International Workshop
Modelling quality traits and their genetic variability for Wheat
18-21 July Clermont Ferrand

Genetic determination of protein quality in wheat grain

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Clermont Ferrand

Genetic determination of protein quality in wheat grain

Genetic aspects of wheat storage proteins

Wheat storage proteins and quality

Quantitative variations of wheat storage proteins

Some other proteins involved in quality

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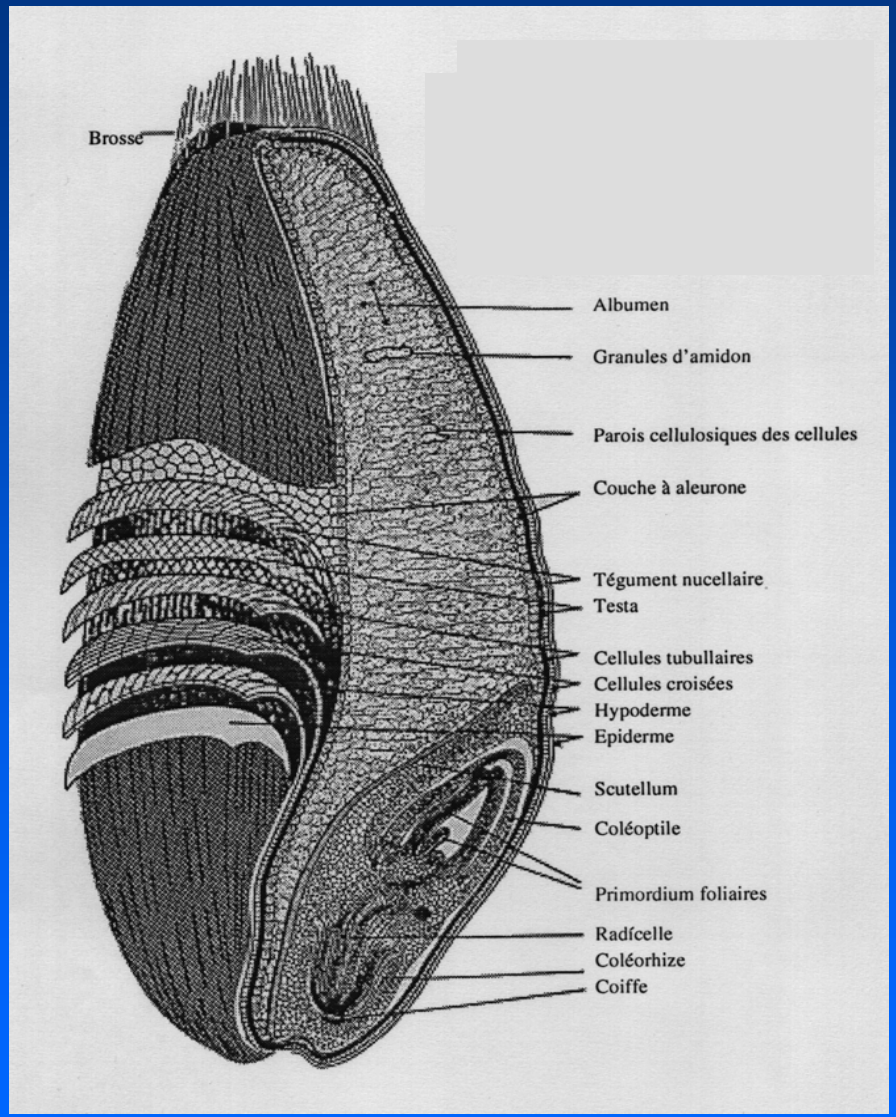
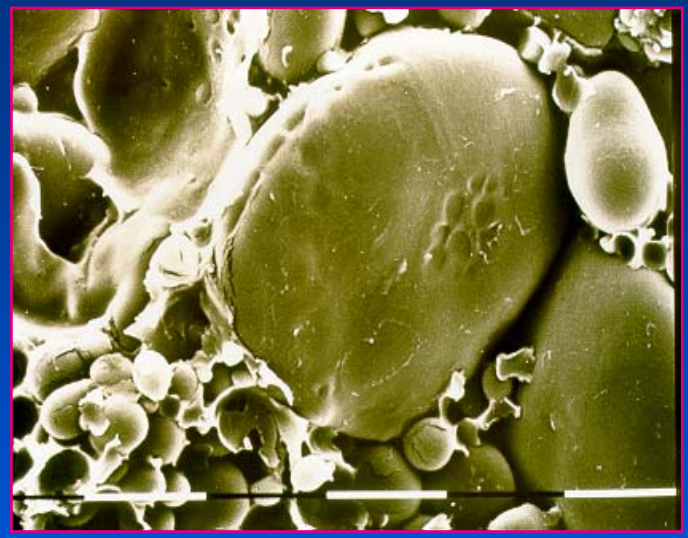
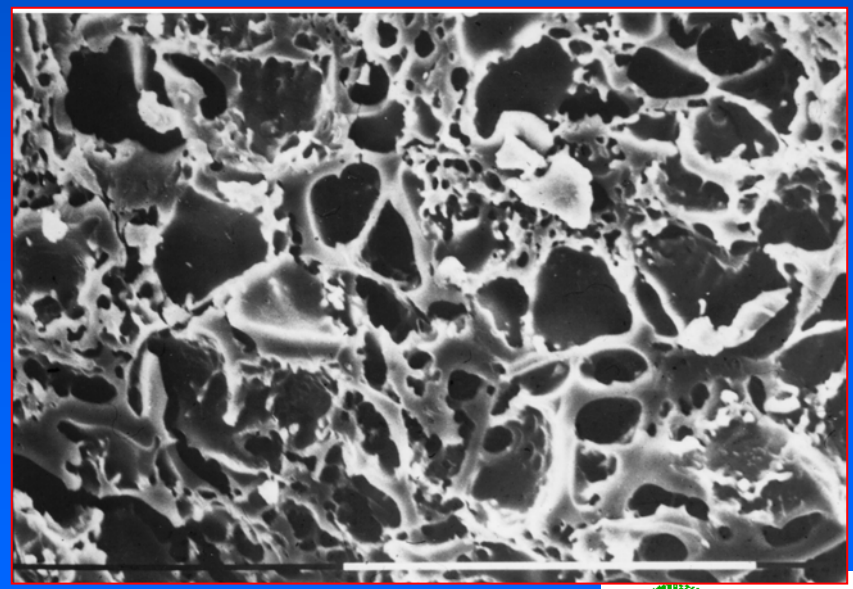
Wheat endosperm and Protein matrix







