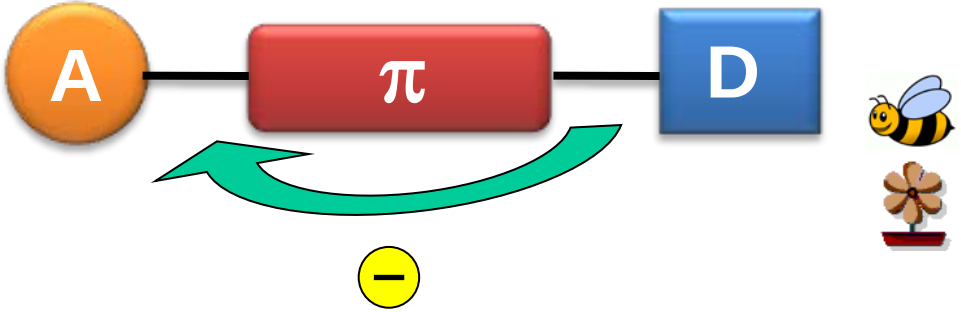
"Entra nella foglia collidendo con altre innumerevoli (ma qui inutili) molecole di azoto e di ossigeno. Aderisce ad una grossa e complicata molecola che lo attiva, e simultaneamente riceve il decisivo messaggio dal cielo, sotto forma di un pacchetto di luce solare: in un istante come un insetto preda del ragno, viene separato dal suo ossigeno, combinato con l'idrogeno e (si crede) fosforo, ed infine inserito in una catena, lunga o breve non importa, ma la catena della vita." (Primo Levi, *Il Sistema Periodico*, Torino: Einaudi, 1975).

