



CHIMICA IN CUCINA

gran parte della tecnologia culinaria ha
profonde radici chimico - fisiche



Perché Mangiamo ?

Fame



Che buono!

Convivialità



Bibliografia

Mario Pieri – *Merceologia* – **Hoepli 1958**

Domenico Meneghini – *Chimica Applicata ed Industriale* – **Vallardi 1961**

Alberto Girelli, Leno Matteoli – *Trattato di Chimica Industriale* – **Zanichelli 1969**

Jearl Walker – *Il Luna Park della Fisica* – **Zanichelli 1991**

Peter W. Atkins – *Molecole* – **Zanichelli 1992**

Gunter Gunter, Manfred Franz – *La Chimica di Tutti i Giorni* – **Zanichelli 1994**

Hervé This – *I Segreti della Pentola* – **Jaca Book 1995**

Penny Le Couteur, Jay Burreson – *I Bottoni di Napoleone* – **Longanesi 2003**

Hervé This – *Pentole & Provette* – **Gambero Rosso 2004**

Emiliano Ricci – *La Fisica in Casa* – **Giunti 2007**

Gli Attori

Acqua



Grassi (lipidi)



Proteine (amminoacidi)



Carboidrati (zuccheri, amidi)



Molecole

Le proprietà della materia sono espressioni delle proprietà dei legami nelle molecole

Le molecole in fondo hanno “solo” proprietà elettriche:

elettroni -

nuclei +

2 famiglie

(presenza OH NH CO)

ionici

$\delta -$

$\delta +$

polari

distribuzione disuniforme

$\delta +$

$\delta +$

$\delta -$

(acqua H₂O)

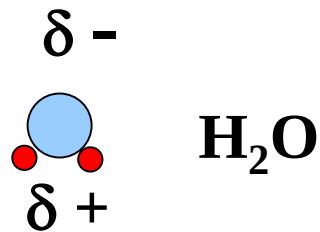
(oli – idrocarburi)

non polari (covalenti)

(quasi tutto CH)

distribuzione uniforme

Acqua – Olio (Due fazioni)



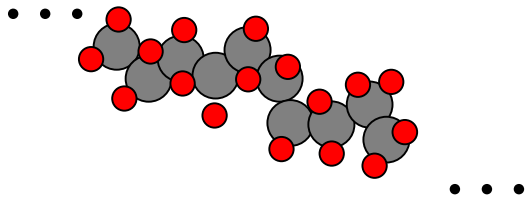
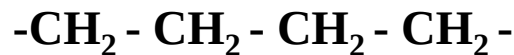
Acqua

Scioglie: Sali, zuccheri, alcoli, acidi,
basi, piccole molecole polari, ...

molecola piccola e polare (carica elettrica)

Composti **IDROFILI**
LIOFOBI

Olio

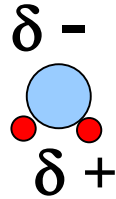


Scioglie: molecole organiche piccole e grandi
non polari (aromi, coloranti, eteri, esteri...)

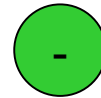
molecola lunga non polare

Composti **LIOFILI** **IDROFOBI**

Acqua



acqua



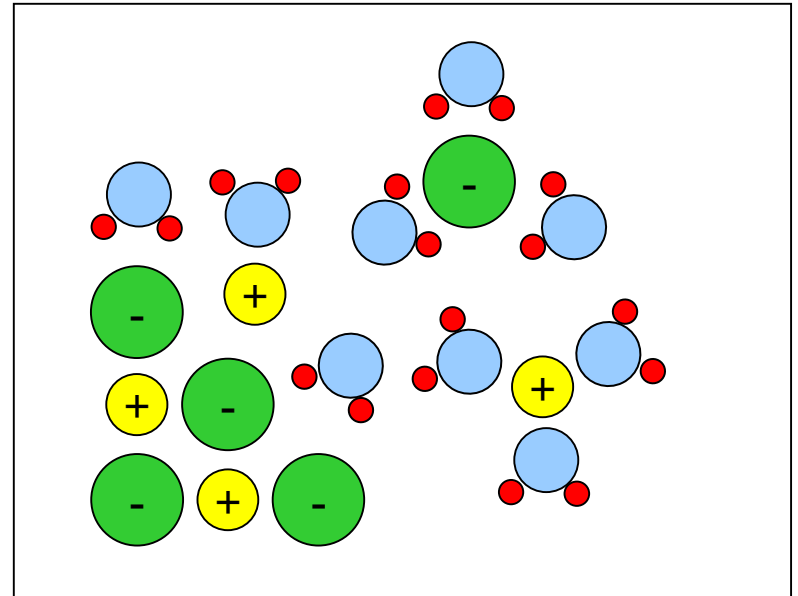
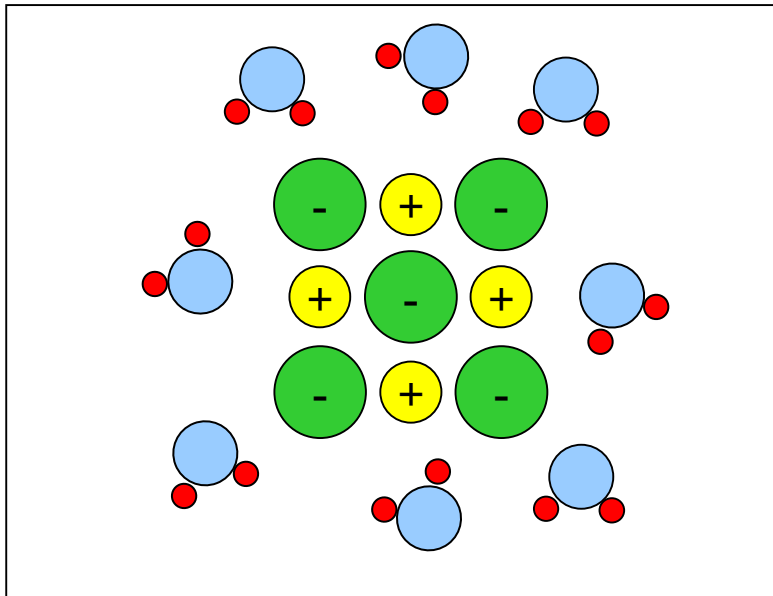
Cl^-

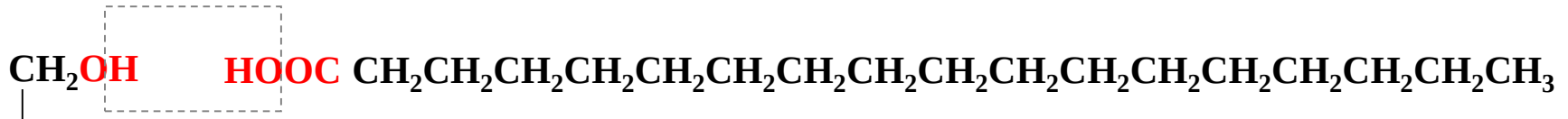


Na^+

sale
cloruro di sodio

In acqua si sciolgono i composti ionici (polari)



[illegible]

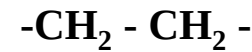
Lipidi

grassi
(lardo)



solidi

$C_{18} \div C_{20}$



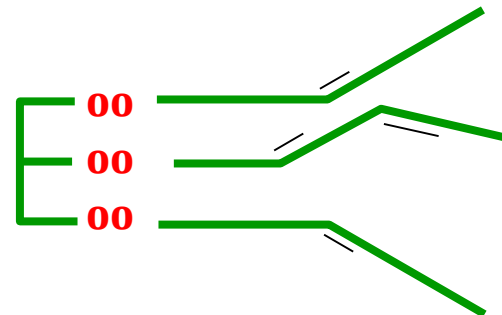
burro



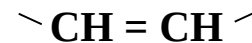
bassofondenti

$C_{14} \div C_{16}$

oli
(insaturi)



liquidi

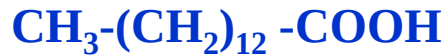


Omega 3

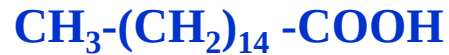
Acidi Grassi (alcuni)

saturi

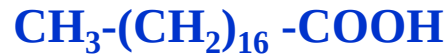
miristico



palmitico

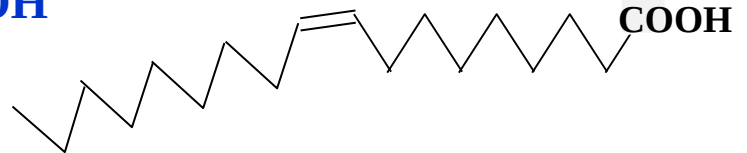


stearico



mono-insaturo

oleico



bi-insaturo

linoleico

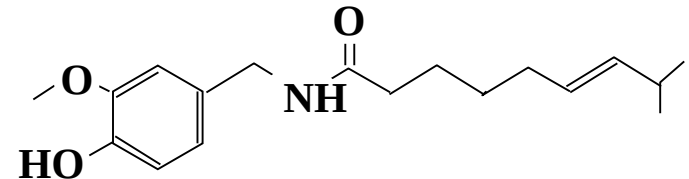
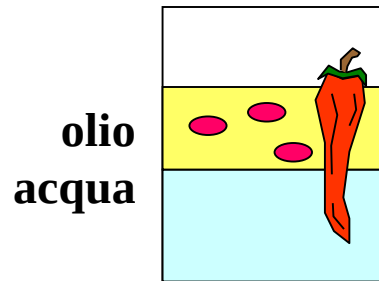


Oli - Grassi - Acidi Grassi

~ %	miristico $C_{14}H_{28}O_2$	palmitico $C_{16}H_{32}O_2$	stearico $C_{18}H_{36}O_2$	= oleico $C_{18}H_{34}O_2$	= = linoleico $C_{18}H_{32}O_2$
	tracce	25	20	45	tracce
	10	30	10	25	tracce
	tracce	10	tracce	75	10

Olio e Condimento

molti aromi sono molecole non polari solubili in olio (e non in acqua)



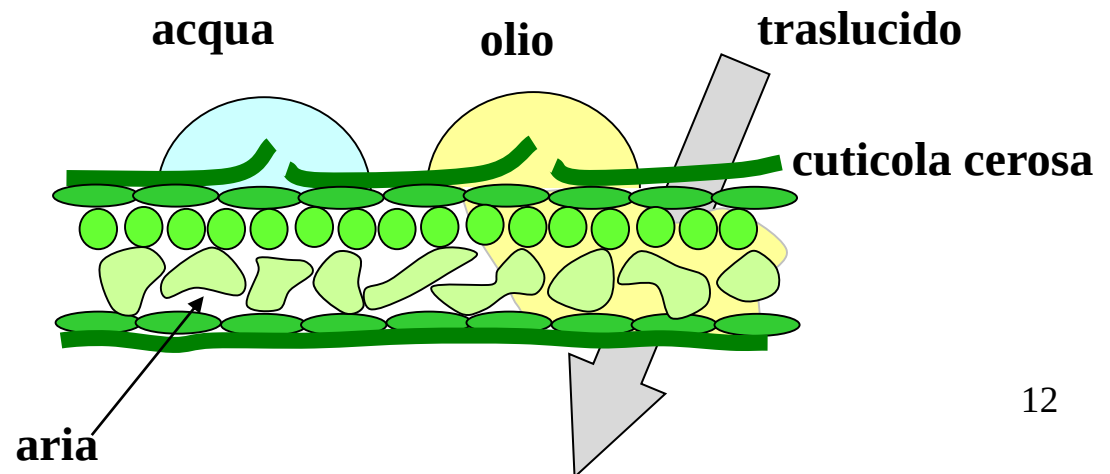
capsaicina

(irritante)

(attiva recettori termici – sensazione di ~ 50°C)

esempi

**insalata
condita**



Pepe e Peperoncino

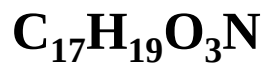
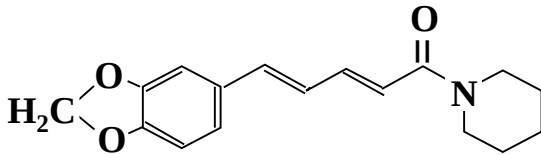
Non hanno gusto ma eccitano sensazioni termiche di dolore



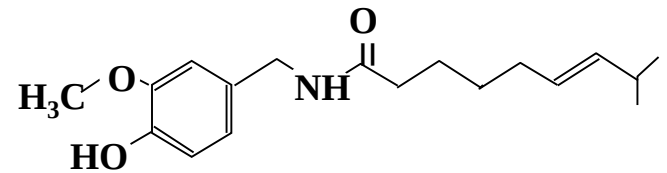
Piper nigrum



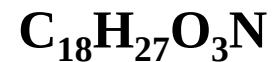
Capsicum



piperina



capsaicina



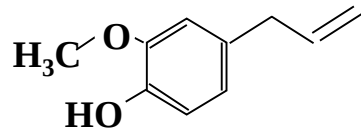
Altre Spezie



Eugenia caryophyllata



Chiodi di garofano



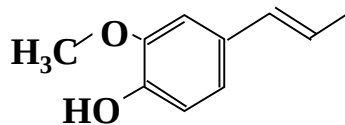
eugenolo



Myristica fragrans



Noce moscata



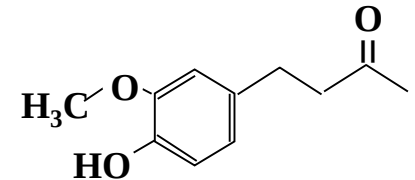
isoeugenolo



Gingiber officinale



Zenzero



zingerone

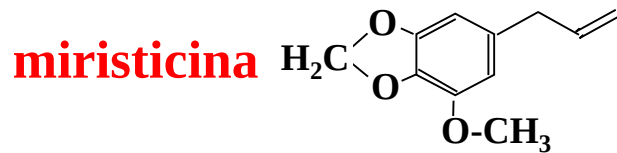
Spezie - Droghe



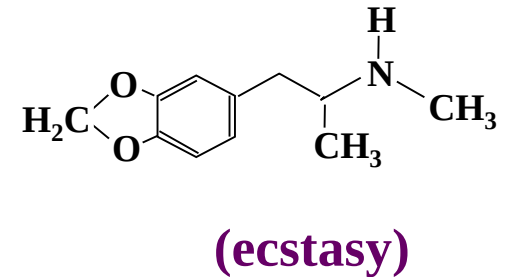
La noce moscata ha proprietà insetticide

