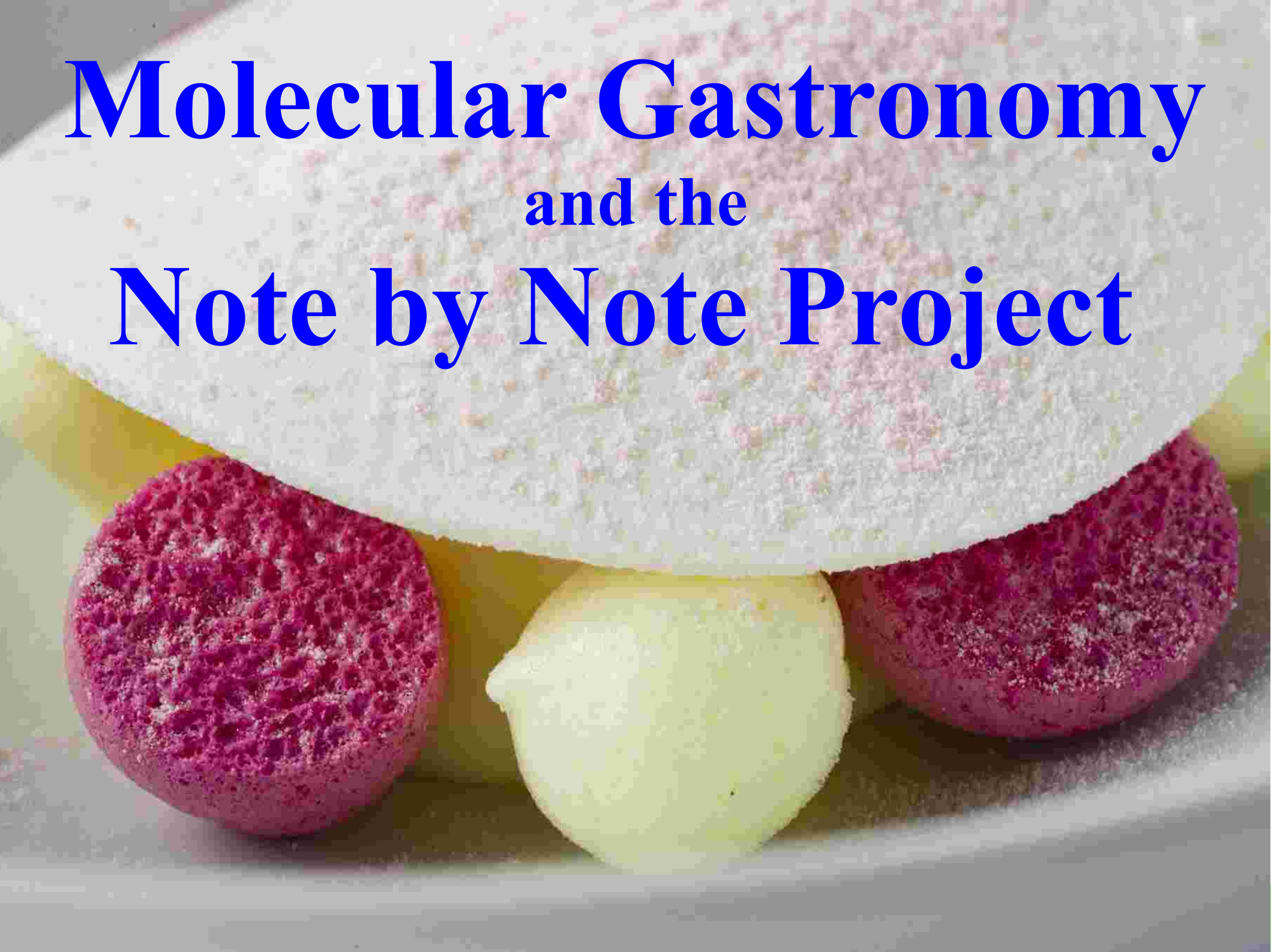
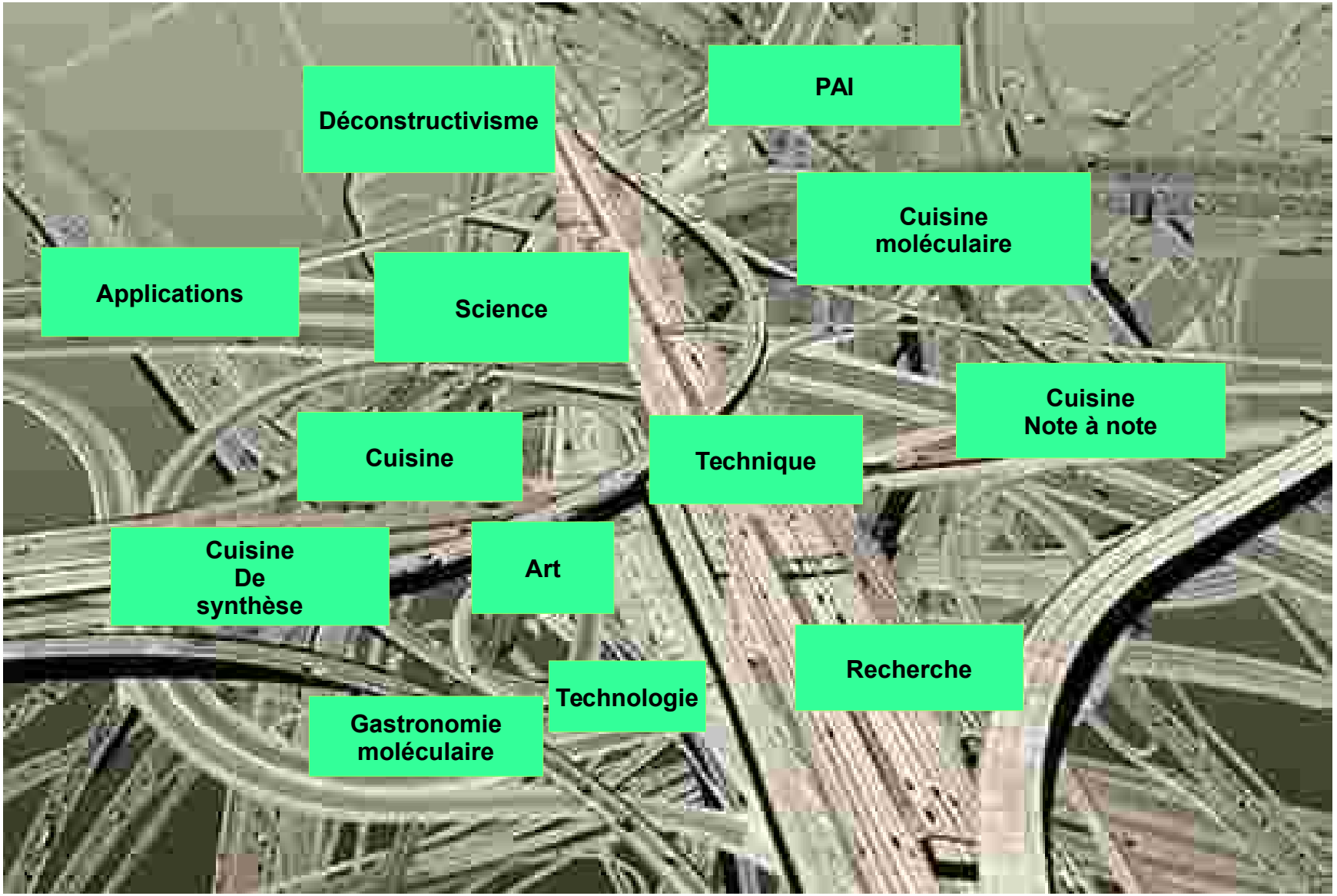

Molecular Gastronomy
and the
Note by Note Project

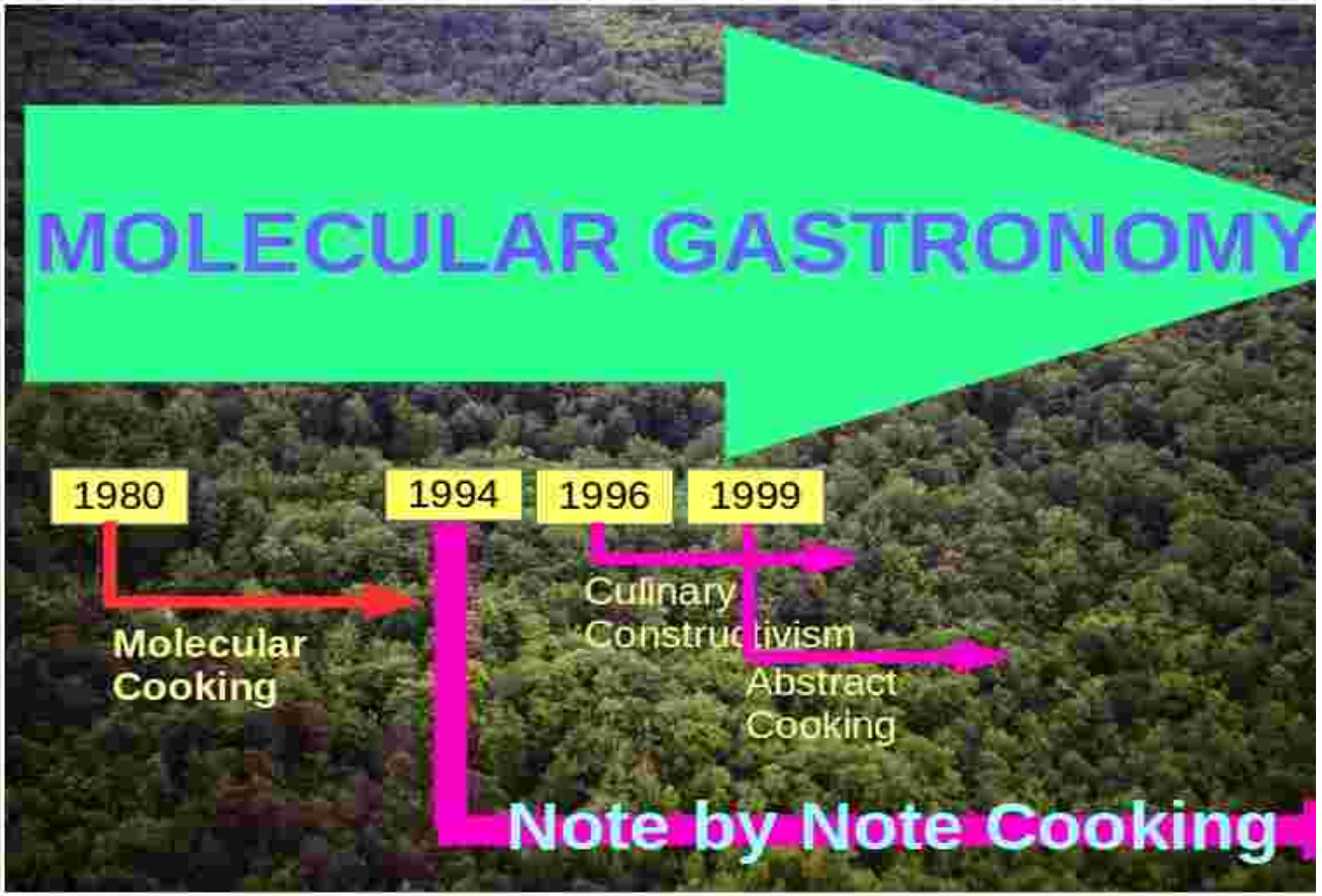
1. Molecular Gastronomy

2. Note by Note Cooking : new questions

Confusion !


Déconstructivisme
PAI
Cuisine moléculaire
Applications
Science
Cuisine Note à note
Cuisine
Technique
Cuisine De synthèse
Art
Recherche
Technologie
Gastronomie moléculaire

Perhaps because I made many proposals



1. Science

is looking for the mechanisms of phenomena

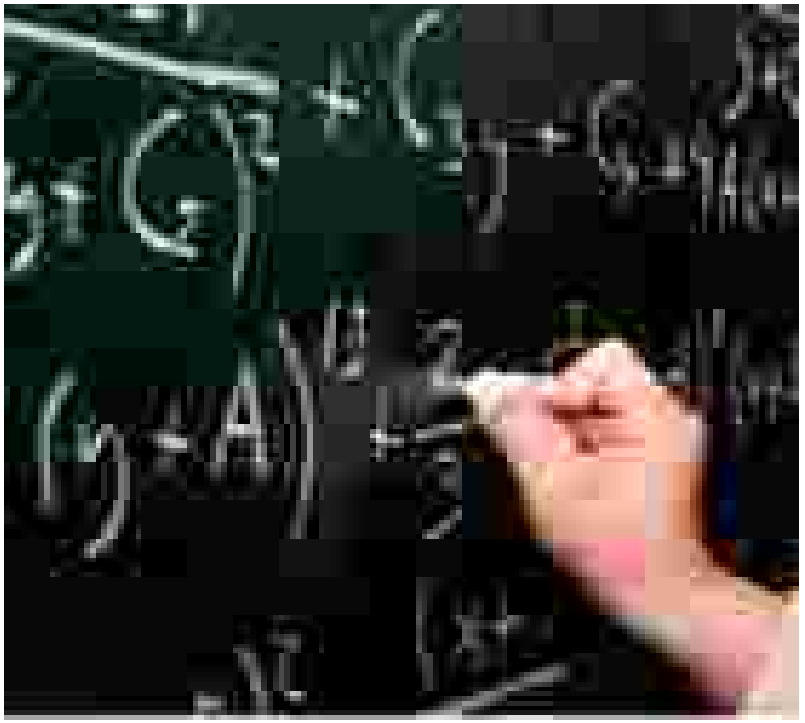
The first "leg": experiments !

- "Un bon moyen pour atteindre la vérité, c'est de **préférer l'expérience à n'importe quel raisonnement**, puisque nous sommes sûrs que lorsqu'un raisonnement est en désaccord avec l'expérience il contient une erreur, au moins sous une forme dissimulée. Il n'est pas possible, en effet, qu'une expérience sensible soit contraire à la vérité. Et c'est vraiment là un précepte qu'Aristote plaçait très haut et dont la force et la valeur dépassent de beaucoup celles qu'il faut accorder à l'autorité de n'importe quel homme au monde«
- Galilée (1564-1642)

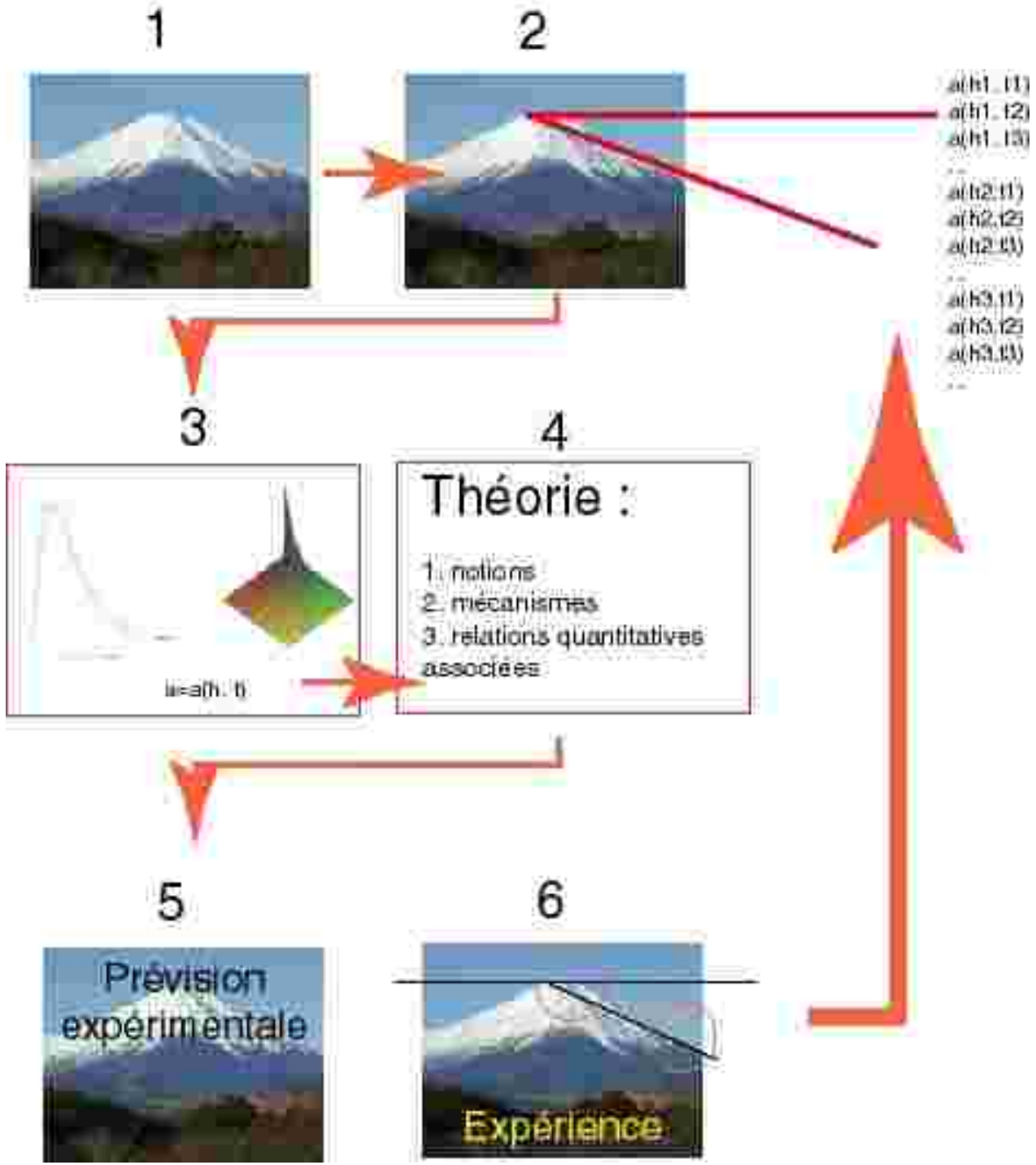
The second one: calculation

- "La philosophie est écrite dans ce livre immense perpétuellement ouvert devant nos yeux (je veux dire l'univers), mais on ne peut le comprendre si l'on n'apprend pas d'abord à connaître la langue et les caractères dans lesquels il est écrit.

Il est écrit en langue mathématique et ses caractères sont des triangles, des cercles, et d'autres figures géométriques, sans l'intermédiaire desquels il est humainement impossible d'en comprendre un seul mot".



Using this method



2. Technology
a link between science and technique

Products

Knowledge

3. Technique

doing things, producing goods and services

4. Art

"Good" means "beautiful to eat"

Differents methods, different goals

1.

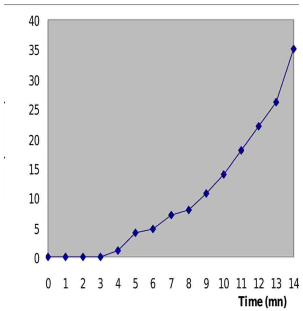
Molecular Gastronomy

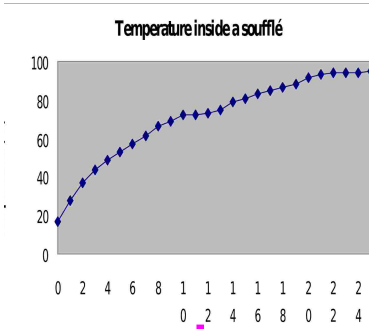
For example with soufflés

(1980!)

Les bulles d'air se dilatent

P V = n R T

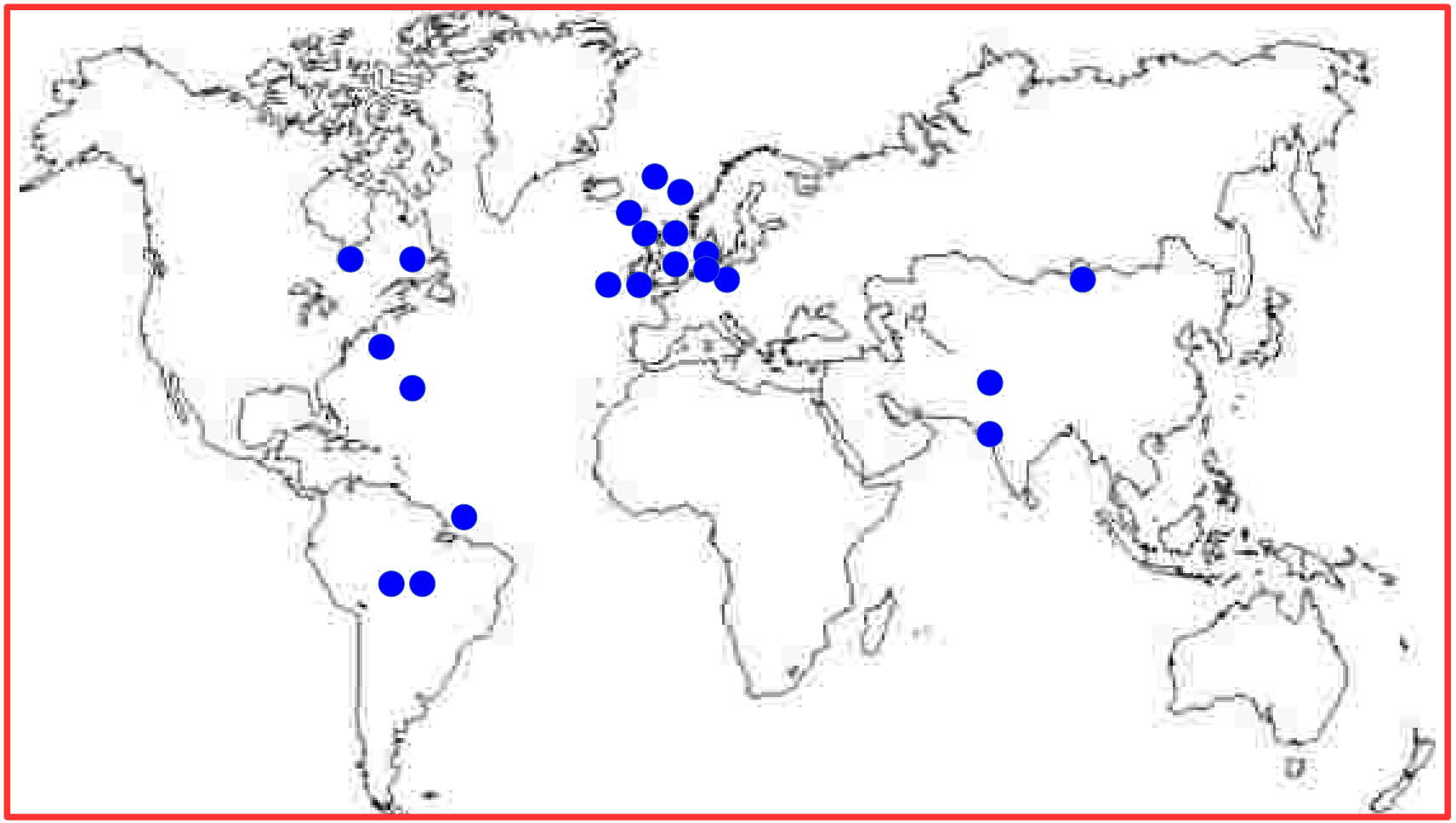




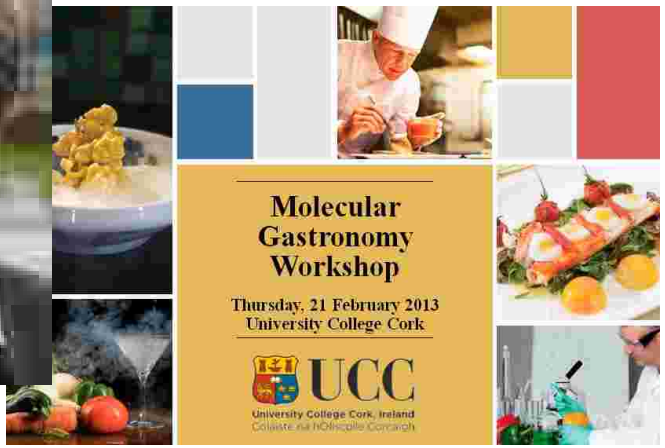
L'eau s'évapore

Etc.
Ad infinitum

It is now in many countries



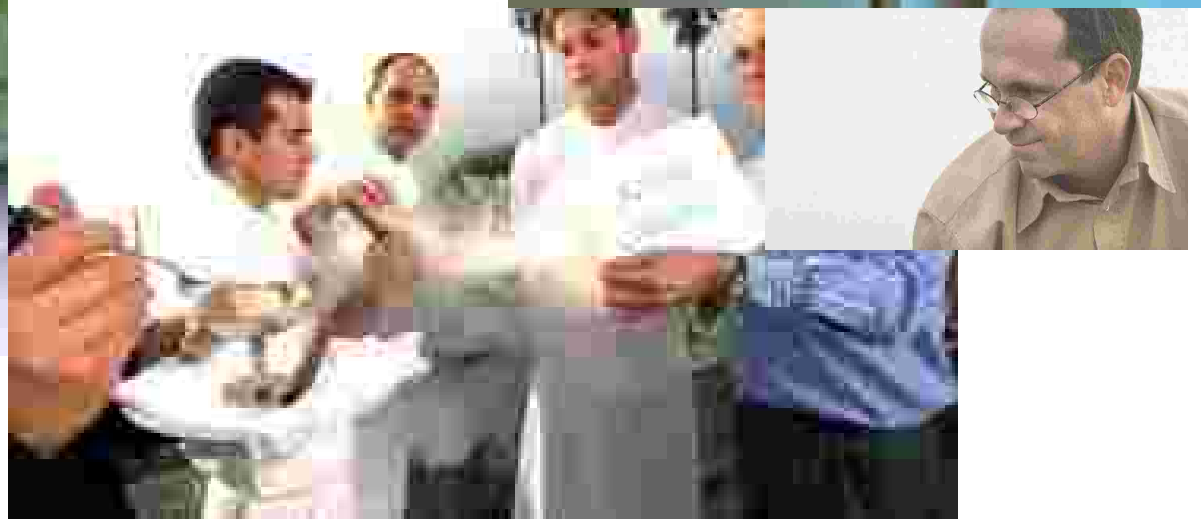
Ireland


Molecular
Gastronomy
Workshop
Thursday, 21 February 2013
University College Cork
UCC
University College Cork, Ireland

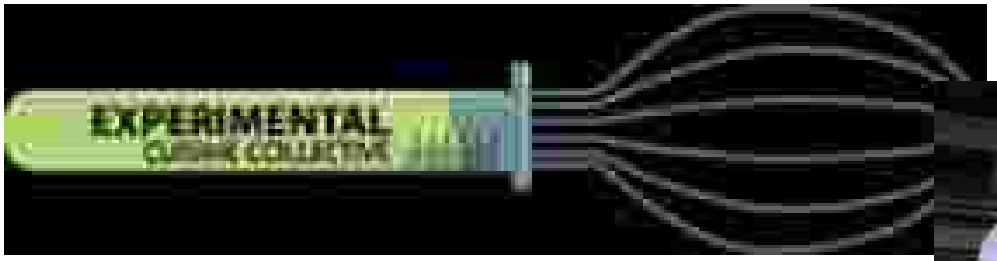
Korea


YOU WANT TO CONTRIBUTE TO THE DEVELOPMENT OF
INNOVATIVE, SUSTAINABLE AND HEALTHY FOOD PRODUCTS

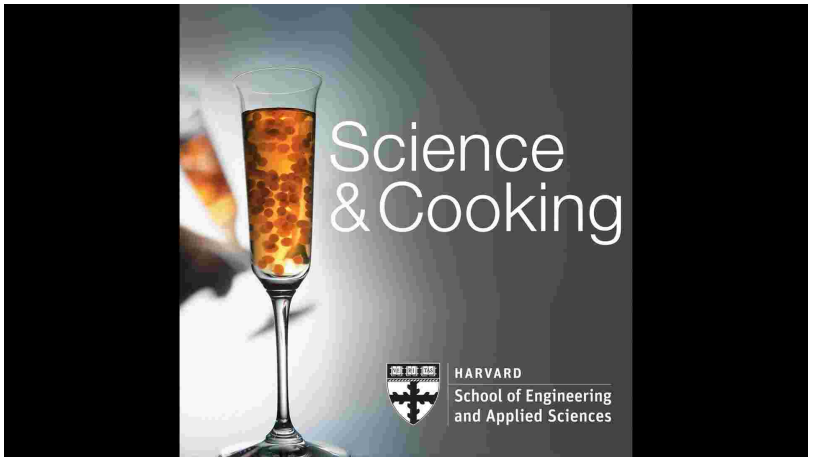
Italy



USA


EXPERIMENTAL


NYU


Science
& Cooking
HARVARD
School of Engineering
and Applied Sciences

Germany

Etc.

It is now in many contexts

Education (1. primary schools)

Comment mettre en oeuvre les ateliers expérim... http://www.agroparistech.fr/podcast/Comment-...

AgroParisTech

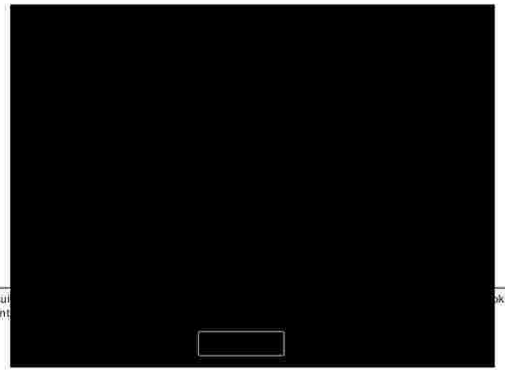
Les podcasts d'AgroParisTech

Accueil (http://www.agroparistech.fr/podcast/) / Gastronomie Moléculaire (-Gastronomie-Moleculaire-.html) / Collèges & Lycées (-Colleges-Lycees-.html) / Comment mettre en oeuvre les ateliers expérimentaux du goût ?

Comment mettre en oeuvre les ateliers expérimentaux du goût ?

Publié le 12 octobre 2011 (2011-10-12T20:36:01Z) / AgroParisTech (+-AgroParisTech-+.html) - Sciences (+-Sciences-+.html) - Vie de l'école (+-Vie-de-l-ecole-+.html) /

Dans le cadre de la fête de la science



1 sur 4 06/04/2016 10:04

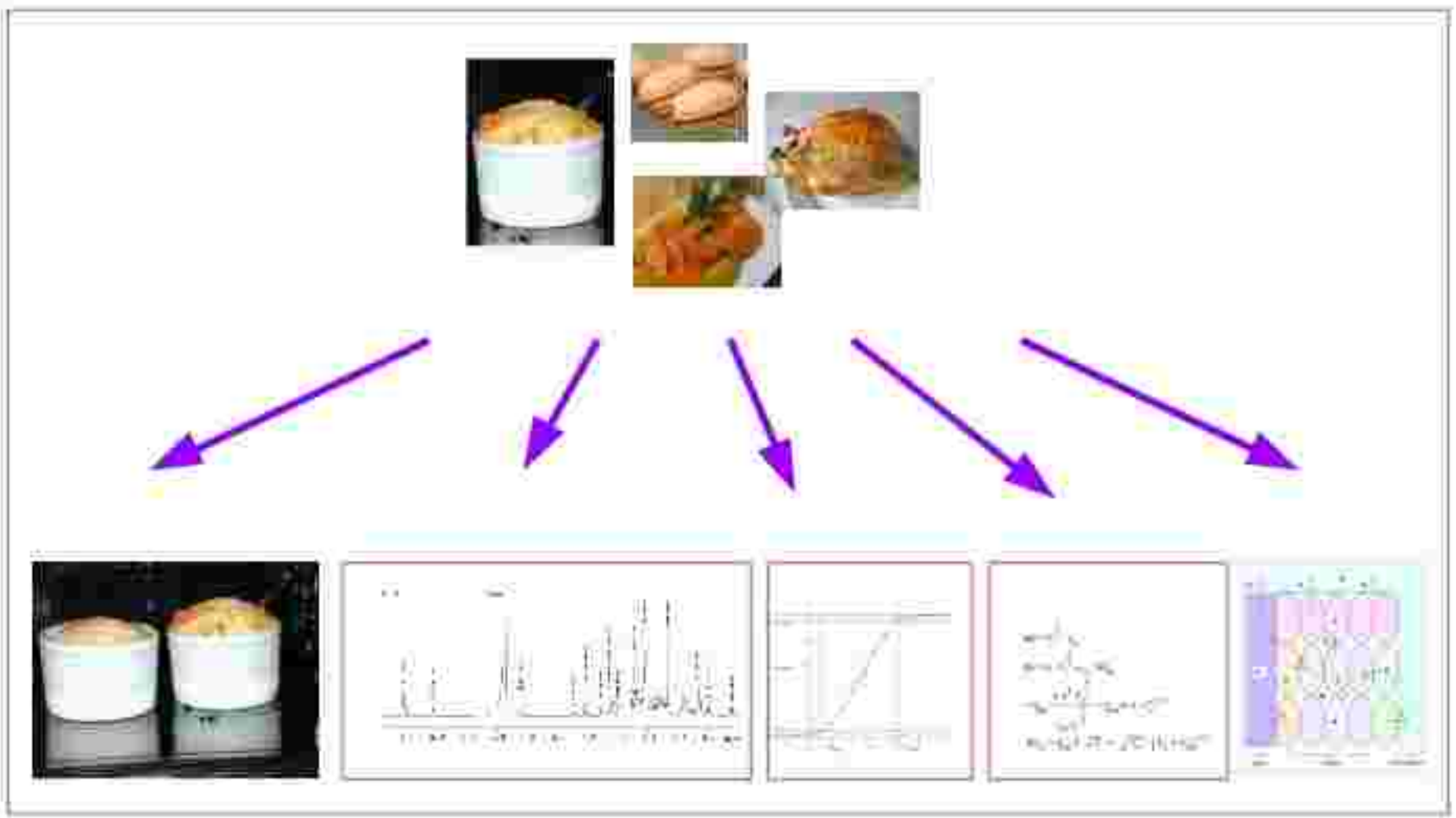
Education (2. high schools)

Education (3. University)

Education (4. continuous education)

Etc.

Molecular Gastronomy as a research



In our Group

Le Centre Claude Bernard d'AgroParisTech, à Paris (5e)

Too many interesting questions ! Which one should we choose ?

-Photosynthetic pigments as being transformed during the thermal treatment of plant tissues

- Release of proteins during animal tissue thermal heating in aqueous solutions

- Green chemistry : thermal treatment at 100°C in aqueous solution of organic compounds from « food »

- Modification of the color of saffron processed in aqueous solution, with or without light

- Distribution of estragole in the various compartments (water, oil, gas, animal tissues) during a culinary recipe

- Extraction nutriments from plant tissues

- Why apricots appear sourer after thermal treatment (31P NMR spectroscopy)

- Differences between wines thermally processed at low or high heating power

- « Freshness » of yogurts : an influence of the microstructure ?

- Exchange between plant tissue and aqueous solution during thermal treatment

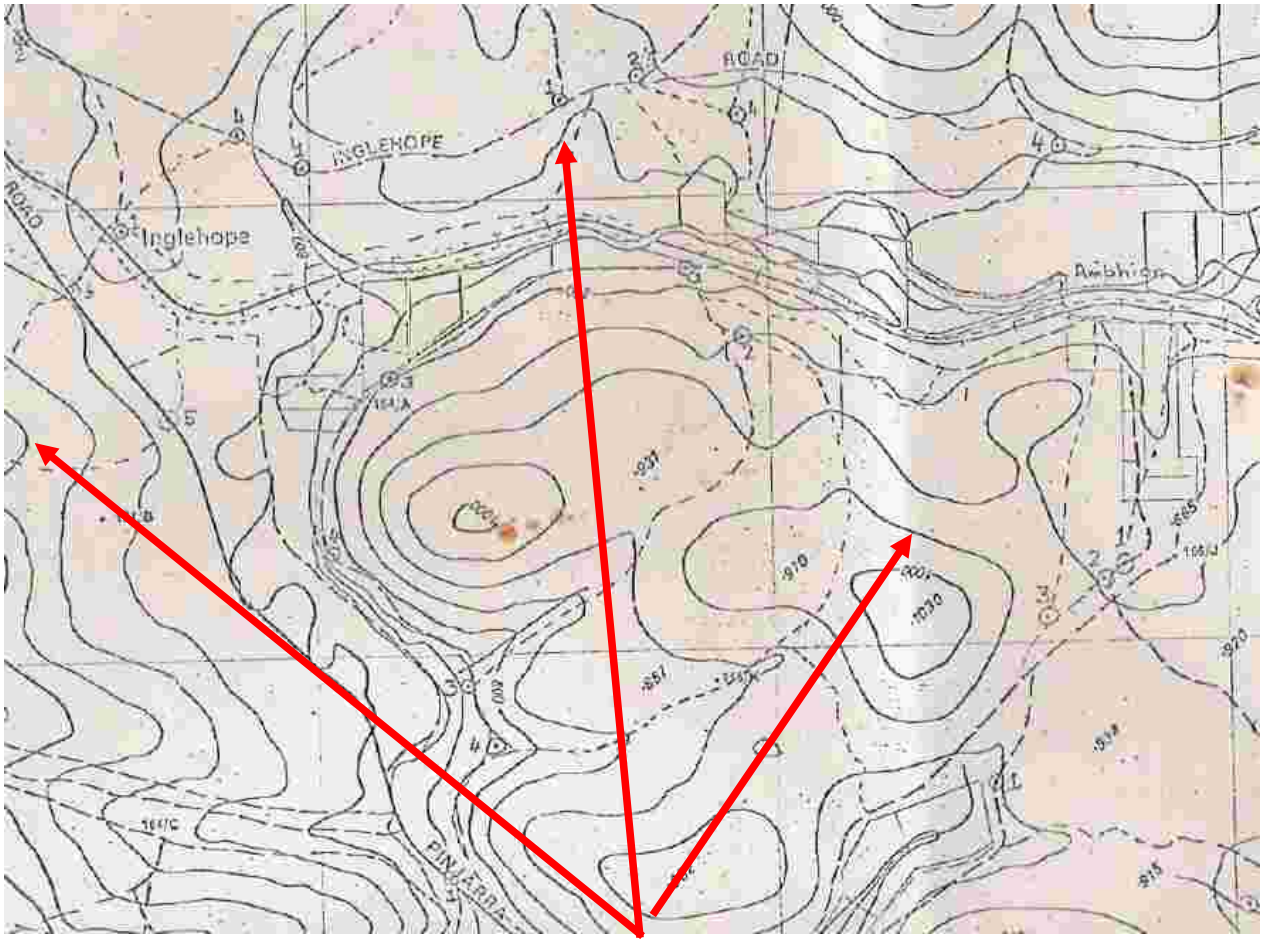
...