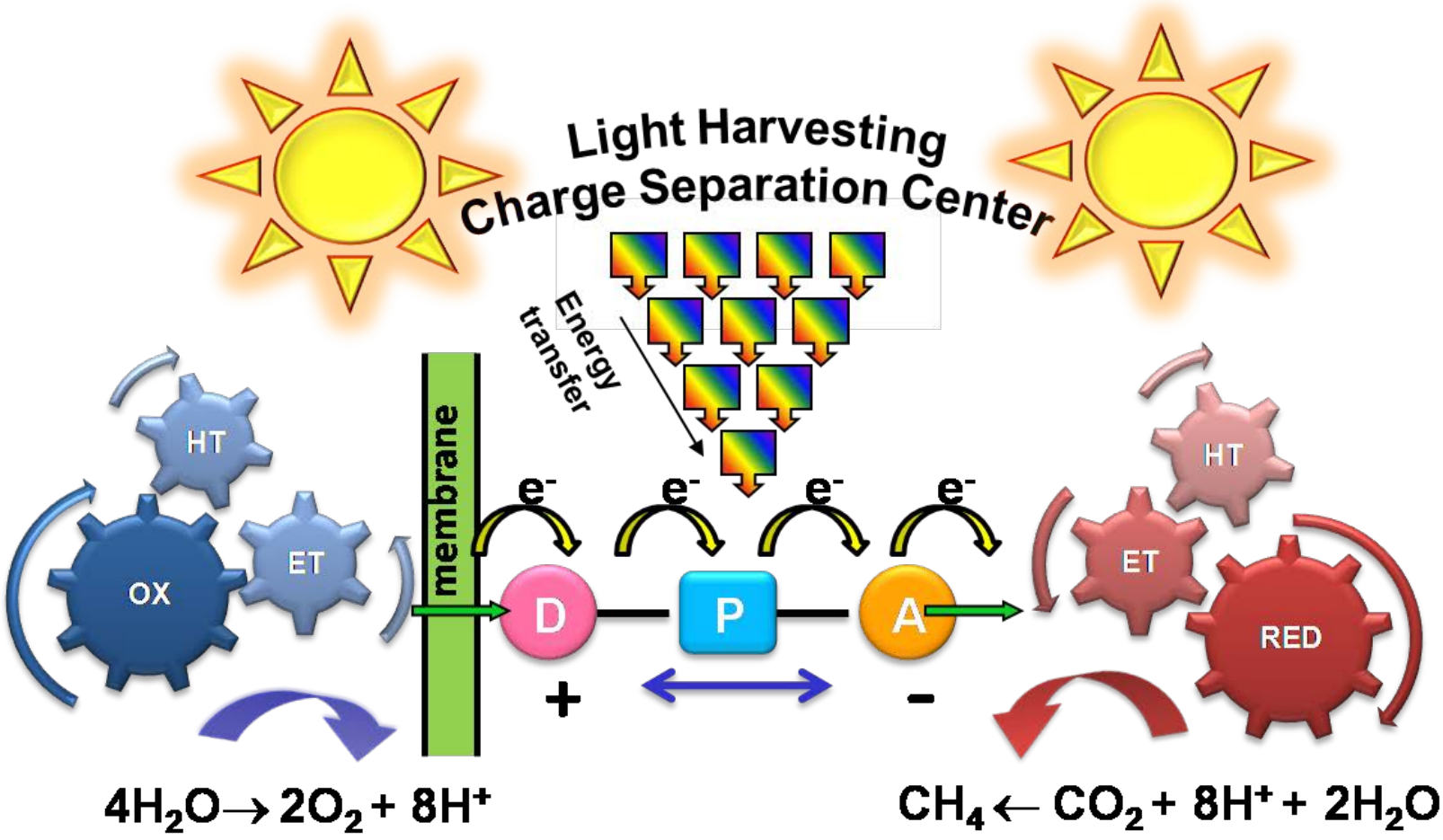


celle solari molecolari organiche a film sottile: molecole che assorbono la luce, trasferiscono elettroni, producono elettricità.

fotosintesi: molecole che assorbono la luce, trasferiscono elettroni, producono energia chimica dal CO_2 e dall'acqua.