La noce moscata in gran quantità è allucinogena

componente minoritario



→ reazioni metaboliche →



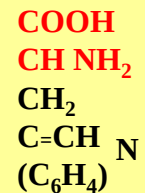
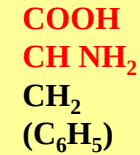
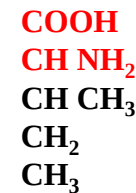
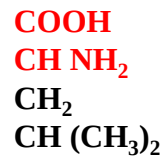
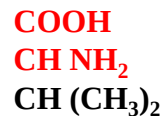
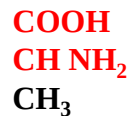


Proteine - Aminoacidi

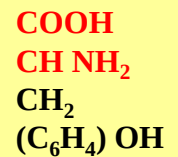
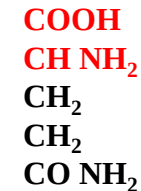
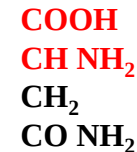
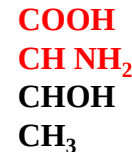
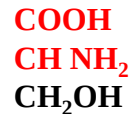
20 aminoacidi biologicamente attivi

(bruciando fanno odore di lana bruciata)

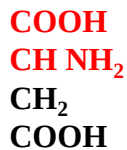
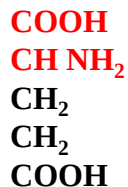
non polari



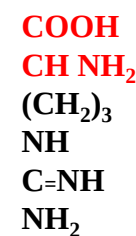
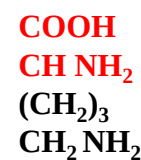
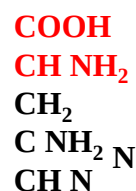
polari



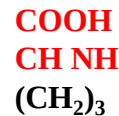
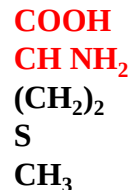
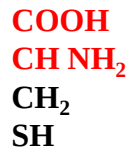
aromatici



acidi



basici

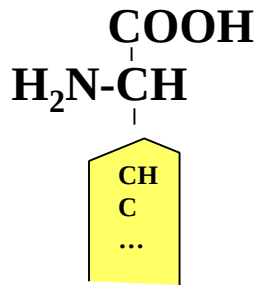


particolari

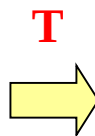
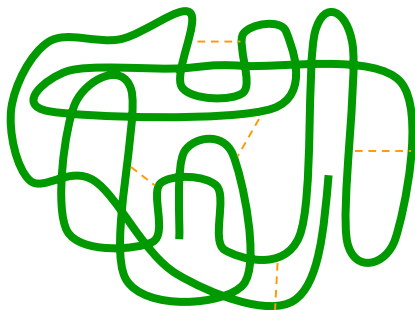
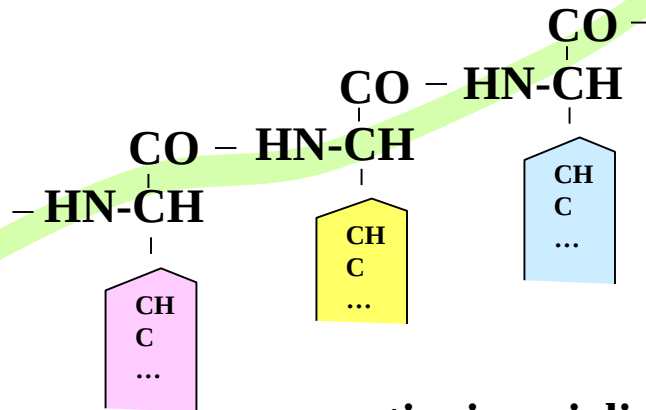


Proteine

Strutture - Enzimi



20 tipi diversi
di aminoacidi

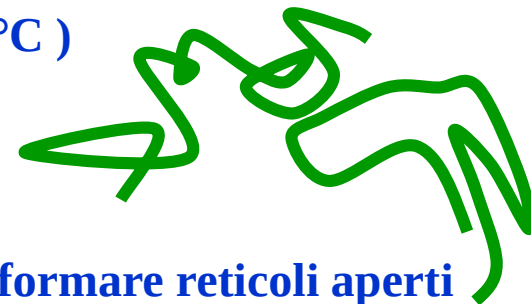


se scaldata (cotta) perde la struttura specifica
e la funzionalità (denaturazione)

(65 – 75 °C)

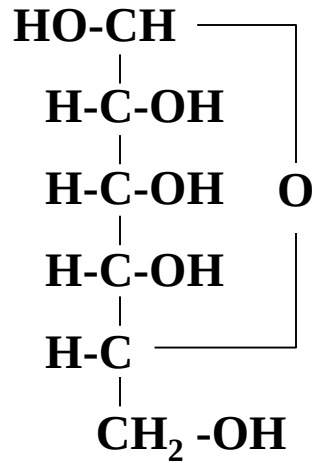
ripiegata in una struttura specifica e funzionante