The issue of scientific strategy (Where is there a montain?)

Behind us

In front of us

Which direction should we use ?



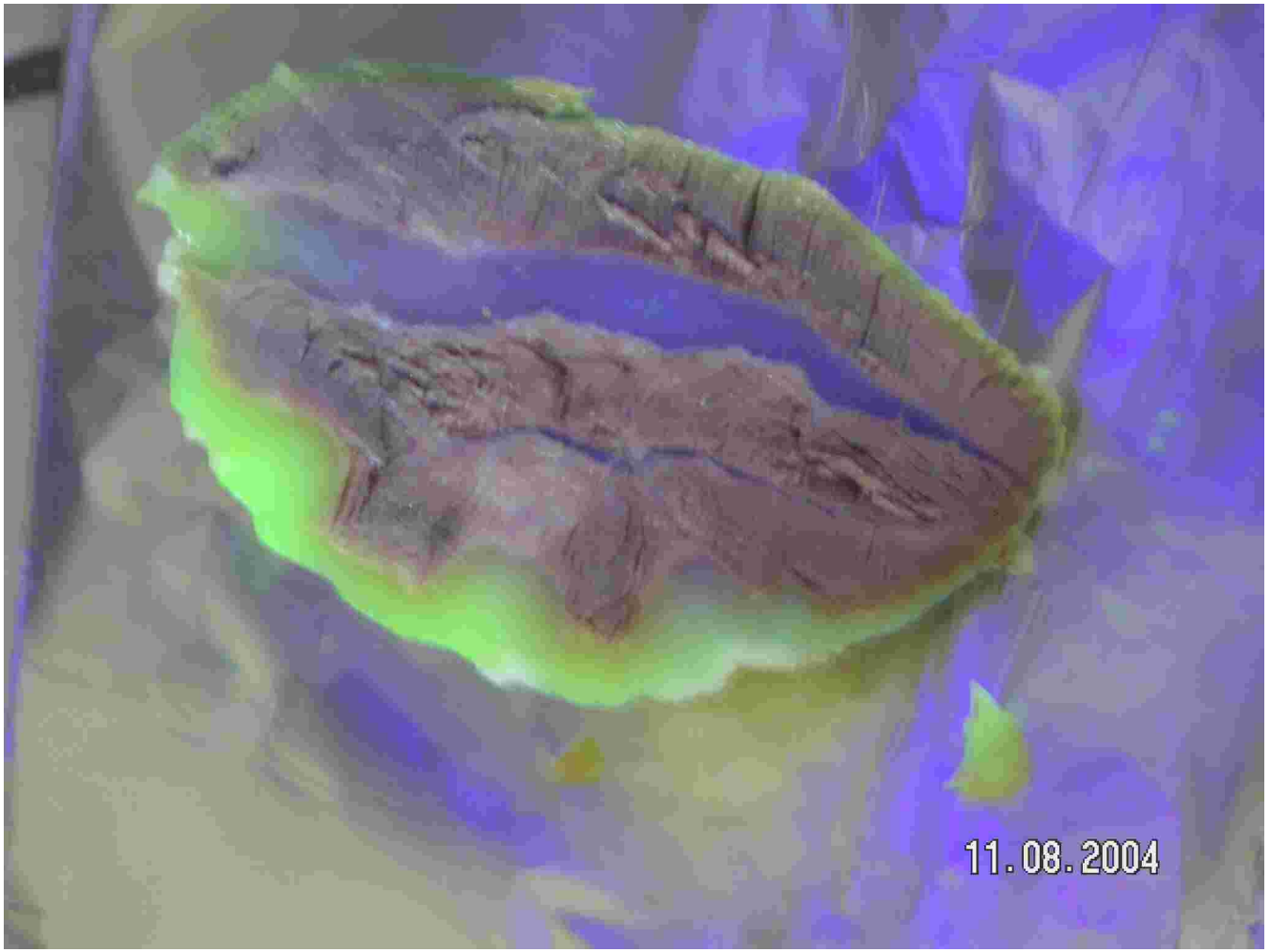
Methods, instead of directions ?

Where is there a montain ?

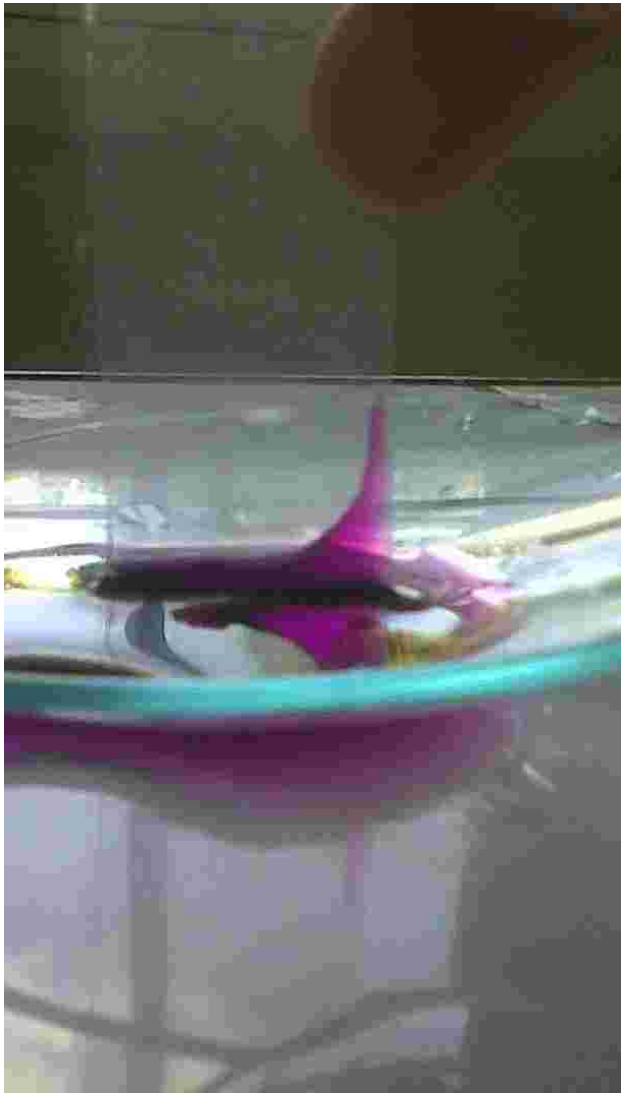
1.
Looking for mechanisms
(with deception when nothing is new)

What's going on during marinating ?

Almost nothing ?



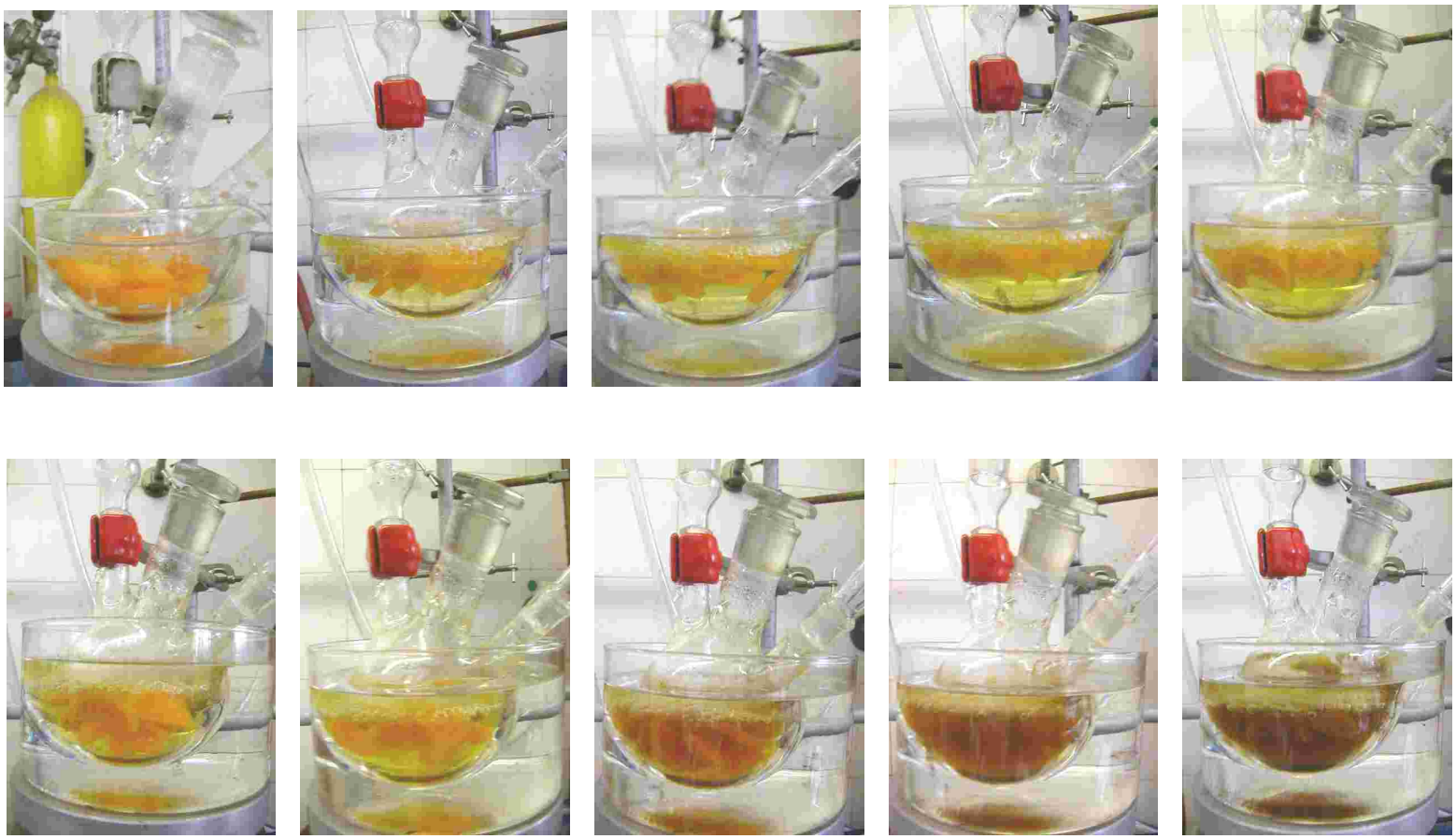
But sometimes...



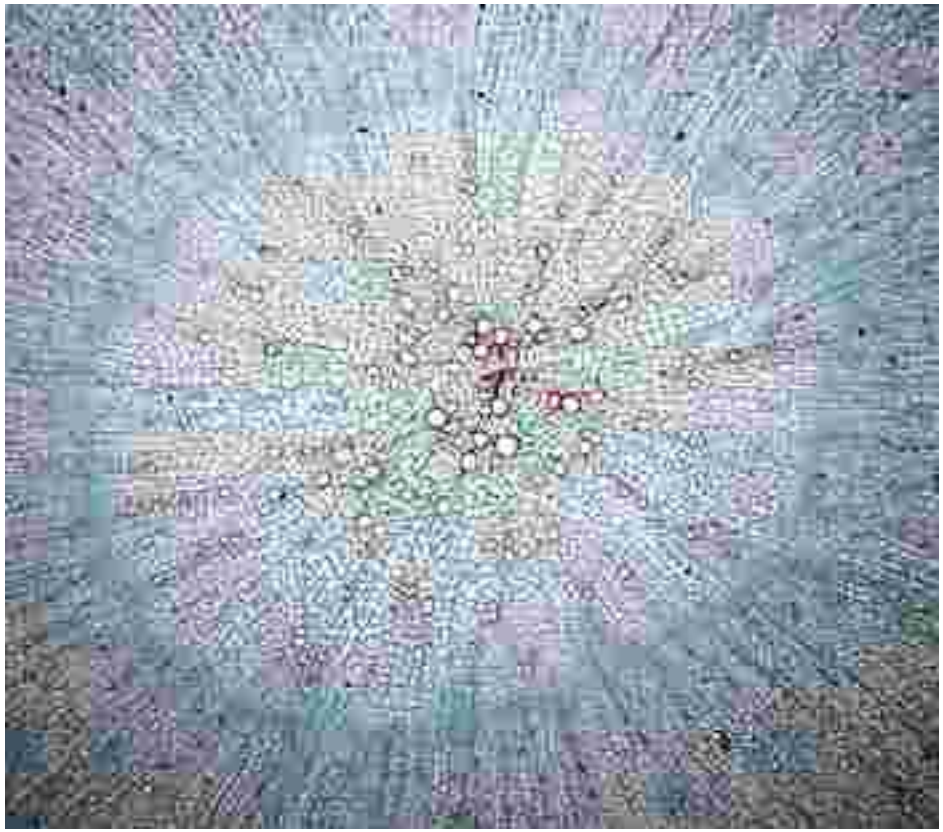
Where is there a montain ?

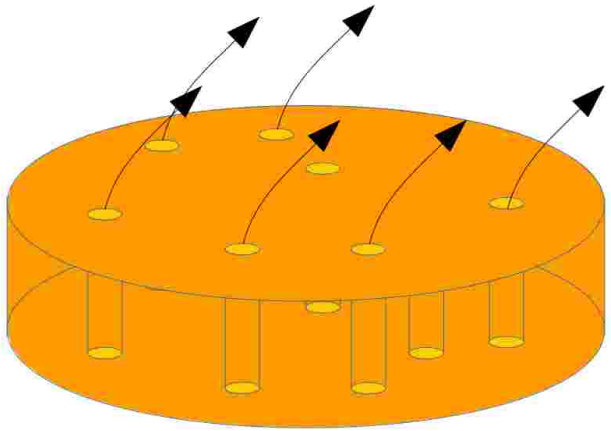
2.
Refuting a theory

What goes out from a plant tissue and how ?

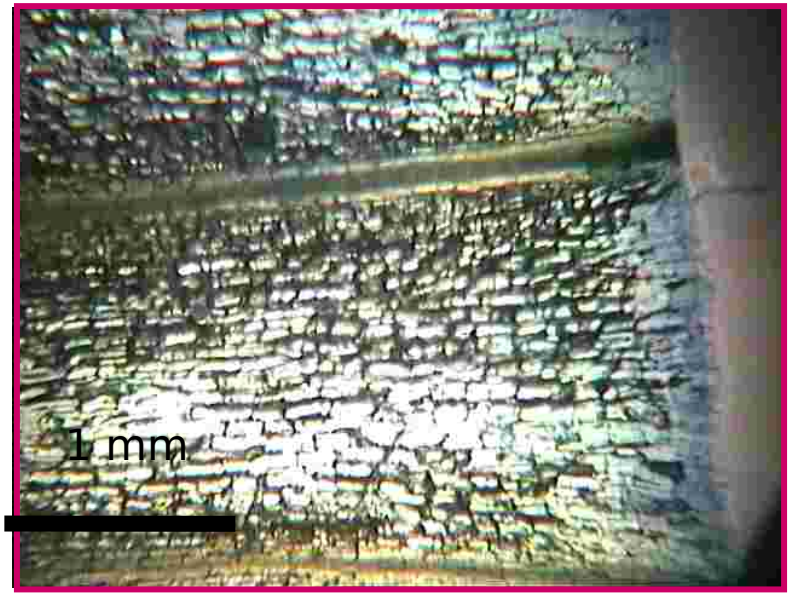


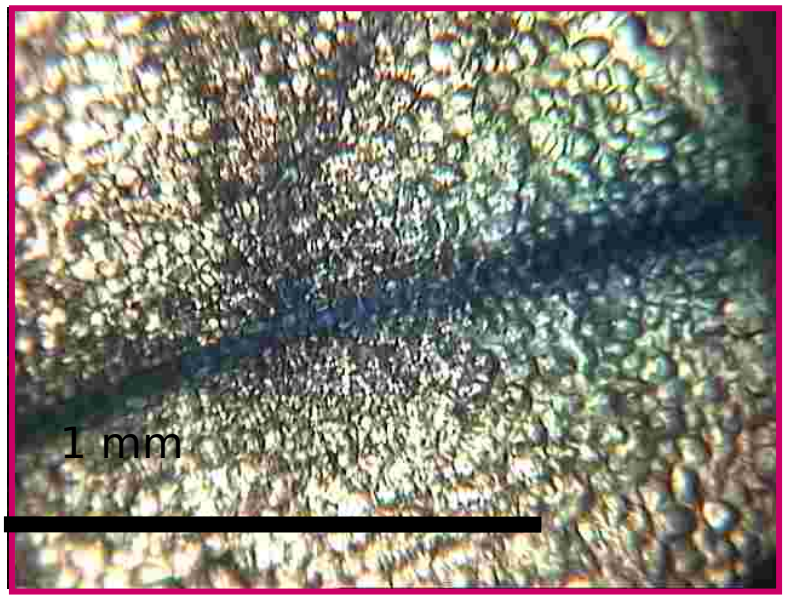
The old theory



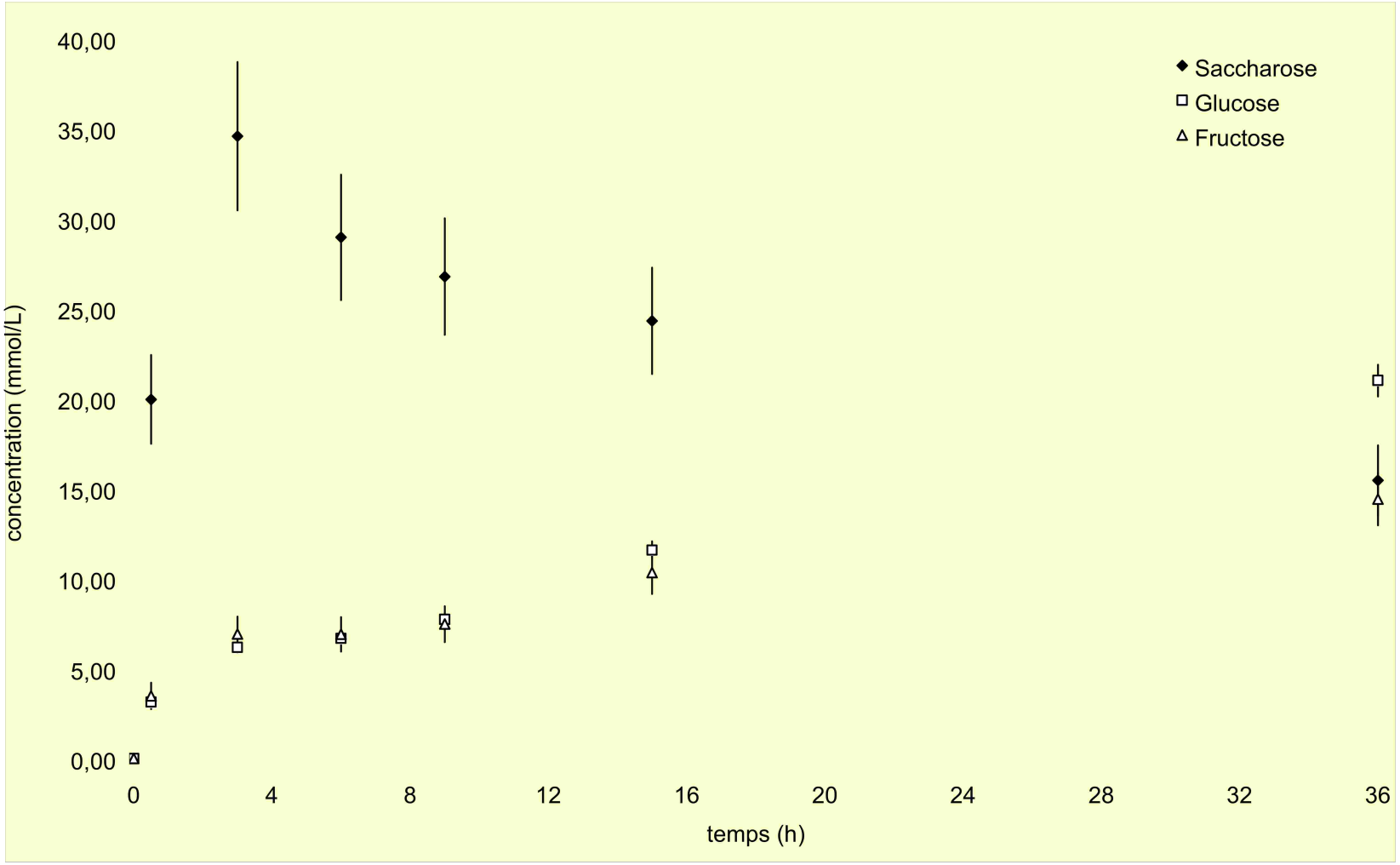


Diffusion ?

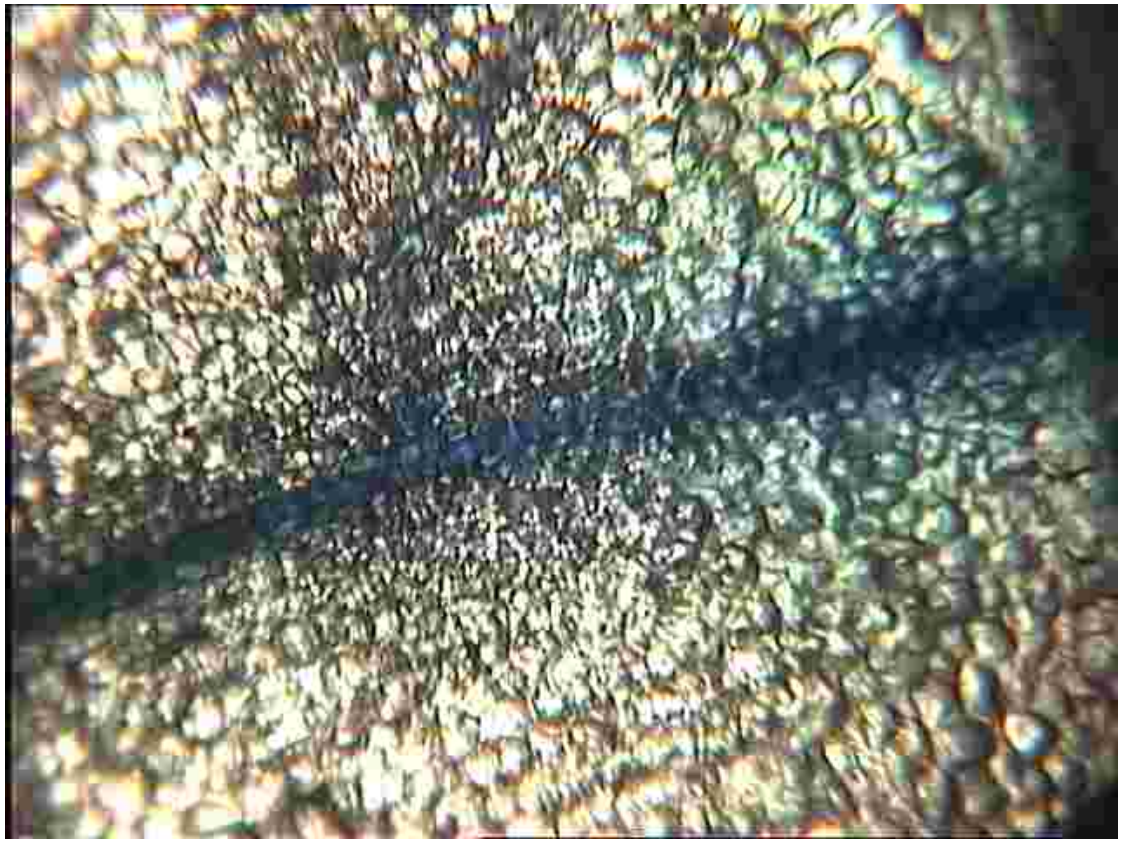




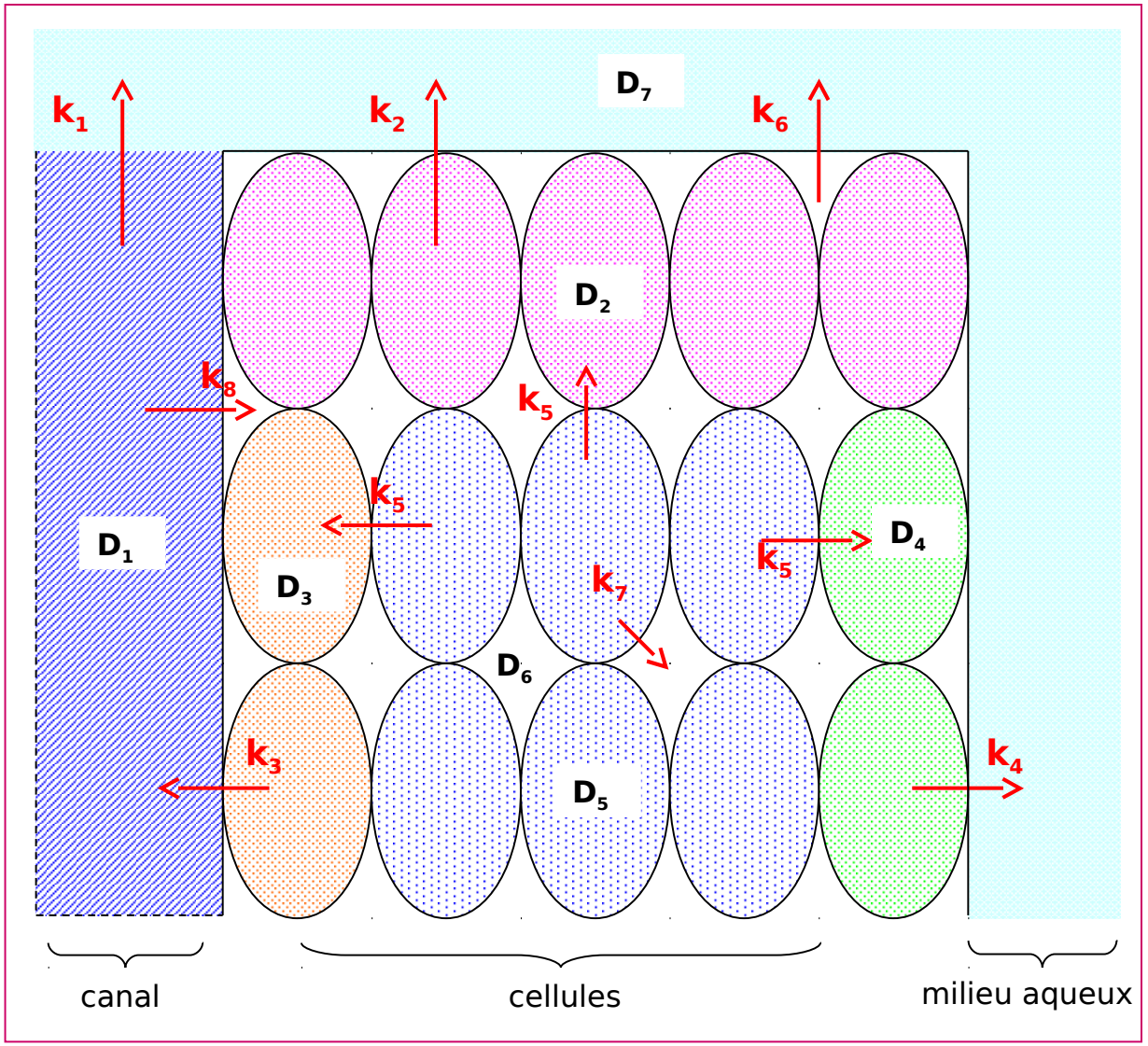
But there are molecular modifications



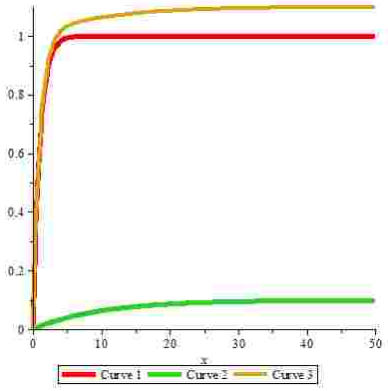
But the model is clearly wrong



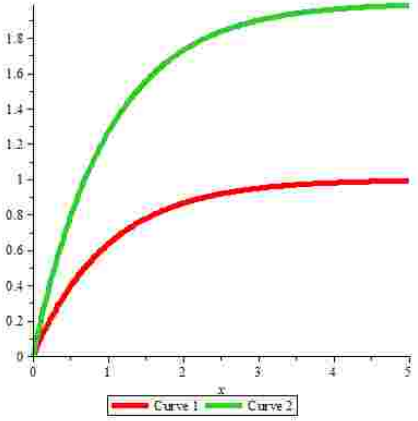
A model to improve (quantitatively)



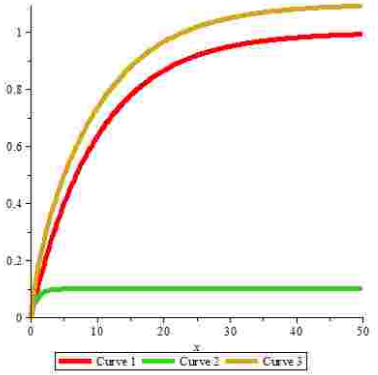
More metabolites in cells,
fast release from cells



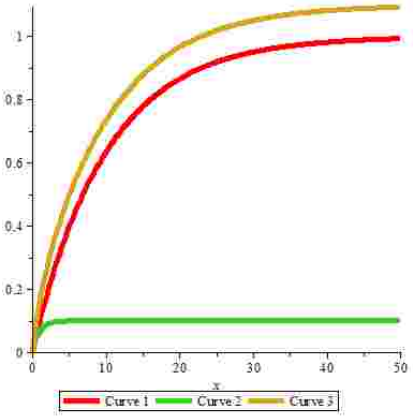
Same quantity, same speed



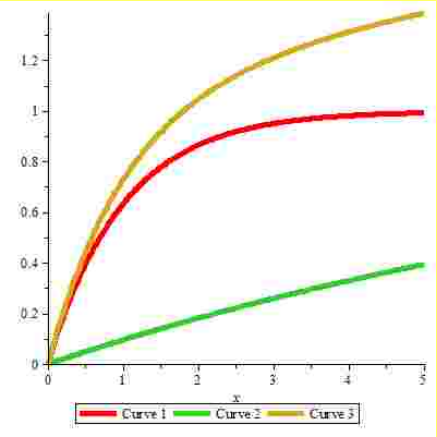
More metabolites in channels,
Slow release from channels



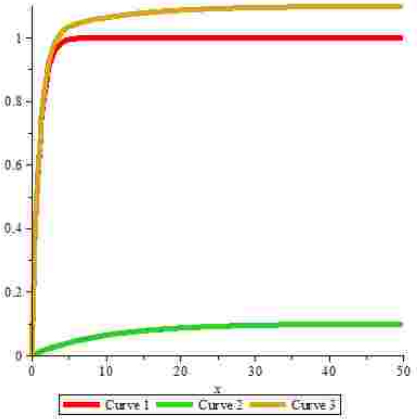
Moere metabolites in cells,
slow release from cells



Same quantity, different speed



More metabolites in channels,
fast release from channels



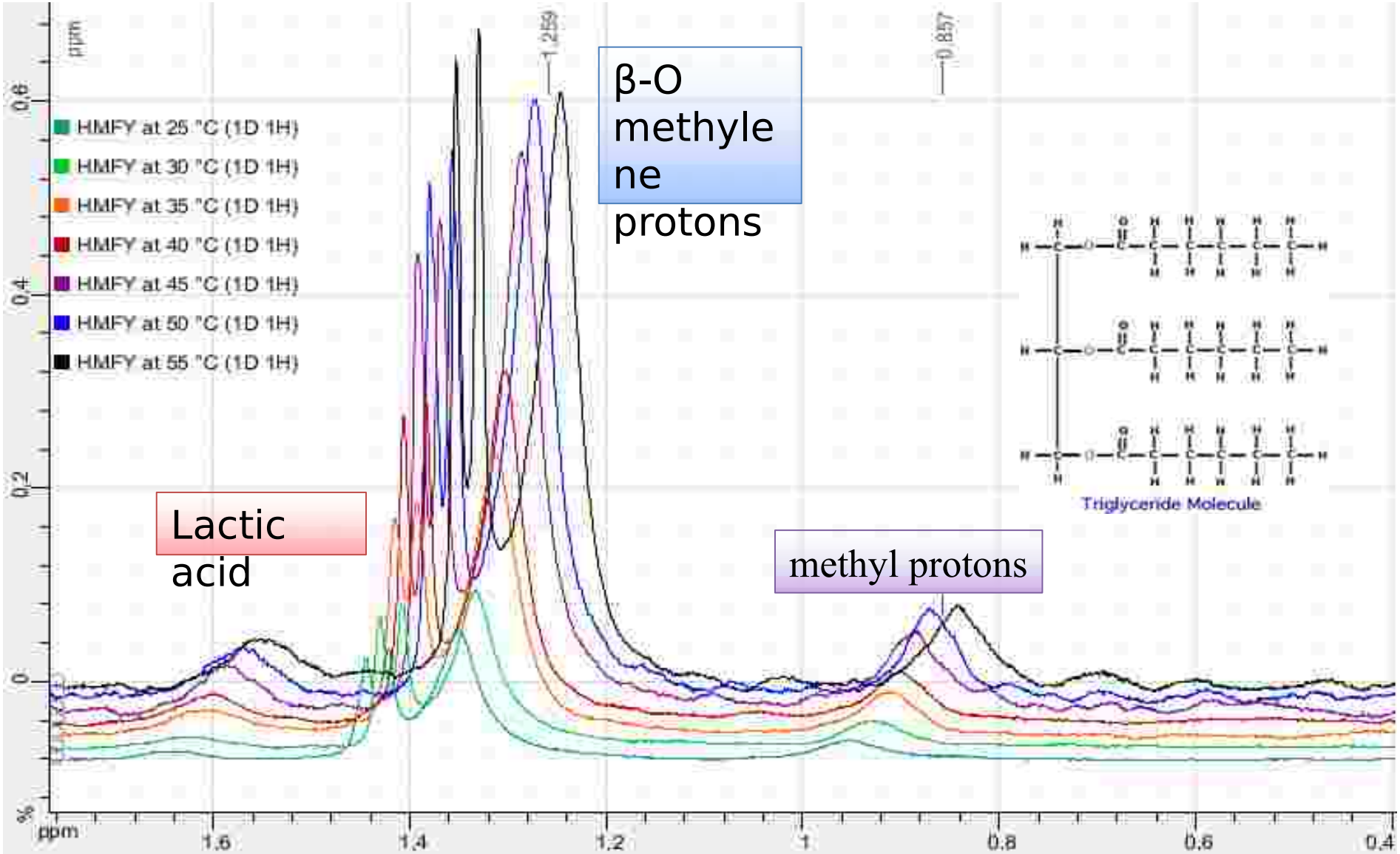
… but validation is needed !

Where is there a montain ?

3.
Solving a problem

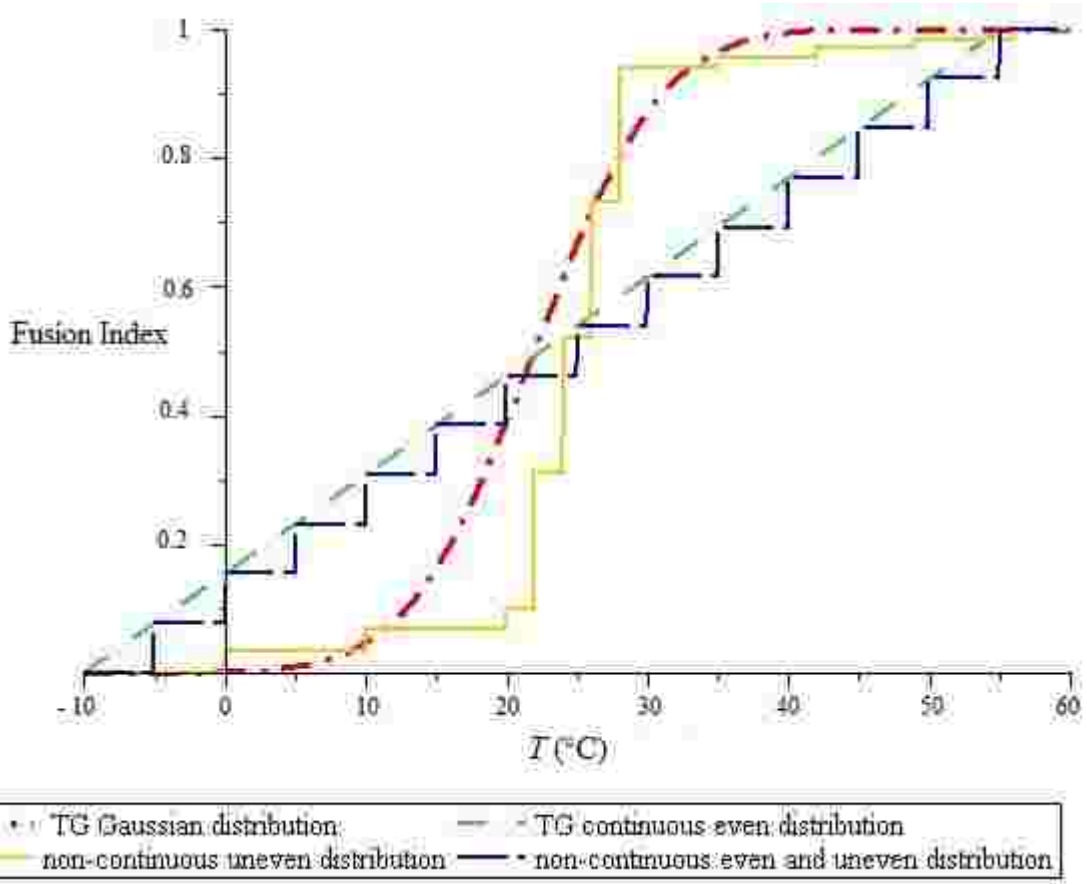
Does fat crystallize differently in emulsions ?