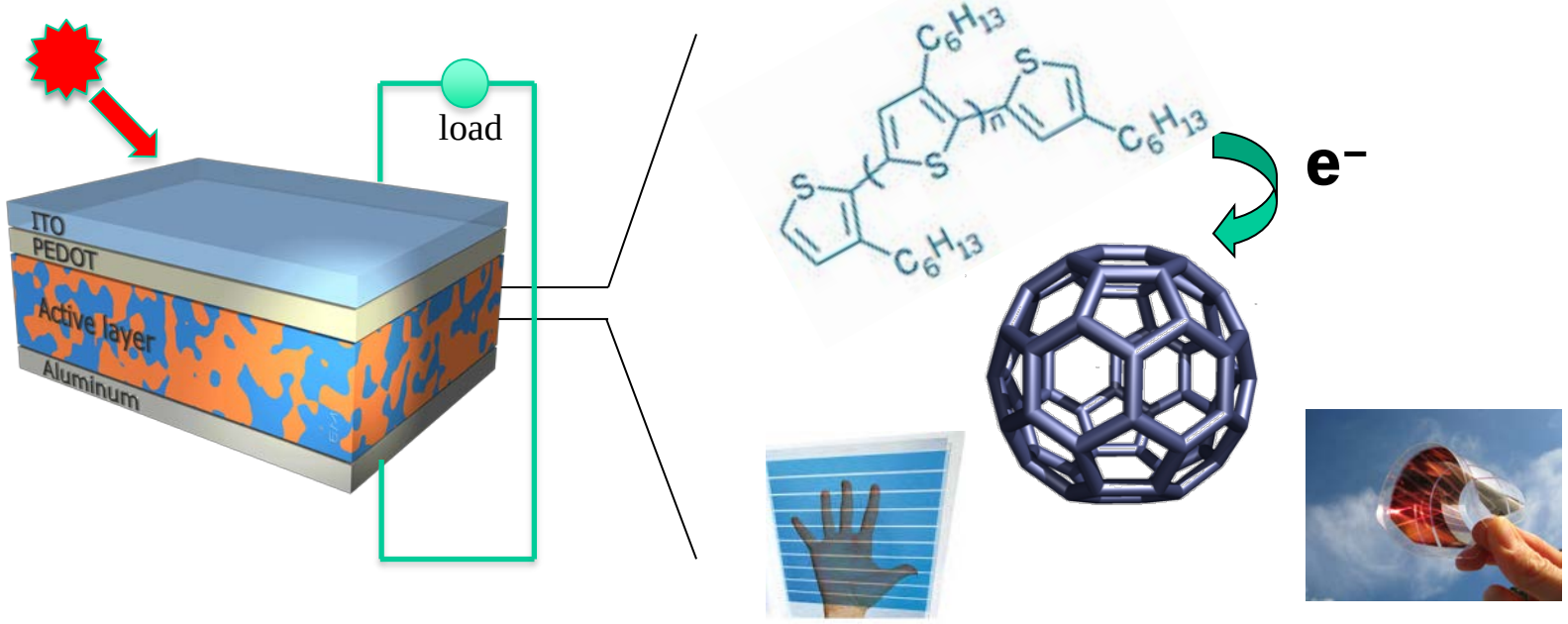






Scheme 1. Modular assembly for Artificial Photosynthesis finalized to CO_2 reduction using water as electron and proton donor

celle OPV – leggere e flessibili



- **Film sottili, semitrasparenti, poco materiale necessario (g/m^2)**
- **Deposizione da soluzione, supporti flessibili e adattabili**
- **Materiali progettabili, architetture del dispositivo variabili**
- **Tecnologia integrabile in strutture pre-esistenti che diventano produttrici di energia elettrica**

Forme allotropiche del carbonio

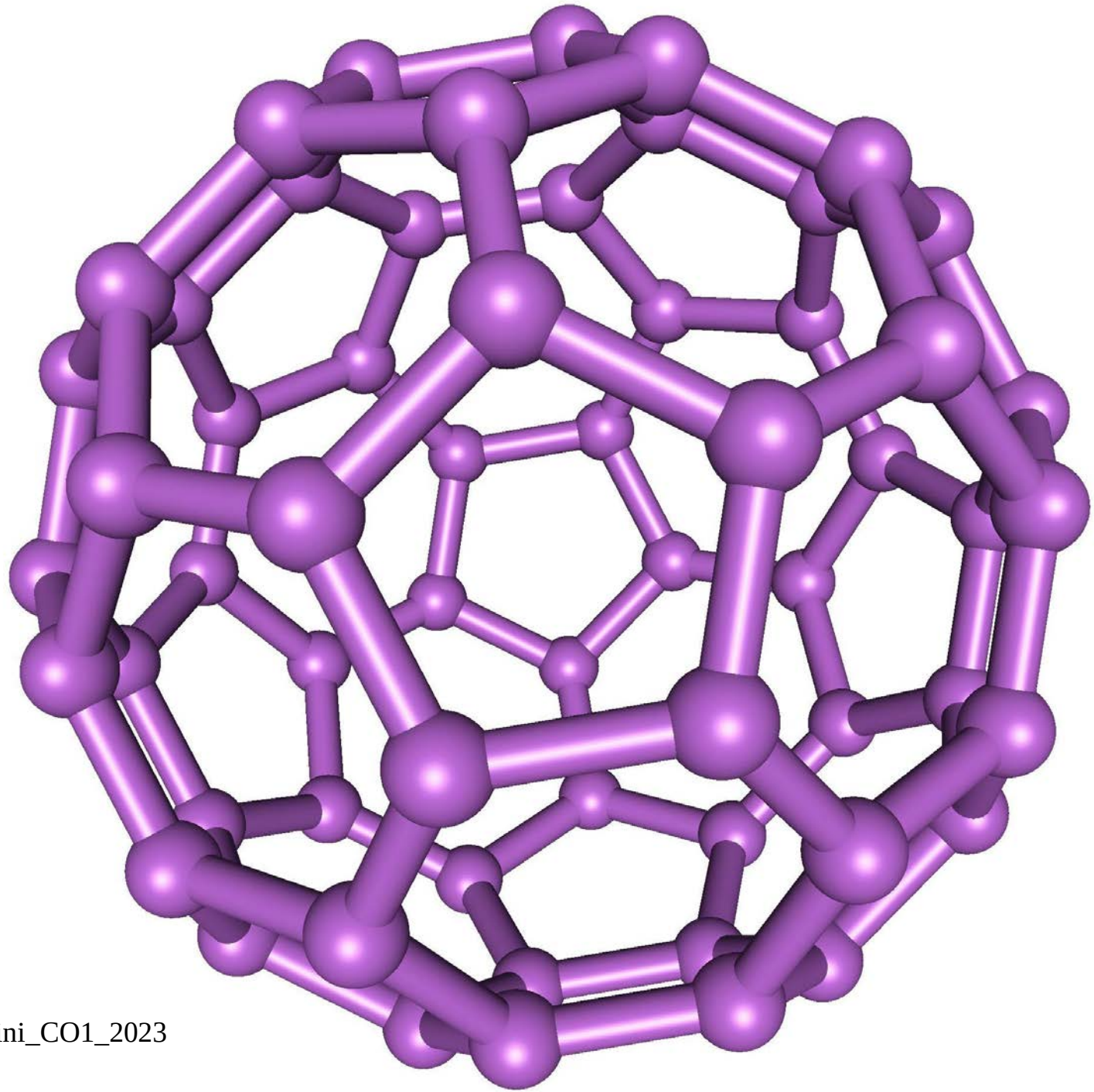
(differente struttura cristallina)