deboli legami trasversali (legami idrogeno) -----

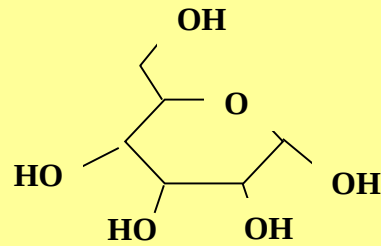


può formare reticoli aperti

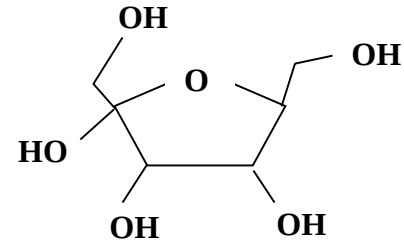
Zuccheri



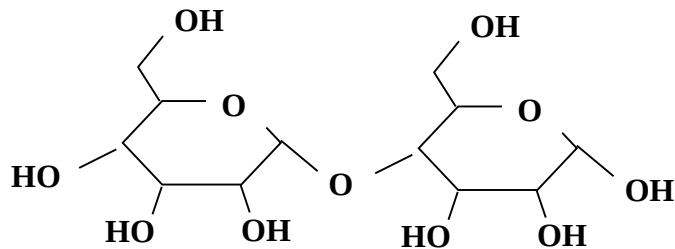
≡



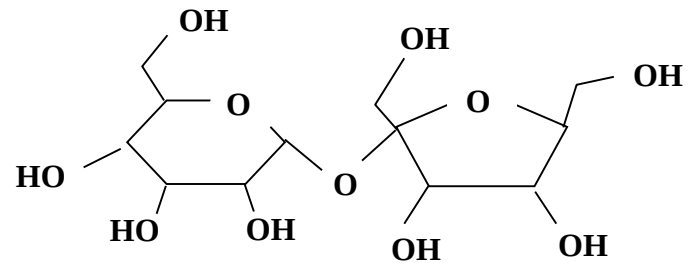
glucosio



fruttosio

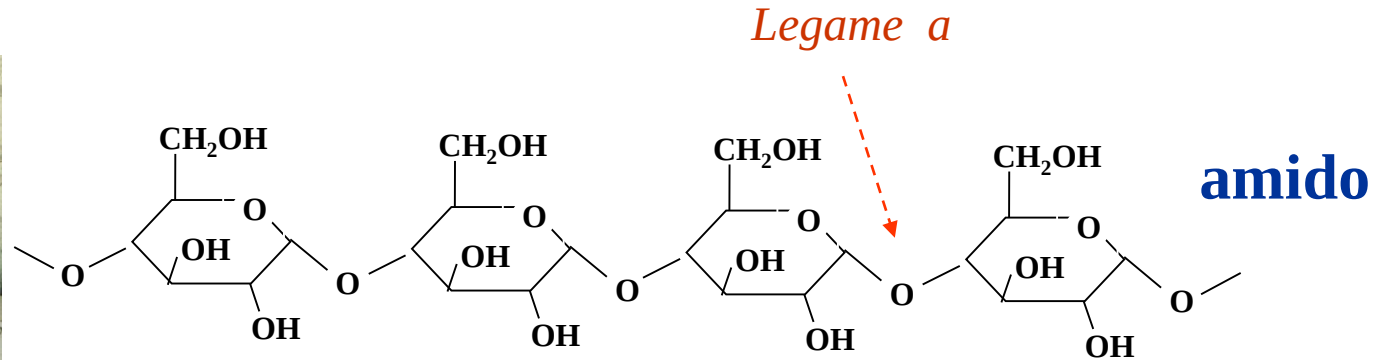


maltosio

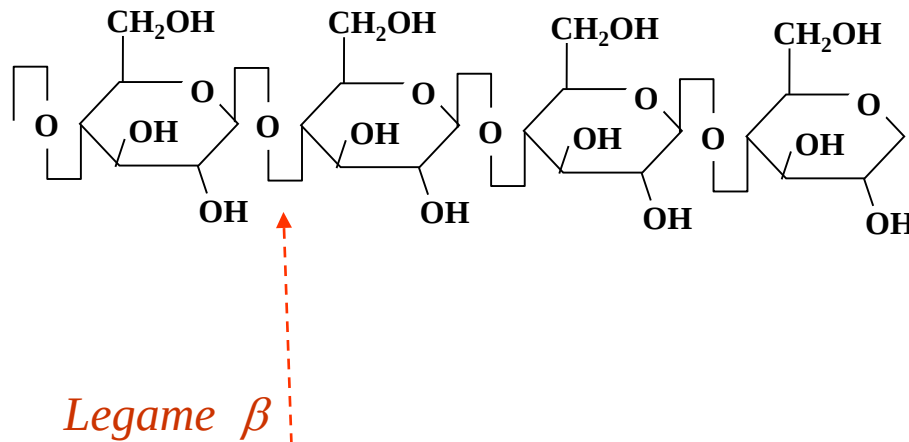


saccarosio

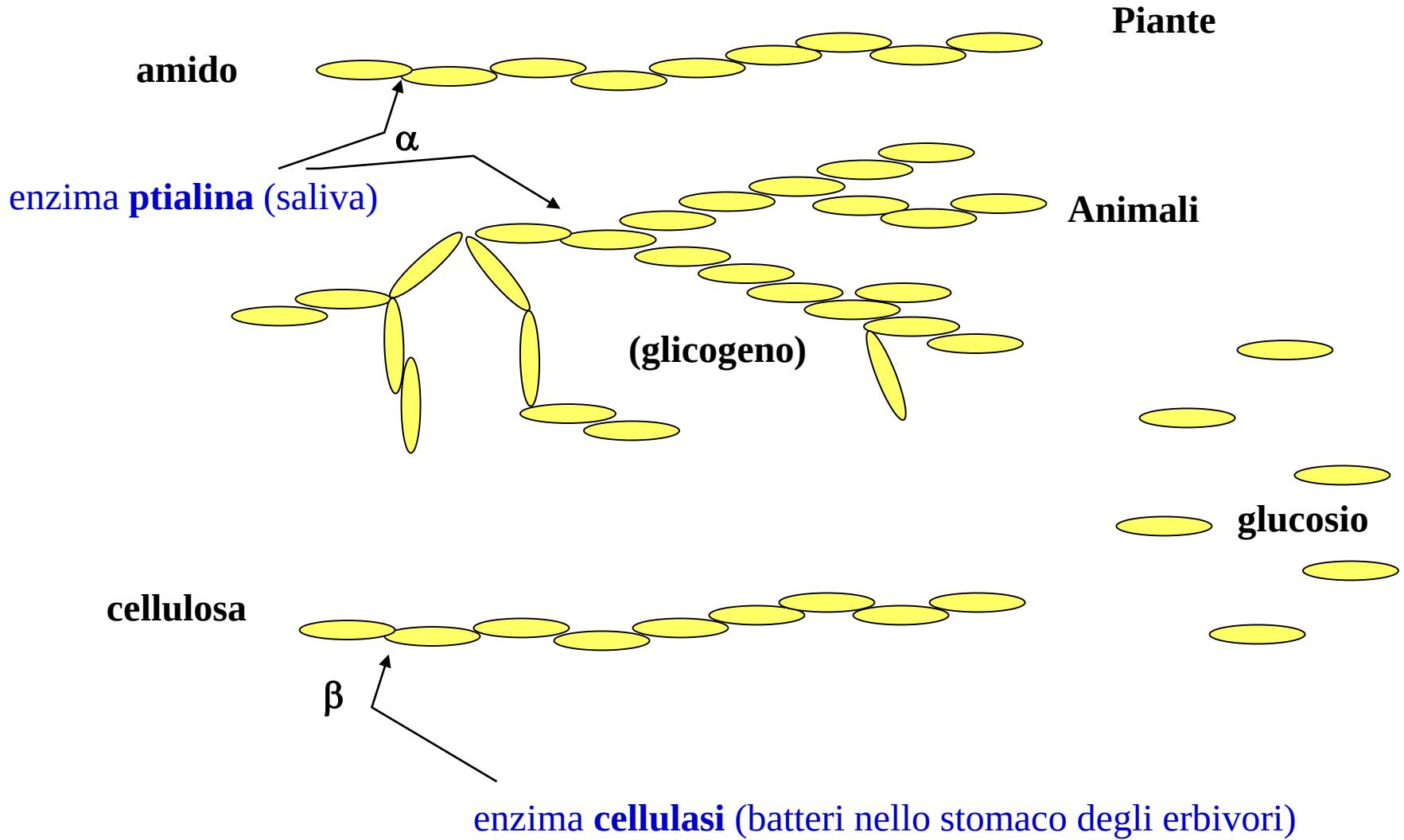
Carboidrati Polisaccaridi



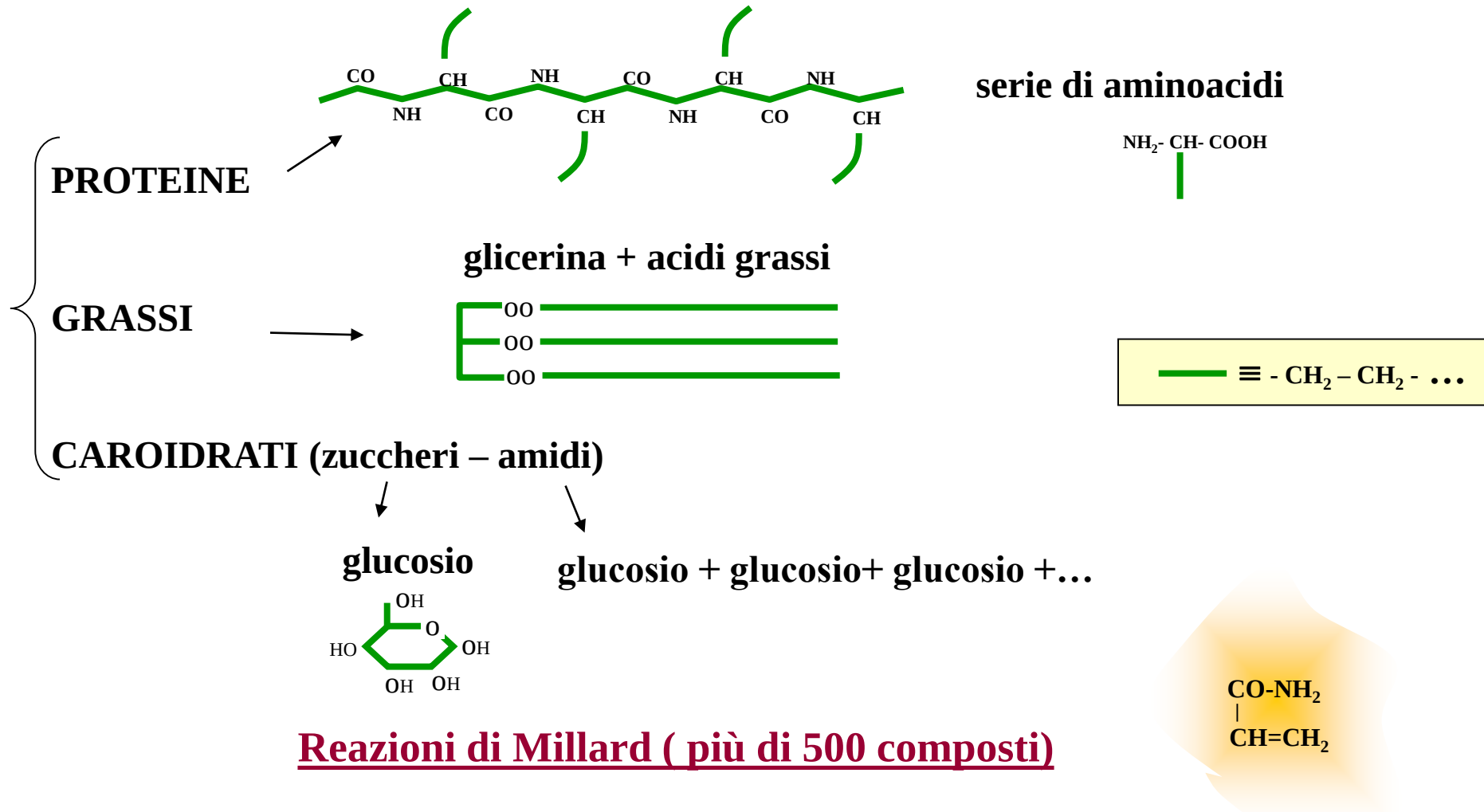
cellulosa



Carboidrati Digestione

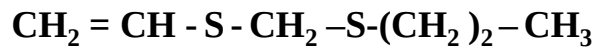


Reazione "Gustose"

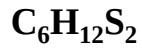
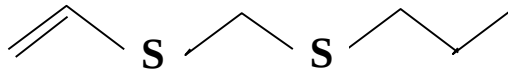


ad alta temperatura (140 – 180 °C), proteine e carboidrati reagiscono formando molecole piccole, di color bruno e saporite

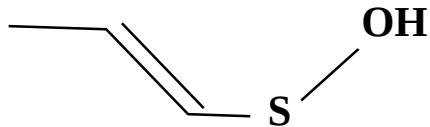
Soffritto



disolfuro di allipropile

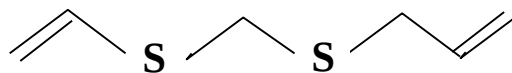
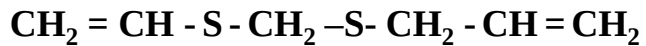


soffritto cipolla

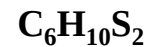


Occhio che piange: rimedio

(gas) acidi sulfenici solubile in acqua



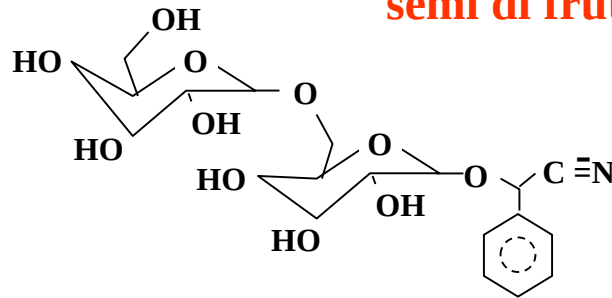
disolfuro di diallile



Reazione “Gustose”

semi di frutta (mandorle, albicocche, pesche ...)

amigdalina

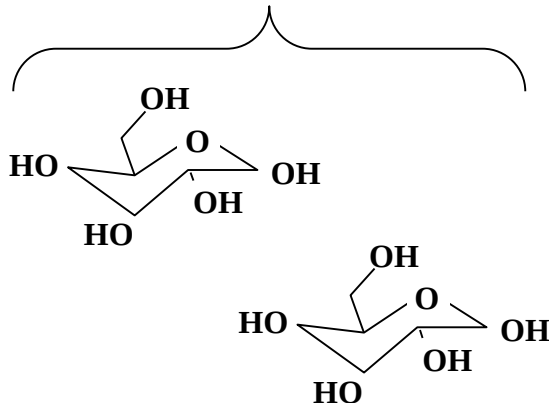


idrolisi

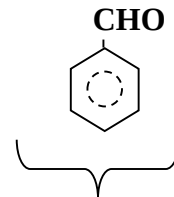
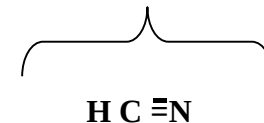


saliva

Glucosio = DOLCE



Acido cianidrico = “mandorle amare”



Benzooino = “orzata”

Caramello



Cotto 130 ÷ 160° C

$C_6H_{12}O_6$ glucosio $\equiv 6 C(H_2O)$

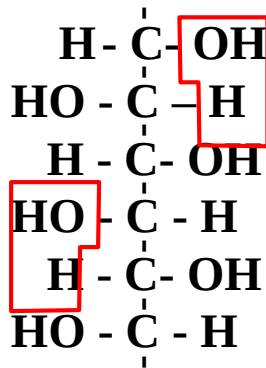
$C_{12}H_{22}O_{11}$ saccarosio (“zucchero”)

$C_{12}H_{18}O_9$ caramellana

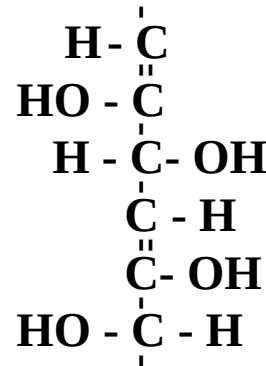
$C_{36}H_{50}O_{25}$ caramellene

$C_{125}H_{188}O_{80}$ caramellino

Polimerizzazione

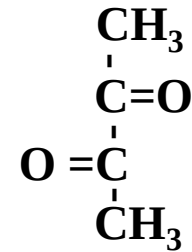


Disidratazione



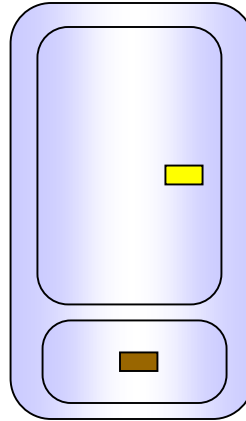
doppi legami con
distribuzione casuale
(colore Marrone)

Decomposizione
(esempio: diacetile)



profumo e gusto

Cioccolato



tempo

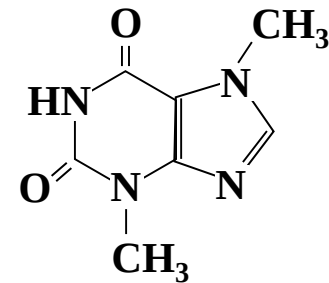


**efflorescenza
Burro di Cacao**

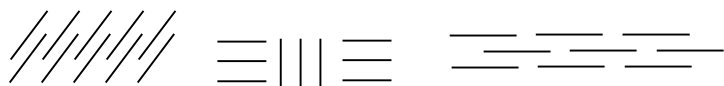
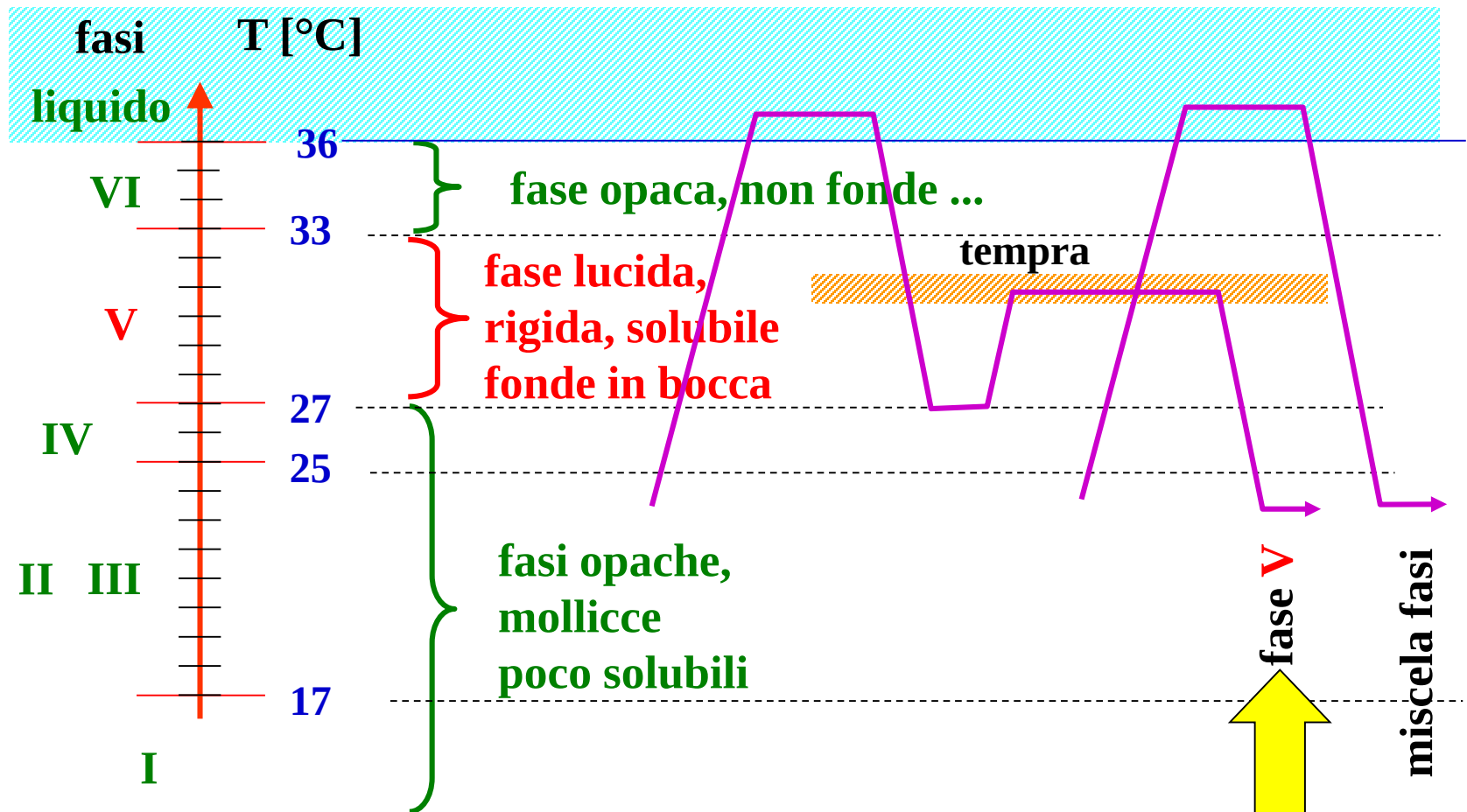
Cacao
Burro di Cacao