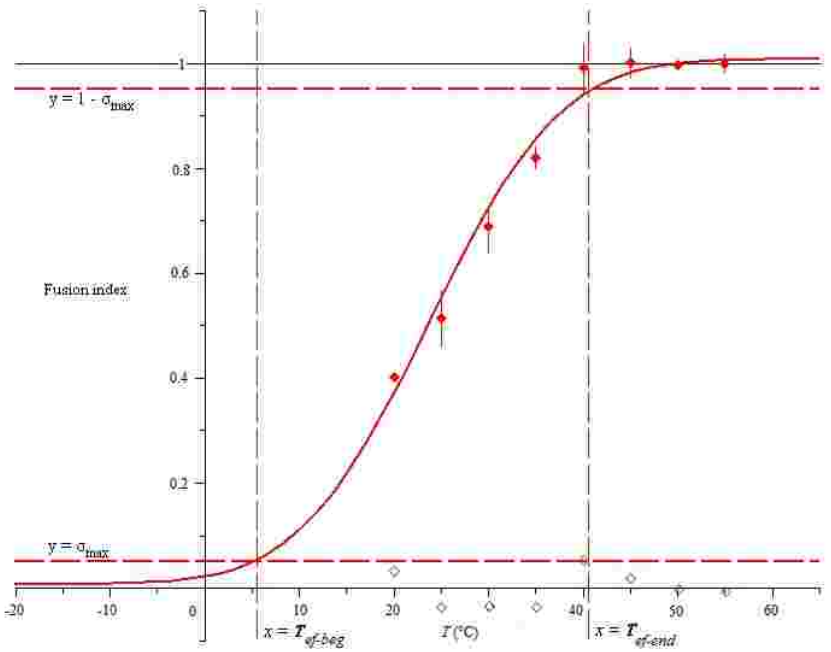
Example of HMFY



Romain Bouteille, H. This

Not, from our experiment





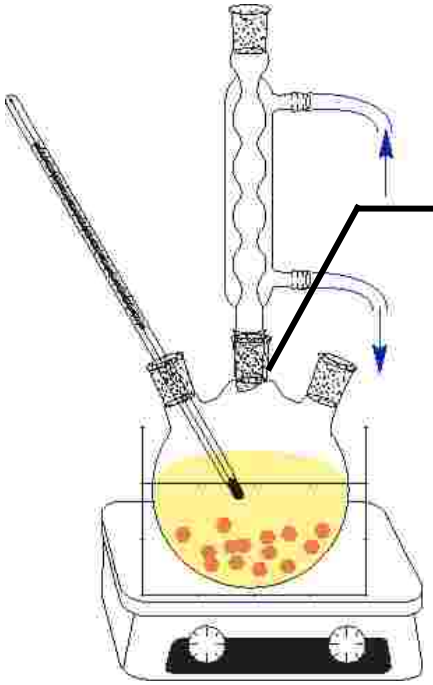
Where is there a montain ?

4.
A new "microscope"

From q NMR to *is* q NMR


BRUKER
300
UltraShield™

Preparing samples: 5 days!



Sampling at different times

1.0 mL → Lyophilization → Lyophilization

↓

1.00 mL of brew in D2O

↓

500.0 µL of sample

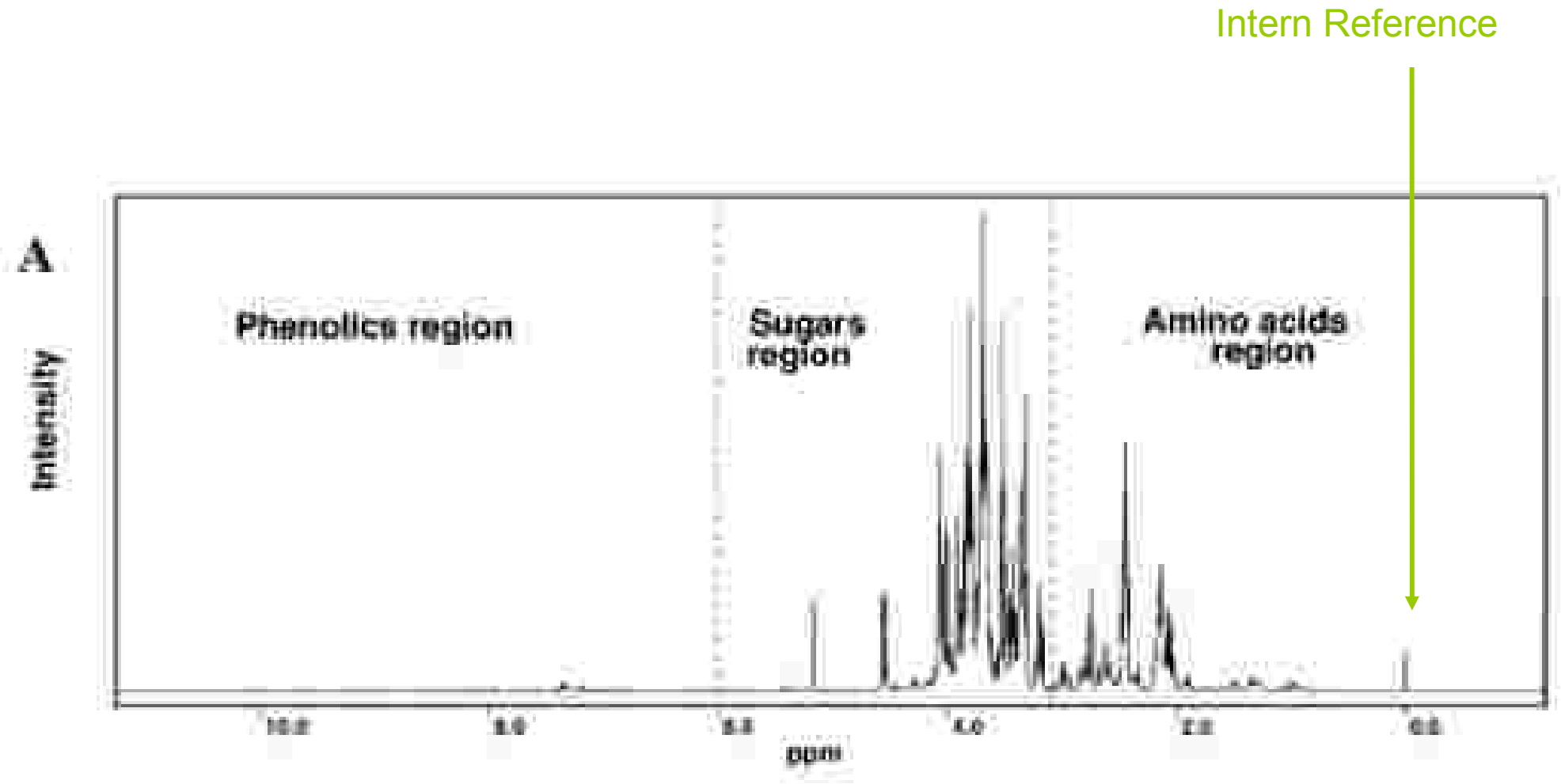
↓

RMN

↓

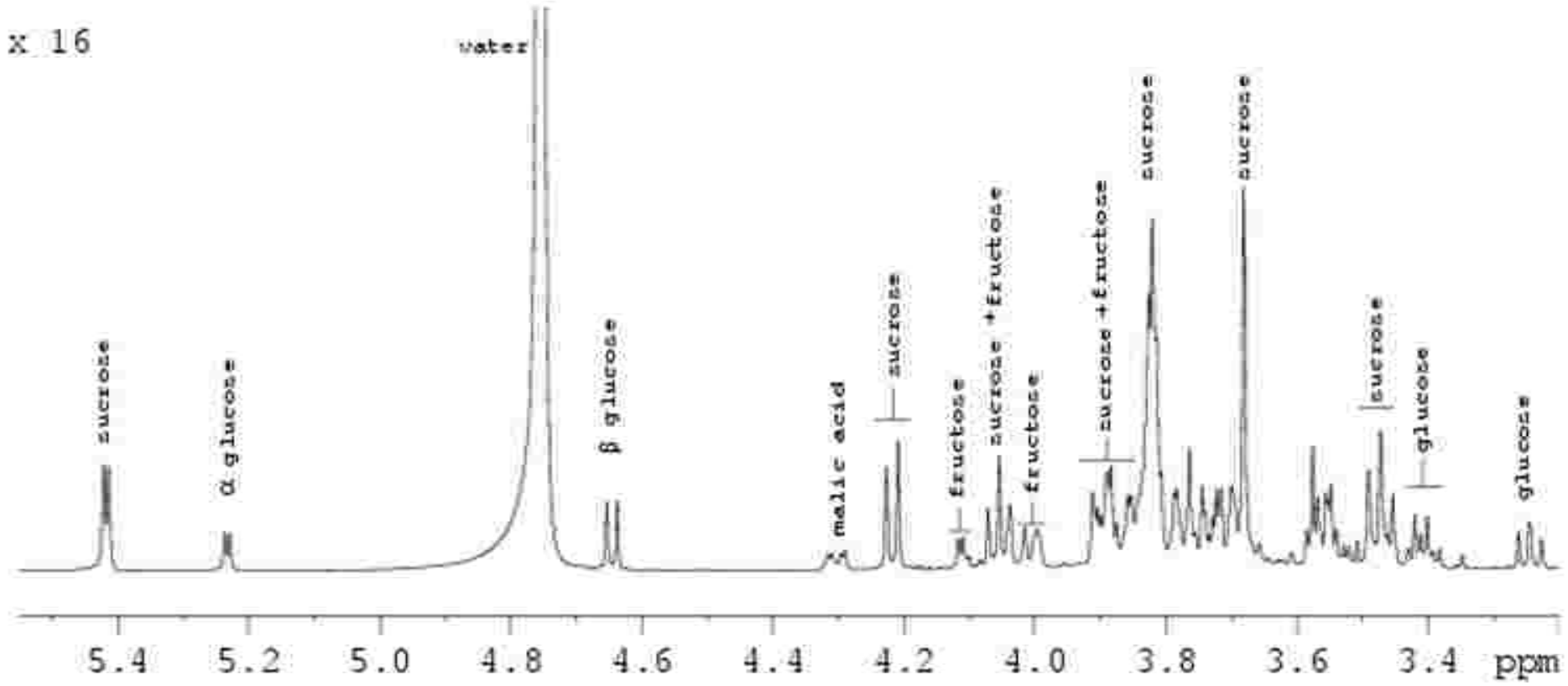
Sugars, amino acids et organics acids quantification

Here is a carrot stock



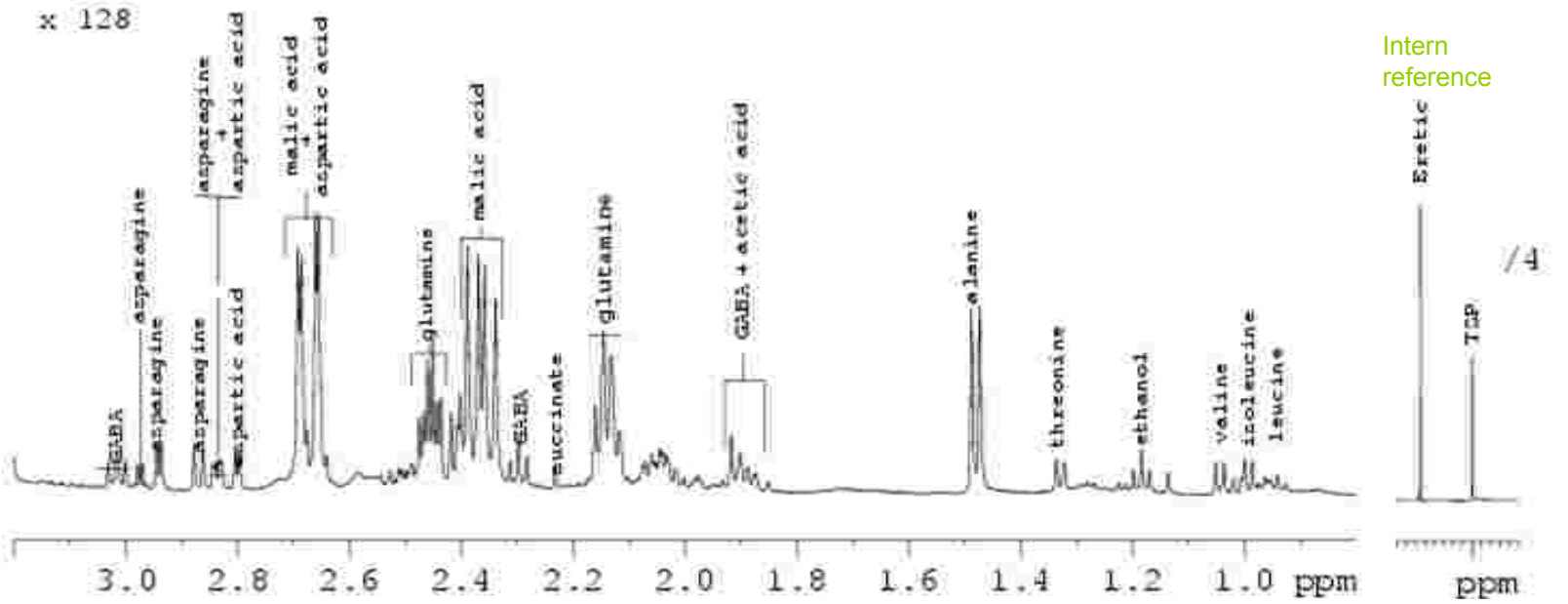
Anne Cazor, H This

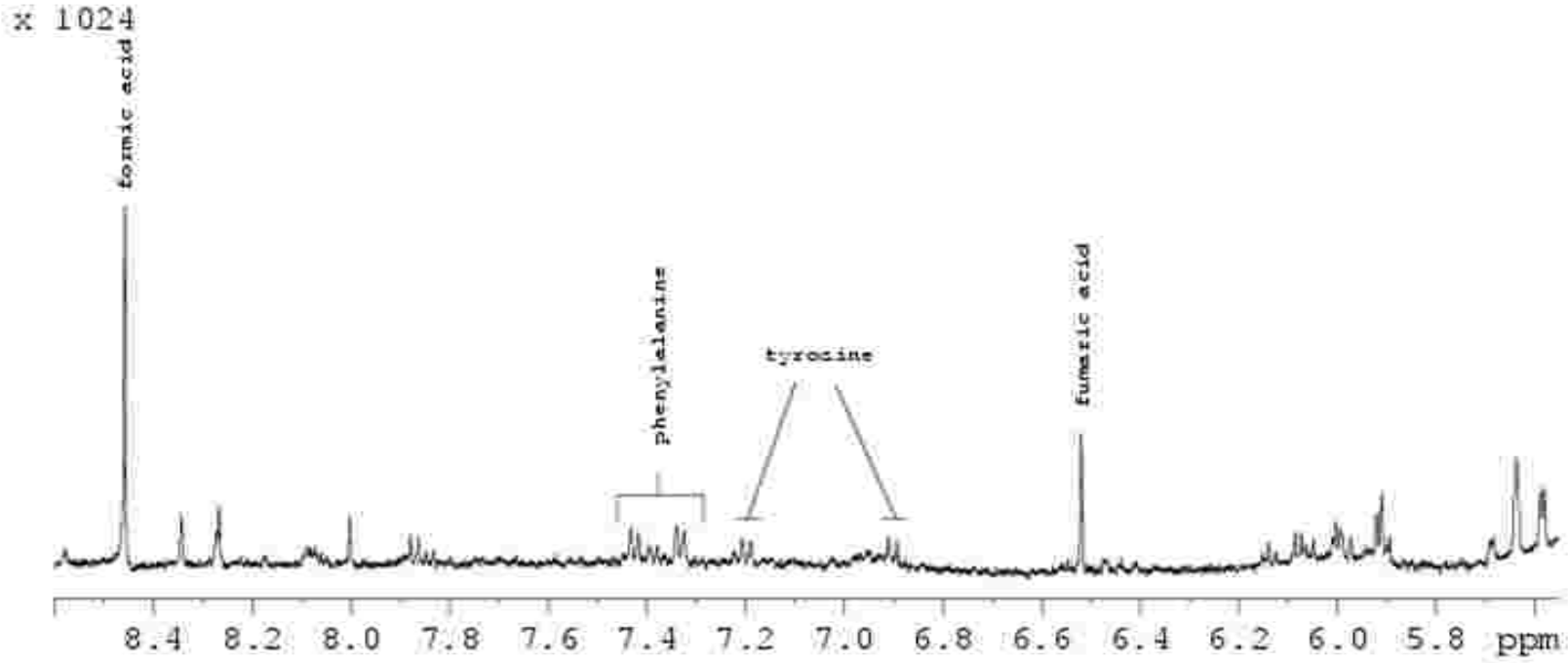
Mainly saccharides



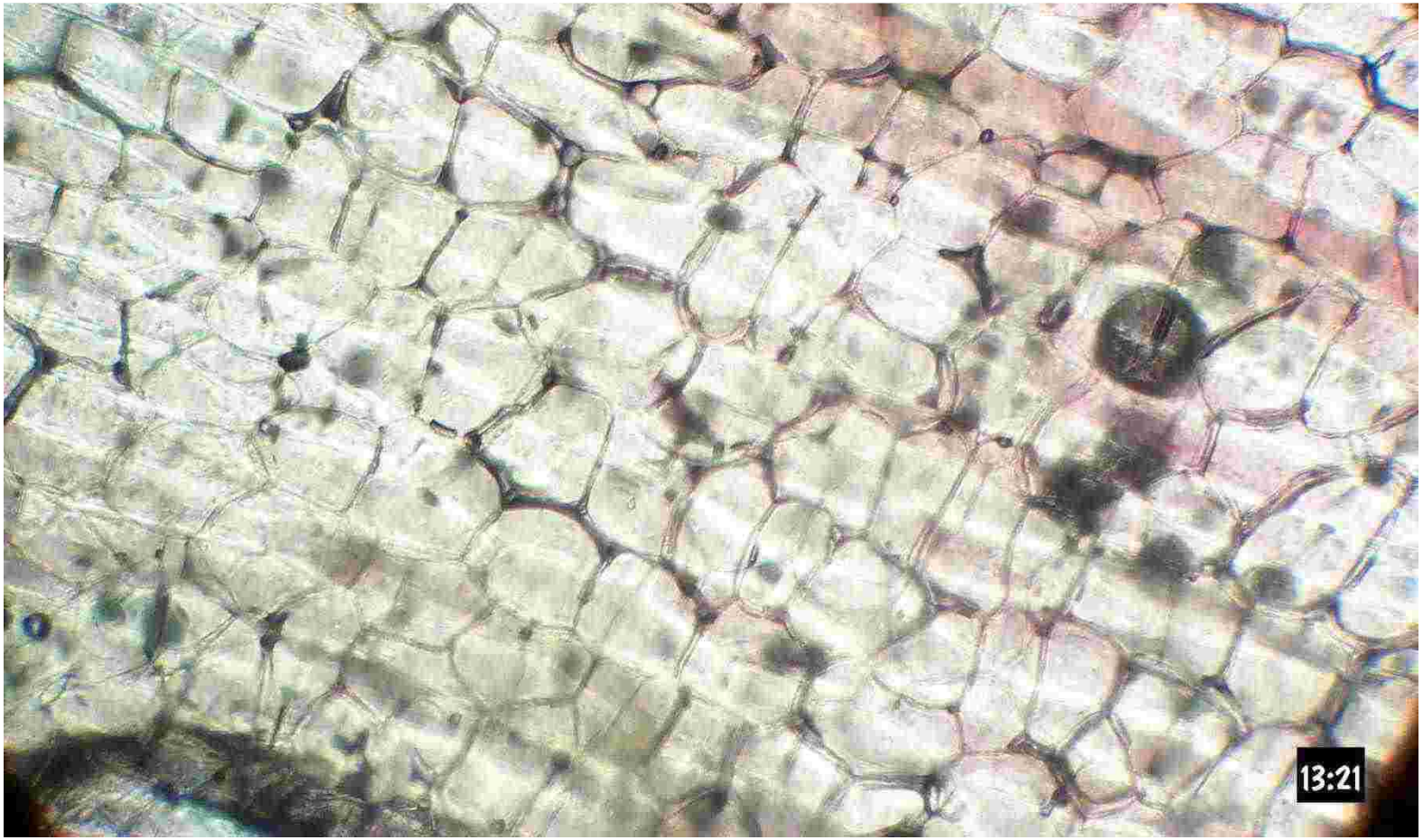
Anne Cazor, H This

And amino acids, organic acids





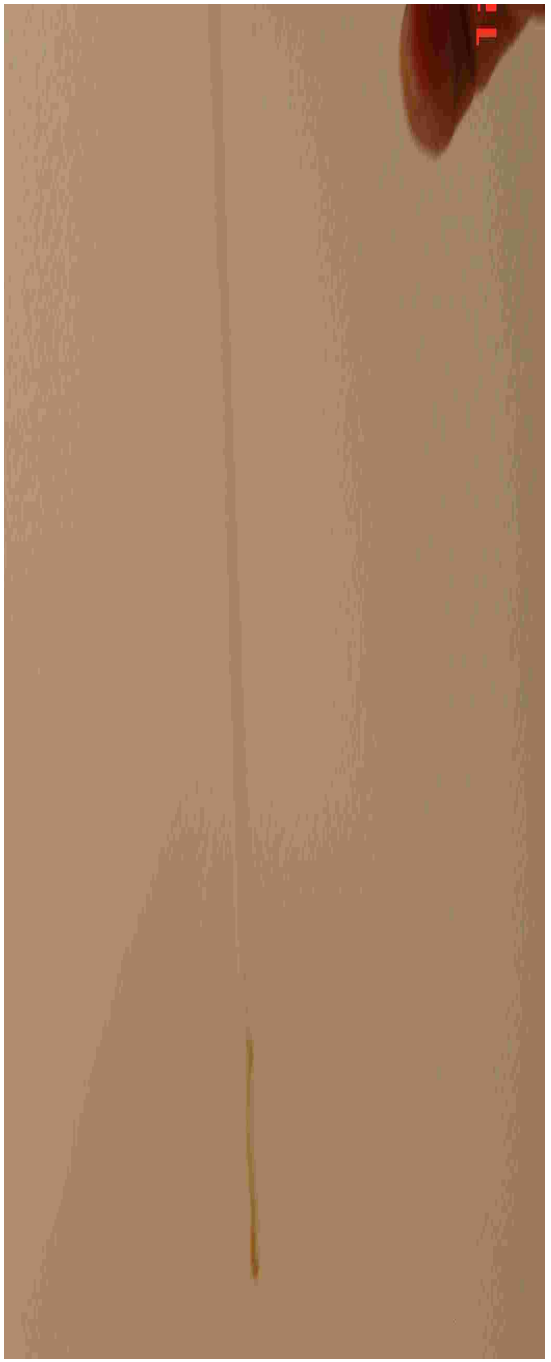
But plant tissues are gels $D_0(W)/D_3(S)$...



Hence quantitative in situ quantitative NMR

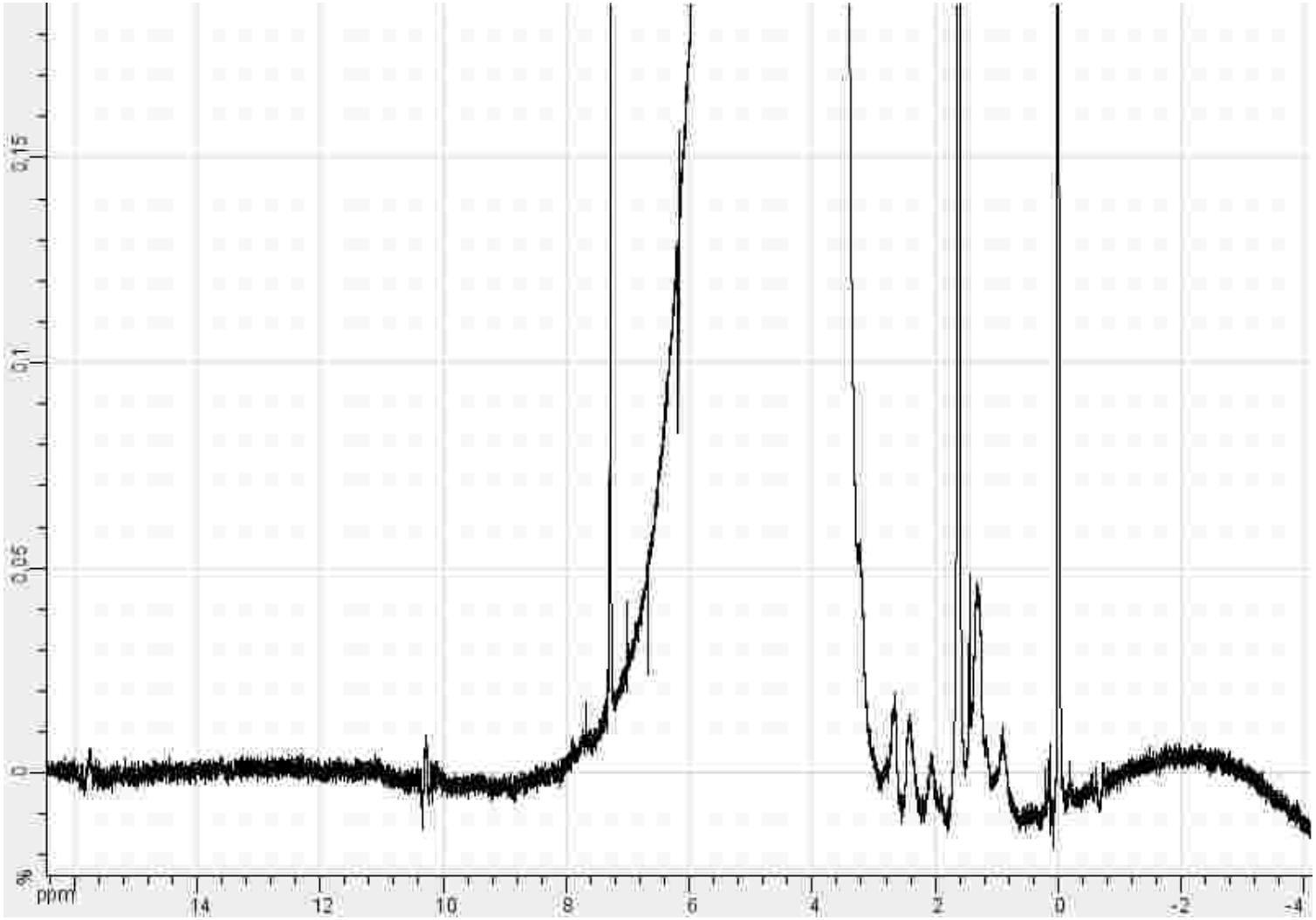
Comparison of two methods for the determination of saccharides in carrot (*Daucus carota* L.) roots: extraction using the standard "modified O'Donoghue" method followed by quantitative proton NMR (q ^{1}H NMR) spectroscopy, and direct, whole tissue q ^{1}H NMR spectroscopy.

LINDA WEBERSKIRCH, ALAN LUNA, SARA SKOGLUND, HERVÉ THIS[1,2]



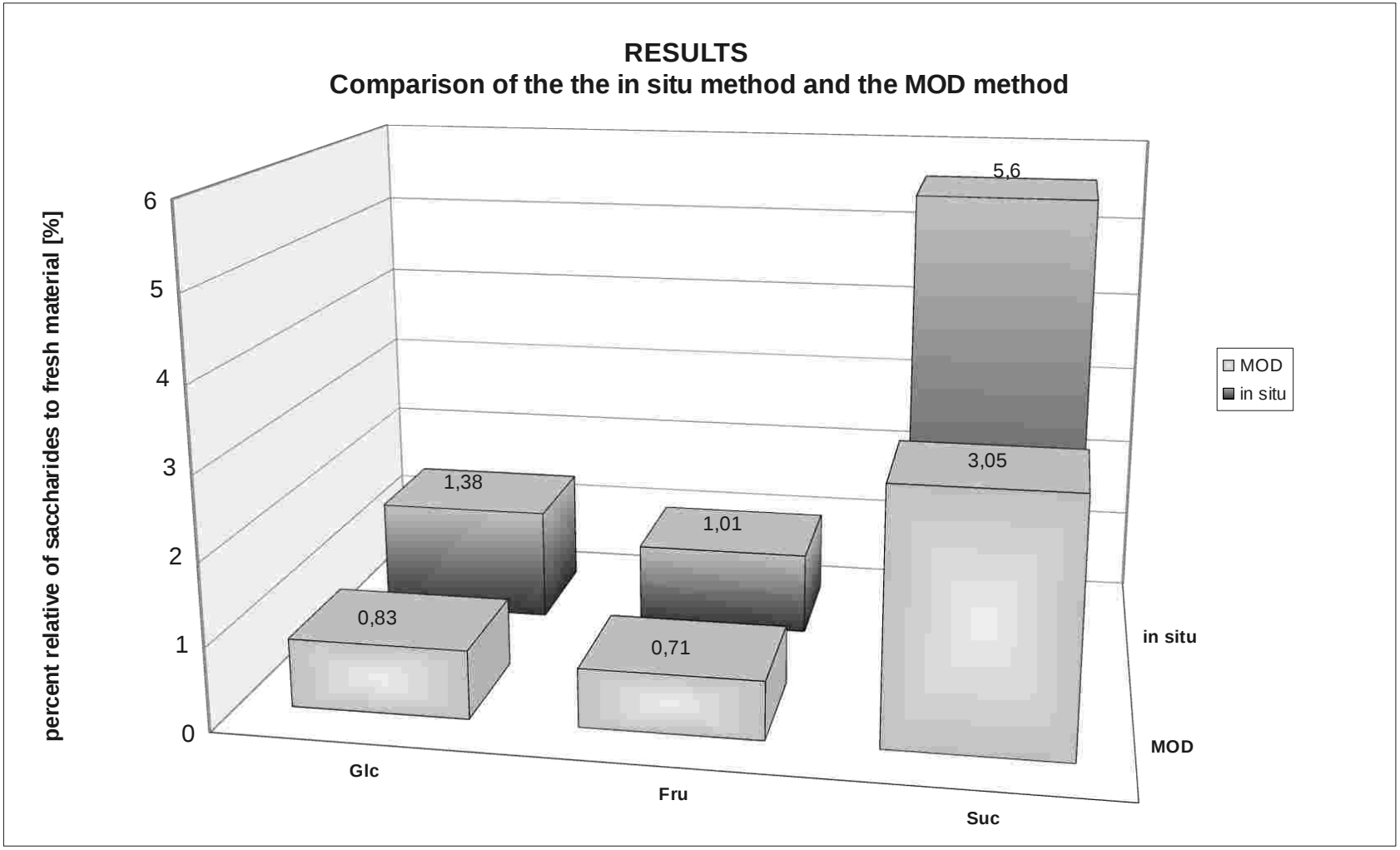
Fast (10 min), no solvant, no preparation, small samples, precision ‰, etc.

Why does drying improve spectra?



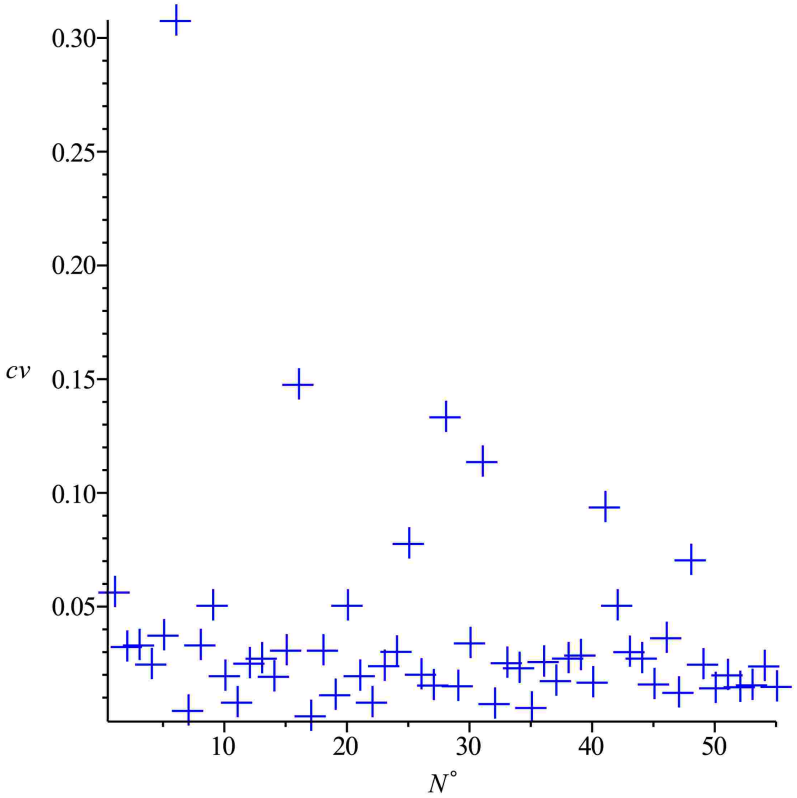
Linda Weberskirch, H. This

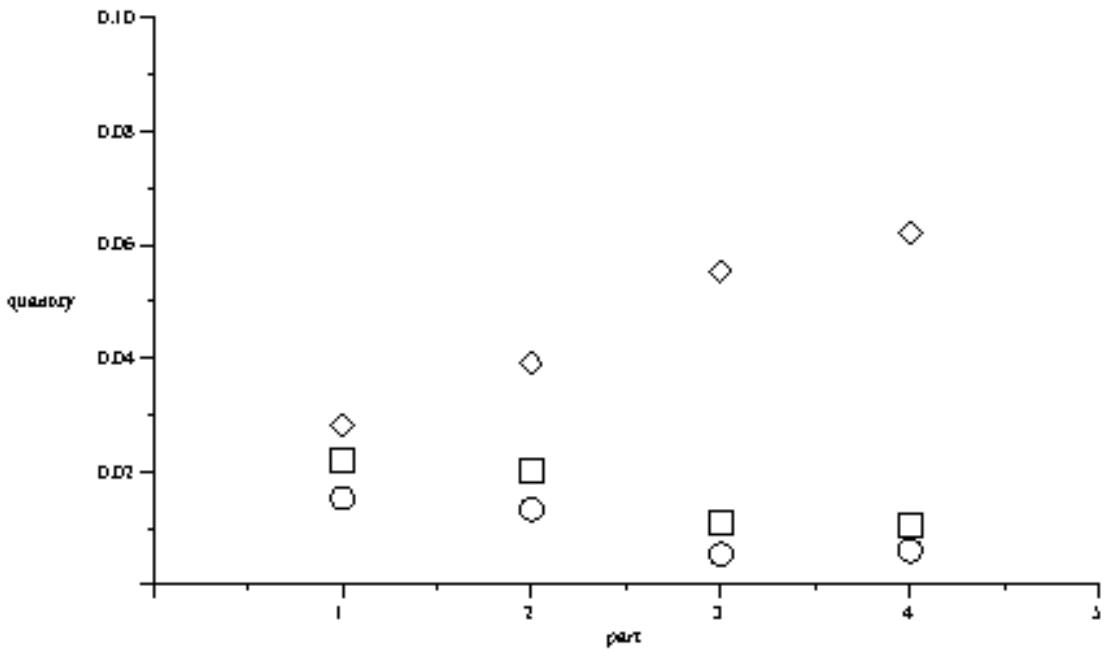
Extraction : beware !



Linda Weberskirch, H. This

Wonderful performances… and new applications





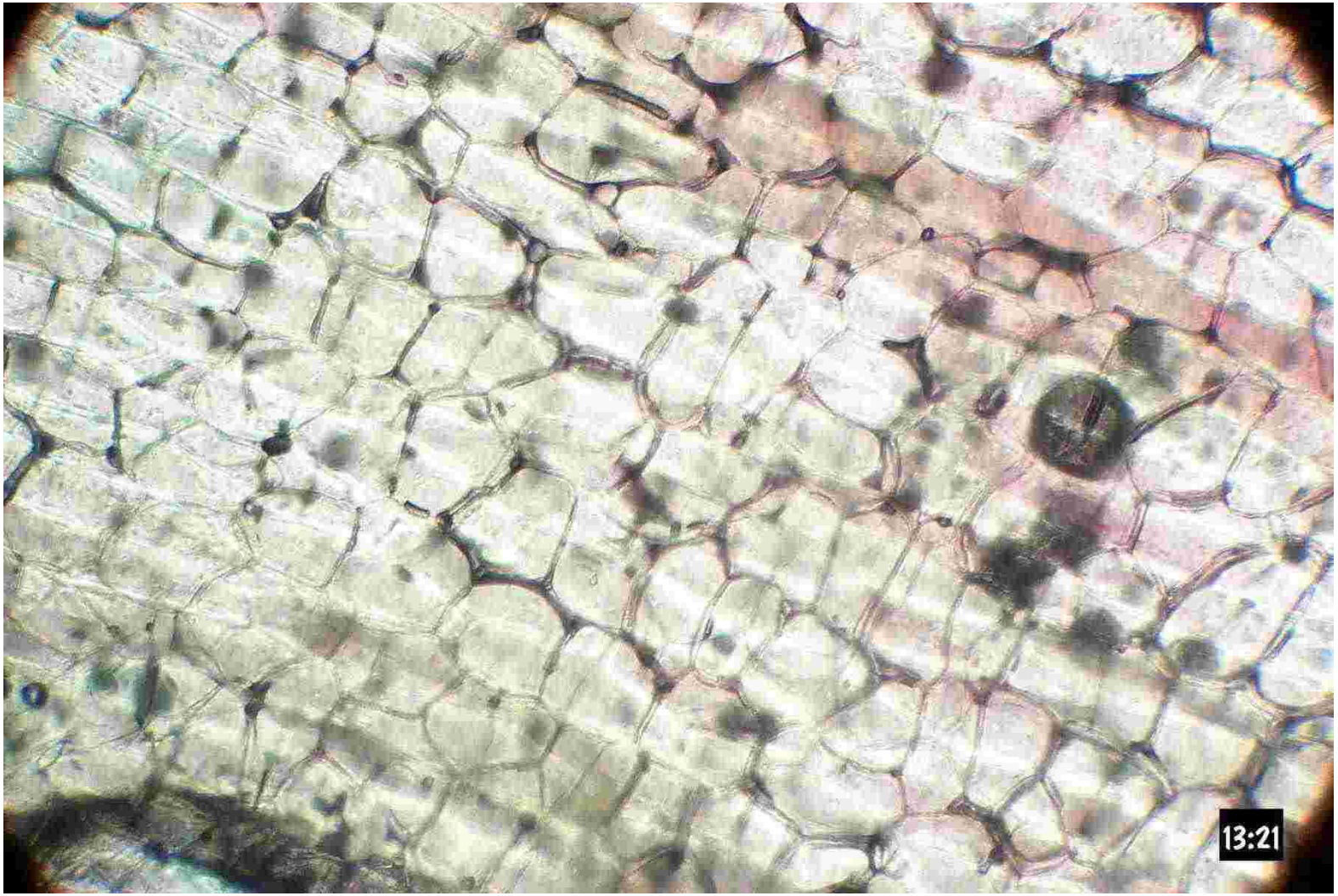
Elsa Bauchard, H. This

Where is there a montain ?