Prima del 1985

Allo stato solido si conoscevano due strutture fondamentali: la ***grafite*** e il ***diamante***.

Dopo il 1985

Si aggiungono i ***fullereni*** e i ***nanotubi di carbonio*** derivati dalla grafite mediante processi di condensazione durante i quali il carbonio passa dalla fase liquida a quella solida, in determinate condizioni di pressione.



maggini_CO1_2023

Fullerene

Fullerenes
1990

Carbon Nanotubes
1991

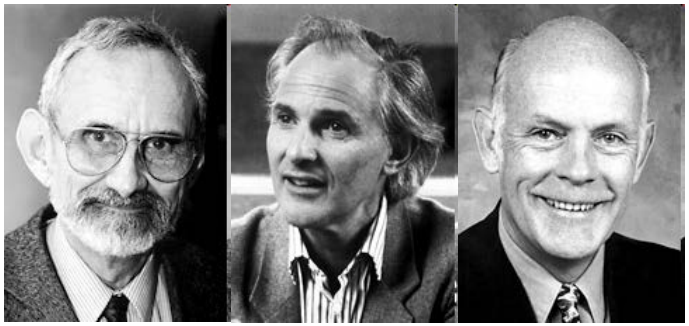
Graphene
2004

many undiscovered allotropes
e.g. sp-sp^2-Graphyne
> 20??

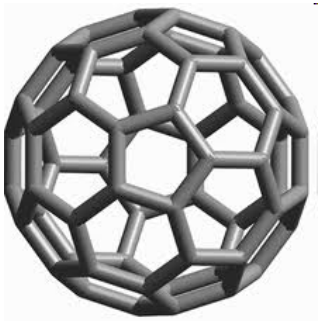
Properties of graphene

- Electron mobility 100 times that of silicon (seemingly massless activity of electrons)
- 100 times stronger than steel
- Graphene transistors operate at more than twice the speed of the best Si transistor of similar size
- Exceptional heat conduction

1996: Nobel per la chimica

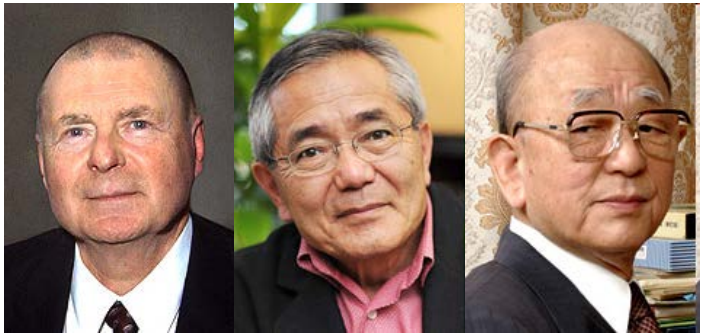


Curl, Kroto, Smalley



fullerene

2010: anno del carbonio



Heck, Negishi, Suzuki
(legami C-C)

Geim, Novoselov