Teobromina < 1 %
Zuccheri ~ 50
Acqua (Sali) ~ 20
Proteine ~ 5
Grasso ~ 25

**stearico
palmitico
oleico**



Burro di Cacao

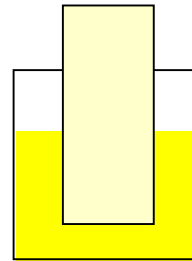


invecchiando (al freddo)
compaiono anche la fase **VI**

Patatine Fritte

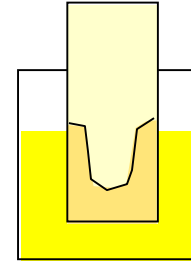


amido



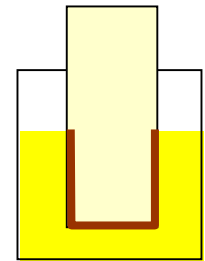
T bassa

assorbimento



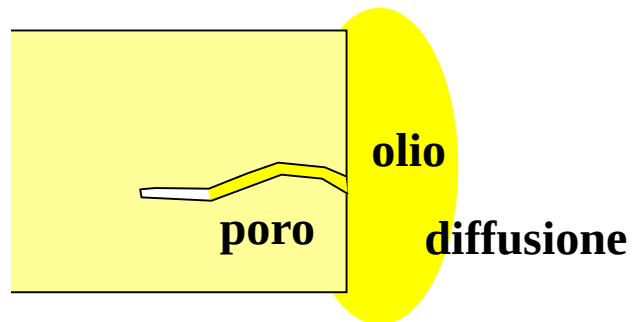
T media

crosta

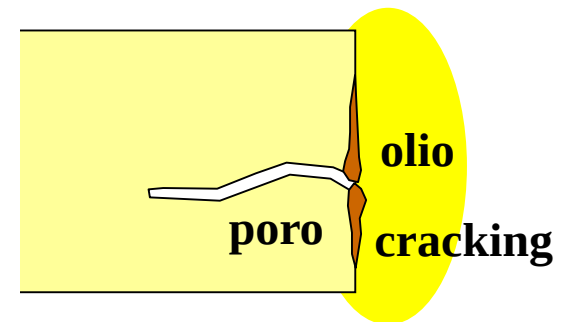


T alta

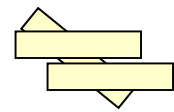
T media



T alta



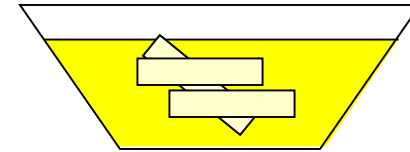
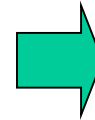
Patatine Fritte



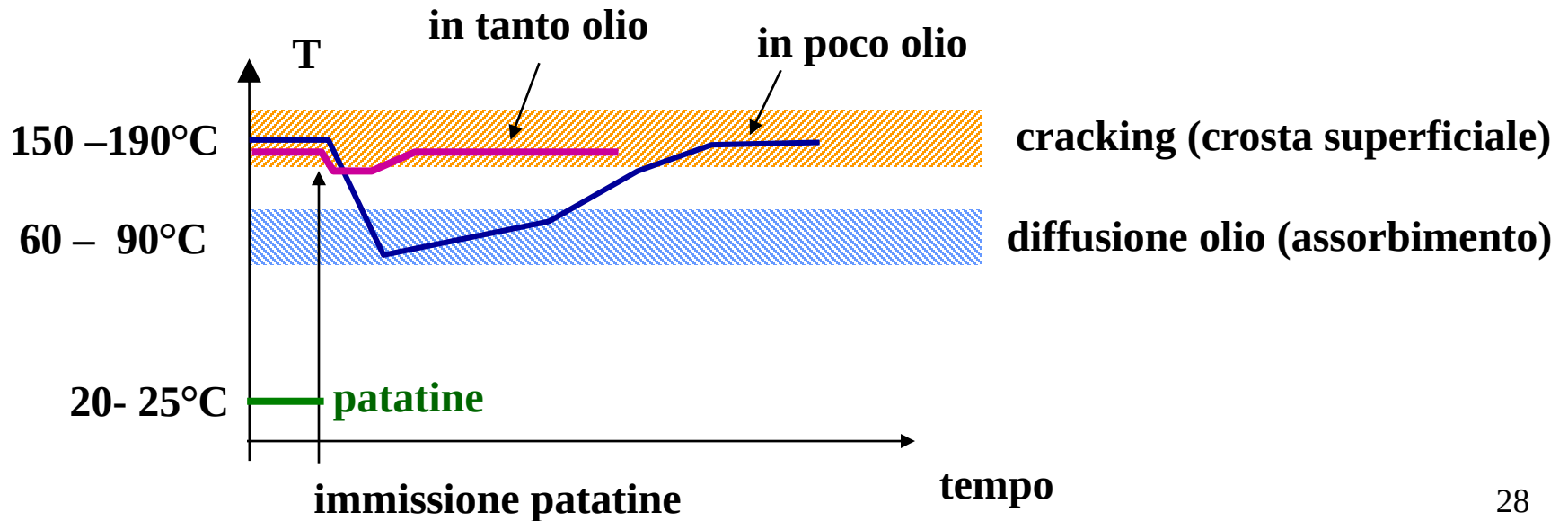
T_{pat}
 M_{pat}
 C_{pat}



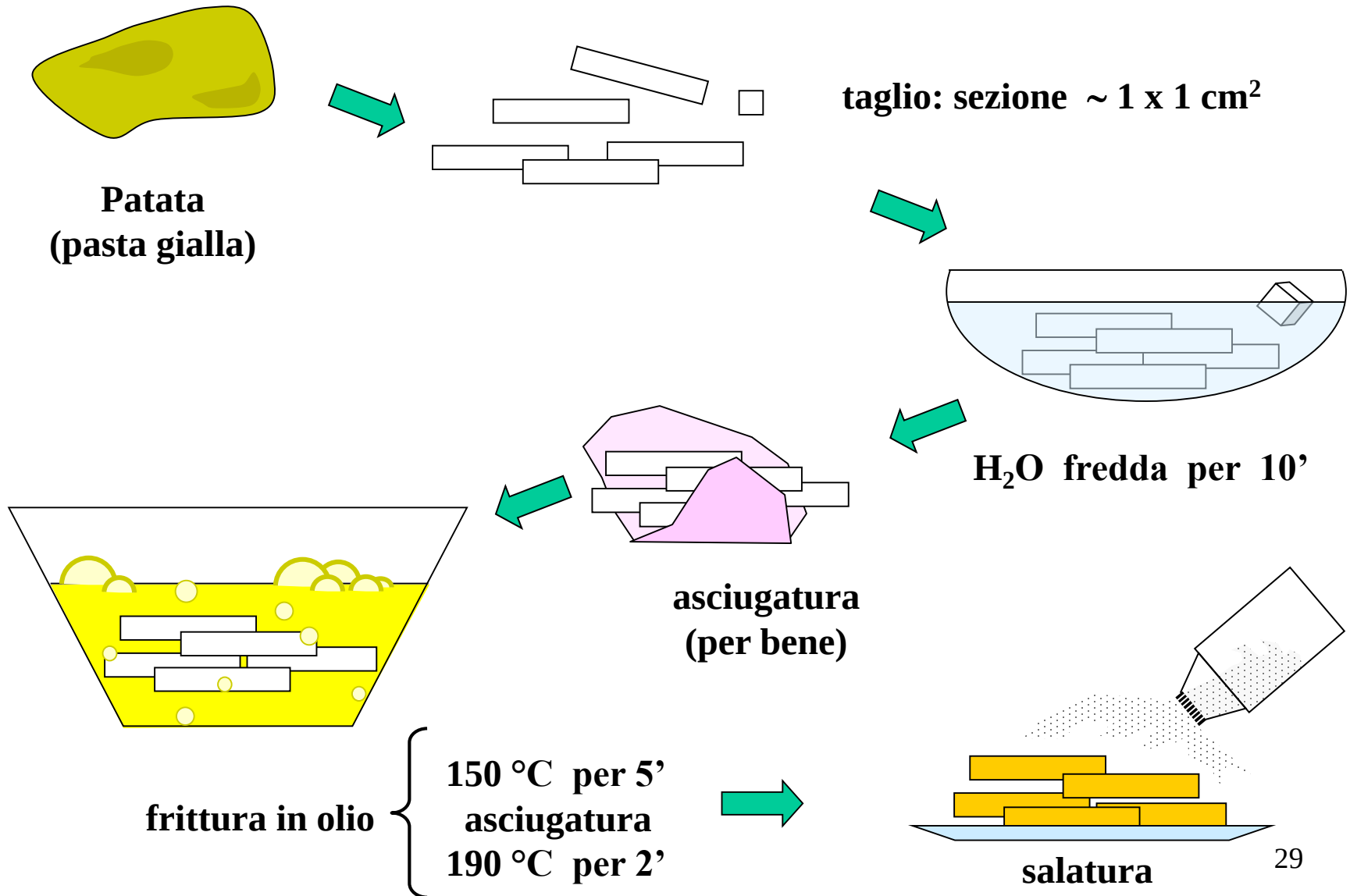
T_{olio}
 M_{olio}
 C_{olio}



$$T = \frac{T_o M_o C_o + T_p M_p C_p}{M_o C_o + M_p C_p}$$



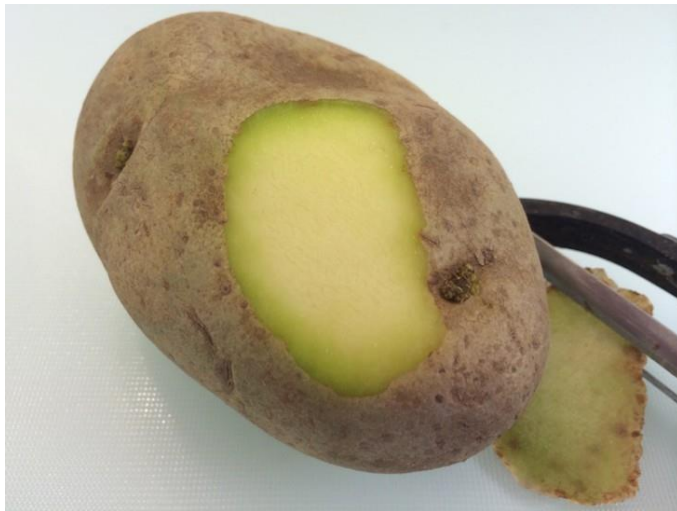
Patatine Fritte



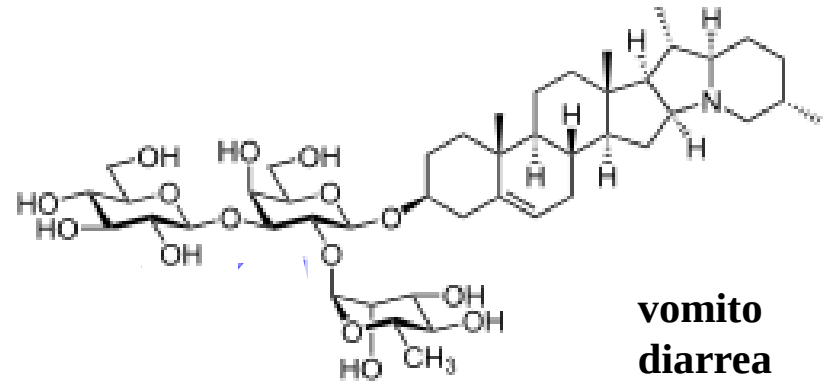
Patate

ATTENZIONE!

Solanina
Alcaloide glicosidico



patate diventate verdi
(luce –freddo)



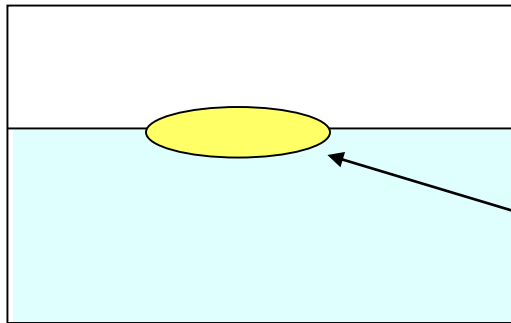
vomito
diarrea
allucinazioni
...



intorno ai germogli

Acqua - Olio

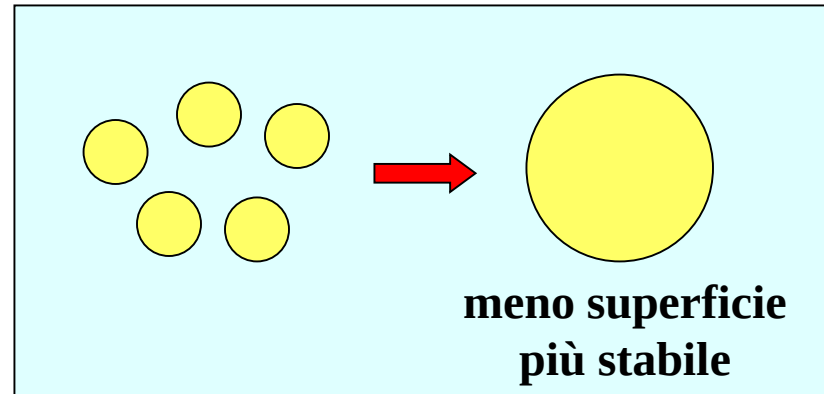
gocce di olio in acqua



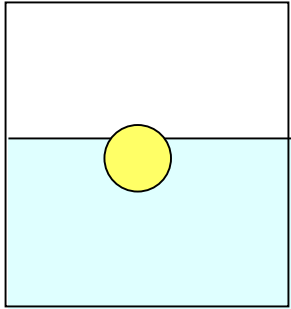
tensione superficiale

energia d'interfaccia (destabilizzante) $W = \sigma S$

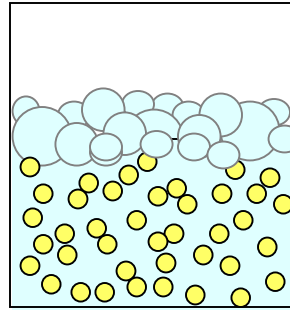
Ogni superficie di interfaccia tra materiali diversi è sede di energia destabilizzante che tende a ridurre il valore. (superficie minima)