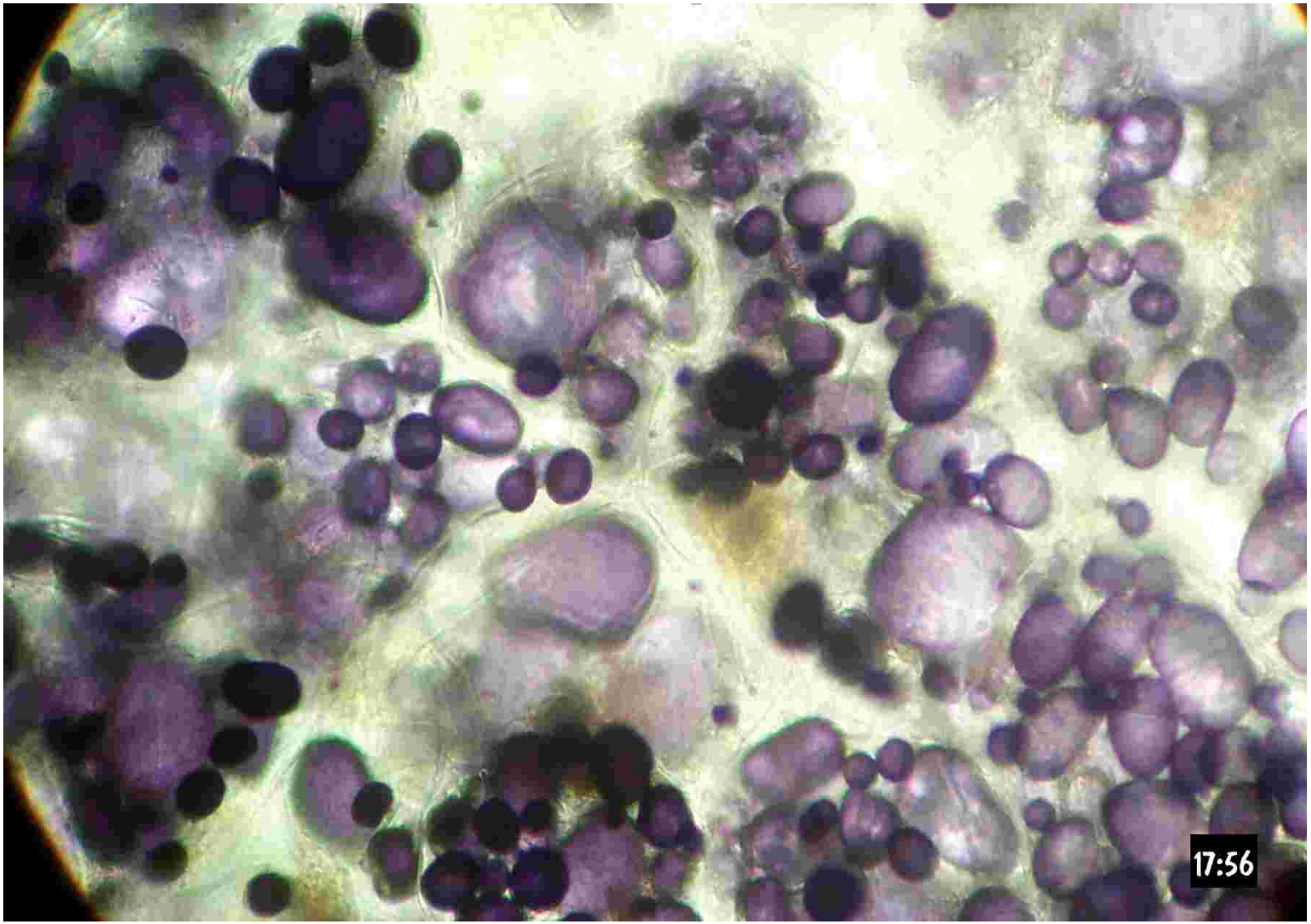
5.

Any fact, result… should be considered as a projection of general cases that we have to invent

Most food is a « gel »



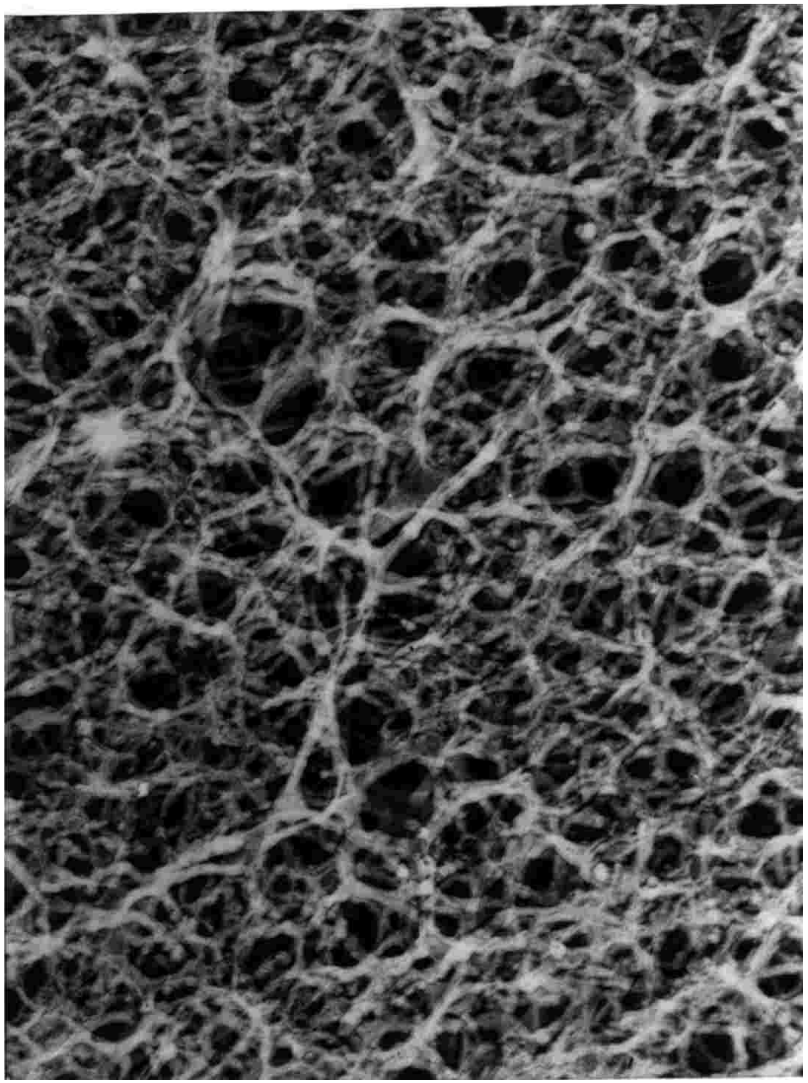
But gels can be complex

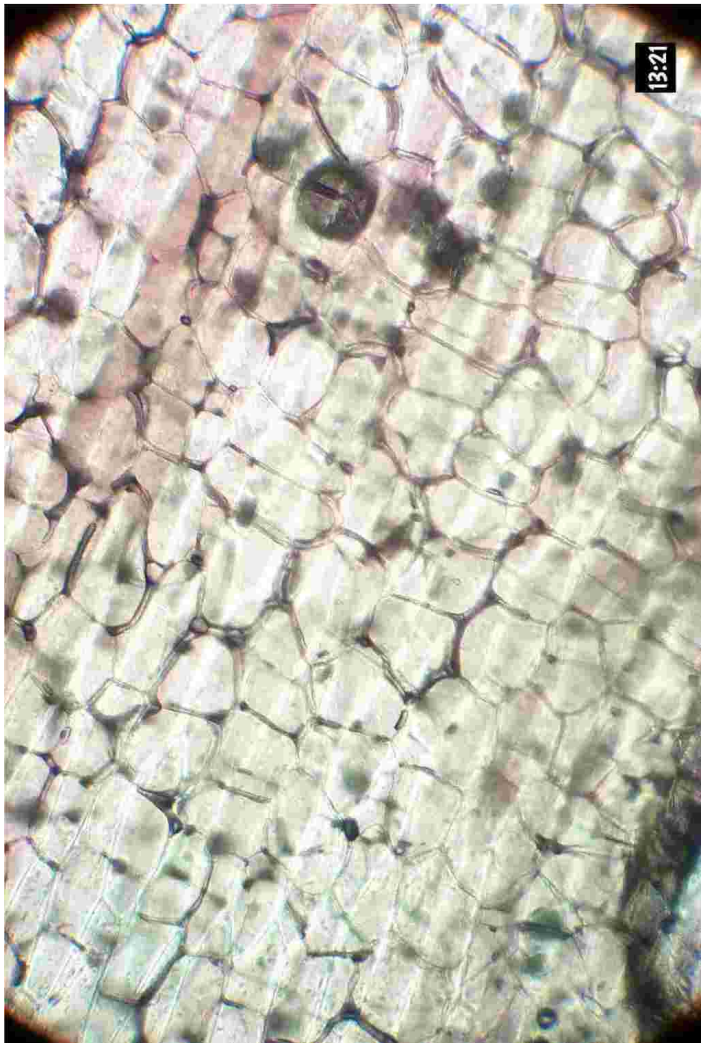


« Dimensionality », an important characteristic

Cliché J. Lacour, INRA Theix

How to distinguish gels ?





Disperse Systems Formalisms (DSF)

Four symbols :

/ : dispersed into

+ : coexistence of phases, mixture

@ : inclusion

σ : superposition (according to x,y,z)

x : interdispersion

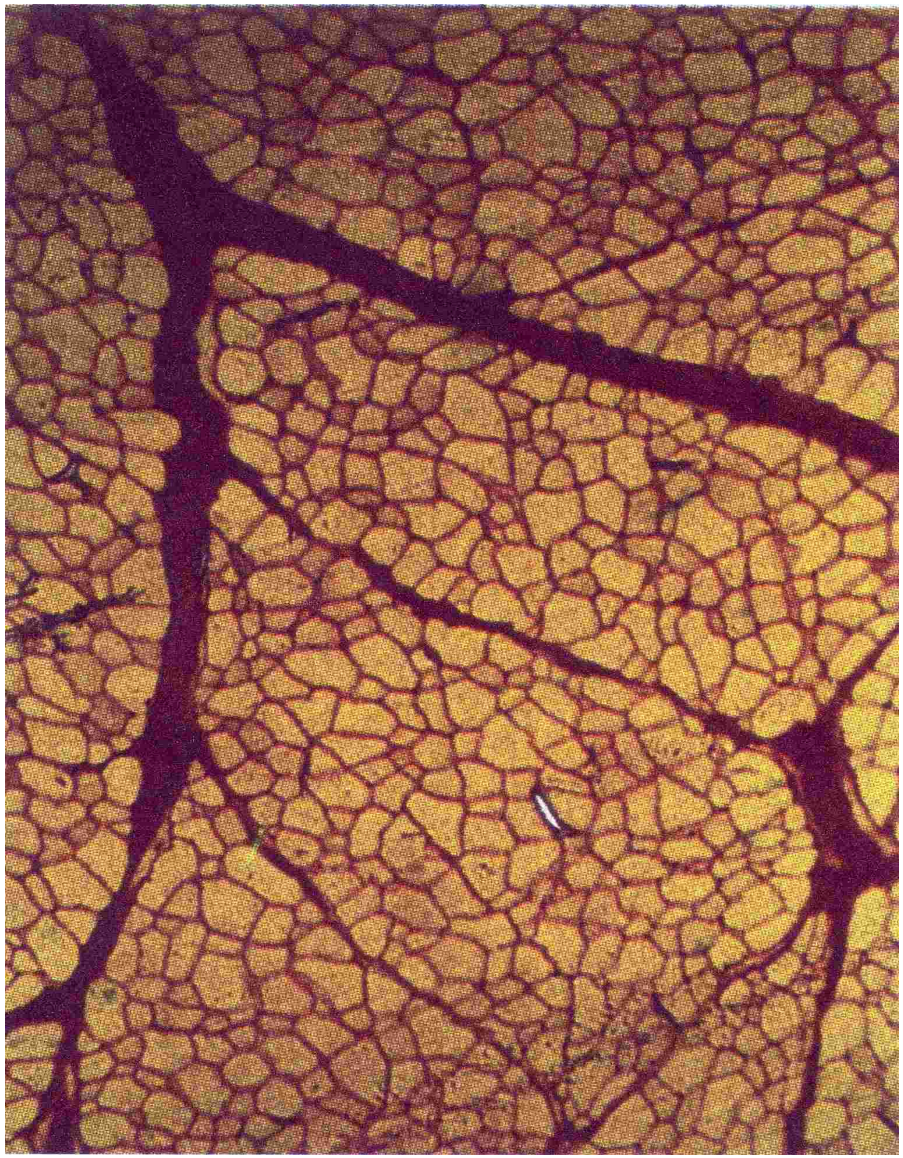
Four kind of phases :

G : gas; O: oil; S: solids; W: aqueous solutions

Four kind of object:

D0 : dimension 0 ; D1: dimension 1 ; D2 : dimension 2 ; D3 : dimension 3

Meat : $D_1(W)/D_3(S)$



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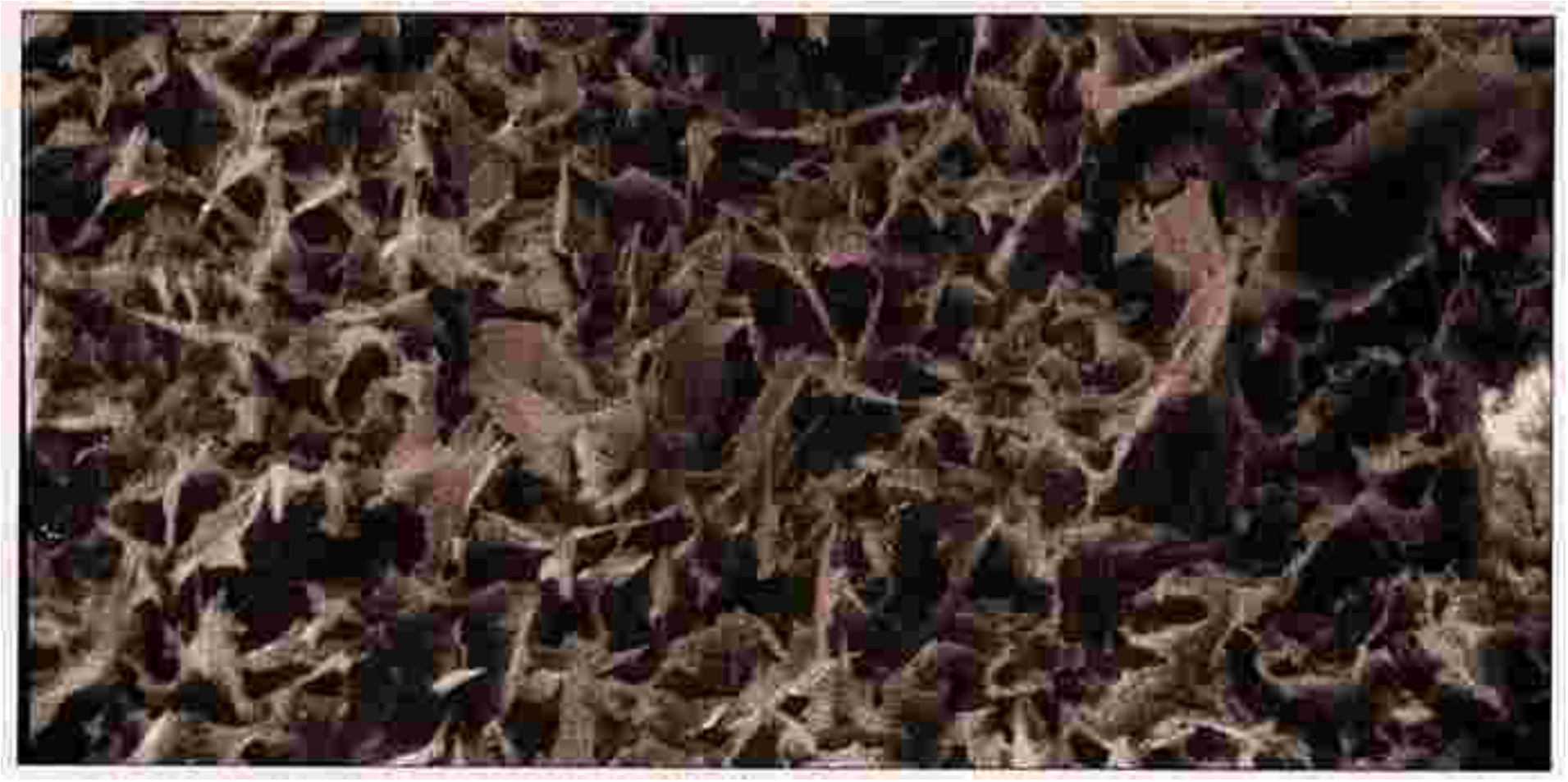
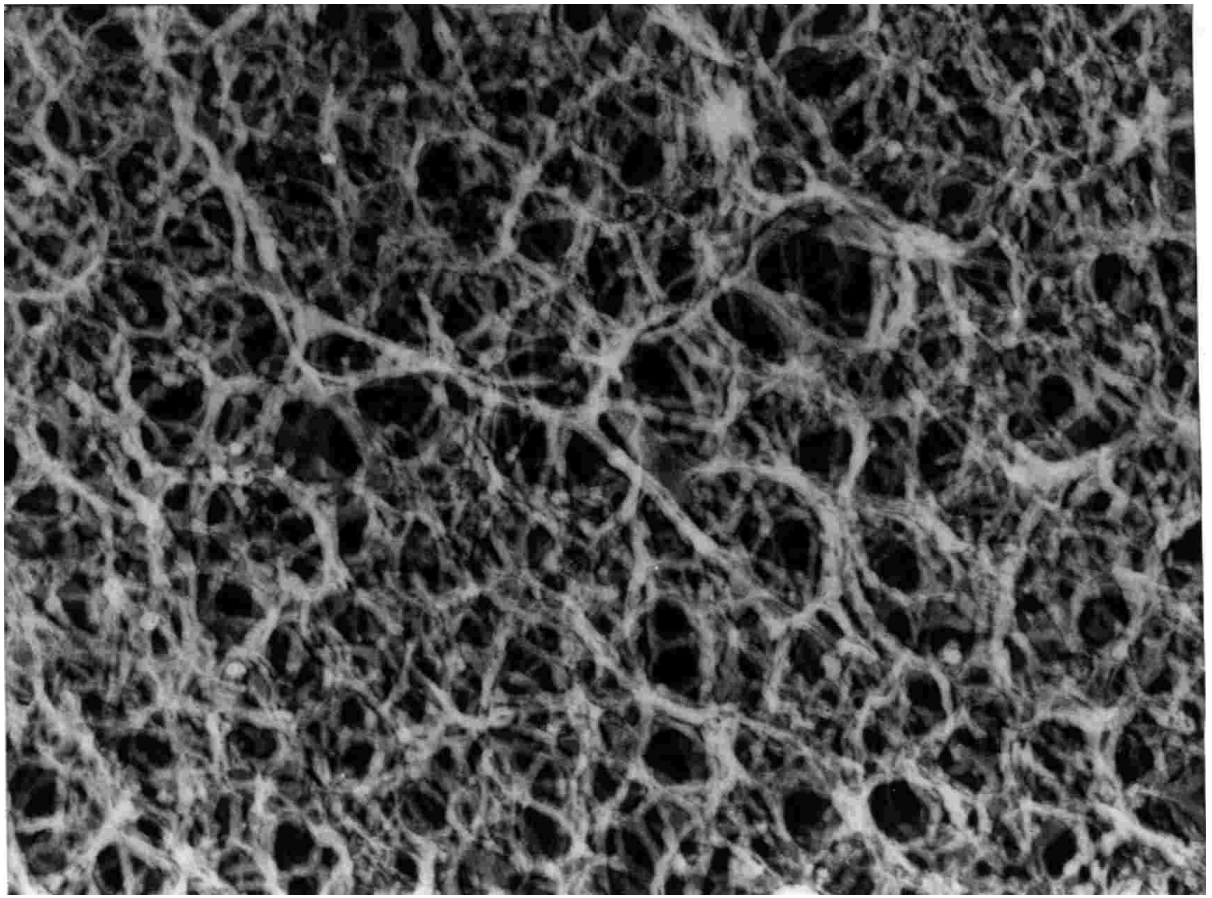
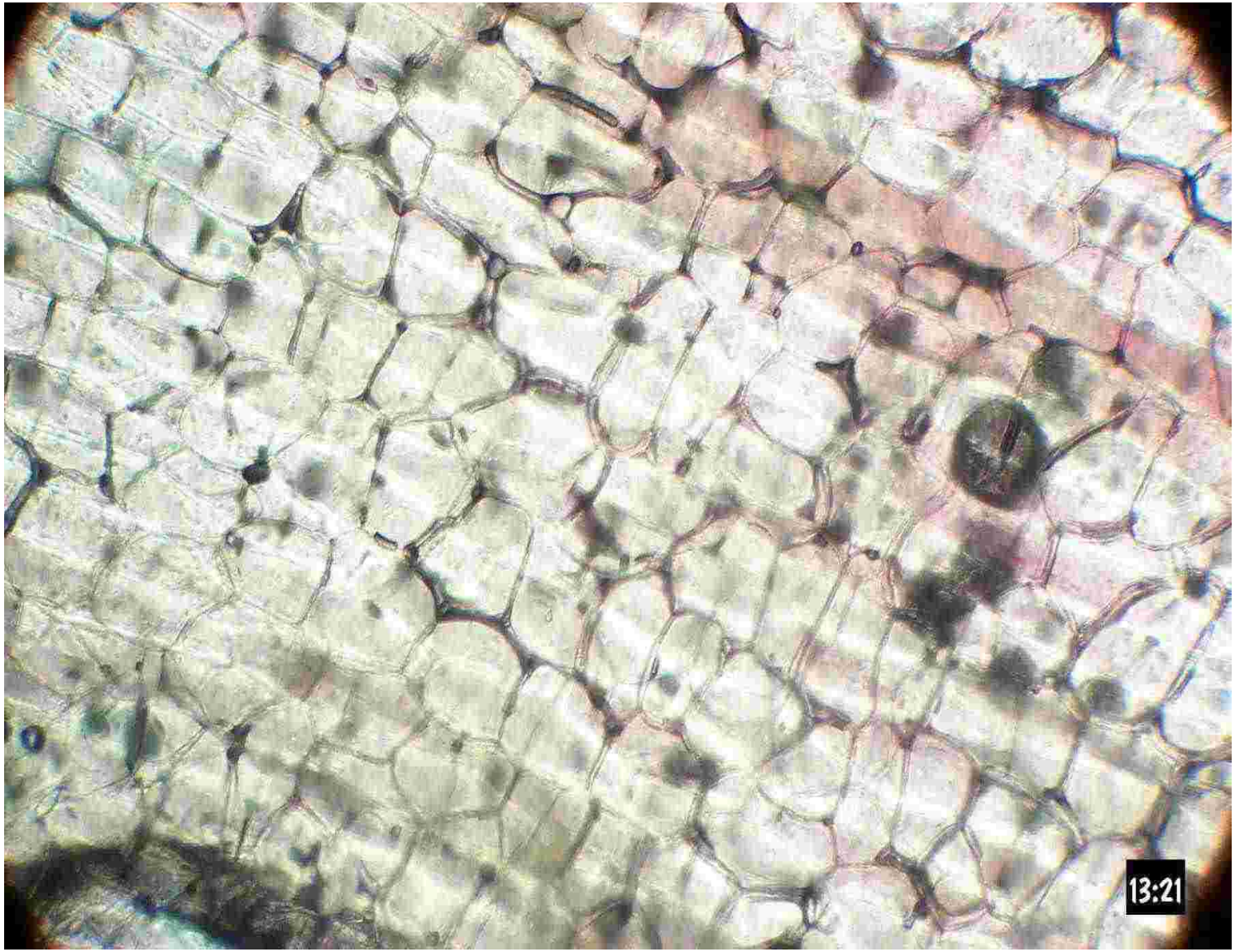
Chocolate : $D_3(O)xD_3(S)$



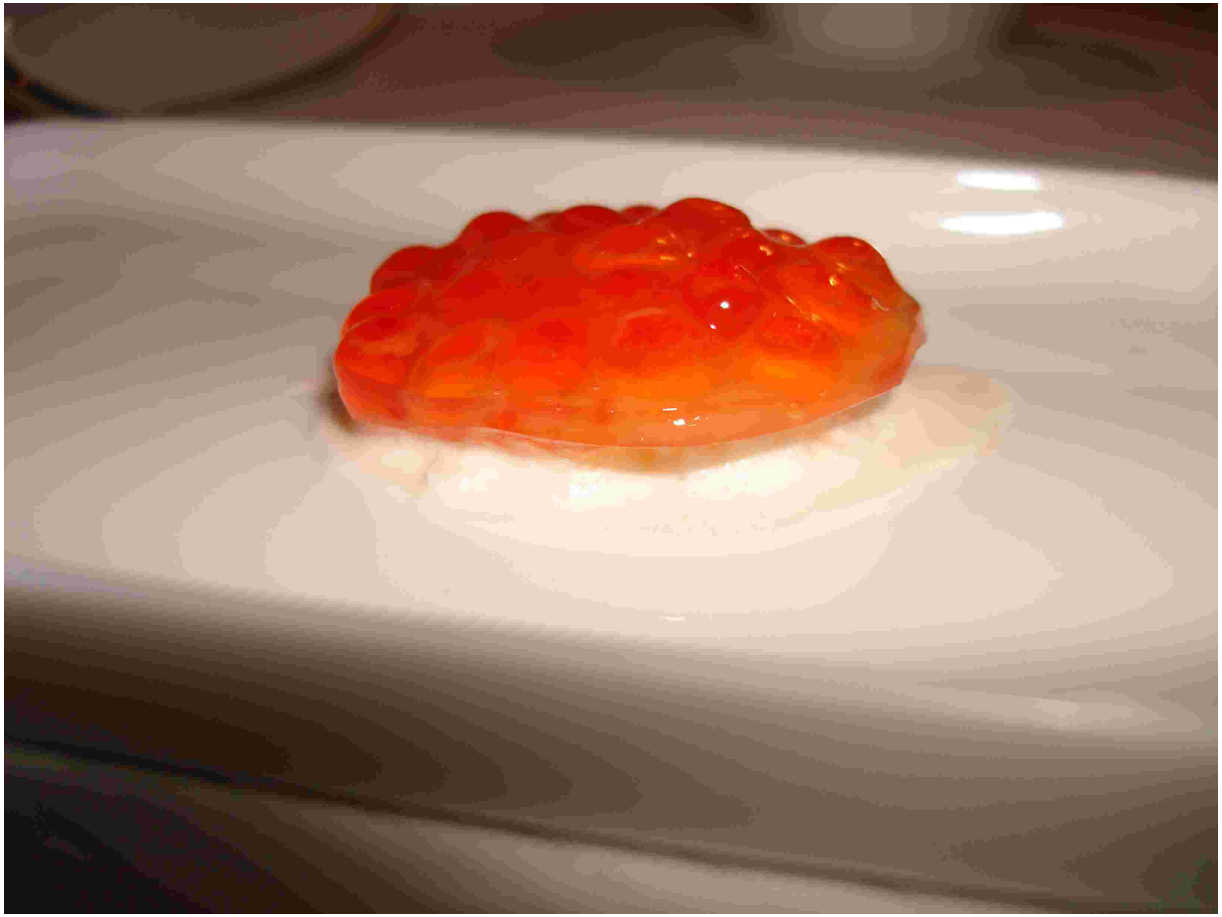
Gelatine gel : $D_3(W)xD_3(S)$



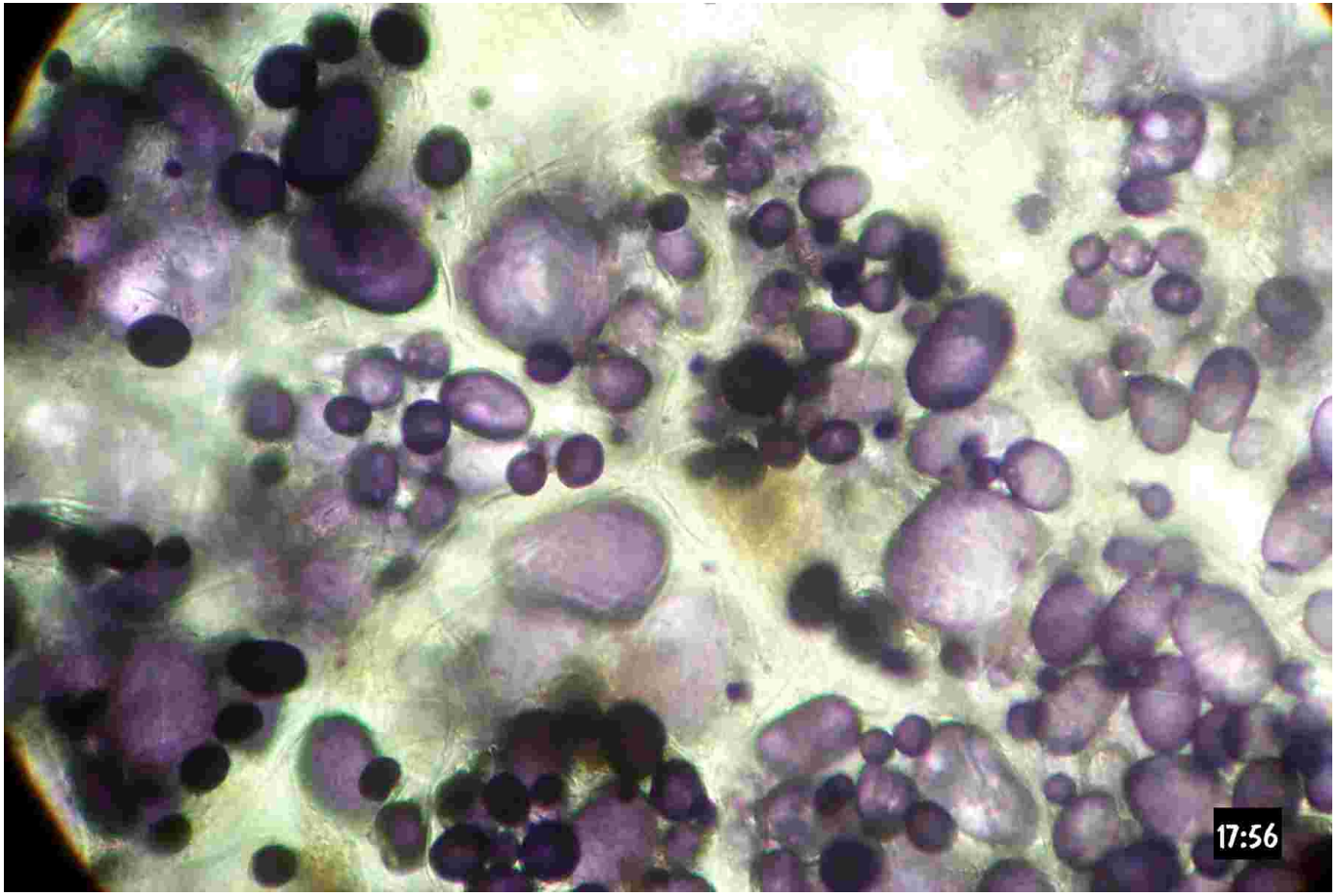
Plant tissues : $D_0(W)/D_3(S)$



Conglomeles: artificial plant tissues
$D_0(W)/D_3(S)$



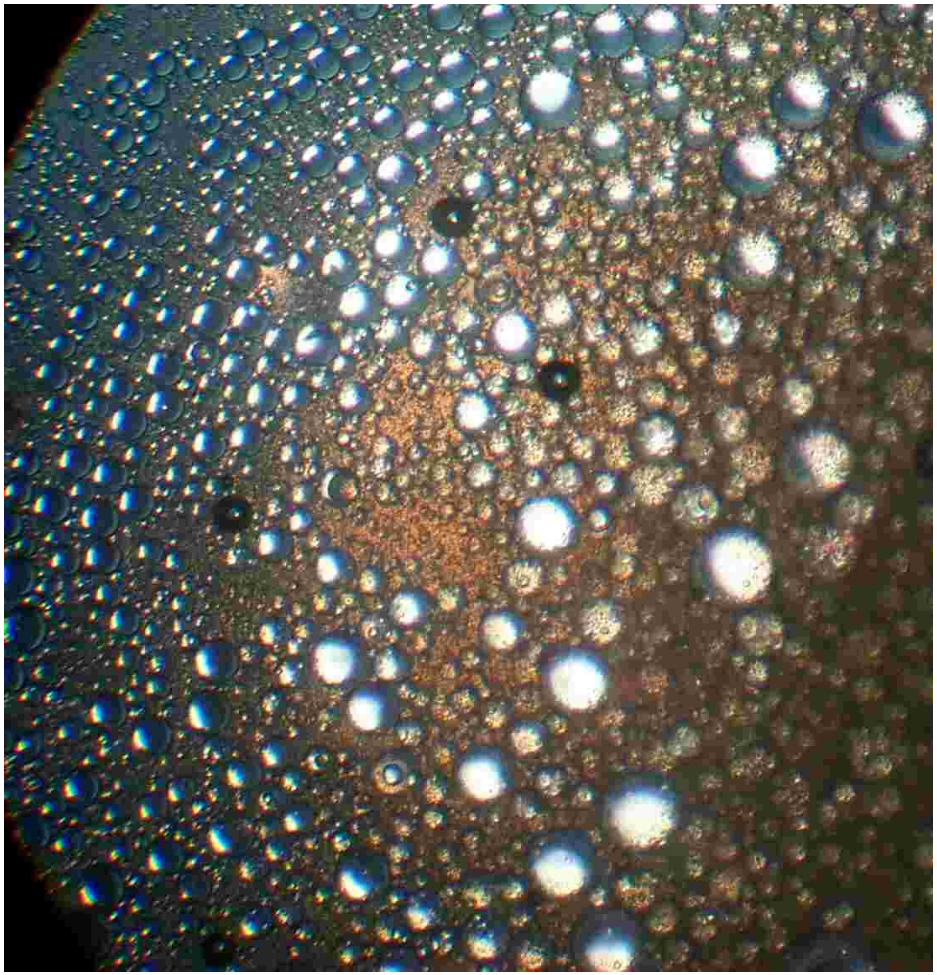
Potato : [D_0(S)/D_0(W)]/D_3(S)



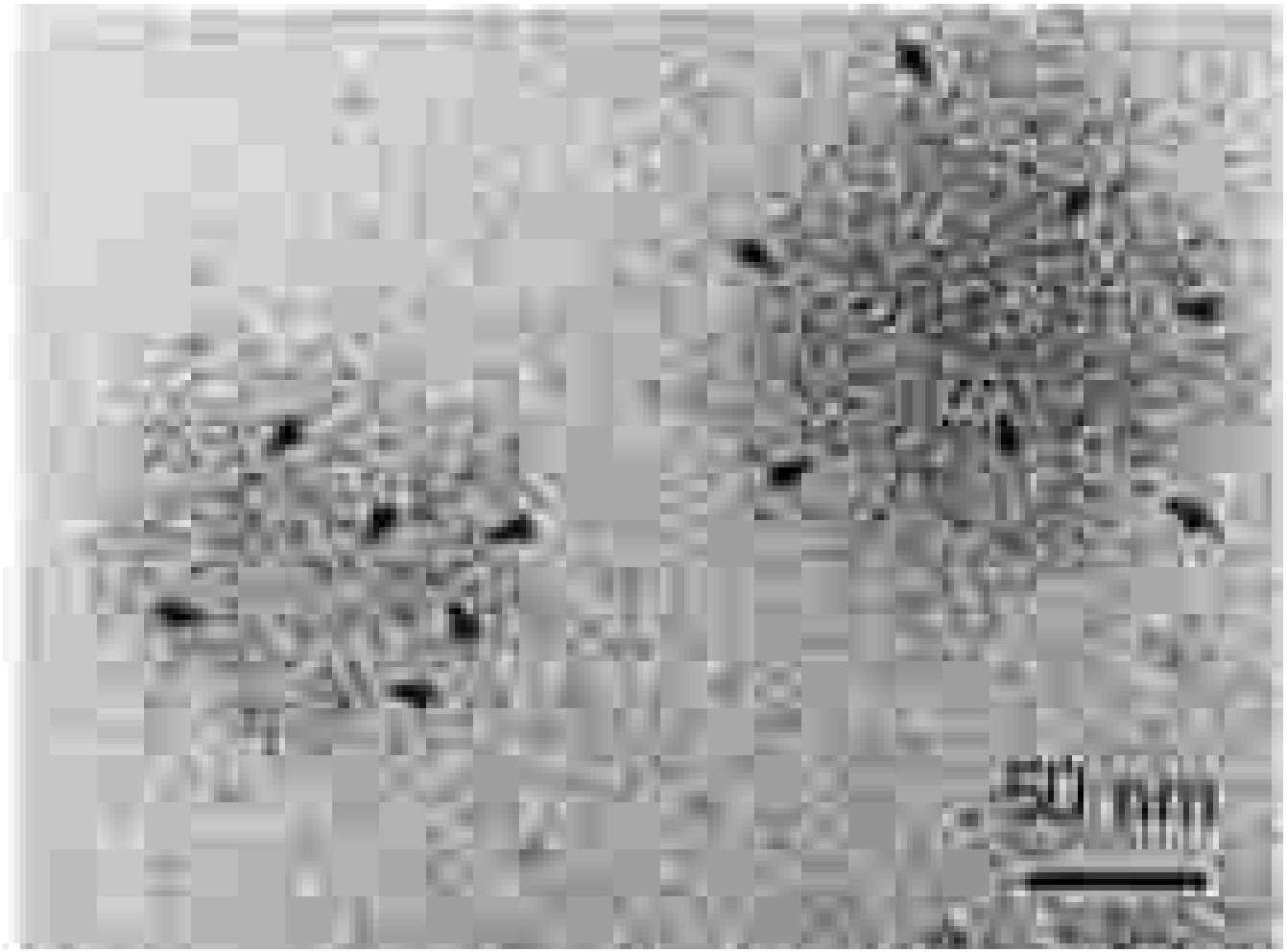
Food ?