Tensione Superficiale



**alta tensione
superficiale**

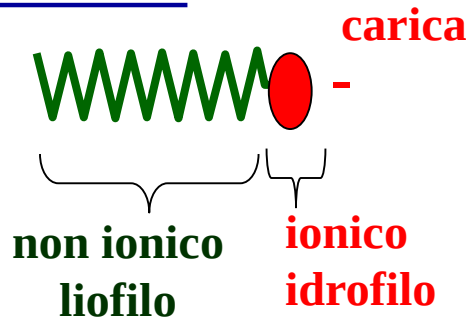


**bassa tensione
superficiale**

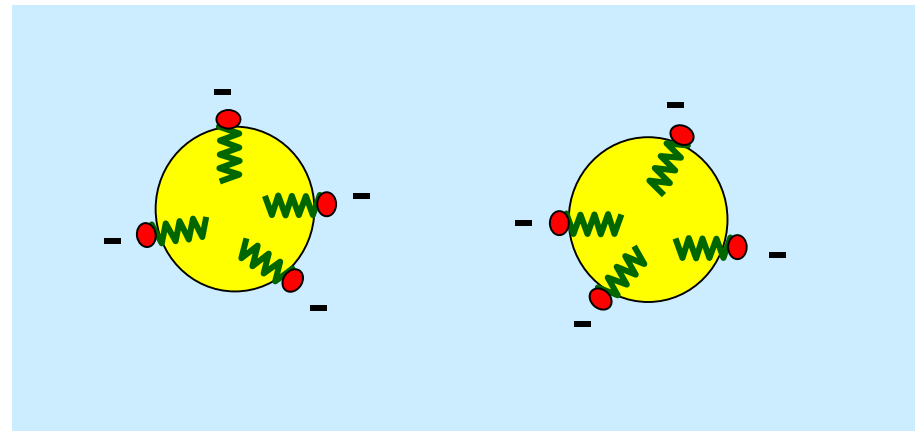
schiuma: liquido + aria

emulsione: liquido + liquido

Tensioattivi

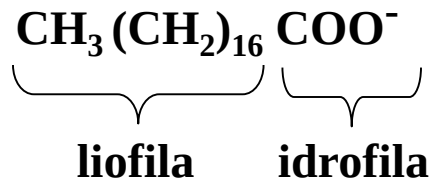


repulsione elettrica che stabilizza le micelle



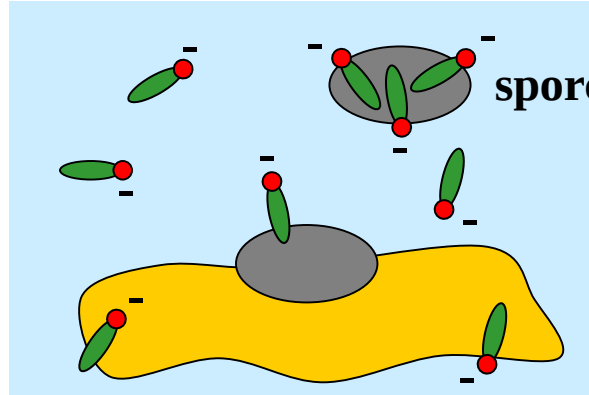
Tensioattivi

sapone



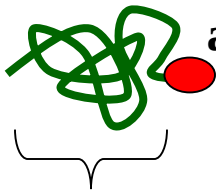
Na^+

stearato di sodio



sporco = grasso

Caseina



acido fosforico

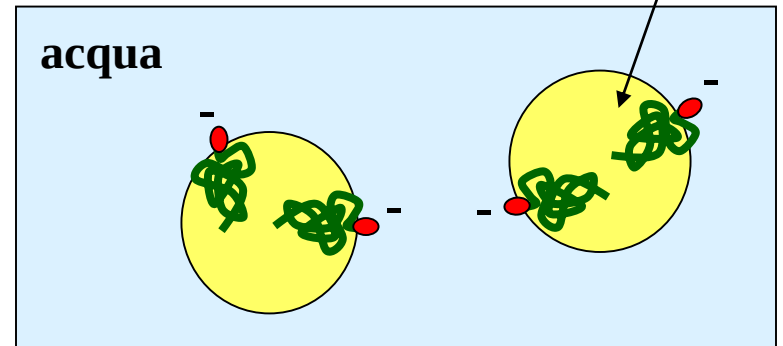


proteina

LATTE

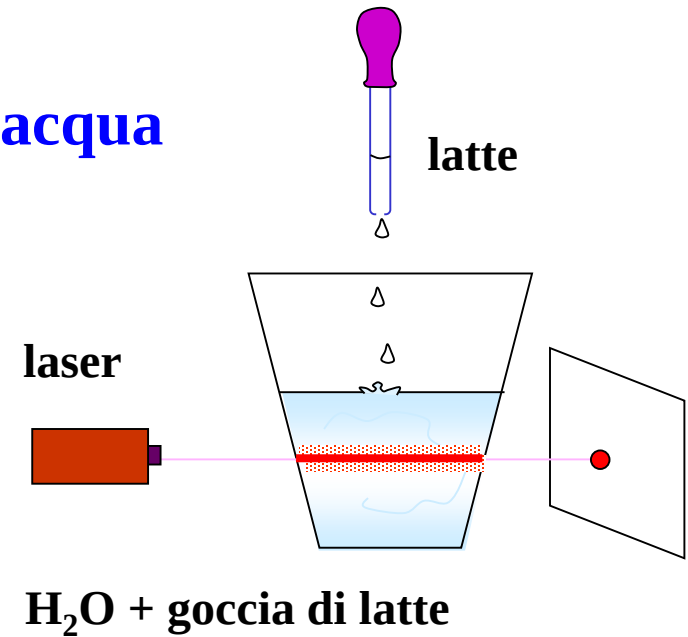
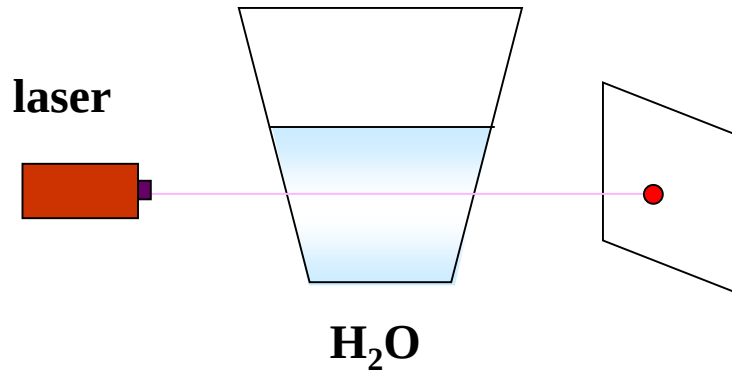
acqua

grasso

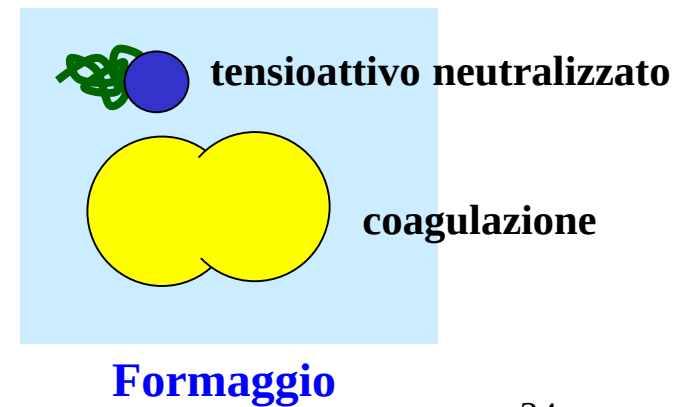


Latte

Sospensione di particelle di grasso in acqua



+ { **caglio**
acido



Uovo

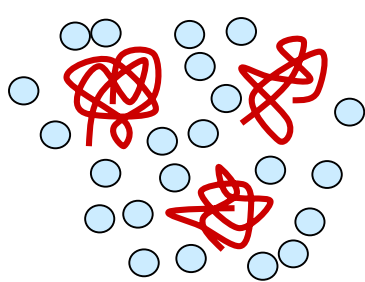


H₂O 50%

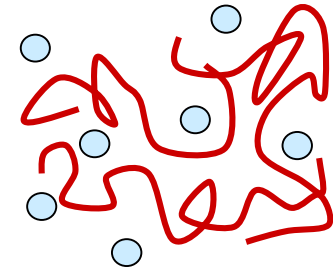
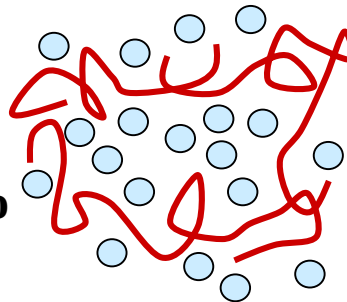
Lipidi 30%

Proteine 15%

Grassi
Colesterolo
Lecitina (tensioattivo)
(lioproteina)



60°C bianco
70°C rosso



crudo
gelatinoso

cottura (8')
reticolazione con
inglobamento acqua
morbido

troppa cottura
perdita di acqua
stopposo



proteina



acqua

DENATURAZIONE

Meringhe – Soufflé - Mousses



bianchi montati a neve

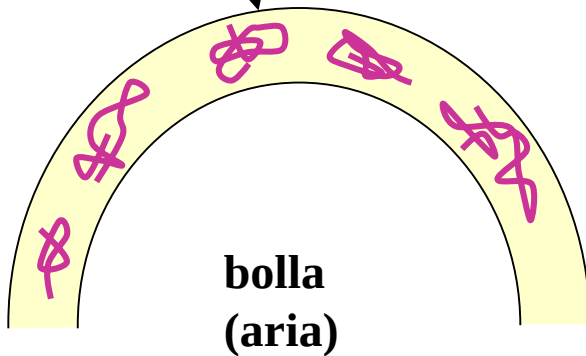


**Schiuma (aria in liquido)
lecitina come tensioattivo**

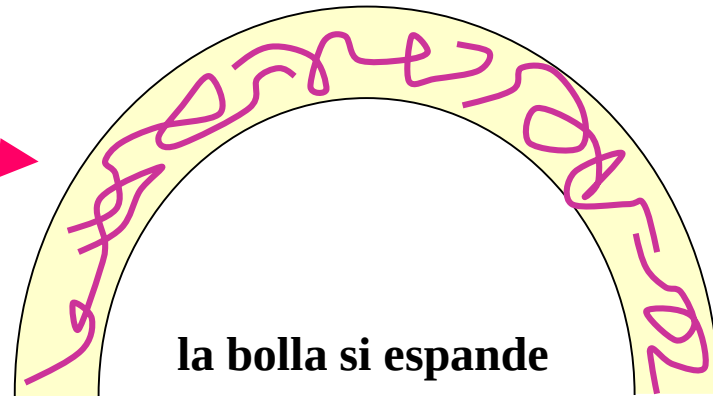
PROTEINE

aumentano la viscosità stabilizzando la schiume

scaldando si denaturano formando un reticolo consistente



T
calore

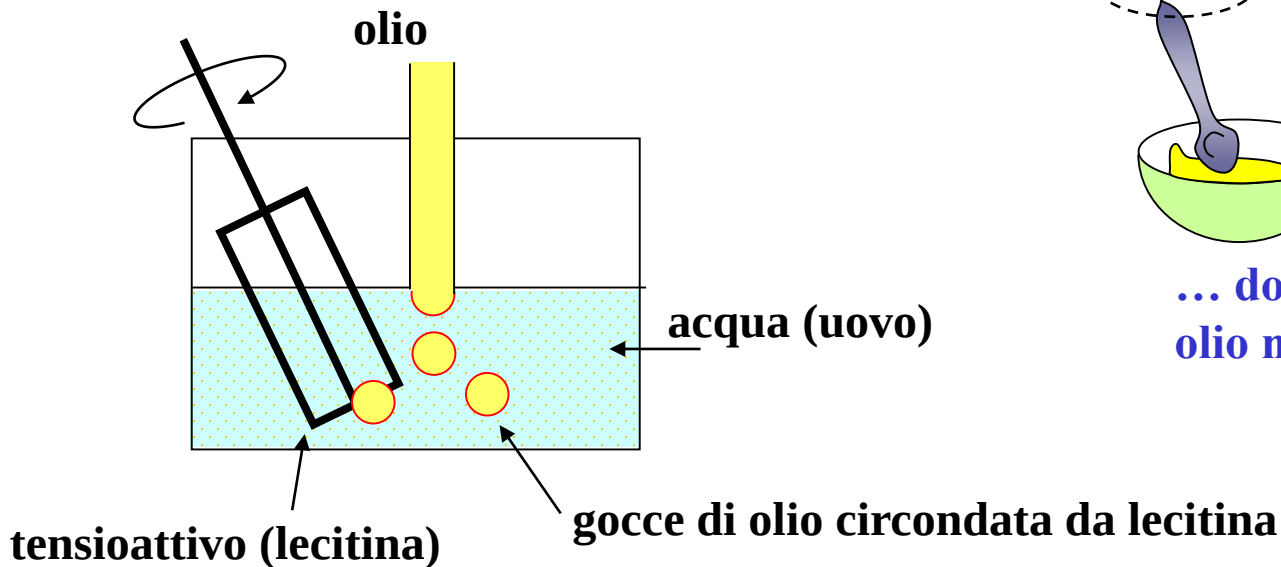


Maionese

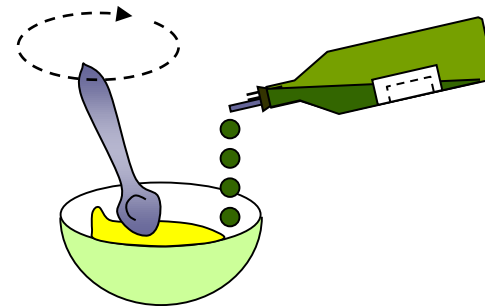


Olio in acqua + tensioattivo

Emulsione (2 fasi) olio in acqua (uovo)



... la maionese si fa così !