A macroscopic organization

For each part,
A microscopic organization



For each part, a nanoscopic organization



For each part, a molecular organization

And DSF applies to any level

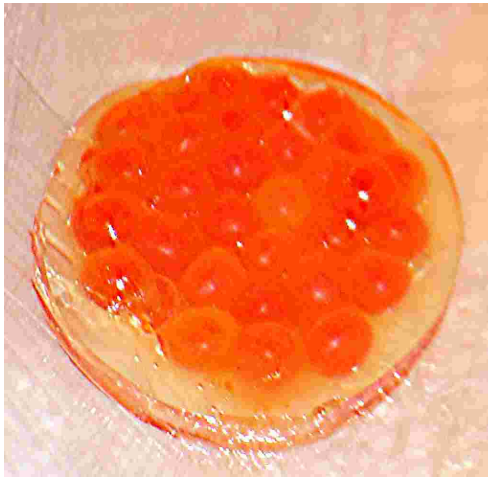
Four symbols :

- / : dispersed into
- + : coexistence of phases, mixture
- @ : inclusion
- σ : superposition (according to x,y,z)
- x : interdispersion

Four kind of phases : **Four kind of object:**

- G : gas D0
- W : solution D1
- O : oil D2
- S1, S2, … : solids D3

Until today,
all food systems could be described…
But is the system "complete" ?



$(D_{1,1}(W_1/S_1)@D_{1,2}(W_2/S_2))/D_3$

$D_0(W_1)@D_0(W_2/S_1)/D_2(W_3/S_2)$

$D_1(S)/D_3$

Hervé This, *Formal description for formulation*, in *International Journal for Pharmaceutics, 2007, 344 (1-2), 4-8. doi:10.1016/j.ijpharm.2007.07.046*.

From some gels to all gels

```
phase := [W, O, S];
dimension := [D0, D1, D2, D3];
operateur := ["X", "/", "@", "&sigma;"];
formule := ""; graine := "";
for dim1 to 4 do
for phas1 to 3 do
for ope to 4 do
for dim2 to 4 do
for phas2 to 3 do
if phas1 <> phas2 then formule := cat(graine, dimension[dim1], "(", phase[phas1], ")", operateur[ope], dimension[dim2], "(",
   phase[phas2], ")")
end if
end do
end do
end do
 end do
 end do;
```

About 1500 new systems!

[D0(W)XD0(W)]XD3(S)
[D0(W)XD0(W)]/D3(S)
[D0(W)XD0(O)]XD3(S)
[D0(W)XD0(O)]/D3(S)
[D0(W)XD0(S)]XD3(S)
[D0(W)XD0(S)]/D3(S)
[D0(W)XD1(W)]XD3(S)
[D0(W)XD1(W)]/D3(S)
[D0(W)XD1(O)]XD3(S)
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And here

[D0(W)XD0(W)]XD3(S) :
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[D0(W)σD2(O)]XD3(S)
[D0(W)σD2(O)]/D3(S)
[D0(W)σD2(S)]XD3(S)
[D0(W)σD2(S)]/D3(S)
[D0(W)σD3(W)]XD3(S)
[D0(W)σD3(W)]/D3(S)
[D0(W)σD3(O)]XD3(S)
[D0(W)σD3(O)]/D3(S)
[D0(W)σD3(S)]XD3(S)
[D0(W)σD3(S)]/D3(S)
[D0(W)+D0(W)]XD3(S) :
[D0(W)+D0(W)]/D3(S)
[D0(W)+D0(O)]XD3(S)
[D0(W)+D0(O)]/D3(S)
[D0(W)+D0(S)]XD3(S)
[D0(W)+D0(S)]/D3(S) :
[D0(W)+D1(W)]XD3(S) :
[D0(W)+D1(W)]/D3(S) :
[D0(W)+D1(O)]XD3(S)
[D0(W)+D1(O)]/D3(S)
[D0(W)+D1(S)]XD3(S)

[D0(W)+D1(S)]/D3(S)
[D0(W)+D2(W)]XD3(S)
[D0(W)+D2(W)]/D3(S)
[D0(W)+D2(O)]XD3(S)
[D0(W)+D2(O)]/D3(S)
[D0(W)+D2(S)]XD3(S)
[D0(W)+D2(S)]/D3(S)
[D0(W)+D3(W)]XD3(S)
[D0(W)+D3(W)]/D3(S)
[D0(W)+D3(O)]XD3(S)
[D0(W)+D3(O)]/D3(S)
[D0(W)+D3(S)]XD3(S)
[D0(W)+D3(S)]/D3(S)
[D0(O)XD0(W)]XD3(S)
[D0(O)XD0(W)]/D3(S)
[D0(O)XD0(O)]XD3(S)
[D0(O)XD0(O)]/D3(S)
[D0(O)XD0(S)]XD3(S)
[D0(O)XD0(S)]/D3(S)
[D0(O)XD1(W)]XD3(S)
[D0(O)XD1(W)]/D3(S)
[D0(O)XD1(O)]XD3(S)
[D0(O)XD1(O)]/D3(S)
[D0(O)XD1(S)]XD3(S)
[D0(O)XD1(S)]/D3(S)
[D0(O)XD2(W)]XD3(S)
[D0(O)XD2(W)]/D3(S)
[D0(O)XD2(O)]XD3(S)
[D0(O)XD2(O)]/D3(S)
[D0(O)XD2(S)]XD3(S)
[D0(O)XD2(S)]/D3(S)
[D0(O)XD3(W)]XD3(S)
[D0(O)XD3(W)]/D3(S)
[D0(O)XD3(O)]XD3(S)
[D0(O)XD3(O)]/D3(S)
[D0(O)XD3(S)]XD3(S)
[D0(O)XD3(S)]/D3(S)

[D0(O)/D0(O)]XD3(S)
[D0(O)/D0(O)]/D3(S)
[D0(O)/D0(S)]XD3(S) :
[D0(O)/D0(S)]/D3(S)
[D0(O)/D1(W)]XD3(S)
[D0(O)/D1(W)]/D3(S) :
[D0(O)/D1(O)]XD3(S) :
[D0(O)/D1(O)]/D3(S) :
[D0(O)/D1(S)]XD3(S) :
[D0(O)/D1(S)]/D3(S) :
[D0(O)/D2(W)]XD3(S) :
[D0(O)/D2(W)]/D3(S) :
[D0(O)/D2(O)]XD3(S)
[D0(O)/D2(O)]/D3(S) :
[D0(O)/D2(S)]XD3(S) :
[D0(O)/D2(S)]/D3(S) :
[D0(O)/D3(W)]XD3(S) :
[D0(O)/D3(W)]/D3(S) :
[D0(O)/D3(O)]XD3(S) :
[D0(O)/D3(O)]/D3(S) :
[D0(O)/D3(S)]XD3(S) :
[D0(O)/D3(S)]/D3(S) :
[D0(O)@D0(W)]XD3(S)
[D0(O)@D0(W)]/D3(S)
[D0(O)@D0(O)]XD3(S)
[D0(O)@D0(O)]/D3(S)
[D0(O)@D0(S)]XD3(S)
[D0(O)@D0(S)]/D3(S)
[D0(O)@D1(W)]XD3(S)
[D0(O)@D1(W)]/D3(S)
[D0(O)@D1(O)]XD3(S)
[D0(O)@D1(O)]/D3(S)
[D0(O)@D1(S)]XD3(S)
[D0(O)@D1(S)]/D3(S)
[D0(O)@D2(W)]XD3(S)
[D0(O)@D2(W)]/D3(S)
[D0(O)@D2(O)]XD3(S)

[D0(O)@D2(O)]/D3(S)
[D0(O)@D2(S)]XD3(S) :
[D0(O)@D2(S)]/D3(S)
[D0(O)@D3(W)]XD3(S)
[D0(O)@D3(W)]/D3(S) :
[D0(O)@D3(O)]XD3(S) :
[D0(O)@D3(O)]/D3(S)
[D0(O)@D3(S)]XD3(S) :
[D0(O)@D3(S)]/D3(S)
[D0(O)σD0(W)]XD3(S)
[D0(O)σD0(W)]/D3(S) :
[D0(O)σD0(O)]XD3(S)
[D0(O)σD0(O)]/D3(S) :
[D0(O)σD0(S)]XD3(S) :
[D0(O)σD0(S)]/D3(S)
[D0(O)σD1(W)]XD3(S)
[D0(O)σD1(W)]/D3(S)
[D0(O)σD1(O)]XD3(S)
[D0(O)σD1(O)]/D3(S)
[D0(O)σD1(S)]XD3(S) :
[D0(O)σD1(S)]/D3(S)
[D0(O)σD2(W)]XD3(S)
[D0(O)σD2(W)]/D3(S) :
[D0(O)σD2(O)]XD3(S) :
[D0(O)σD2(O)]/D3(S) :
[D0(O)σD2(S)]XD3(S) :
[D0(O)σD2(S)]/D3(S) :
[D0(O)σD3(W)]XD3(S) :
[D0(O)σD3(W)]/D3(S) :
[D0(O)σD3(O)]XD3(S)
[D0(O)σD3(O)]/D3(S) :
[D0(O)σD3(S)]XD3(S) :
[D0(O)σD3(S)]/D3(S) :

And here

[D0(W)XD0(W)]XD3(S) : :
[D0(W)XD0(W)]/D3(S) :
[D0(W)XD0(O)]XD3(S) :
[D0(W)XD0(O)]/D3(S) :
[D0(W)XD0(S)]XD3(S) :
[D0(W)XD0(S)]/D3(S) :
[D0(W)XD1(W)]XD3(S) :
[D0(W)XD1(W)]/D3(S) :
[D0(W)XD1(O)]XD3(S) :
[D0(W)XD1(O)]/D3(S)
[D0(W)XD1(S)]XD3(S) :
[D0(W)XD1(S)]/D3(S)
[D0(W)XD2(W)]XD3(S)
[D0(W)XD2(W)]/D3(S)
[D0(W)XD2(O)]XD3(S)
[D0(W)XD2(O)]/D3(S)
[D0(W)XD2(S)]XD3(S)
[D0(W)XD2(S)]/D3(S)
[D0(W)XD3(W)]XD3(S)
[D0(W)XD3(W)]/D3(S) :
[D0(W)XD3(O)]XD3(S)
[D0(W)XD3(O)]/D3(S)
[D0(W)XD3(S)]XD3(S) :
[D0(W)XD3(S)]/D3(S)
[D0(W)/D0(W)]XD3(S) :
[D0(W)/D0(W)]/D3(S)
[D0(W)/D0(O)]XD3(S)
[D0(W)/D0(O)]/D3(S)
[D0(W)/D0(S)]XD3(S)
[D0(W)/D0(S)]/D3(S) :
[D0(W)/D1(W)]XD3(S) :
[D0(W)/D1(W)]/D3(S)
[D0(W)/D1(O)]XD3(S)
[D0(W)/D1(O)]/D3(S)
[D0(W)/D1(S)]XD3(S)
[D0(W)/D1(S)]/D3(S) :

[D0(W)/D2(W)]XD3(S)
[D0(W)/D2(W)]/D3(S)
[D0(W)/D2(O)]XD3(S)
[D0(W)/D2(O)]/D3(S)
[D0(W)/D2(S)]XD3(S)
[D0(W)/D2(S)]/D3(S)
[D0(W)/D3(W)]XD3(S)
[D0(W)/D3(W)]/D3(S)
[D0(W)/D3(O)]XD3(S)
[D0(W)/D3(O)]/D3(S)
[D0(W)/D3(S)]XD3(S)
[D0(W)/D3(S)]/D3(S)
[D0(W)@D0(W)]XD3(S)
[D0(W)@D0(W)]/D3(S)
[D0(W)@D0(O)]XD3(S)
[D0(W)@D0(O)]/D3(S)
[D0(W)@D0(S)]XD3(S)
[D0(W)@D0(S)]/D3(S)
[D0(W)@D1(W)]XD3(S)
[D0(W)@D1(W)]/D3(S)
[D0(W)@D1(O)]XD3(S)
[D0(W)@D1(O)]/D3(S)
[D0(W)@D1(S)]XD3(S)
[D0(W)@D1(S)]/D3(S)
[D0(W)@D2(W)]XD3(S)
[D0(W)@D2(W)]/D3(S)
[D0(W)@D2(O)]XD3(S)
[D0(W)@D2(O)]/D3(S)
[D0(W)@D2(S)]XD3(S)
[D0(W)@D2(S)]/D3(S)
[D0(W)@D3(W)]XD3(S)
[D0(W)@D3(W)]/D3(S)
[D0(W)@D3(O)]XD3(S)
[D0(W)@D3(O)]/D3(S)
[D0(W)@D3(S)]XD3(S)
[D0(W)@D3(S)]/D3(S)
[D0(W)σD0(W)]XD3(S)

[D0(W)σD0(W)]/D3(S)
[D0(W)σD0(O)]XD3(S)
[D0(W)σD0(O)]/D3(S)
[D0(W)σD0(S)]XD3(S)
[D0(W)σD0(S)]/D3(S) :
[D0(W)σD1(W)]XD3(S) :
[D0(W)σD1(W)]/D3(S) :
[D0(W)σD1(O)]XD3(S) :
[D0(W)σD1(O)]/D3(S) :
[D0(W)σD1(S)]XD3(S) :
[D0(W)σD1(S)]/D3(S)
[D0(W)σD2(W)]XD3(S)
[D0(W)σD2(W)]/D3(S)
[D0(W)σD2(O)]XD3(S)
[D0(W)σD2(O)]/D3(S)
[D0(W)σD2(S)]XD3(S)
[D0(W)σD2(S)]/D3(S)
[D0(W)σD3(W)]XD3(S)
[D0(W)σD3(W)]/D3(S)
[D0(W)σD3(O)]XD3(S)
[D0(W)σD3(O)]/D3(S)
[D0(W)σD3(S)]XD3(S)
[D0(W)σD3(S)]/D3(S)
[D0(W)+D0(W)]XD3(S) :
[D0(W)+D0(W)]/D3(S)
[D0(W)+D0(O)]XD3(S)
[D0(W)+D0(O)]/D3(S)
[D0(W)+D0(S)]XD3(S)
[D0(W)+D0(S)]/D3(S) :
[D0(W)+D1(W)]XD3(S) :
[D0(W)+D1(W)]/D3(S) :
[D0(W)+D1(O)]XD3(S)
[D0(W)+D1(O)]/D3(S)
[D0(W)+D1(S)]XD3(S)

[D0(W)+D1(S)]/D3(S)
[D0(W)+D2(W)]XD3(S)
[D0(W)+D2(W)]/D3(S)
[D0(W)+D2(O)]XD3(S)
[D0(W)+D2(O)]/D3(S)
[D0(W)+D2(S)]XD3(S)
[D0(W)+D2(S)]/D3(S)
[D0(W)+D3(W)]XD3(S)
[D0(W)+D3(W)]/D3(S)
[D0(W)+D3(O)]XD3(S)
[D0(W)+D3(O)]/D3(S)
[D0(W)+D3(S)]XD3(S)
[D0(W)+D3(S)]/D3(S)
[D0(O)XD0(W)]XD3(S)
[D0(O)XD0(W)]/D3(S)
[D0(O)XD0(O)]XD3(S)
[D0(O)XD0(O)]/D3(S)
[D0(O)XD0(S)]XD3(S)
[D0(O)XD0(S)]/D3(S)
[D0(O)XD1(W)]XD3(S)
[D0(O)XD1(W)]/D3(S)
[D0(O)XD1(O)]XD3(S)
[D0(O)XD1(O)]/D3(S)
[D0(O)XD1(S)]XD3(S)
[D0(O)XD1(S)]/D3(S)
[D0(O)XD2(W)]XD3(S)
[D0(O)XD2(W)]/D3(S)
[D0(O)XD2(O)]XD3(S)
[D0(O)XD2(O)]/D3(S)
[D0(O)XD2(S)]XD3(S)
[D0(O)XD2(S)]/D3(S)
[D0(O)XD3(W)]XD3(S)
[D0(O)XD3(W)]/D3(S)
[D0(O)XD3(O)]XD3(S)
[D0(O)XD3(O)]/D3(S)
[D0(O)XD3(S)]XD3(S)
[D0(O)XD3(S)]/D3(S)

[D0(O)/D0(O)]XD3(S)
[D0(O)/D0(O)]/D3(S)
[D0(O)/D0(S)]XD3(S) :
[D0(O)/D0(S)]/D3(S)
[D0(O)/D1(W)]XD3(S)
[D0(O)/D1(W)]/D3(S) :
[D0(O)/D1(O)]XD3(S) :
[D0(O)/D1(O)]/D3(S) :
[D0(O)/D1(S)]XD3(S) :
[D0(O)/D1(S)]/D3(S) :
[D0(O)/D2(W)]XD3(S) :
[D0(O)/D2(W)]/D3(S) :
[D0(O)/D2(O)]XD3(S)
[D0(O)/D2(O)]/D3(S) :
[D0(O)/D2(S)]XD3(S) :
[D0(O)/D2(S)]/D3(S) :
[D0(O)/D3(W)]XD3(S) :
[D0(O)/D3(W)]/D3(S) :
[D0(O)/D3(O)]XD3(S) :
[D0(O)/D3(O)]/D3(S) :
[D0(O)/D3(S)]XD3(S) :
[D0(O)/D3(S)]/D3(S) :
[D0(O)@D0(W)]XD3(S)
[D0(O)@D0(W)]/D3(S)
[D0(O)@D0(O)]XD3(S)
[D0(O)@D0(O)]/D3(S)
[D0(O)@D0(S)]XD3(S)
[D0(O)@D0(S)]/D3(S)
[D0(O)@D1(W)]XD3(S)
[D0(O)@D1(W)]/D3(S)
[D0(O)@D1(O)]XD3(S)
[D0(O)@D1(O)]/D3(S)
[D0(O)@D1(S)]XD3(S)
[D0(O)@D1(S)]/D3(S)
[D0(O)@D2(W)]XD3(S)
[D0(O)@D2(W)]/D3(S)
[D0(O)@D2(O)]XD3(S)

[D0(O)@D2(O)]/D3(S)
[D0(O)@D2(S)]XD3(S) :
[D0(O)@D2(S)]/D3(S)
[D0(O)@D3(W)]XD3(S)
[D0(O)@D3(W)]/D3(S) :
[D0(O)@D3(O)]XD3(S) :
[D0(O)@D3(O)]/D3(S)
[D0(O)@D3(S)]XD3(S) :
[D0(O)@D3(S)]/D3(S)
[D0(O)σD0(W)]XD3(S)
[D0(O)σD0(W)]/D3(S) :
[D0(O)σD0(O)]XD3(S)
[D0(O)σD0(O)]/D3(S) :
[D0(O)σD0(S)]XD3(S) :
[D0(O)σD0(S)]/D3(S)
[D0(O)σD1(W)]XD3(S)
[D0(O)σD1(W)]/D3(S)
[D0(O)σD1(O)]XD3(S)
[D0(O)σD1(O)]/D3(S)
[D0(O)σD1(S)]XD3(S) :
[D0(O)σD1(S)]/D3(S)
[D0(O)σD2(W)]XD3(S)
[D0(O)σD2(W)]/D3(S) :
[D0(O)σD2(O)]XD3(S) :
[D0(O)σD2(O)]/D3(S) :
[D0(O)σD2(S)]XD3(S) :
[D0(O)σD2(S)]/D3(S) :
[D0(O)σD3(W)]XD3(S) :
[D0(O)σD3(W)]/D3(S) :
[D0(O)σD3(O)]XD3(S) :
[D0(O)σD3(O)]/D3(S) :
[D0(O)σD3(S)]XD3(S) :
[D0(O)σD3(S)]/D3(S) :

And finally here

[D0(W)XD0(W)]XD3(S) :
[D0(W)XD0(W)]/D3(S) :
[D0(W)XD0(O)]XD3(S) :
[D0(W)XD0(O)]/D3(S) :
[D0(W)XD0(S)]XD3(S) :
[D0(W)XD0(S)]/D3(S) :
[D0(W)XD1(W)]XD3(S) :
[D0(W)XD1(W)]/D3(S) :
[D0(W)XD1(O)]XD3(S) :
[D0(W)XD1(O)]/D3(S)
[D0(W)XD1(S)]XD3(S) :
[D0(W)XD1(S)]/D3(S)
[D0(W)XD2(W)]XD3(S)
[D0(W)XD2(W)]/D3(S)
[D0(W)XD2(O)]XD3(S)
[D0(W)XD2(O)]/D3(S)
[D0(W)XD2(S)]XD3(S)
[D0(W)XD2(S)]/D3(S)
[D0(W)XD3(W)]XD3(S)
[D0(W)XD3(W)]/D3(S) :
[D0(W)XD3(O)]XD3(S)
[D0(W)XD3(O)]/D3(S)
[D0(W)XD3(S)]XD3(S) :
[D0(W)XD3(S)]/D3(S)
[D0(W)/D0(W)]XD3(S) :
[D0(W)/D0(W)]/D3(S)
[D0(W)/D0(O)]XD3(S)
[D0(W)/D0(O)]/D3(S)
[D0(W)/D0(S)]XD3(S)
[D0(W)/D0(S)]/D3(S) :
[D0(W)/D1(W)]XD3(S) :
[D0(W)/D1(W)]/D3(S)
[D0(W)/D1(O)]XD3(S)
[D0(W)/D1(O)]/D3(S)
[D0(W)/D1(S)]XD3(S)
[D0(W)/D1(S)]/D3(S) :

[D0(W)/D2(W)]XD3(S)
[D0(W)/D2(W)]/D3(S)
[D0(W)/D2(O)]XD3(S)
[D0(W)/D2(O)]/D3(S)
[D0(W)/D2(S)]XD3(S)
[D0(W)/D2(S)]/D3(S)
[D0(W)/D3(W)]XD3(S)
[D0(W)/D3(W)]/D3(S)
[D0(W)/D3(O)]XD3(S)
[D0(W)/D3(O)]/D3(S)
[D0(W)/D3(S)]XD3(S)
[D0(W)/D3(S)]/D3(S)
[D0(W)@D0(W)]XD3(S)
[D0(W)@D0(W)]/D3(S)
[D0(W)@D0(O)]XD3(S)
[D0(W)@D0(O)]/D3(S)
[D0(W)@D0(S)]XD3(S)
[D0(W)@D0(S)]/D3(S)
[D0(W)@D1(W)]XD3(S)
[D0(W)@D1(W)]/D3(S)
[D0(W)@D1(O)]XD3(S)
[D0(W)@D1(O)]/D3(S)
[D0(W)@D1(S)]XD3(S)
[D0(W)@D1(S)]/D3(S)
[D0(W)@D2(W)]XD3(S)
[D0(W)@D2(W)]/D3(S)
[D0(W)@D2(O)]XD3(S)
[D0(W)@D2(O)]/D3(S)
[D0(W)@D2(S)]XD3(S)
[D0(W)@D2(S)]/D3(S)
[D0(W)@D3(W)]XD3(S)
[D0(W)@D3(W)]/D3(S)
[D0(W)@D3(O)]XD3(S)
[D0(W)@D3(O)]/D3(S)
[D0(W)@D3(S)]XD3(S)
[D0(W)@D3(S)]/D3(S)
[D0(W)σD0(W)]XD3(S)

[D0(W)σD0(W)]/D3(S)
[D0(W)σD0(O)]XD3(S)
[D0(W)σD0(O)]/D3(S)
[D0(W)σD0(S)]XD3(S)
[D0(W)σD0(S)]/D3(S) :
[D0(W)σD1(W)]XD3(S) :
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[D0(W)σD1(O)]XD3(S) :
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[D0(W)σD1(S)]/D3(S)
[D0(W)σD2(W)]XD3(S)
[D0(W)σD2(W)]/D3(S)
[D0(W)σD2(O)]XD3(S)
[D0(W)σD2(O)]/D3(S)
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[D0(W)σD2(S)]/D3(S)
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[D0(W)σD3(W)]/D3(S)
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[D0(W)σD3(S)]/D3(S)
[D0(W)+D0(W)]XD3(S) :
[D0(W)+D0(W)]/D3(S)
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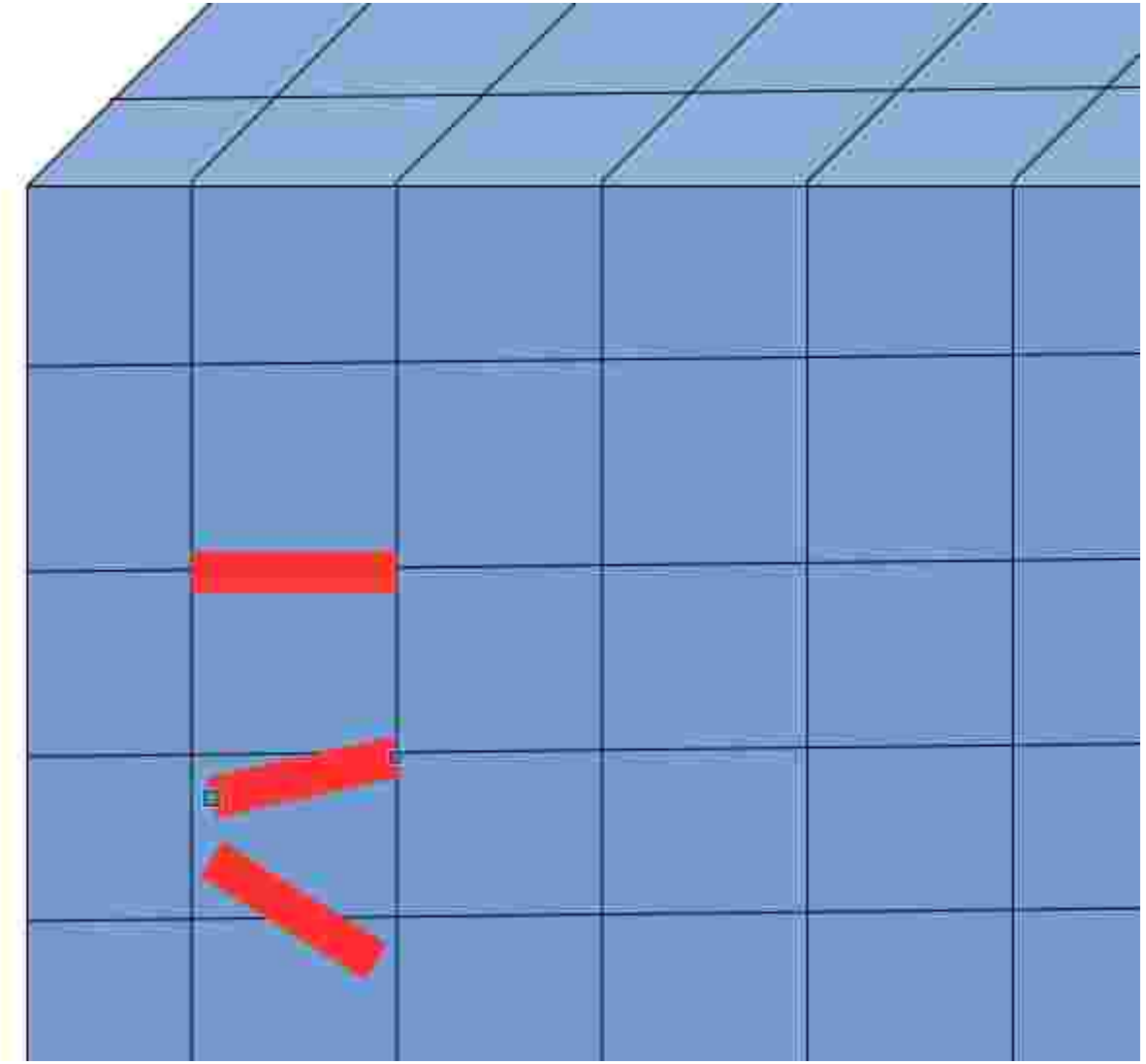
[D0(O)σD3(O)]/D3(S) :
[D0(O)σD3(S)]XD3(S) :
[D0(O)σD3(S)]/D3(S) :

Plus "dynagels"

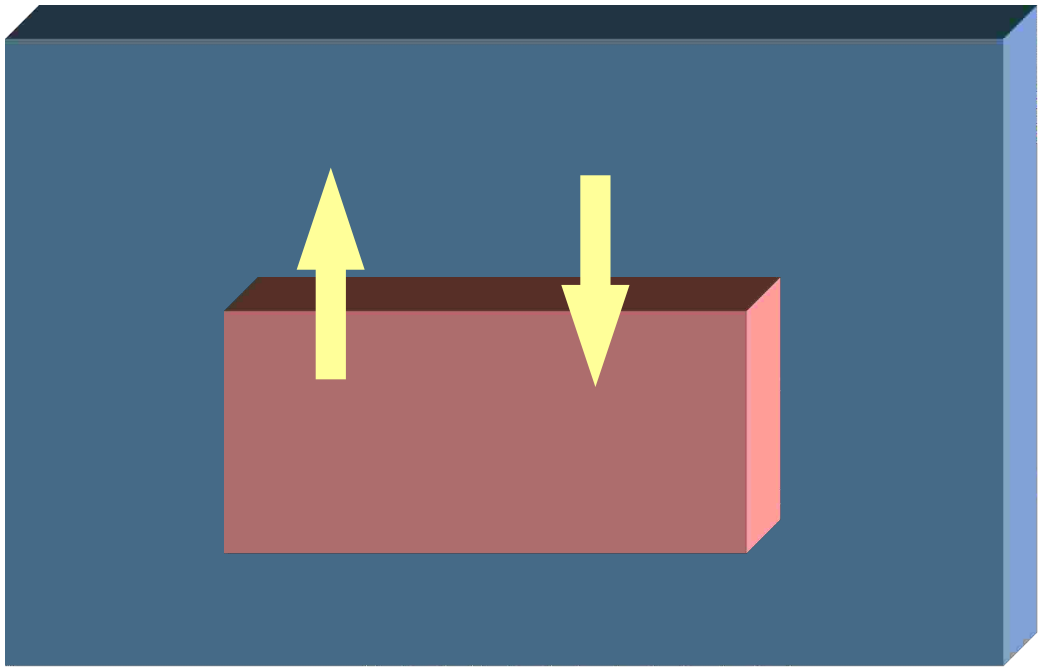
If E is the binding energy,
The proportion of linked ends at one end at a temperature T is :
K exp(-E/kBT)



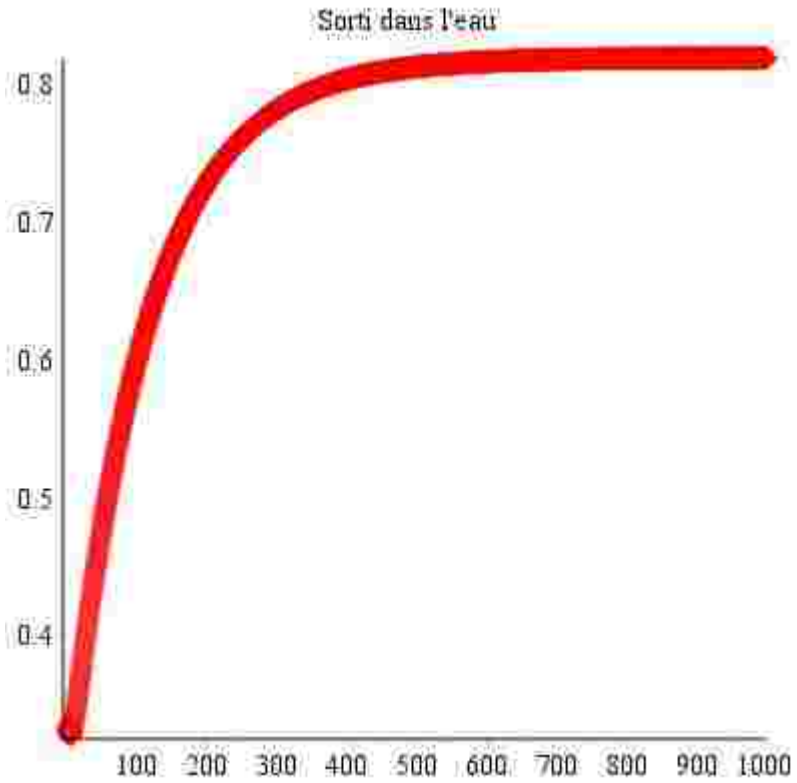
What shall we do with all this

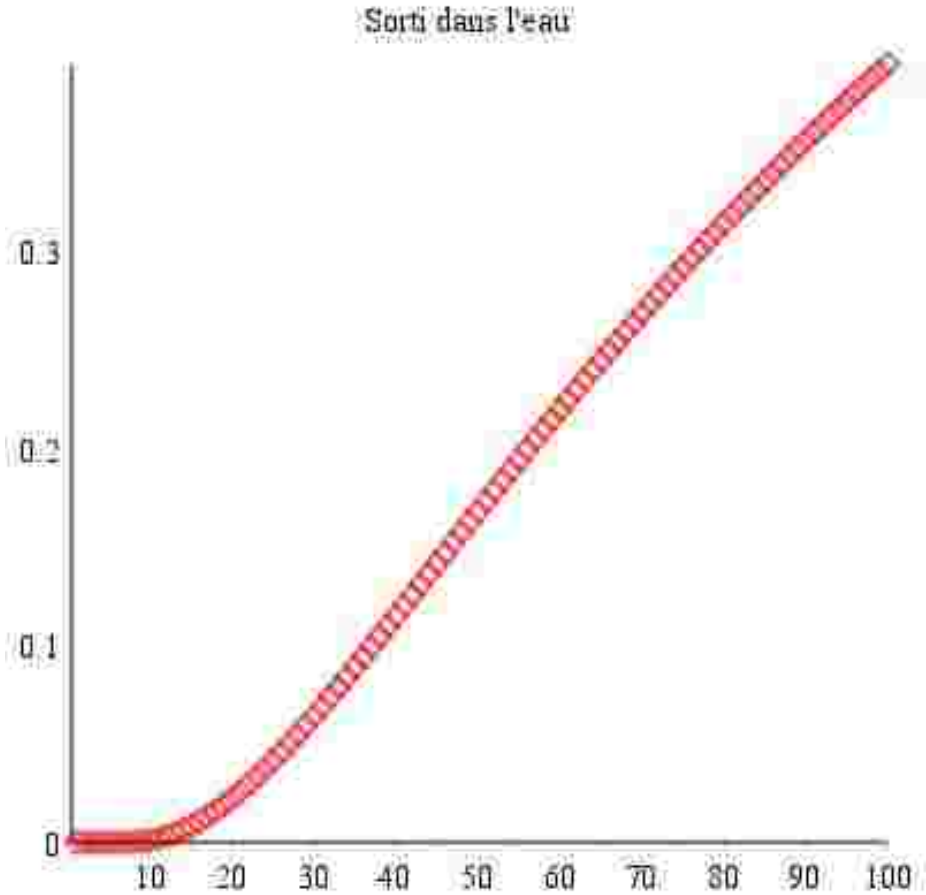
?

Food is not simple a physical/chemical system : "bioactivity" is fundamental !

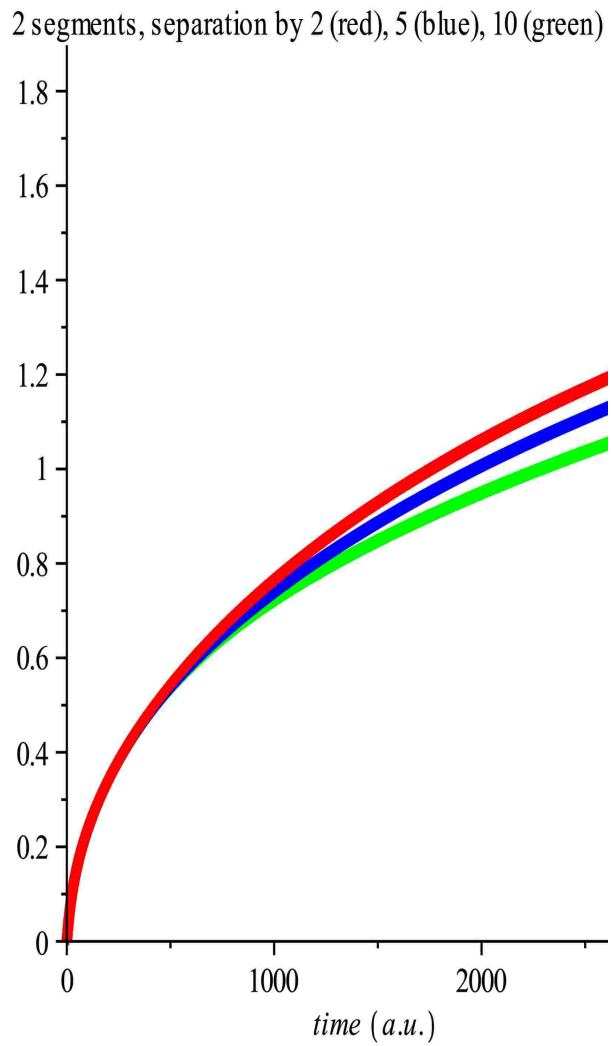


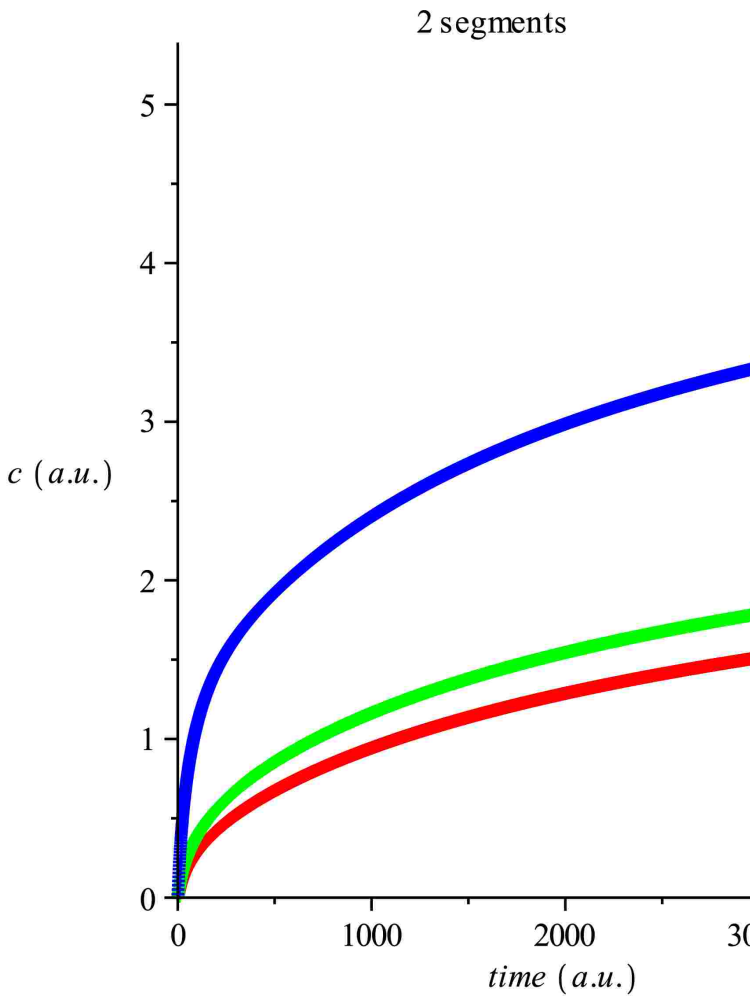
And other laws…
How many kinds ? Which kinds ?

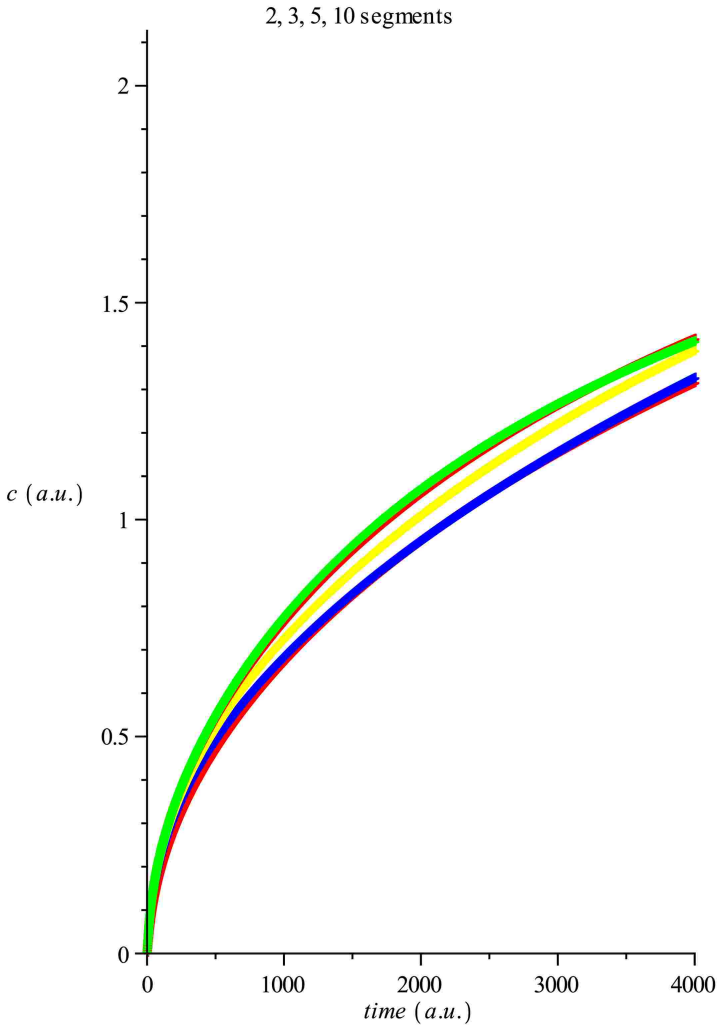




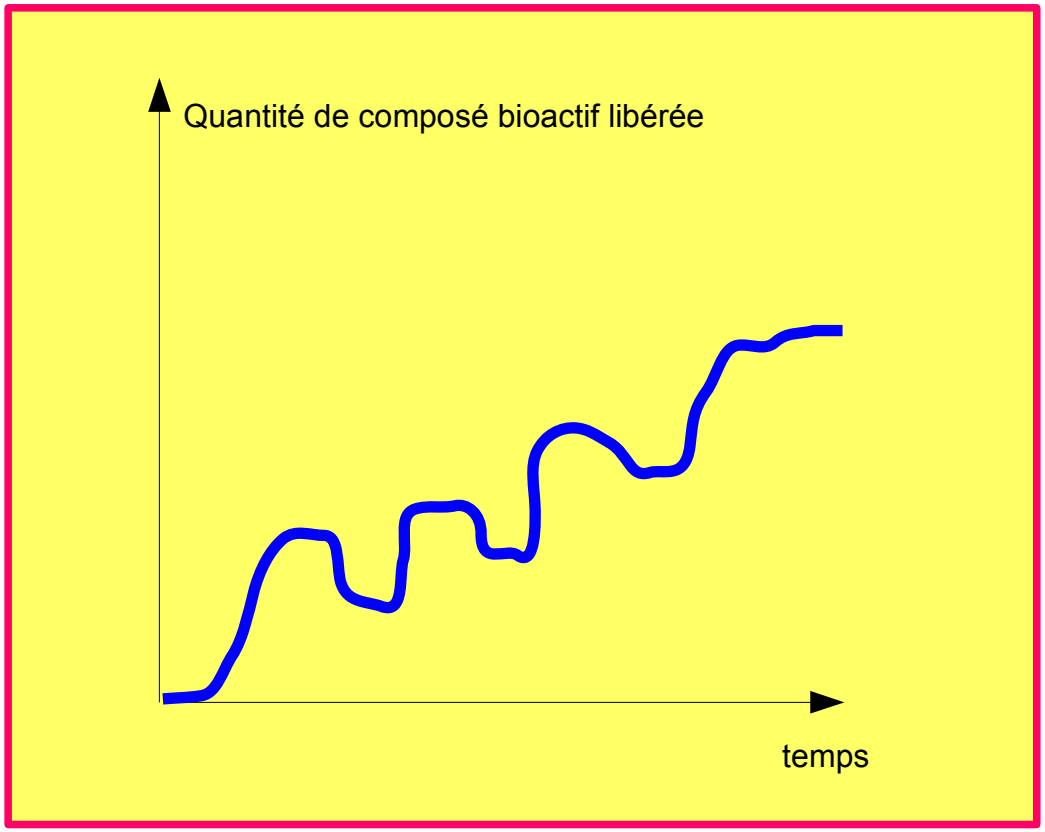
Looking for "bioactivity"



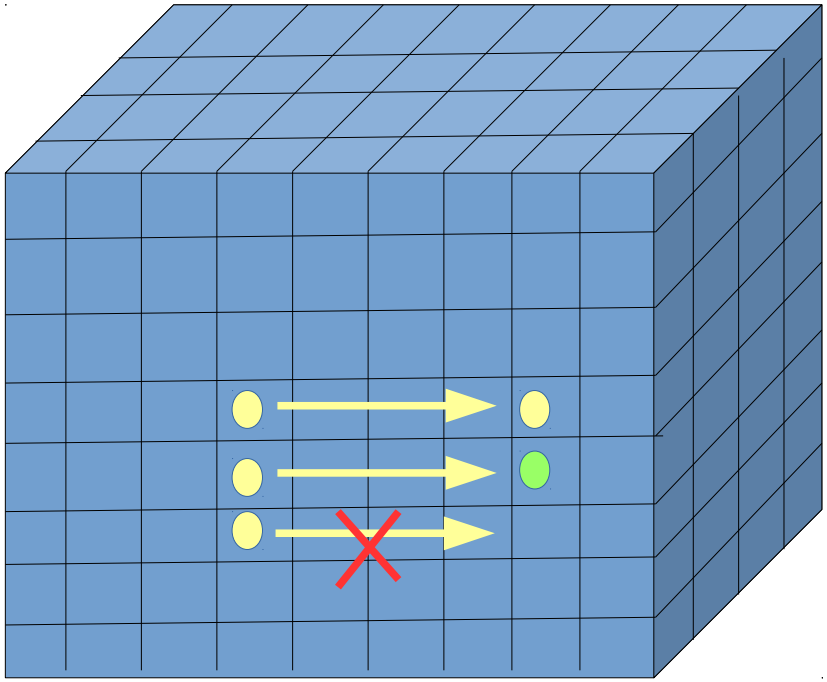




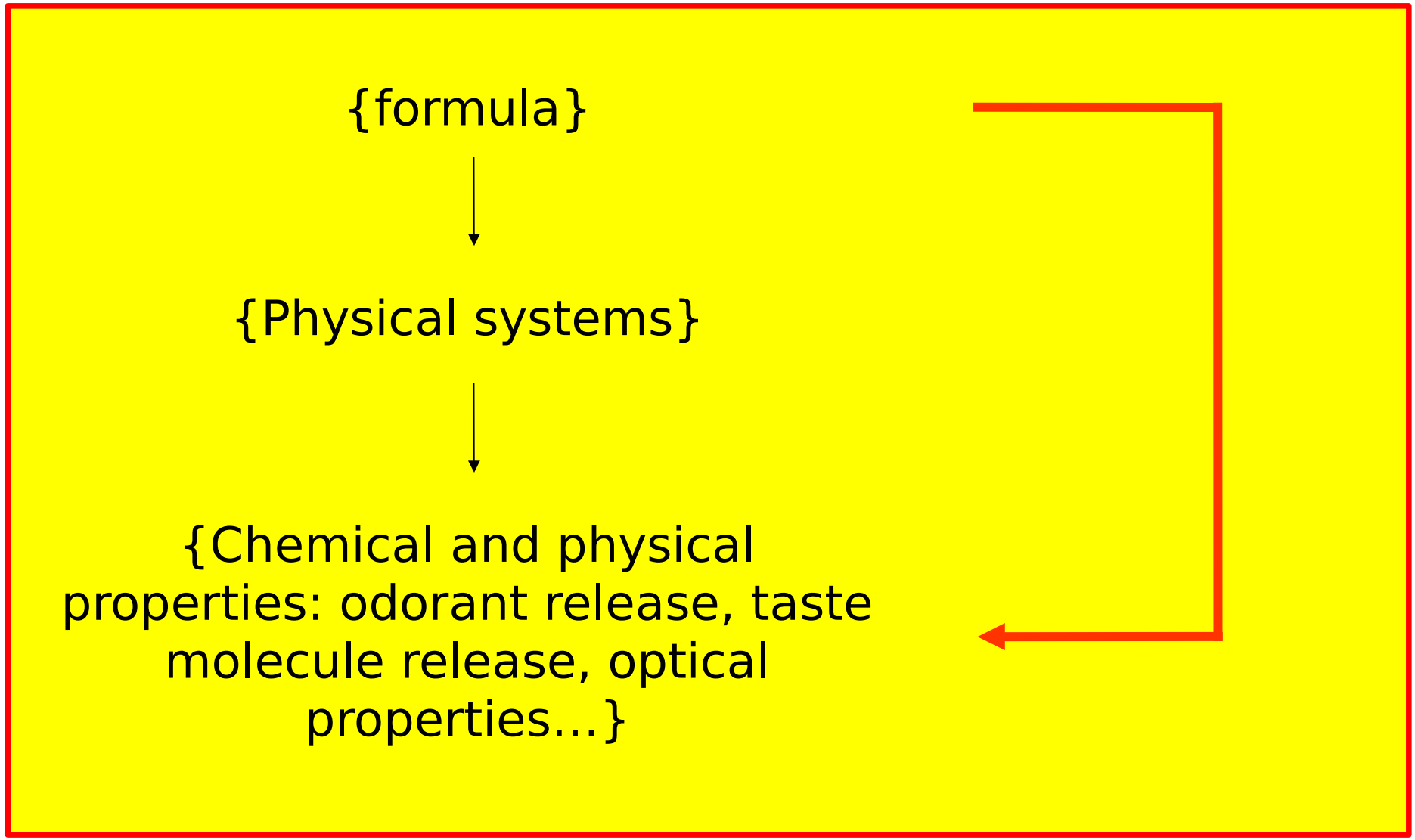
Can we do this ? (yes)



Without forgetting chemistry !



And the main issue of bioactivity



Many friends contributed

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How to study this question in practice

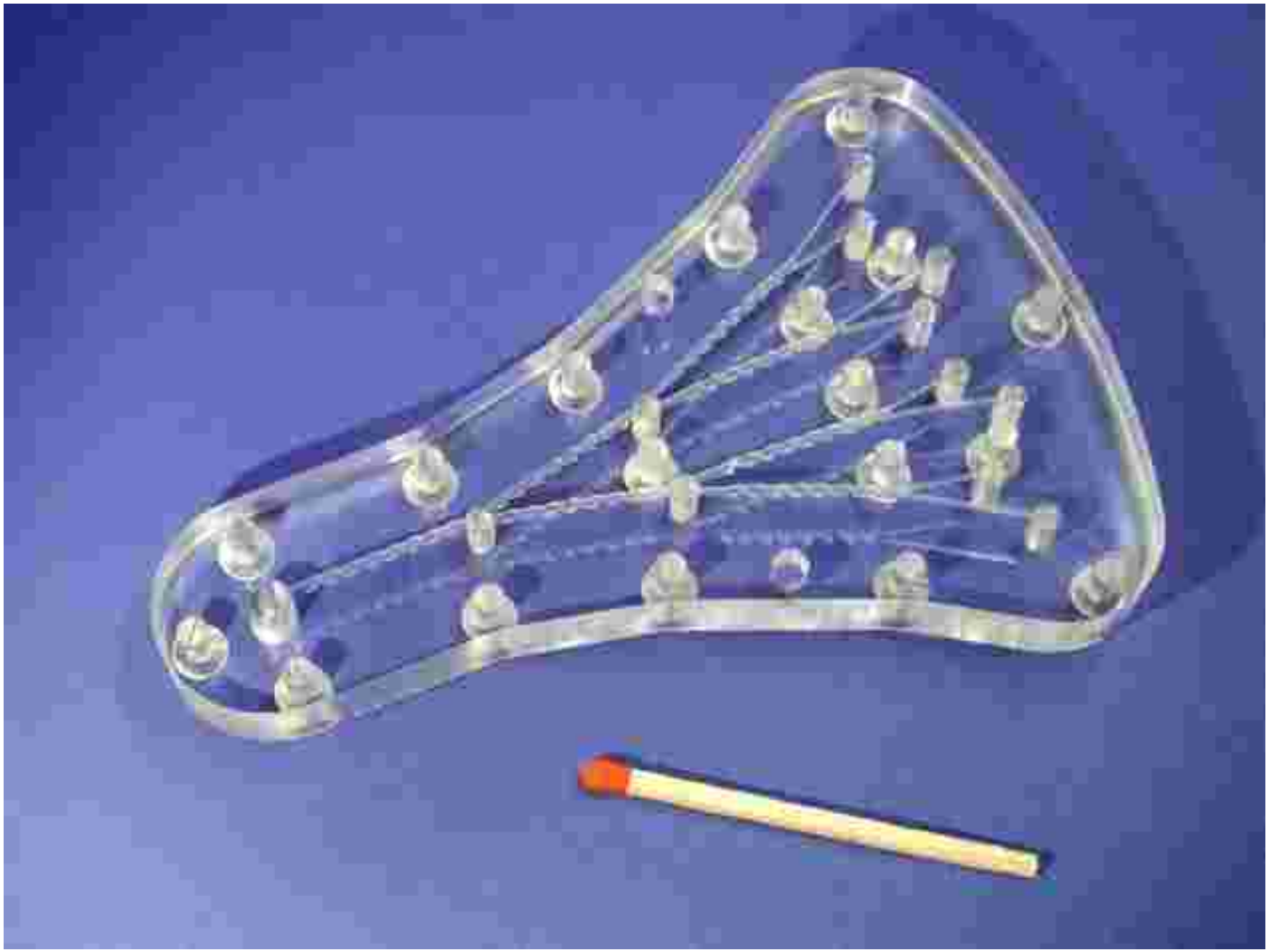
(G + O + S) / W

Mai 2003, Frankfurt, Germany

Cocktails, sauces, dishes

November 2003 : home "pianocktail"

500 billions of possibilities

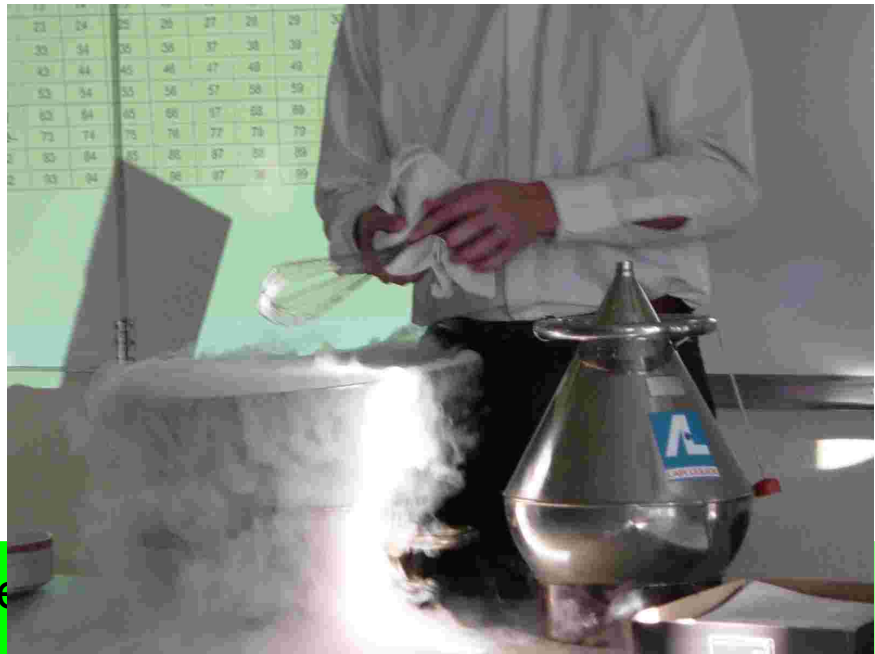


2.

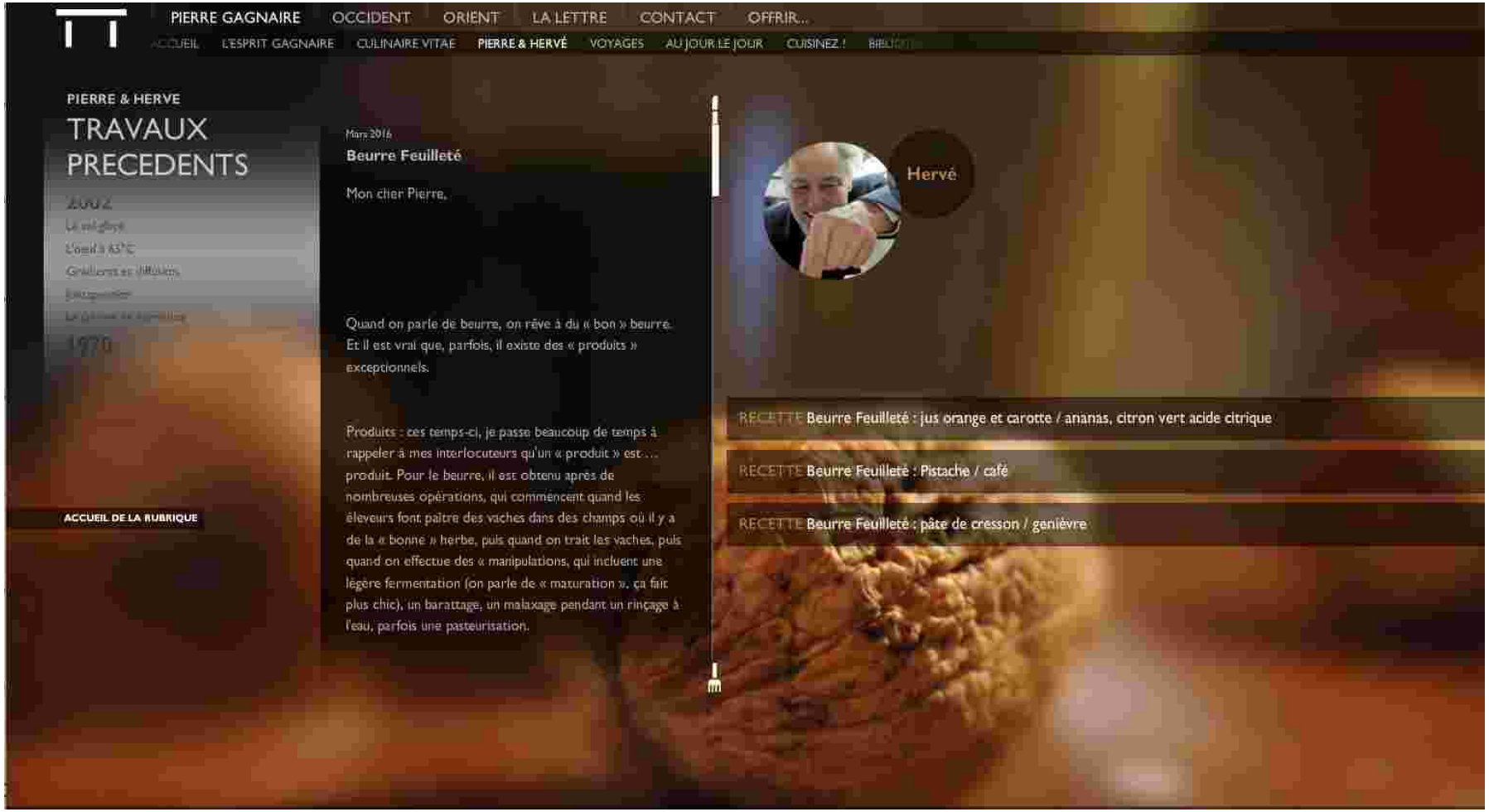
Applications

First, Molecular Cooking since 1980

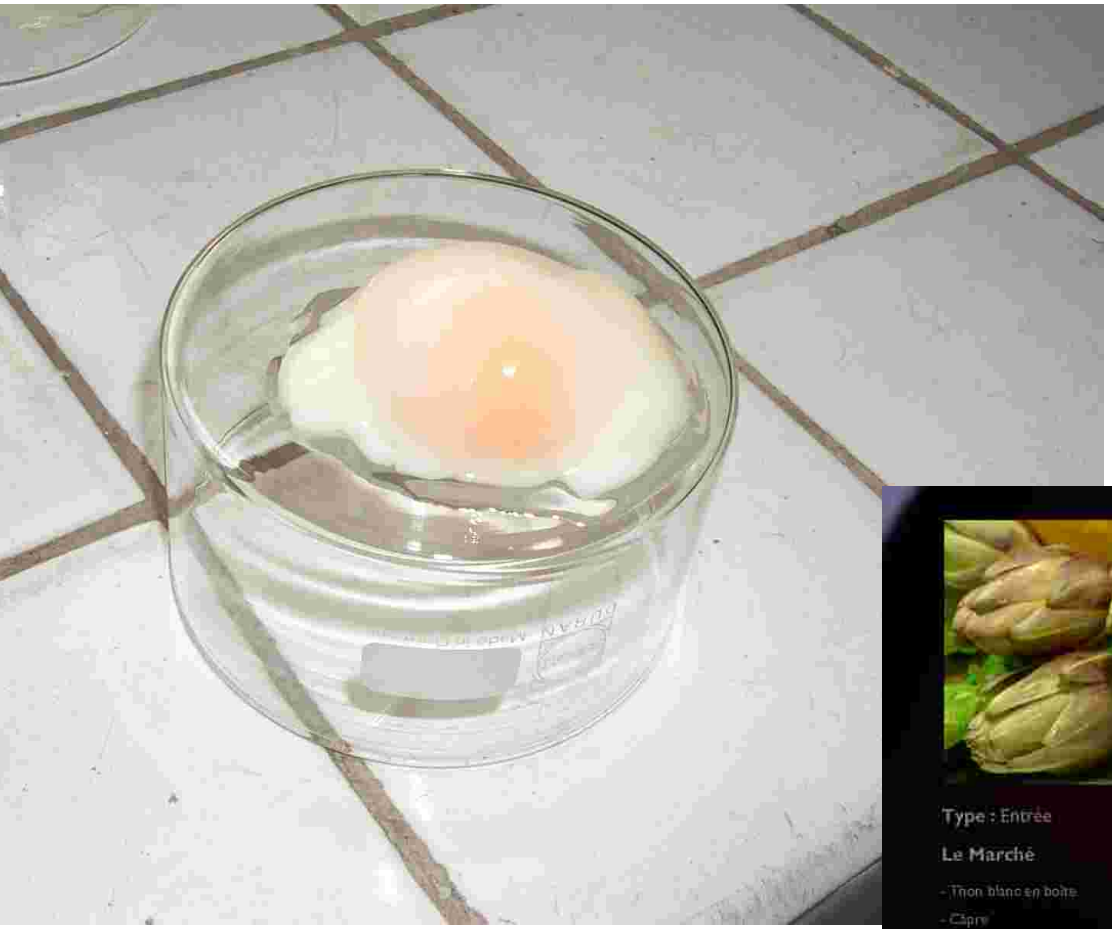
The definition :
Molecular Cooking means using new tools

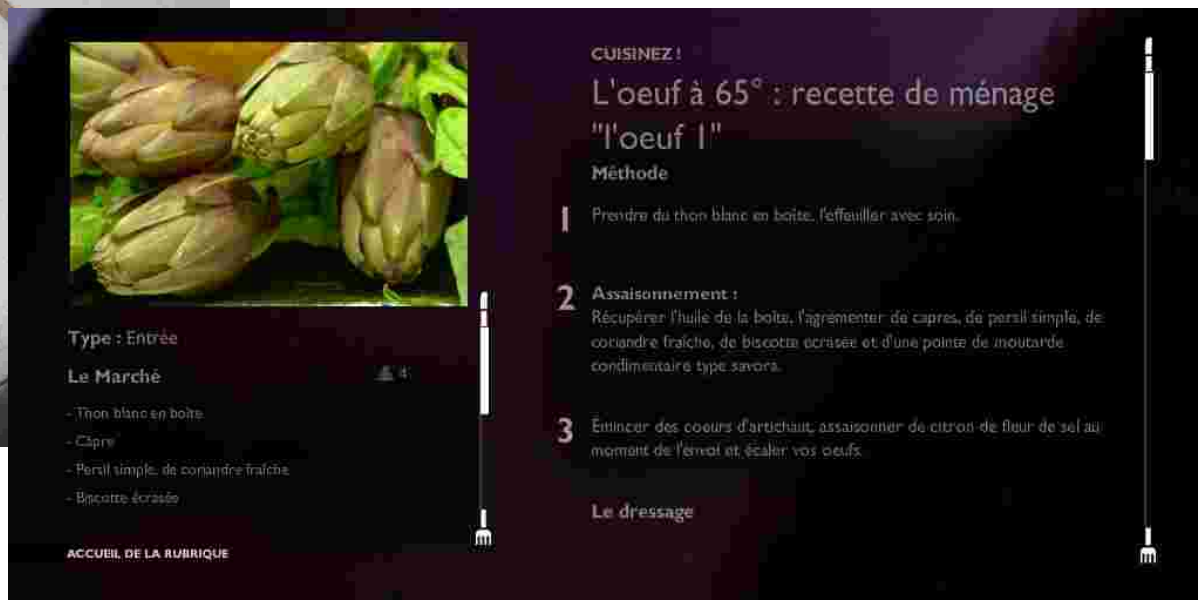


One invention per month since 1999

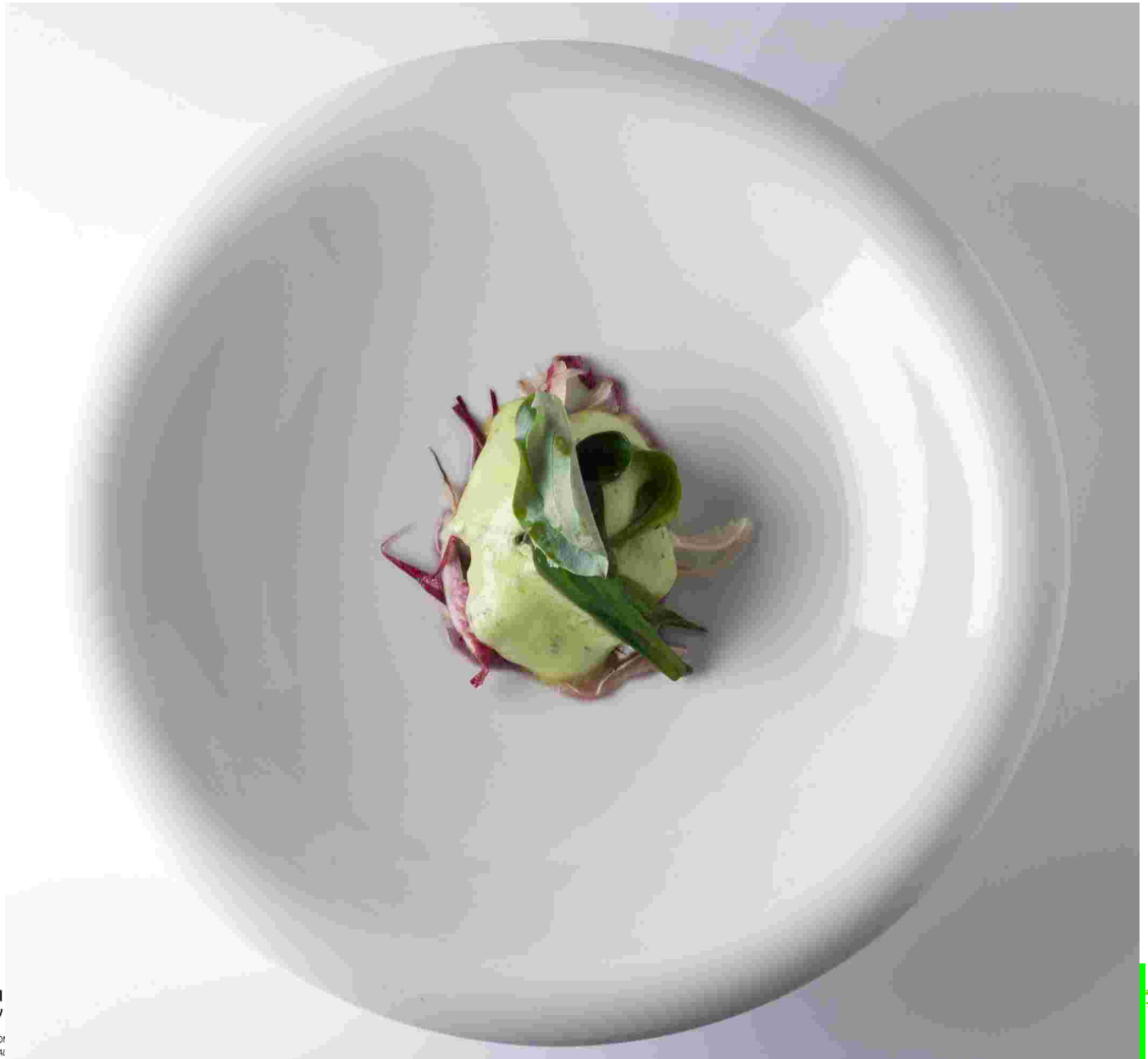


The egg at 6X °C





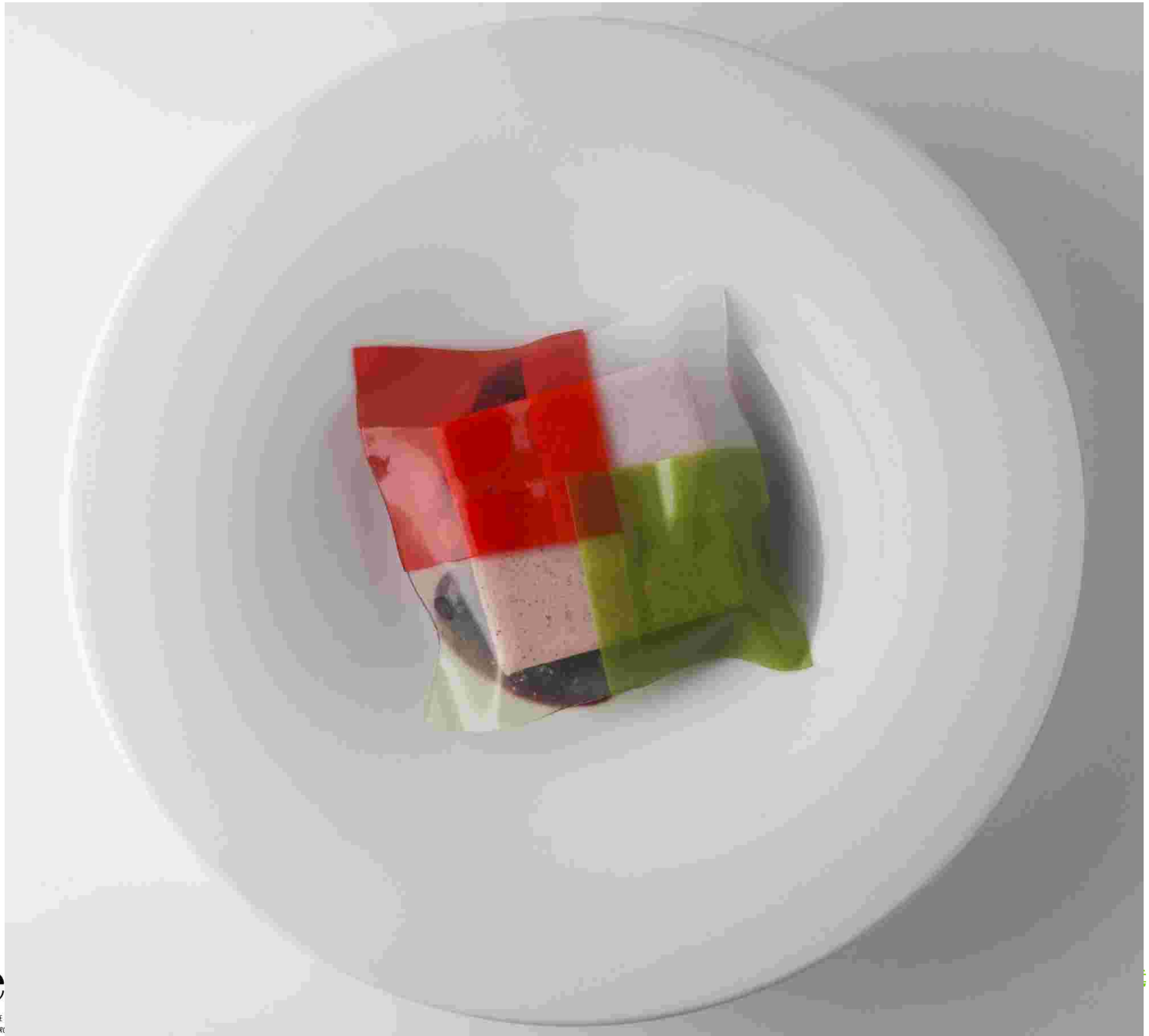
Liebig



Priestley

Wurtz

Salade à la Nollet



Gibbs

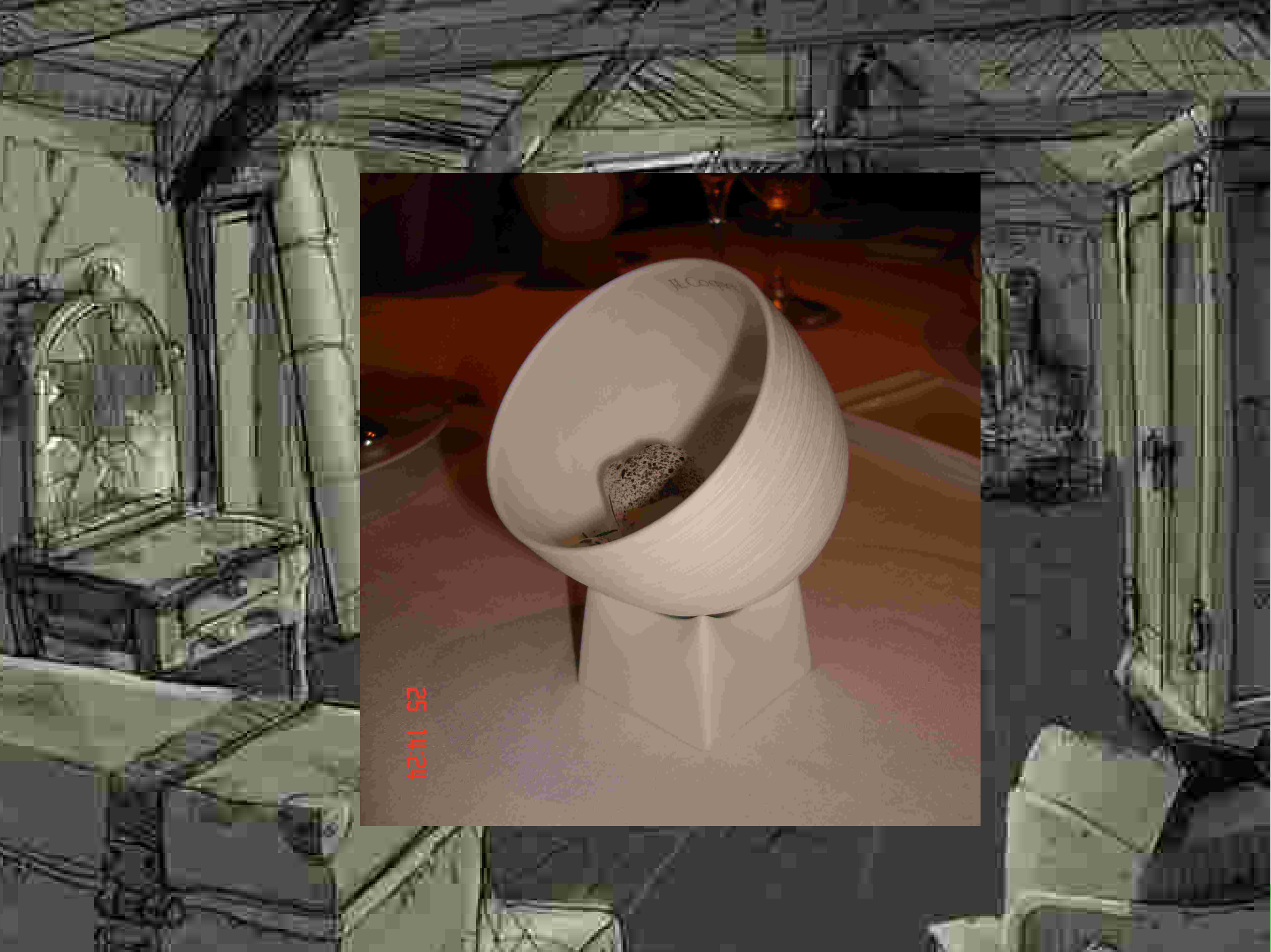
Chocolate Chantilly

And many others...