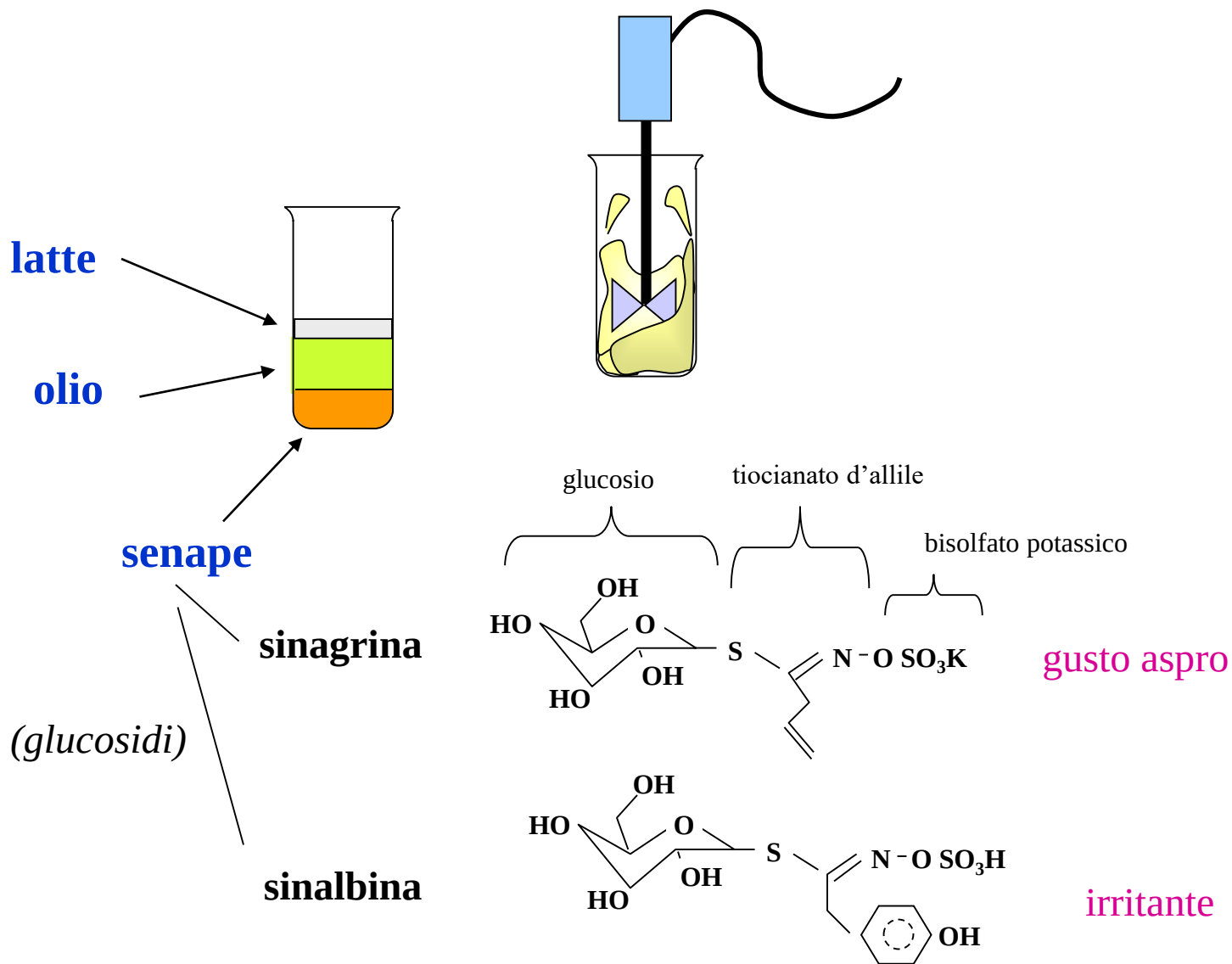
... dopo i primi 3 cucchiaini di
olio non impazzisce più ...

Maionese **impazzita** = coalescenza delle gocce di olio

T bassa

poca acqua (uovo)

Maionese senza Uovo



Pane

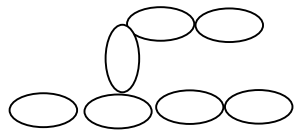
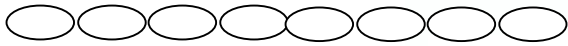


impasto { **FARINA**
ACQUA
LIEVITO
(sale, zucchero, olio ...)



Grano

amilosio



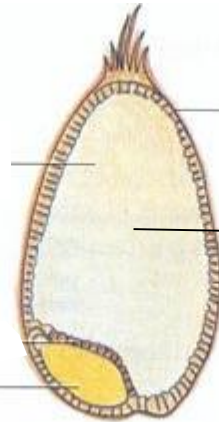
amilopectine

○ ≡ **glucosio**

cariosside (chicco)

amido (~ 60%)

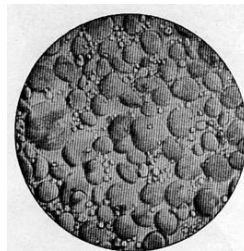
germe



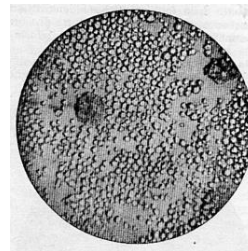
scorza – crusca (~ 20%)

glutine – semola (~ 10%)

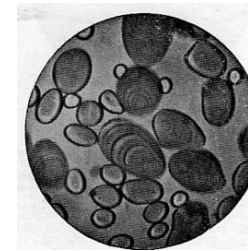
proteine (gliadine e glutenine)



amido di: grano



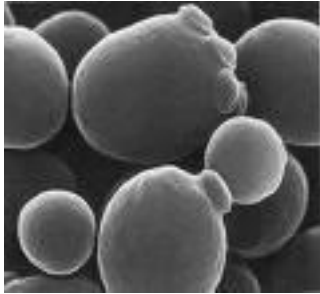
riso



patata

Test Amido ○ → **tintura di iodio** ●

Impasto



Lievito di birra (Saccharomices cerevegia)

Il lievito consuma i carboidrati producendo bollicine di gas



Lievitazione 20 – 35 °C (poche ore)

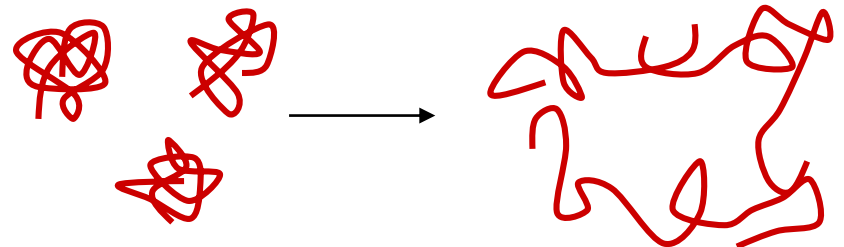


Glutine (forza della farina W)

W	% H ₂ O	
100	50	deboli
200	70	media
300	80	forti

Le molecole di glutine reticolano (assorbendo H₂O) rendendo elastica la pasta

reticolazione anche a T basse (parecchie ore)



Cottura Carne



BOLLITO



ARROSTO



BRASATO



GRIGLIATA

Cottura

Perché si cuoce la carne?

ammorbidire

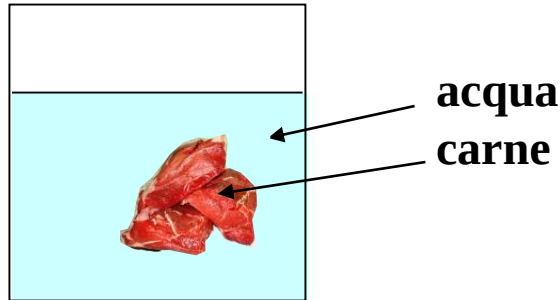
dare gusto



Collagene
Fosfoproteina a tripla elica
solubile in acqua calda

- **Mantenere i sali e composti costituenti all'interno delle cellule**
- **Reazioni di Millard: formazione di composti aromatici tra proteine – grassi - carboidrati**
molecole piccole, brune, saporite

Bollito

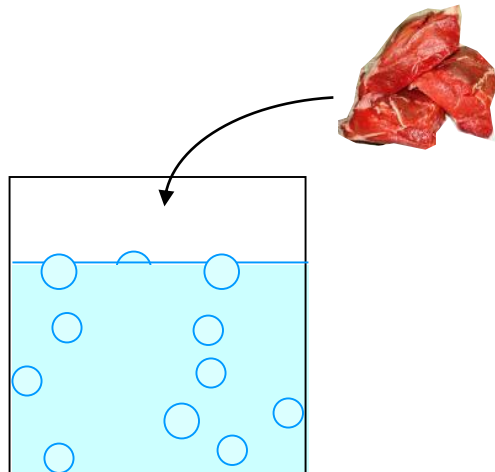


acqua
carne

acqua fredda

**Intensa estrazione da pori, lesioni,
dissoluzione durante il riscaldamento ...
Carne morbida (sciolto il collagene) ma
ha perso molti sali e sughi**

Buono il Brodo!



acqua bollente

Temperatura ottimale 65 –75 °C

**Semichiusura pori superficiali
Lenta dissoluzione ...**

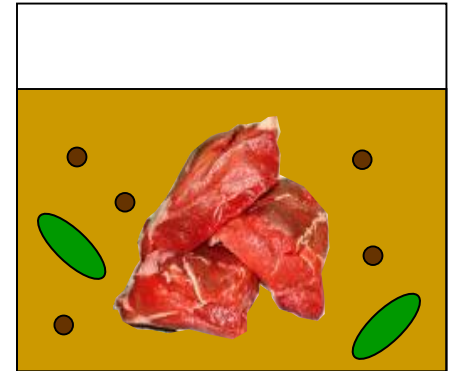
Buona la Carne!

... ora è messo in dubbio la chiusura dei pori ... (teoria di Liebig)

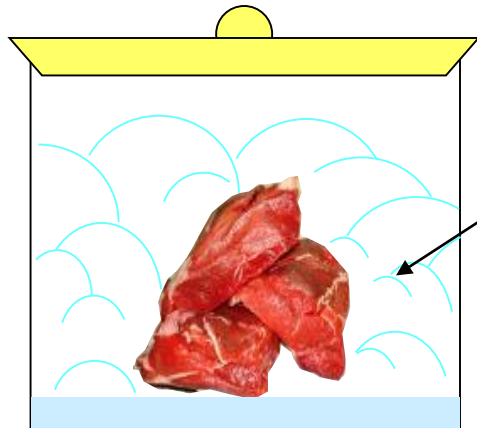
Cottura

BRASATO

Diffusione di Sali ed aromi dal sugo alla carne durante le ore prima della cottura



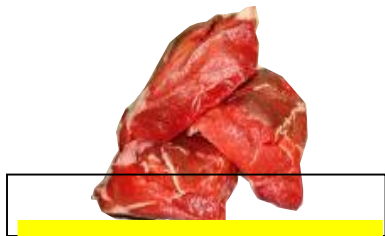
STUFATO



vapore

Il vapore ammorbidisce la carne (scioglie il collagena) ma mantiene il sapore (non estrae i sali)

ARROSTO

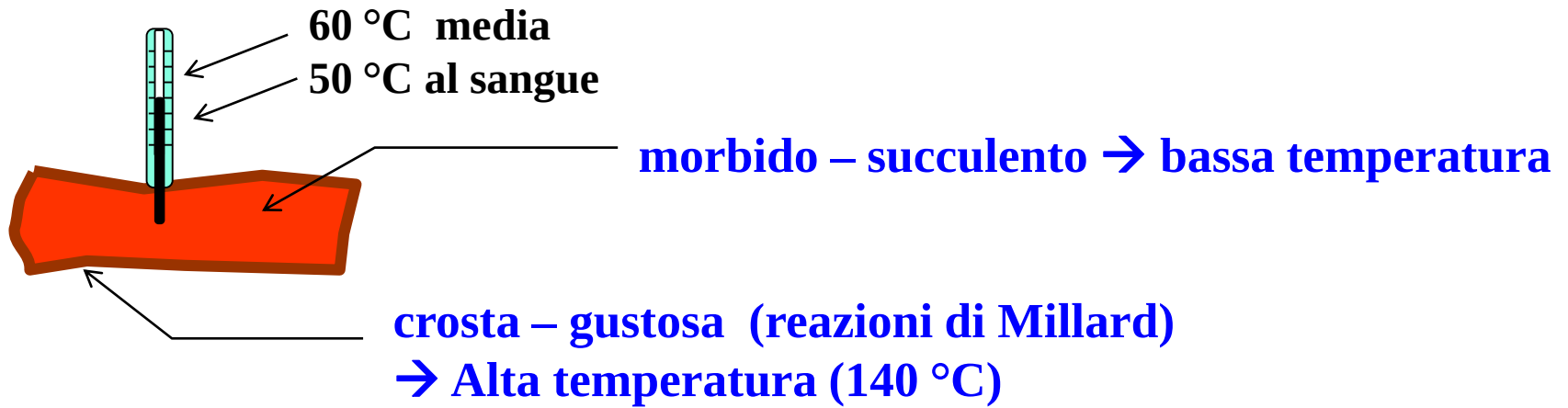


Il calore chiude gran parte dei pori superficiali (ridotte perdite di sughi) e induce le reazioni di Millard (molecole gustose)

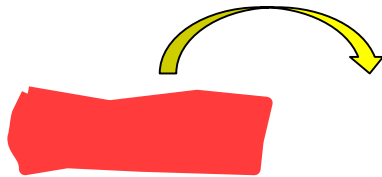
GRIGLIA



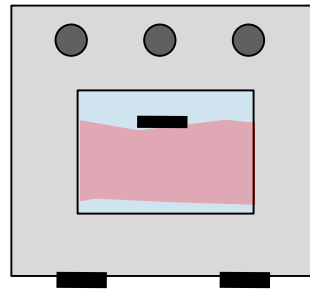
Bistecca



“reverse sear”



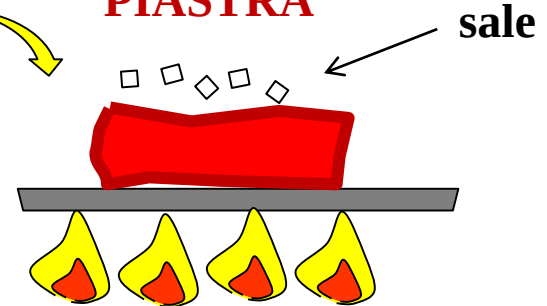
FORNO



Bassa Temperatura



PIASTRA



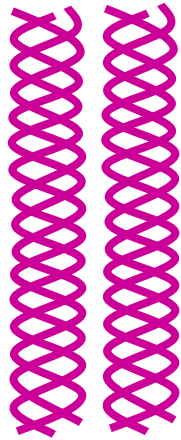
Alta Temperatura

Gelatina

Carne ossa



**collagene
trippla eliche
fosfoproteine**



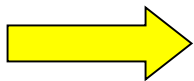
**solubile con
dissociazione delle eliche**

acqua calda



a freddo si riassociano ma in modo casuale formando reti stabili che inglobano l'acqua

**tornando a bassa
temperatura**



Cachi



**I cachi sono buoni!
Sono molto zuccherini!**

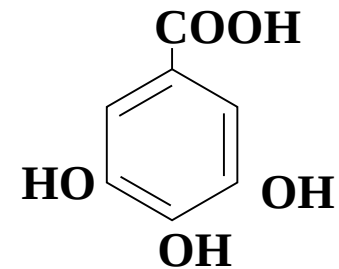
**... ma se sono acerbi...
“ALLAPPANO”**

è il TANNINO



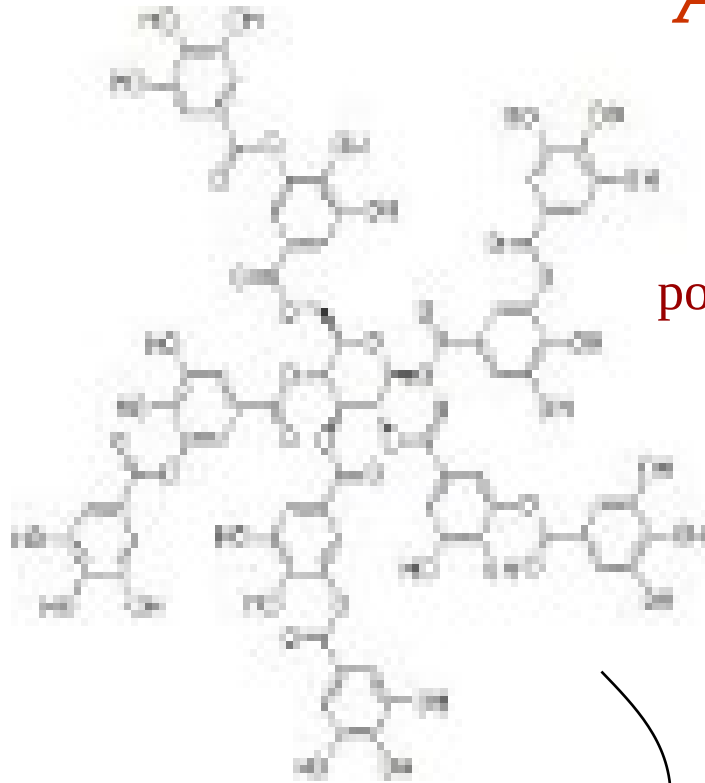
castagna

Polifenoli dall'acido gallico



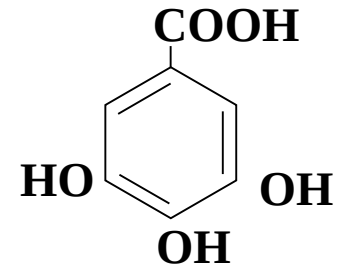
acido gallico

Allappa



TANNINO

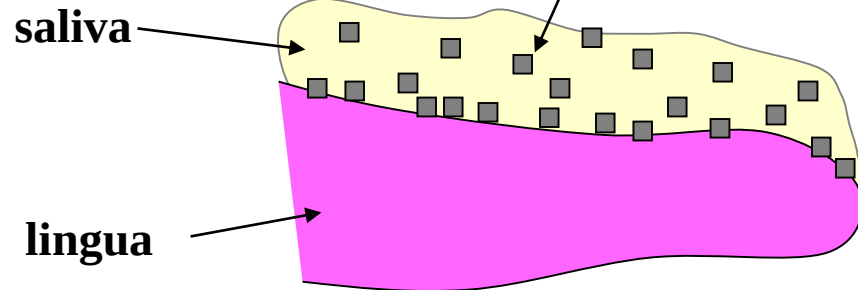
polifenolo



acido gallico

fa precipitare alcune proteine della saliva

patina sulla lingua

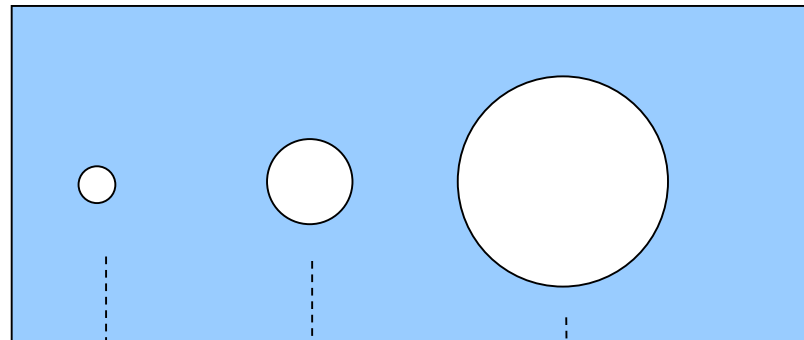


Bollicine

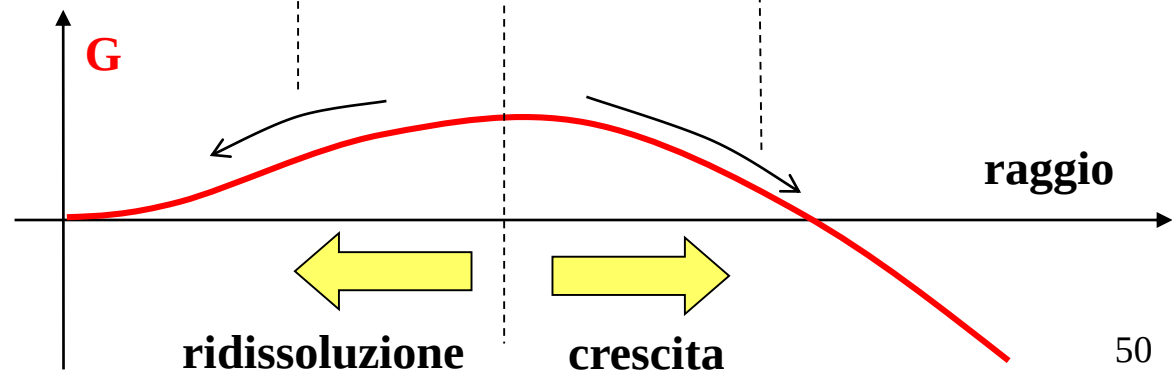


nascita delle bolle (nucleazione)

- il volume stabilizza
- la superficie destabilizza

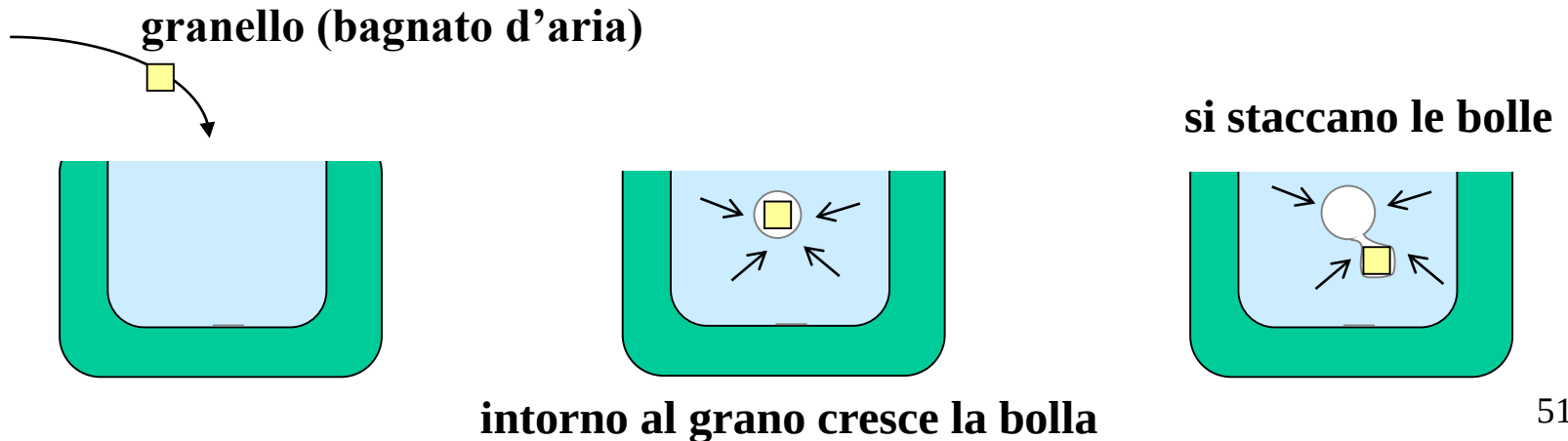
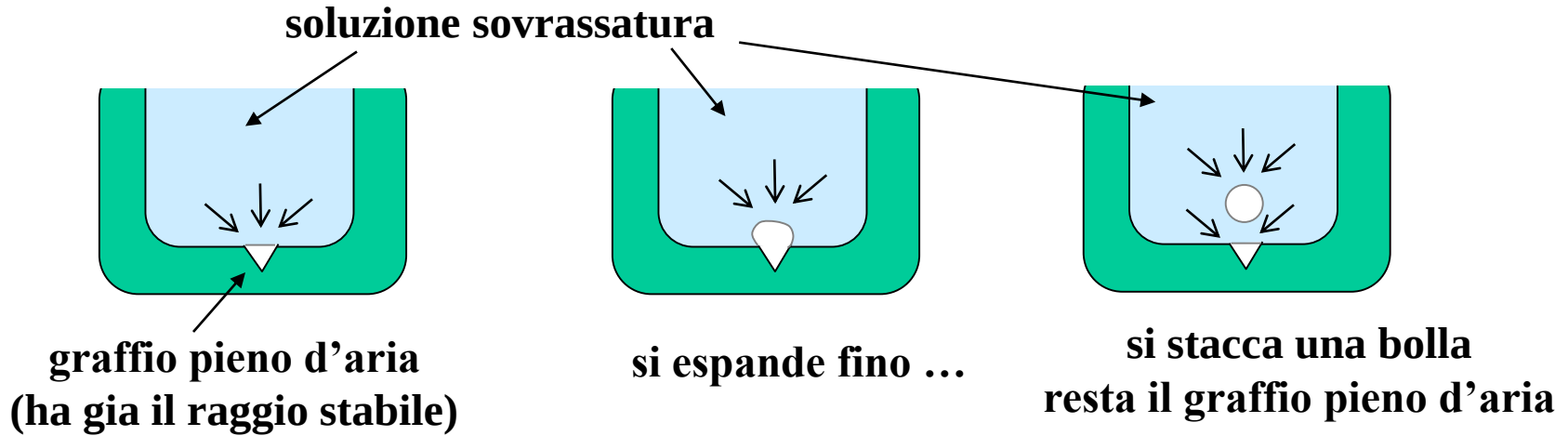