Avogadros, lavoisier, baumé, berzelius, braconnot, cailletets, caventoux, chaptals, chateliers, chevreuls, debyes, descartes, diracs, faradays, ficks, faradays, florys, gay-lussacs, gauss, de gennes, goefroys, gibbs, graham, kesselmeyer, laplaces, liebigs, maillards, mendeleievs, metchnikoffs, nollets, onnes, parés, parmentiers, pasteurs, péliggots, poiseuilles, pravaz, priestleys, quesnays, roux, thenards, vauquelins, wöhler, wurtz, dalton, dumas...

Forget it, even if it's funny


25 14:17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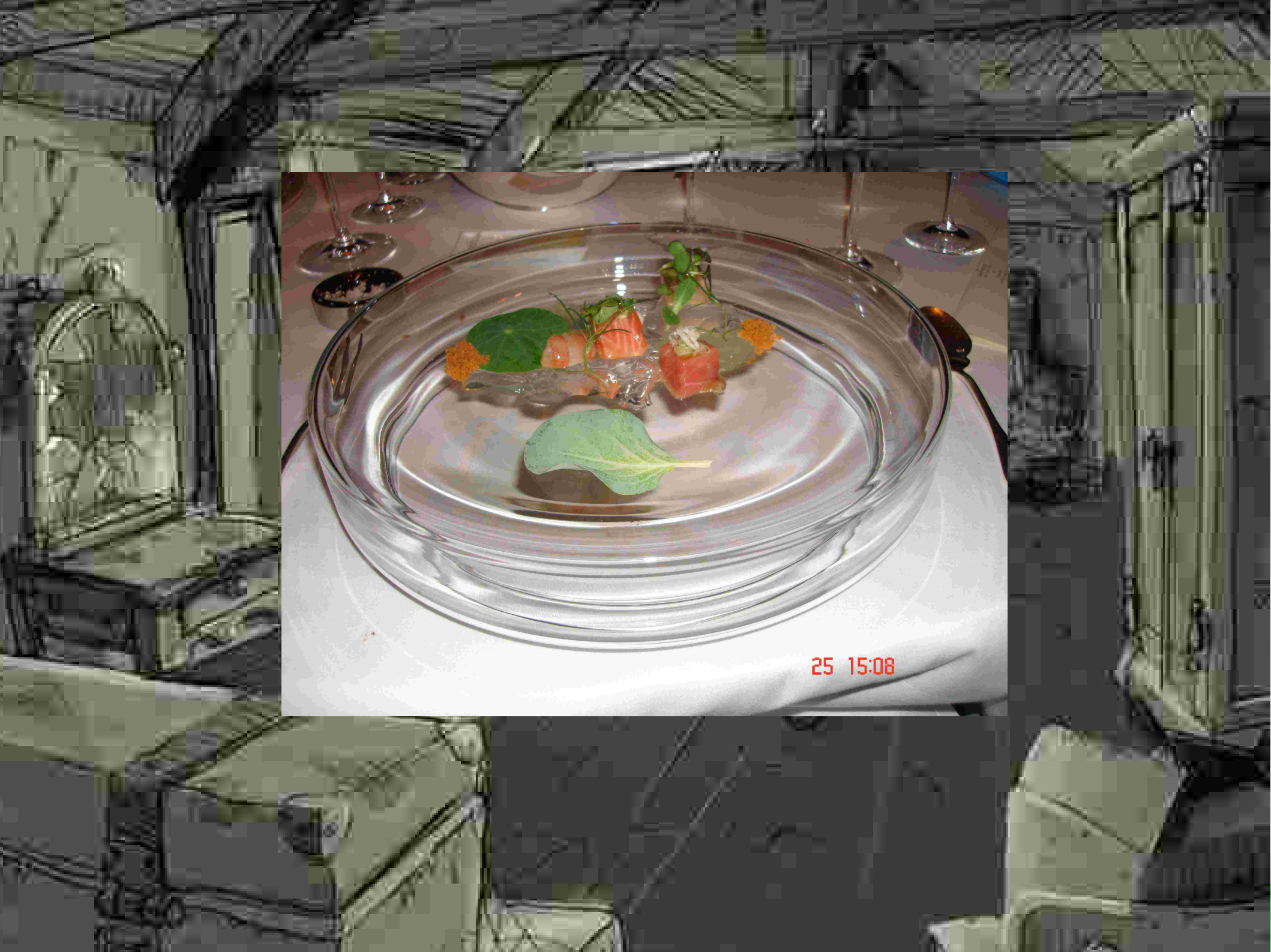
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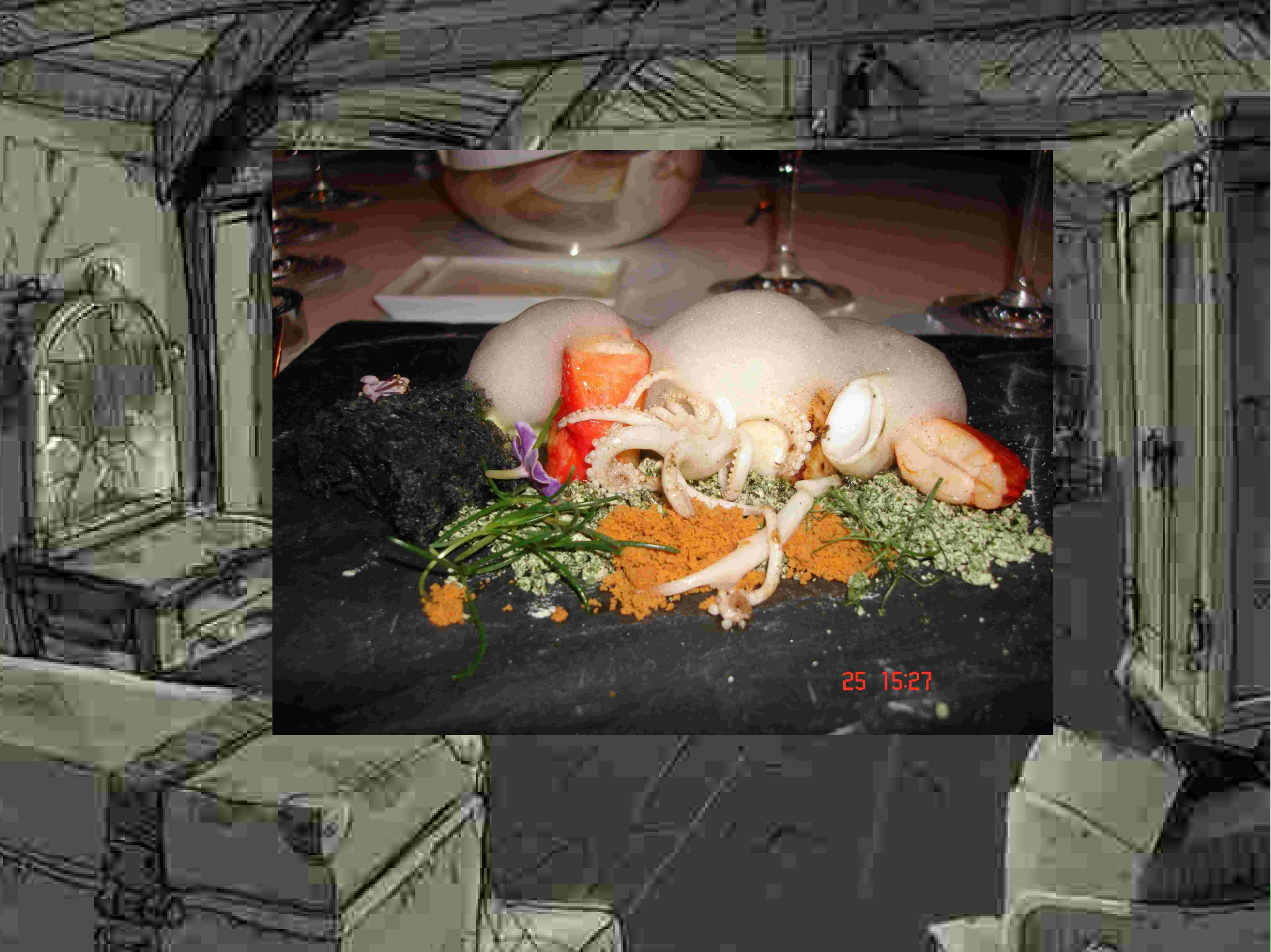
25 15:27


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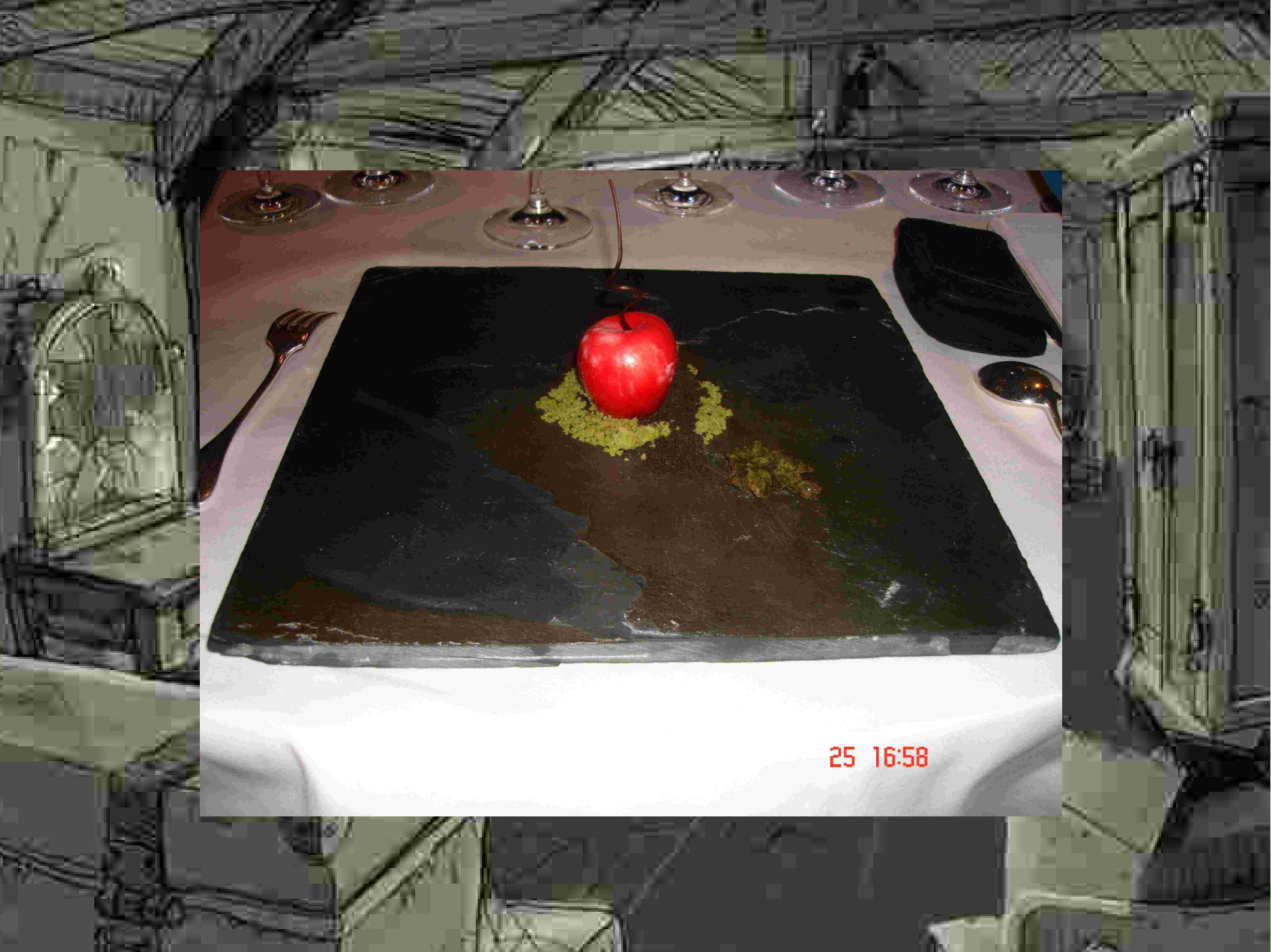
25 16:18


25 16:19


25 16:33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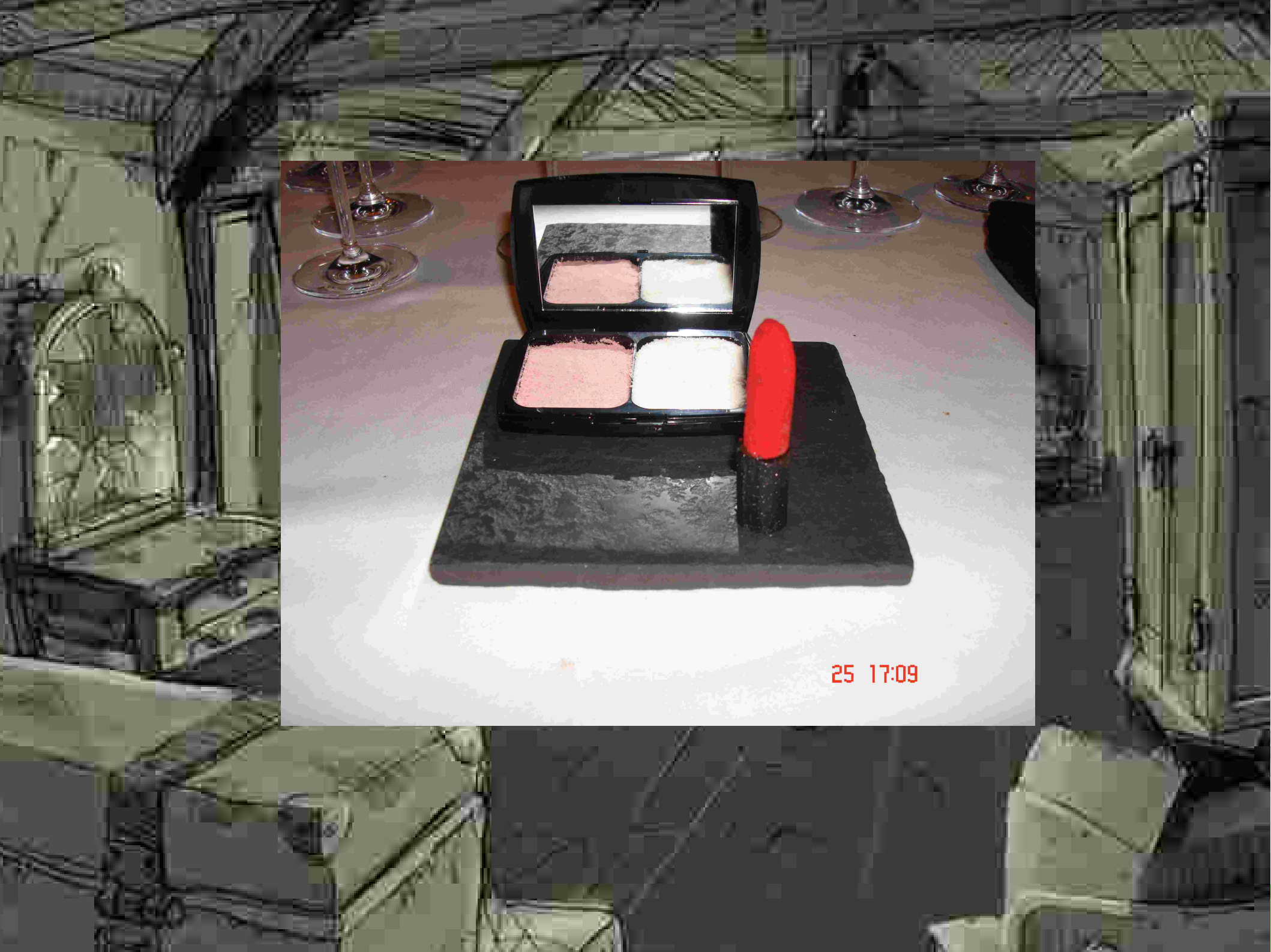
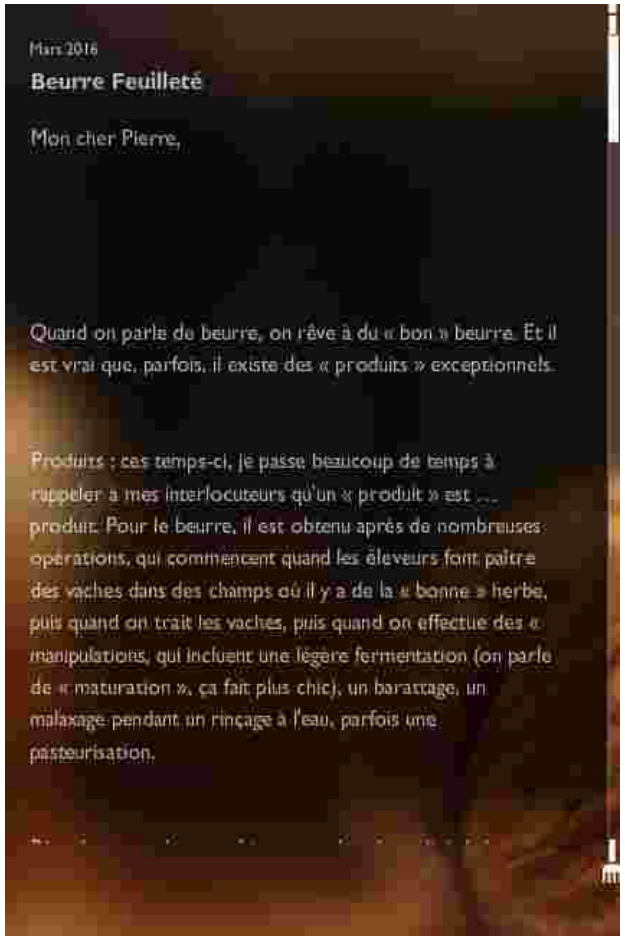

25 17:09

The latest, with my friend Pierre

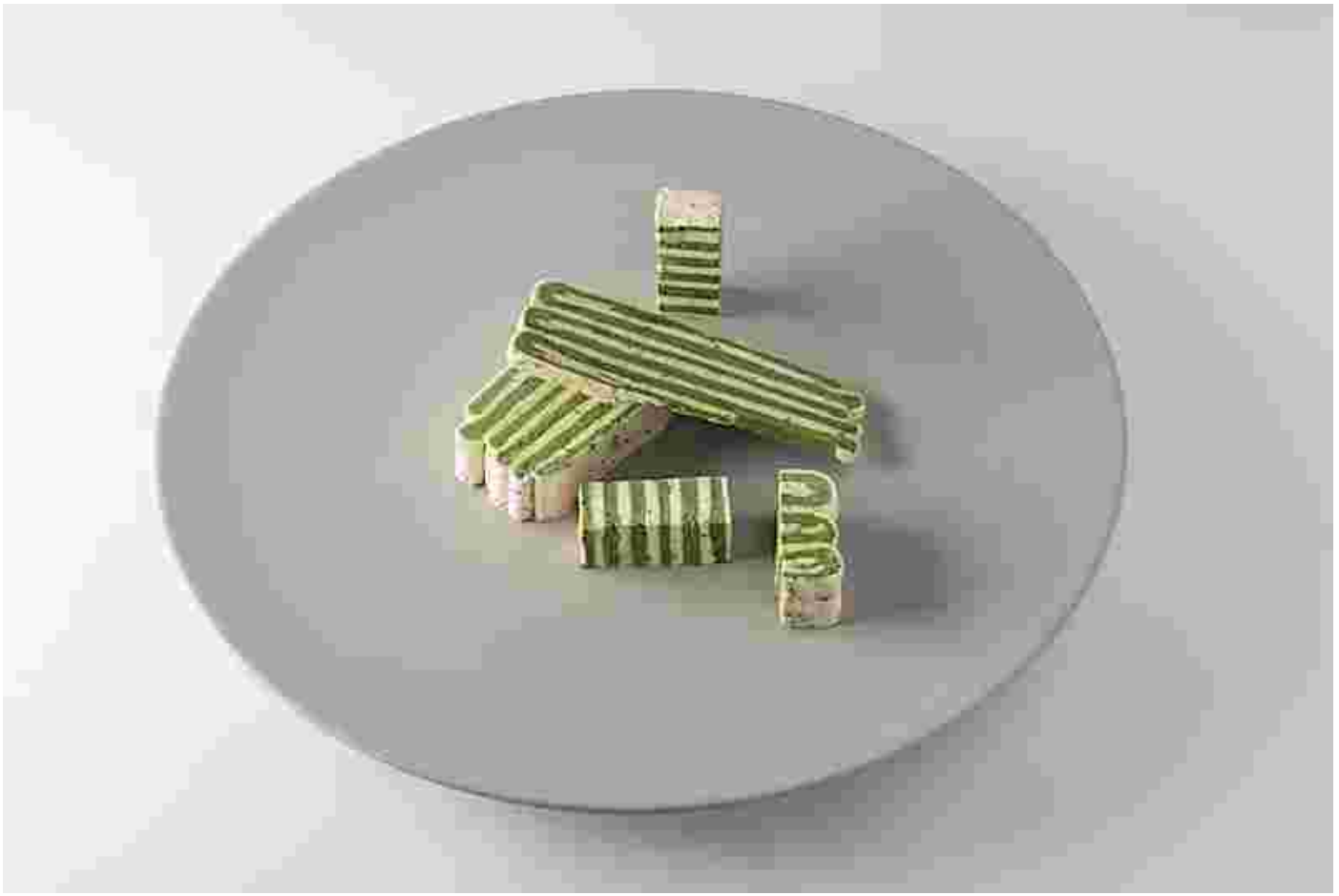

Mars 2016

Beurre Feuilleté

Mon cher Pierre,

Quand on parle de beurre, on rêve à du « bon » beurre. Et il est vrai que, parfois, il existe des « produits » exceptionnels.

Produits : ces temps-ci, je passe beaucoup de temps à rappeler à mes interlocuteurs qu'un « produit » est … produit. Pour le beurre, il est obtenu après de nombreuses opérations, qui commencent quand les éleveurs font paître des vaches dans des champs où il y a de la « bonne » herbe, puis quand on trait les vaches, puis quand on effectue des « manipulations, qui incluent une légère fermentation (on parle de « maturation », ça fait plus chic), un barattage, un malaxage pendant un rinçage à l'eau, parfois une pasteurisation.



All this is over

Note by Note Cooking was first proposed in 1994

glucose.

Pour le «gastronome moléculaire», la découverte la plus intéressante était sans doute que la vanilline (le principal composé aromatique de la vanille) était un produit final de dégradation de la lignine. On perçoit d'ailleurs des notes vanillées dans les vieux cognacs, dans les vieux rhums ou dans les vieux whiskies. La loi interdit aux fabricants de vins et de spiritueux d'améliorer le goût de leurs produits en ajoutant des composés chimiques, mais le consommateur est libre de s'amuser à utiliser des résultats scientifiques pour transformer les produits qu'il consomme. Il peut, notamment, ajouter de l'extrait de vanille liquide dans des alcools trop jeunes (deux ou trois gouttes par bouteille suffisent).

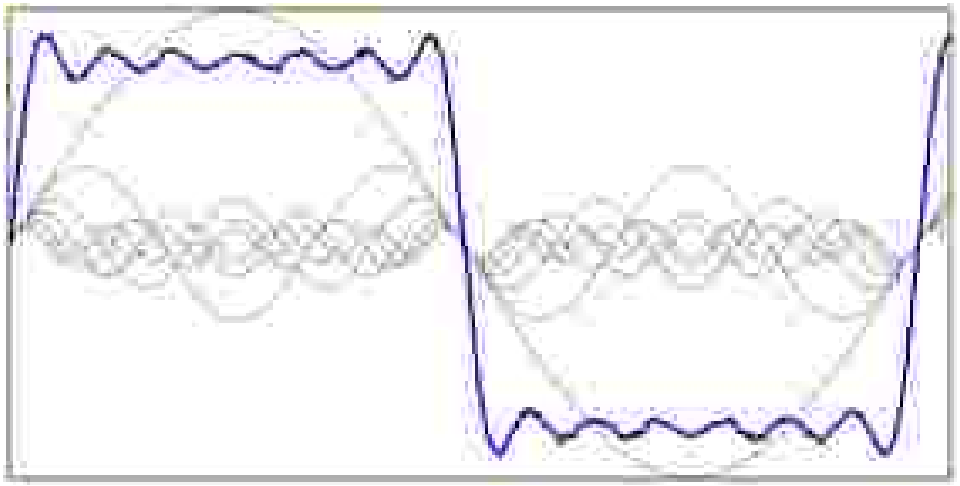
Ce type d'expérience pourrait être généralisé à de nombreuses boissons ou plats préparés à domicile. Les livres de cuisine du futur contiendront-ils des instructions telles que «Ajoutez à votre bouillon deux gouttes d'une solution dans l'alcool de [illegible] à 0,001 pour cent» ? La proposition n'est pas insensée : depuis toujours, les cuisiniers et les cuisinières modifient le goût de leurs plats en ajoutant des épices et des herbes aromatiques, qui ne sont en fait que des conditionnements particuliers de mélanges de molécules aromatiques.

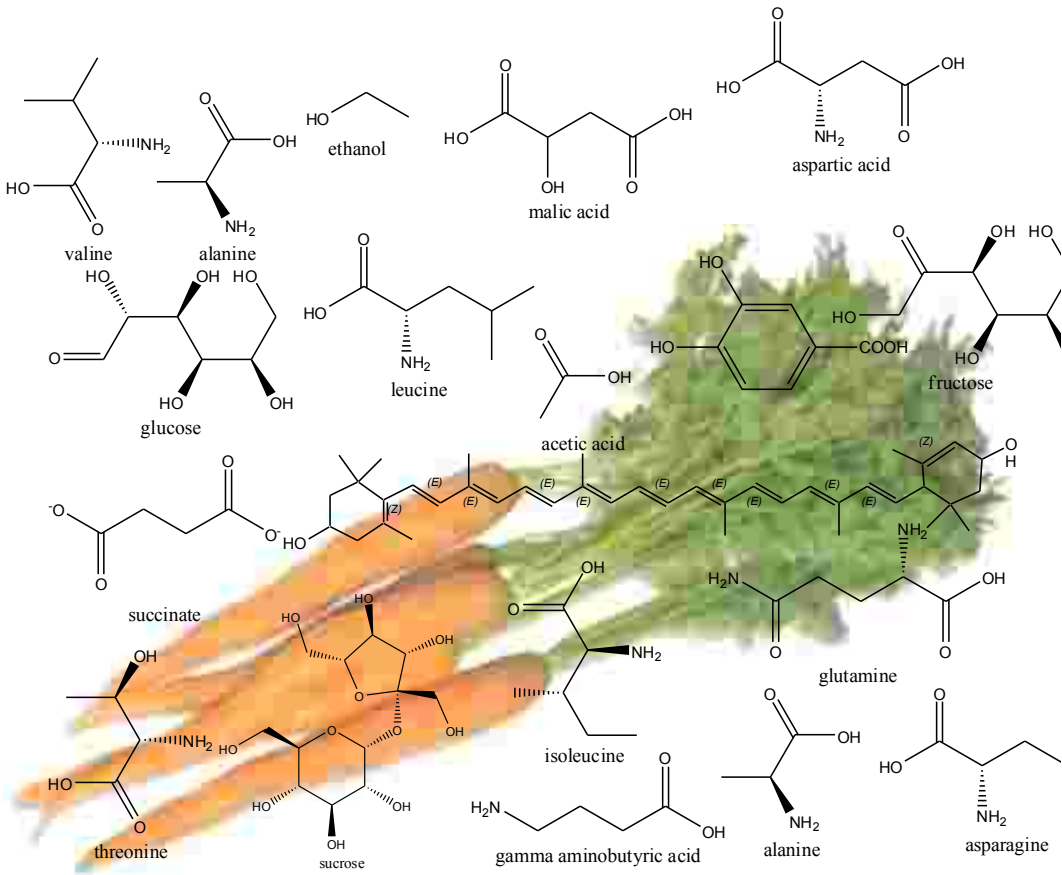
La science explique et ana-

The idea:
instead of meat, fish, vegetables and fruits, use
COMPOUNDS

A comparison with music in order to make it more obvious

Analyzing organizations





And synthesis

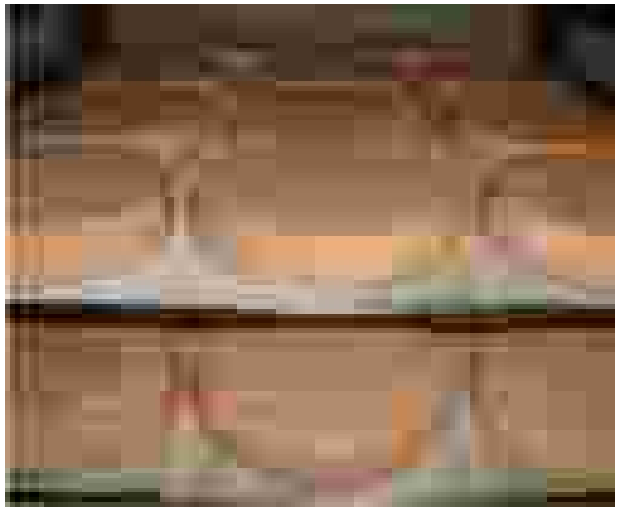
The future is clear

Why ?
Because we have to prepare the future

Some species disappear

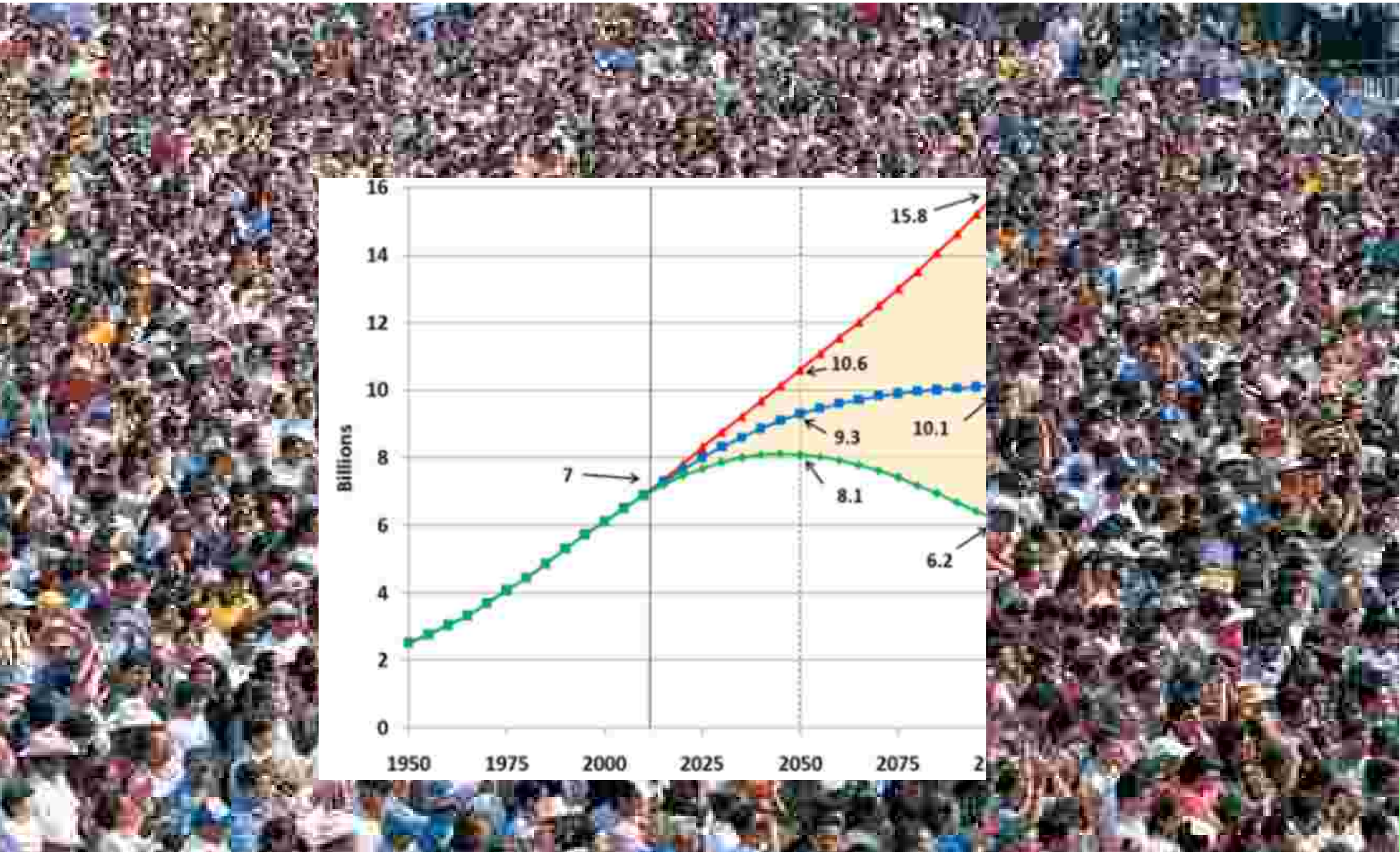
We cannot eat anything

What can we eat ?



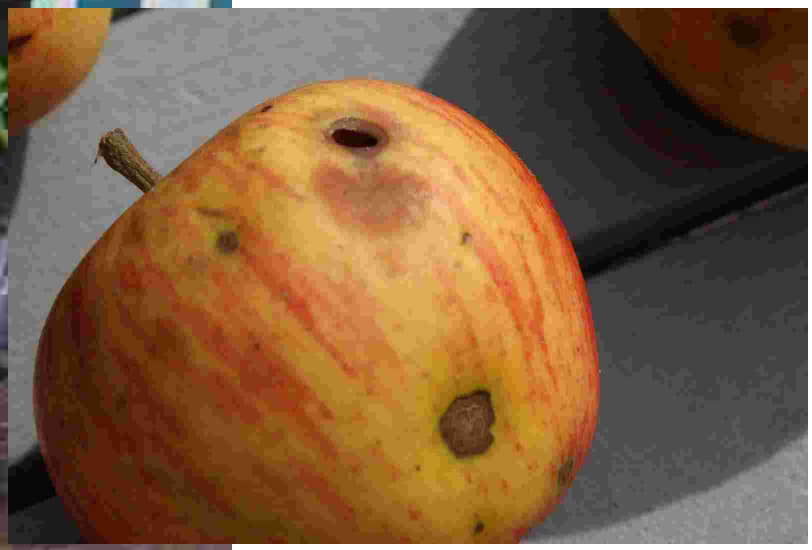
A possible energy crisis

Perhaps 10 billion people !



1/3 is spoiled!

Reasons and hope



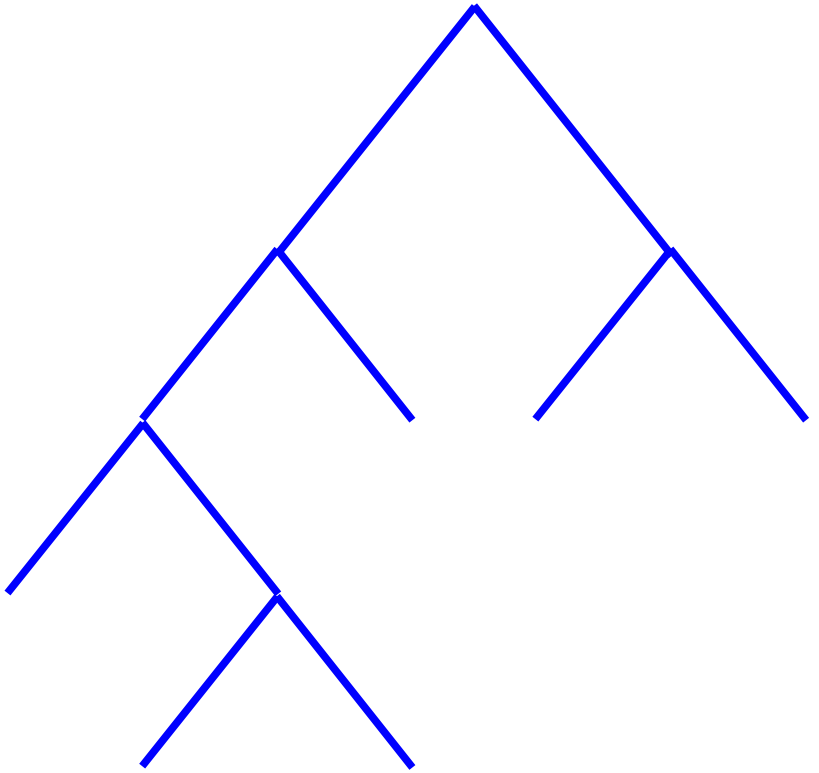
Can we avoid transporting water ?