**le bolle grandi sono più
stabili di quelle piccole
...ma per crescere
devono nascere ...**



Bollicine

... le bolle nascono solo su nuclei di bolla già presenti

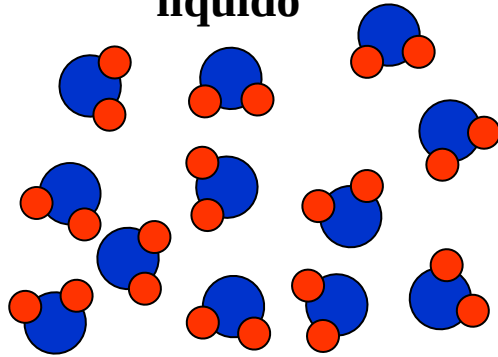


Ghiaccio

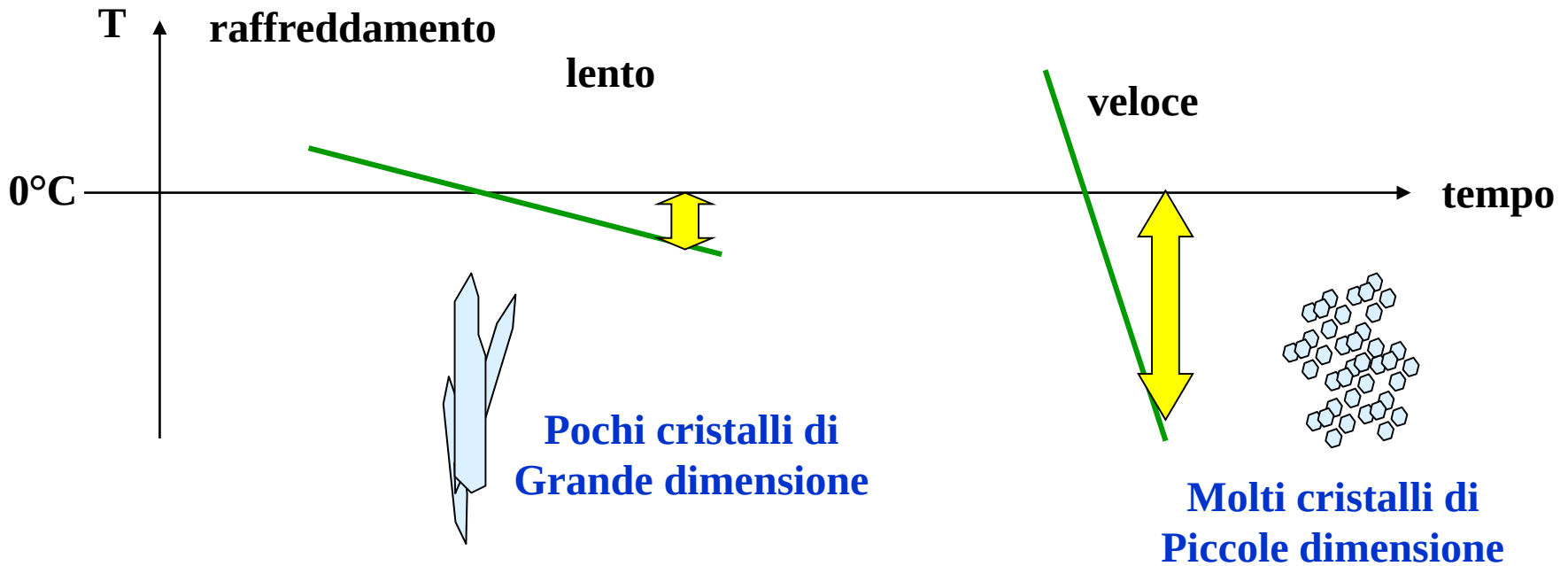
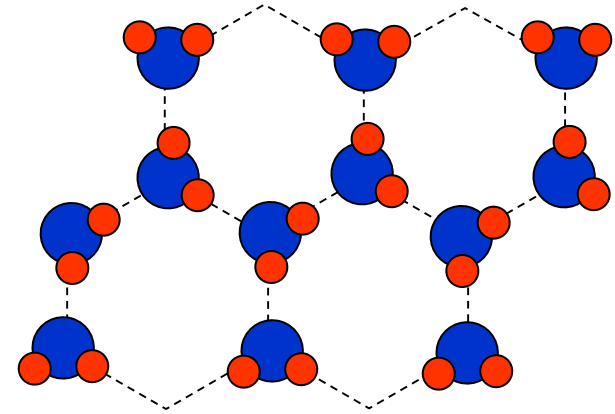
H₂O



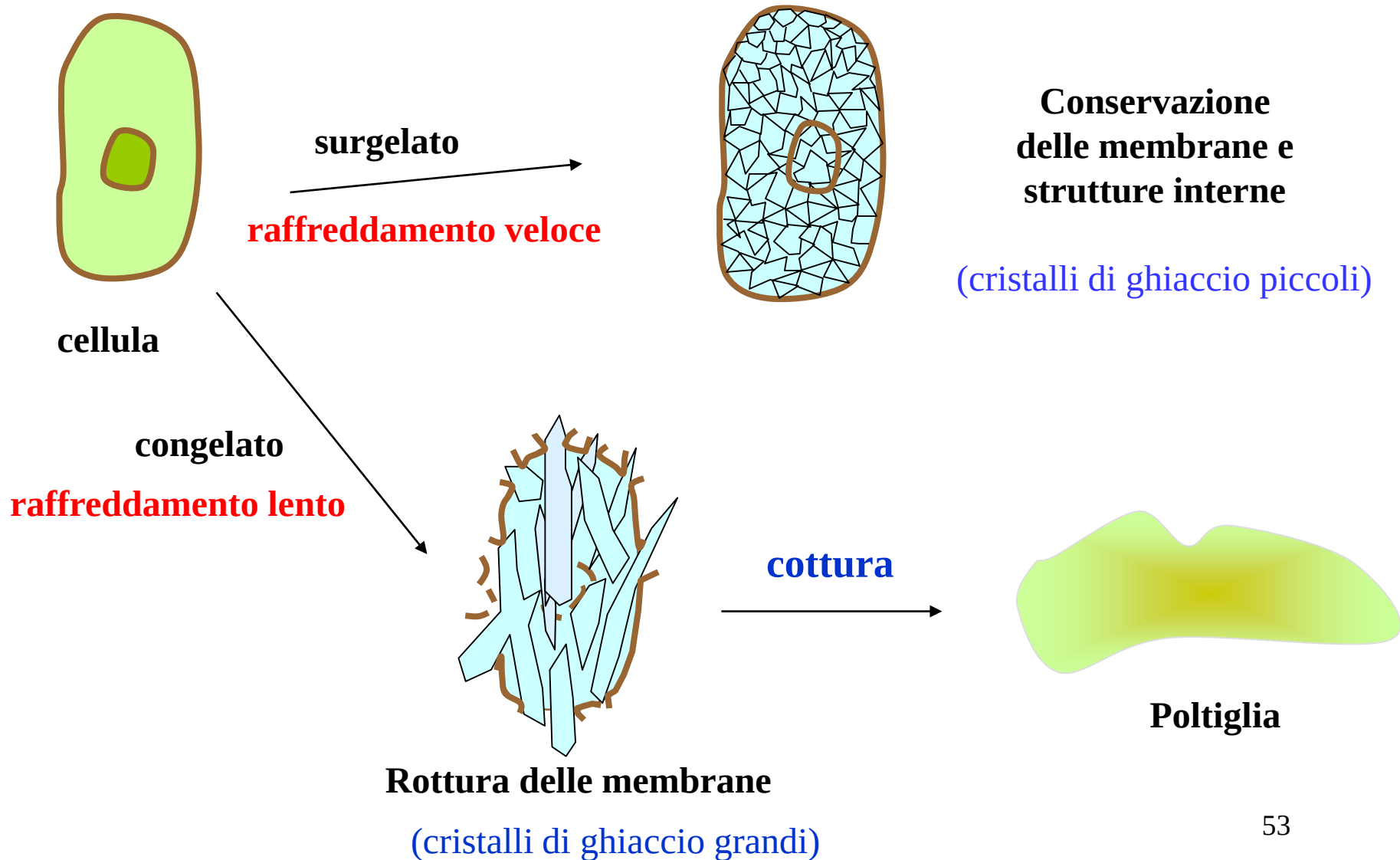
liquido



solido



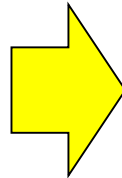
Congelato - Surgelato



Liofilizzati

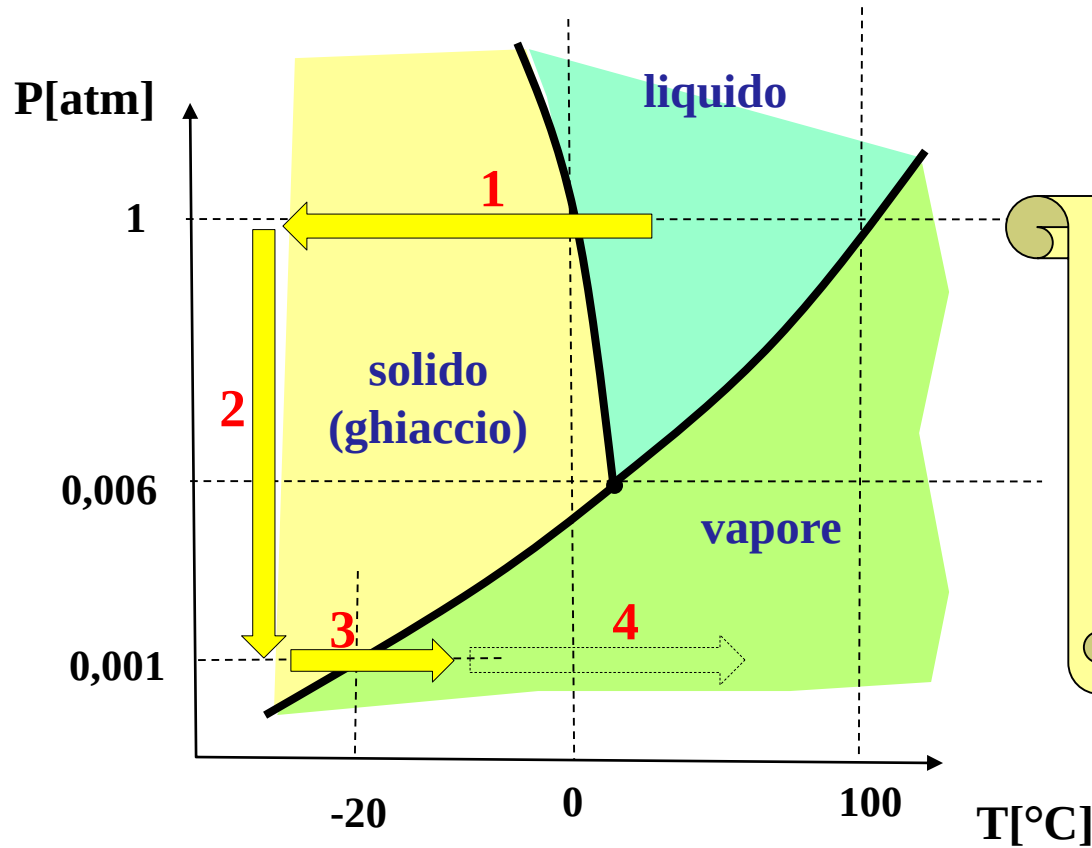
**Disidratazione senza degradazione molecolare
a freddo e sottovuoto**

- **Contenuto H_2O < 3%**
- **Mantenimento qualità nutrizionali**
- **Conservazione alimenti nel tempo**
- **Facile reidratazione**



caffè

Liofilizzazione

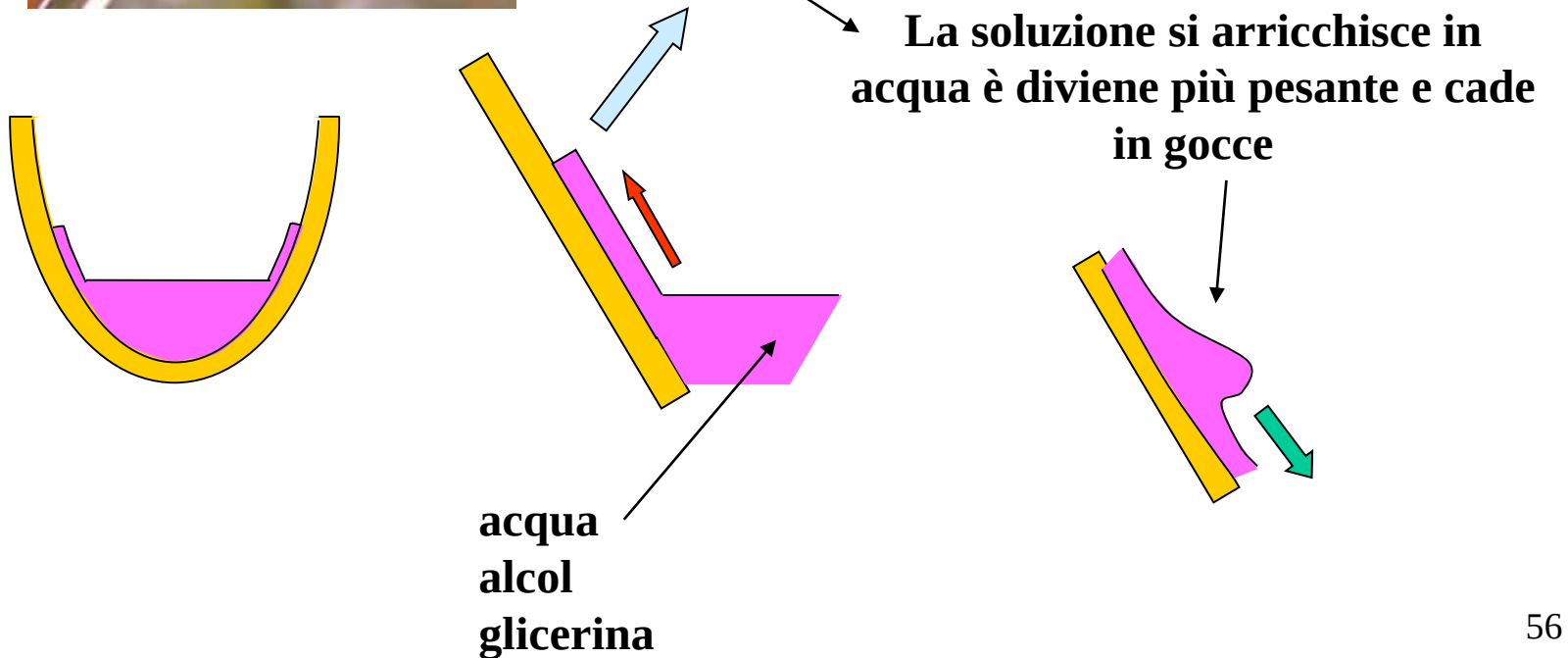


processo

- 1 - congelamento ($-50^{\circ}C$)
- 2 - sotto vuoto
- 3 - { riscaldamento
sublimazione
- 4 - riscaldamento ($< 60^{\circ}C$)
- 5 - riempimento con N_2

H_2O

Le Lacrime del Vino



FINE

GRAZIE PER L'ATTENZIONE