= 95 % eau

= 85 % eau

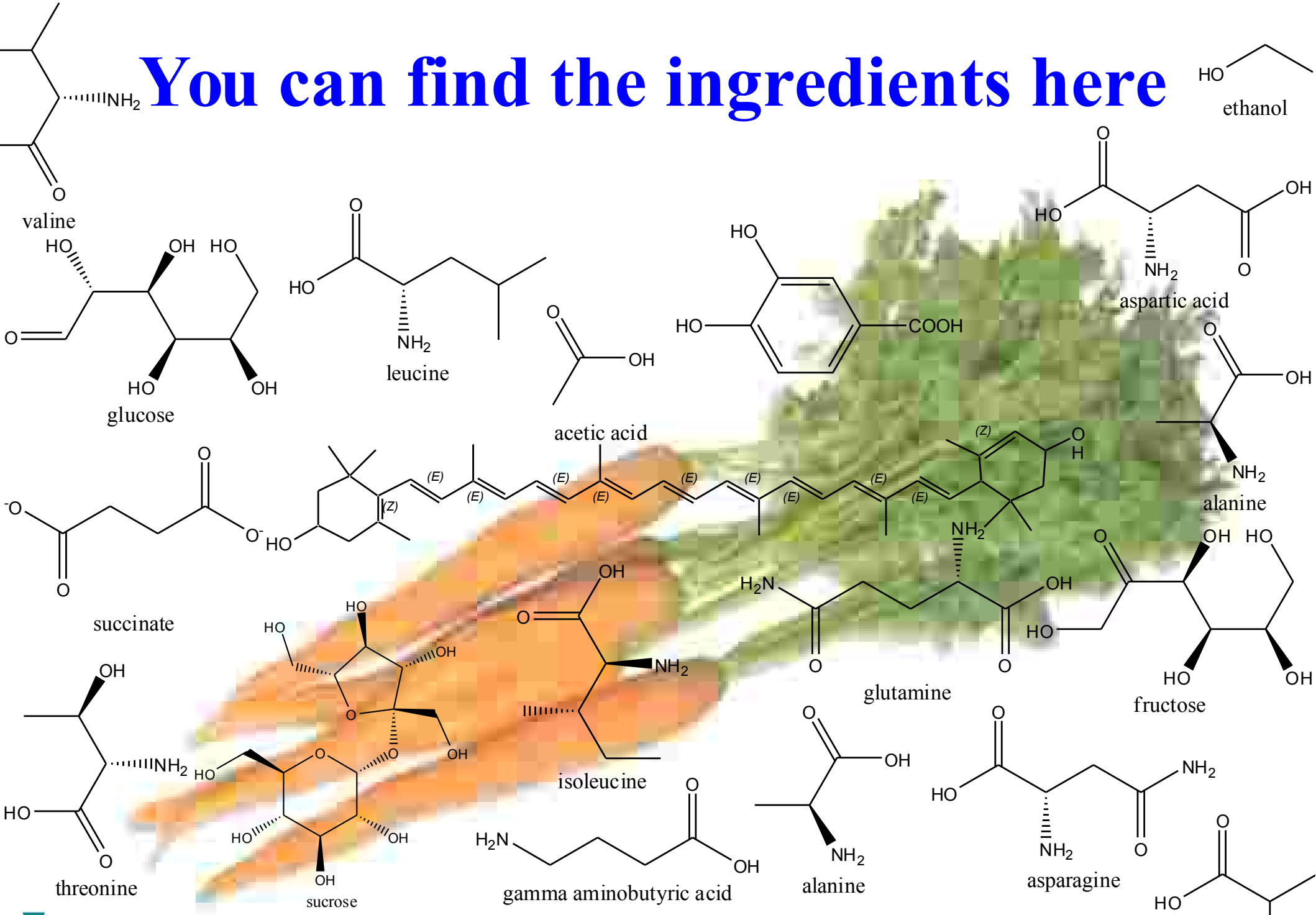
= 80 % eau

Yes : let's fractionnate

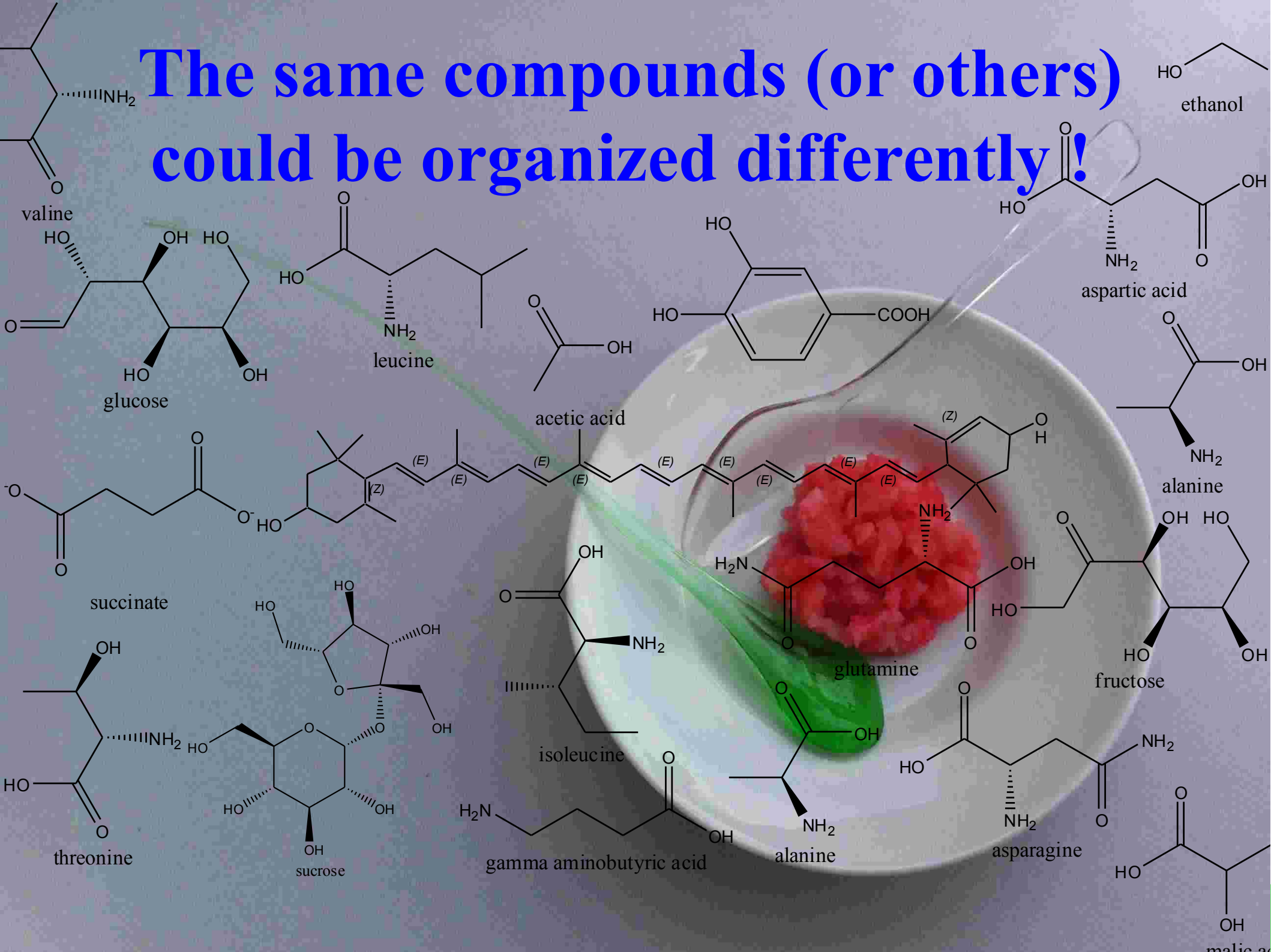


Using already existing techniques

You can find the ingredients here

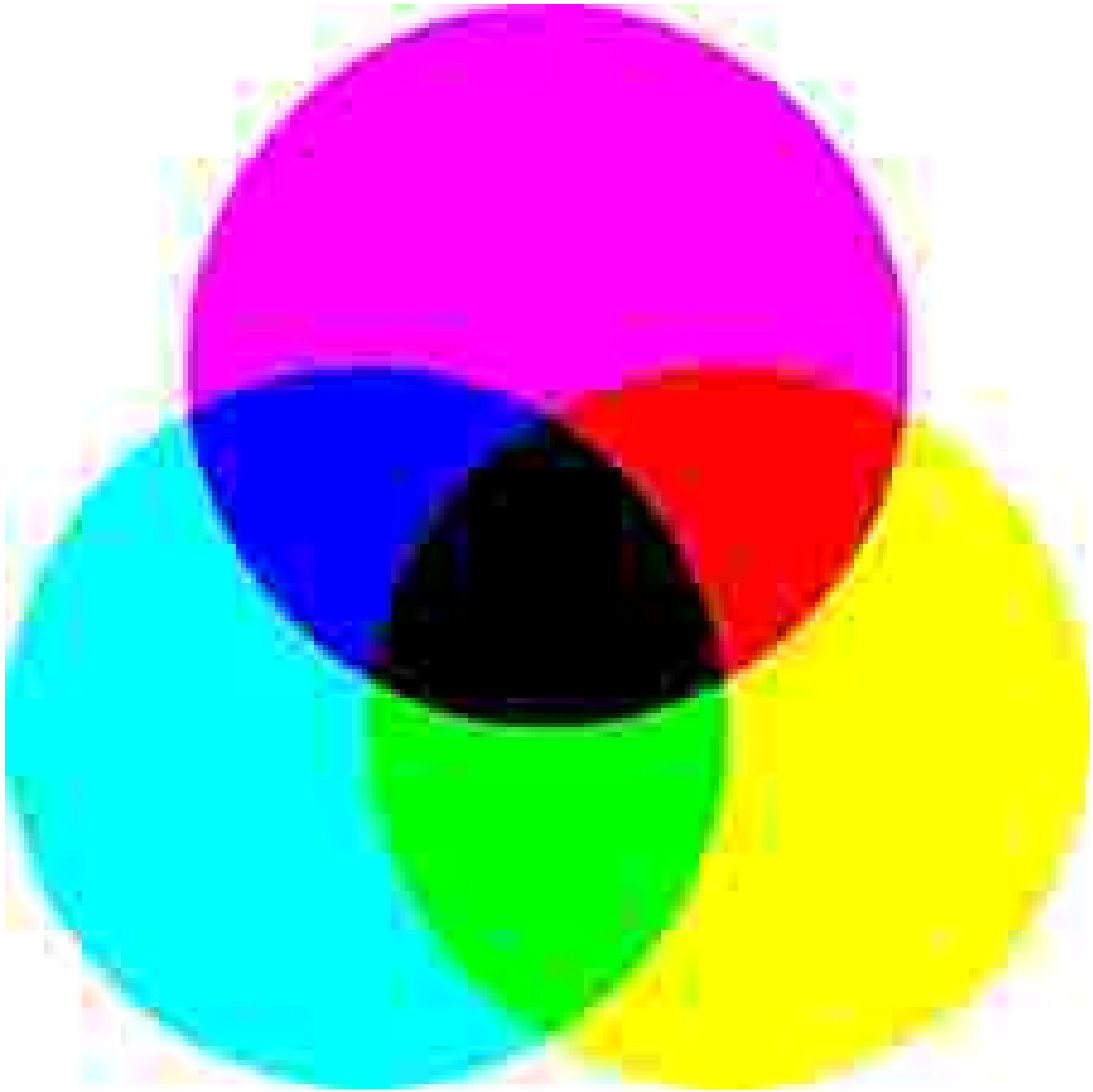


The same compounds (or others) could be organized differently!

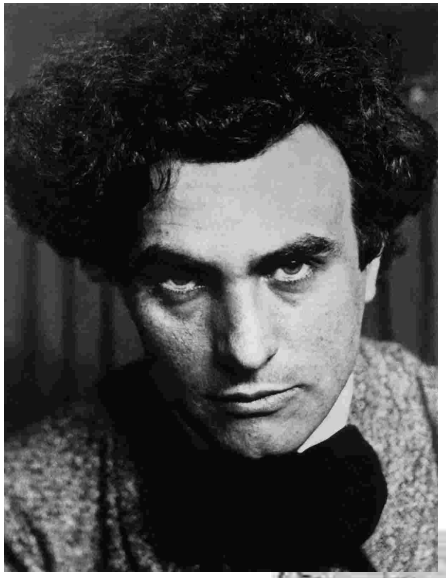


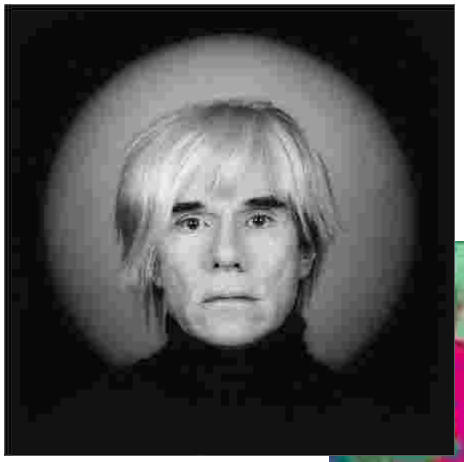
We can enrich farmers and improve sustainability

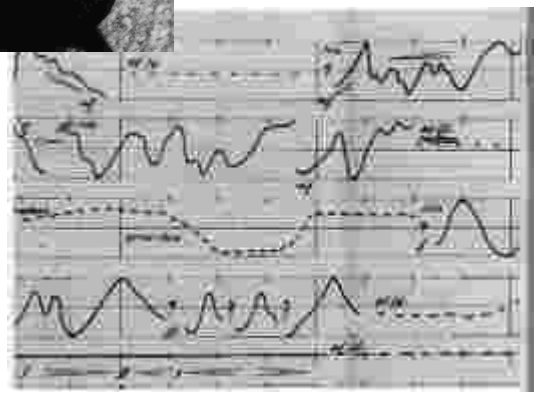
The number of possibilities is INFINITE !



Note by Note Cooking : a new Art





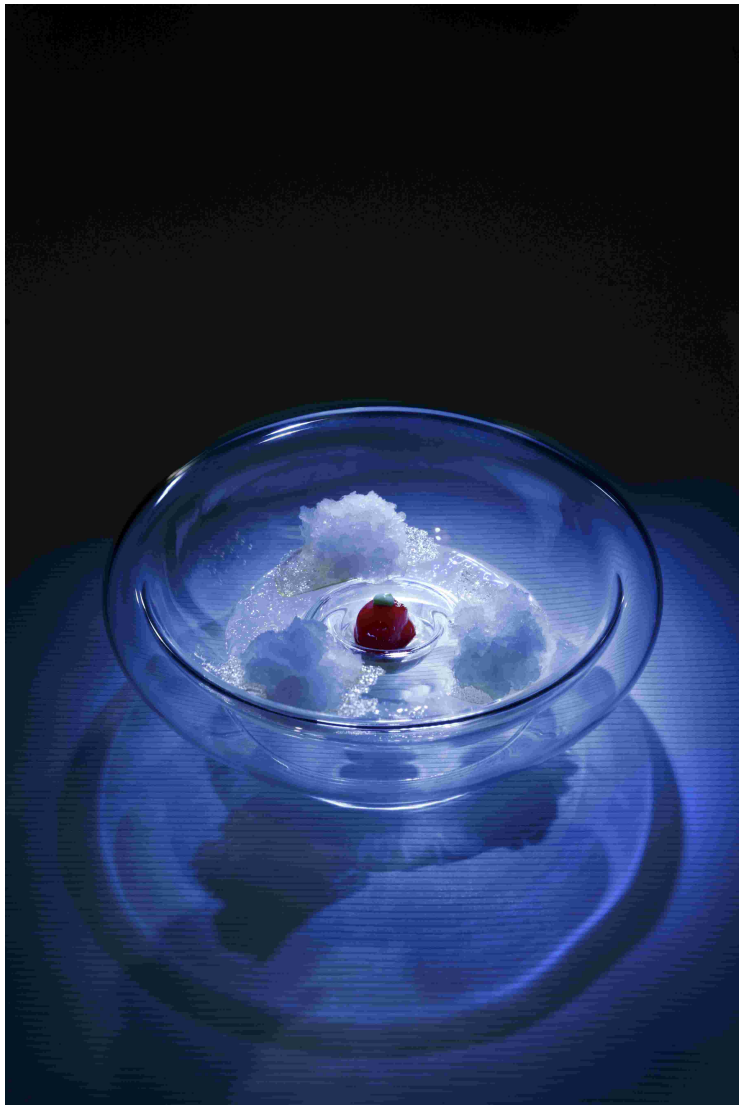


We can now learn to build food with new:

- shapes
- consistencies
- colors
- tastes
- odors
- trigeminal sensations (fresh, pungent...)
- Nutritional properties

Everything is possible
From seasoning to fully note by note

2009 : the first note by note dish ever served in a restaurant



At the Cordon bleu Paris (2010) ...

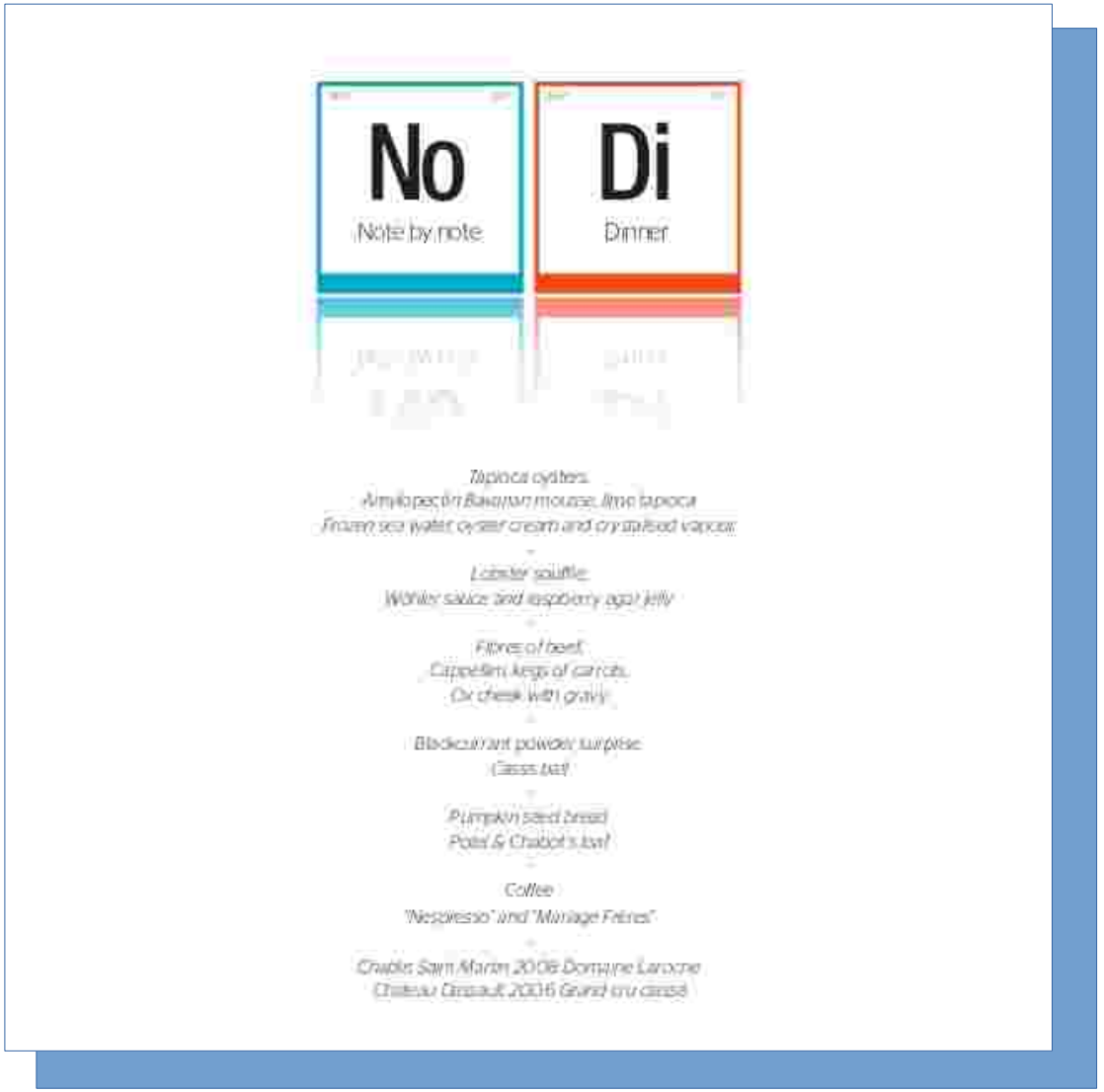

16 20:40


Ce dîner a été préparé par les Chefs Le Cordon Bleu
16 21:52


16 22:24


16 22:40

2011 : for the opening banquet of the International Year of Chemistry



AgroParisTech
INSTITUT DES SCIENCES ET INDUSTRIES DU VIVANT ET DE L'ENVIRONNEMENT
PARIS INSTITUTE OF TECHNOLOGY FOR LIFE, FOOD AND ENVIRONMENTAL SCIENCES

International Centre for Molecular Gastronomy

INRA
SCIENCE & IMPACT

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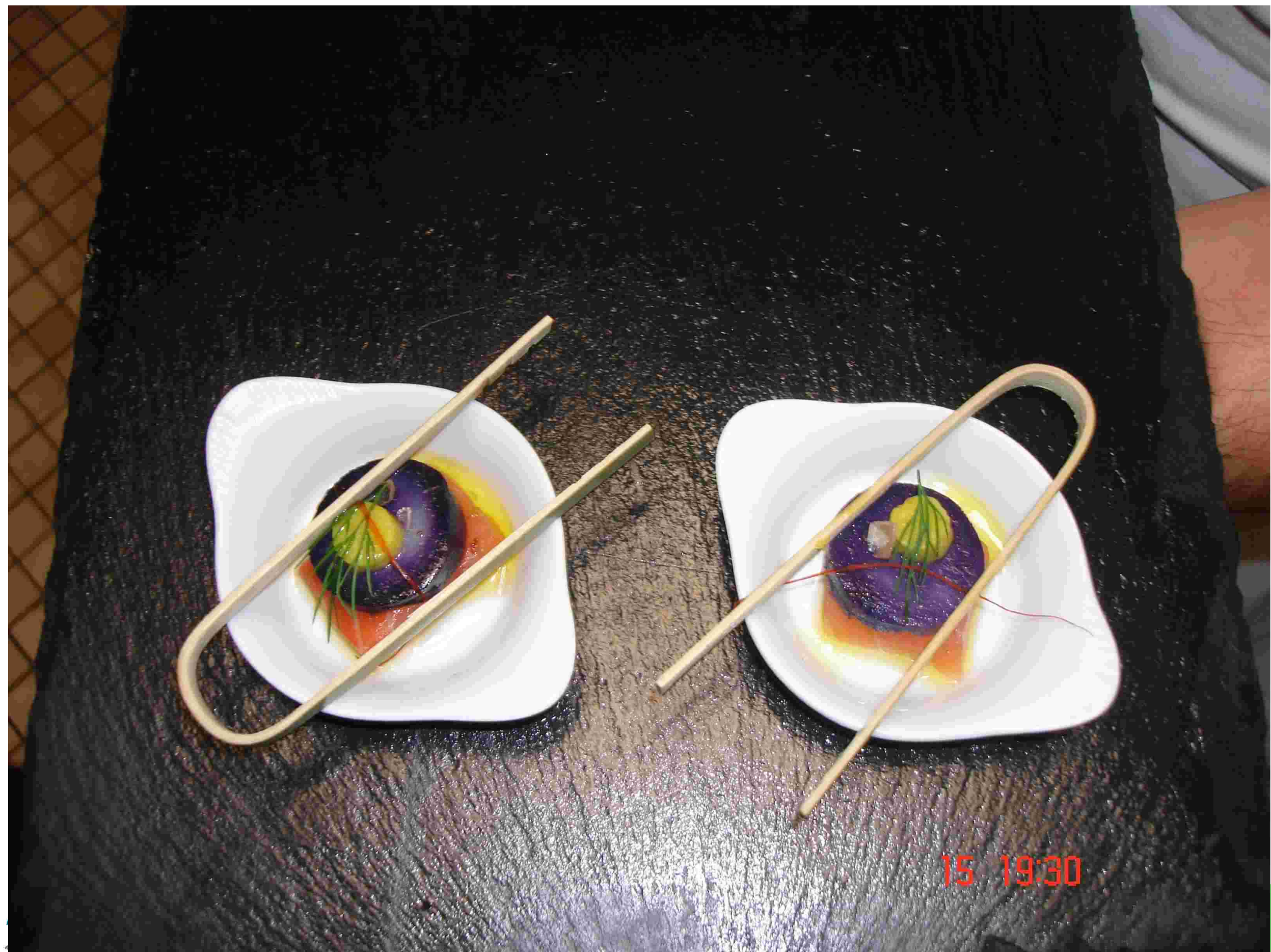
International Centre for Molecular Gastronomy

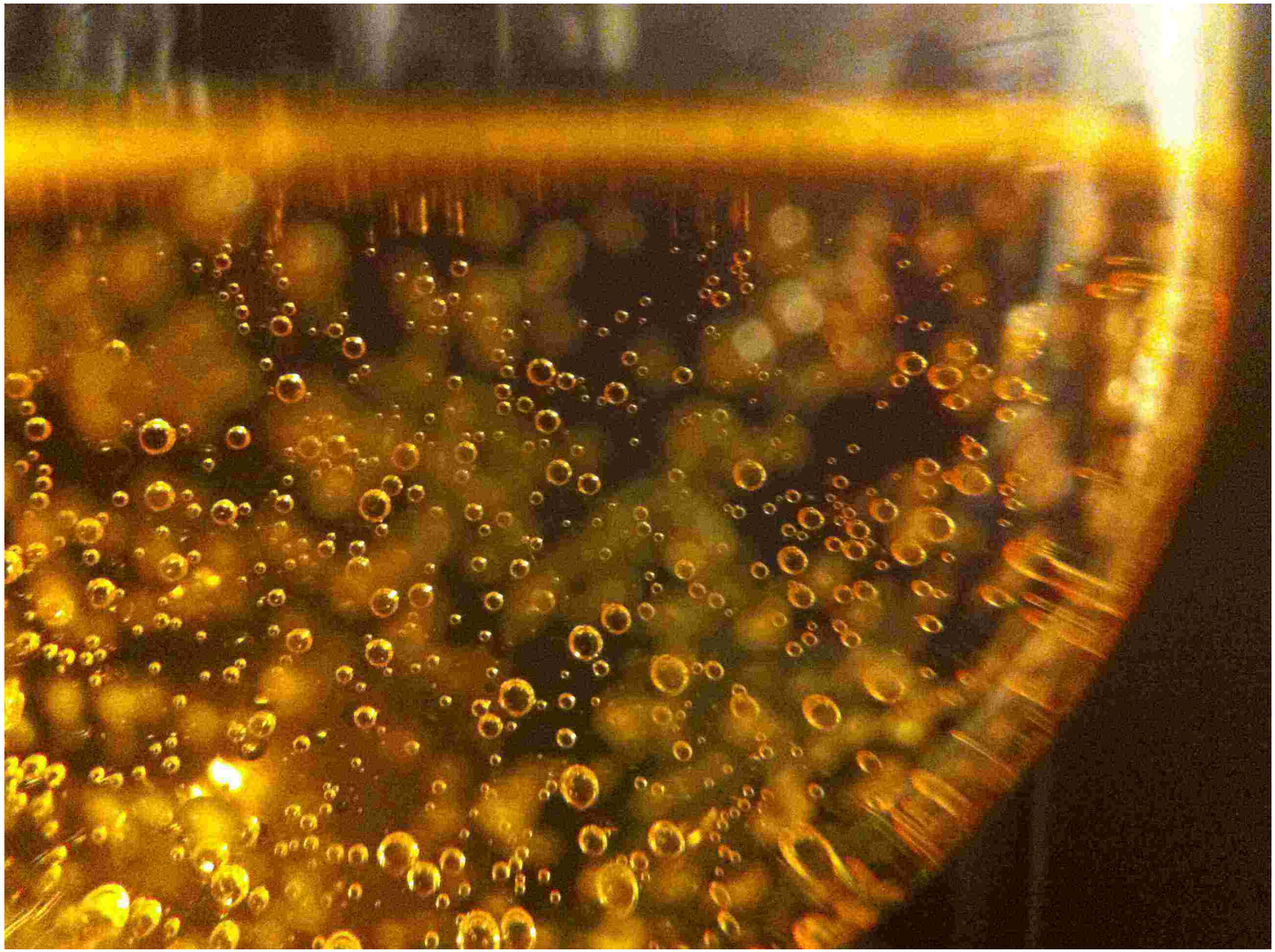
INRA
SCIENCE & IMPACT

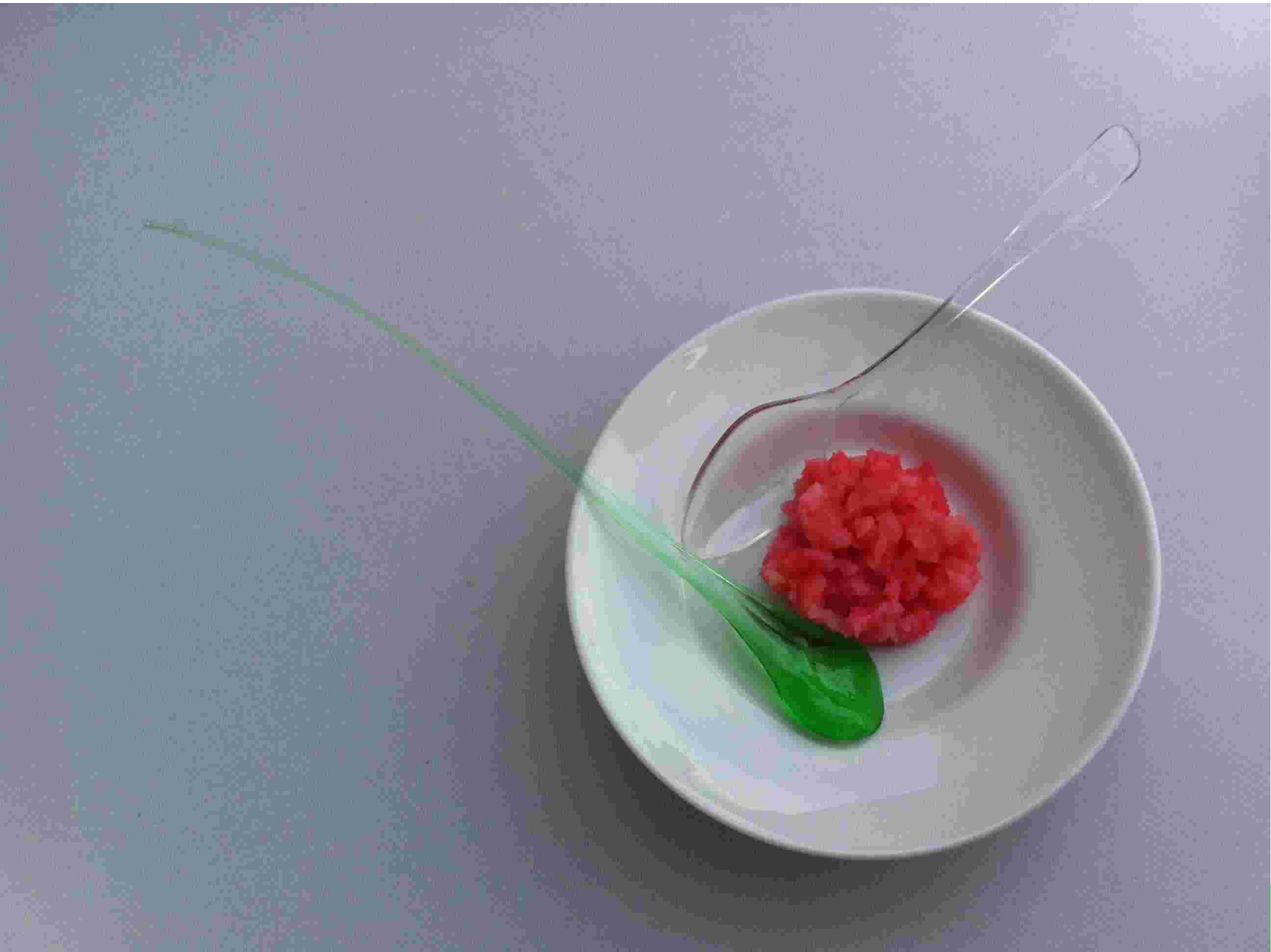
Le Corbon Bleu Paris, 11 octobre 2011


15 19:30

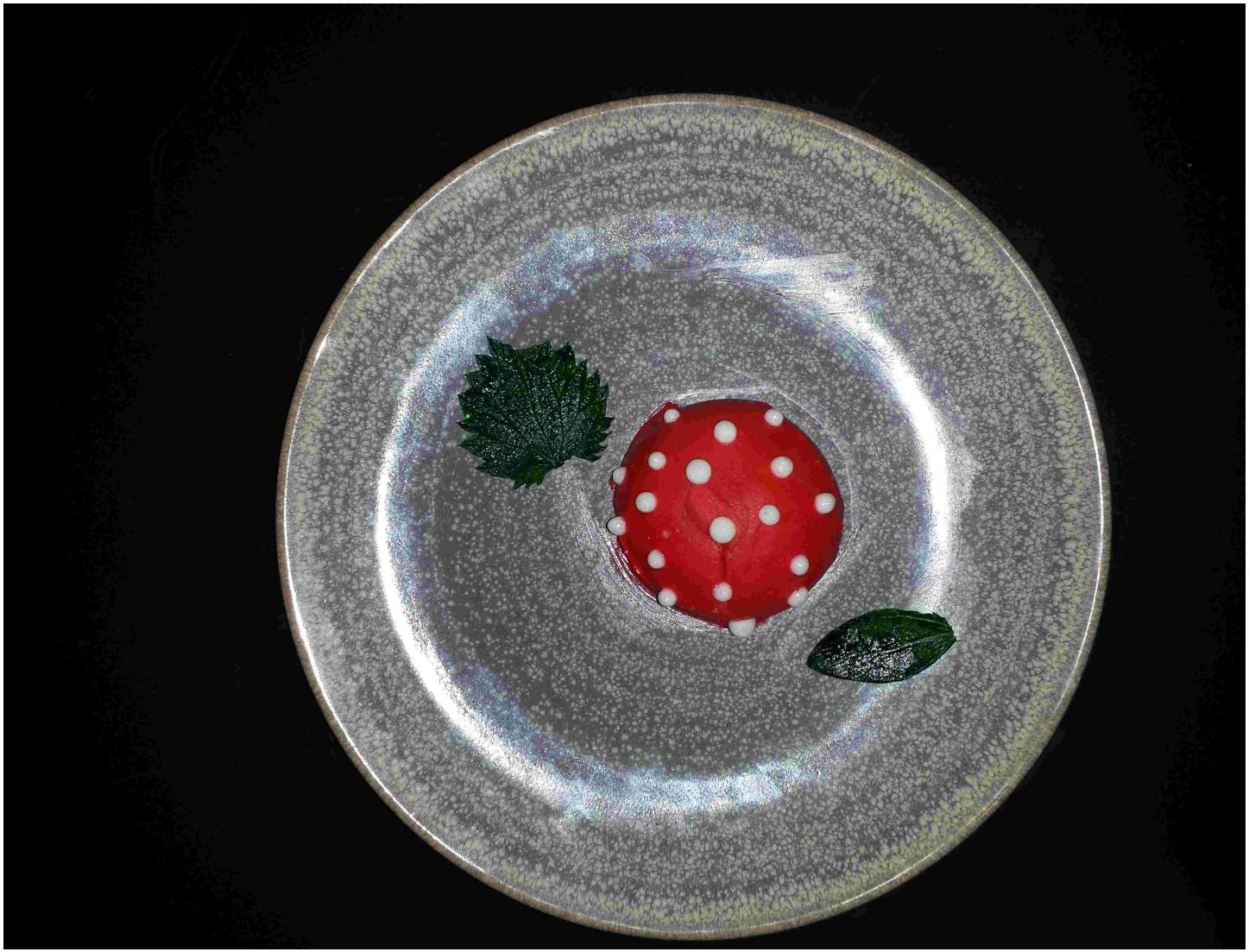

15 22:50

Montréal, Canada
April 2012





Copenhagen, Denmark, April 2014




2

Winner of the 2015 International Contest for Note by Note Cooking

Winner 2014

In Japan, by Guillaume Siegler (chef of the Cordon Bleu)

A note by note meal at Pierre Gagnaire

cis-hexen-3-ol

gaïacol and 2,4,6-triisobutyl-5,--dihydro-4H-1,3,5- dithiazine

2-acetylthiazole

acetyl methyl carbinol acetyl propionyl

Piperine

Chick corea (entirely note by note)

benzaldehyde

And the International Contest for Note by Note Cooking

Celebrate Molecular Gastronomy

forum : http://scfconfhervethis.forumactif.org