Wheat Endosperm Proteins

Protein type	Solubility	% flour protein	Characteristics
Albumins	Water	10	Enzymes and cell structure
Globulins	NaCl 0.5M	10	MWs 5 – 100 kDa
Gliadins	Alcohol	35-45	Monomeric MWs 30 – 80 kDa
Glutenins	SDS		Polymeric
HMW-GS	+ R. A.	10-15	MWs 75 -120 kDa
LMW-GS		20-30	MWs 25 - 45 kDa

Soluble proteins

Storage proteins

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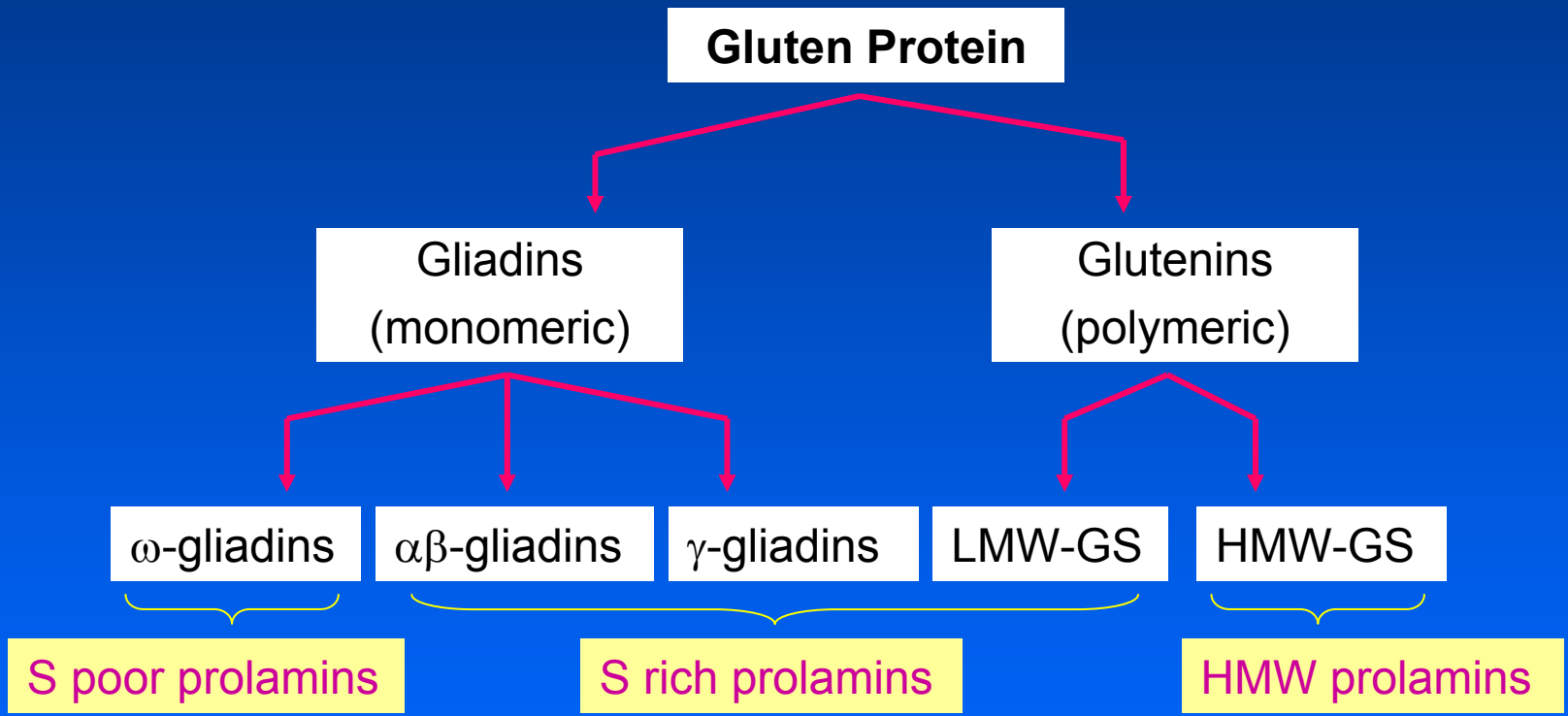
Gluten protein classification



From Shewry P. *et al*. 1986

Genetic determination of protein quality in wheat grain

Genetic aspects of wheat storage proteins

Wheat storage protein diversity

Ch 1 A B D

Glu-1 → HMW-GS

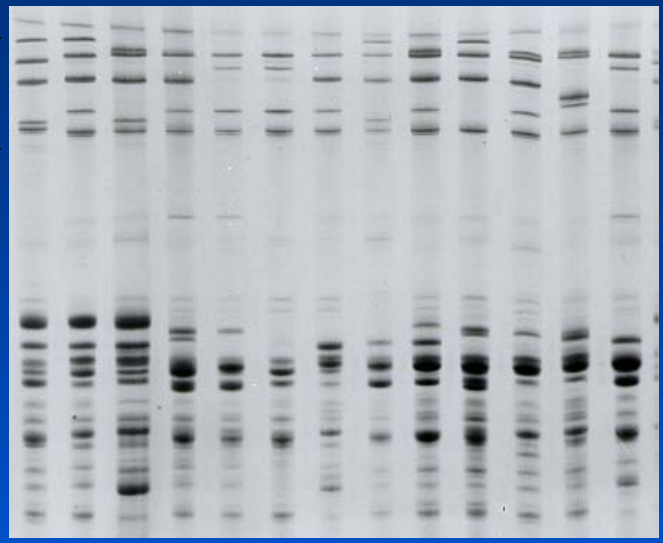
Glu-3 → LMW-GS

Gli-1

Ch 6 A B D

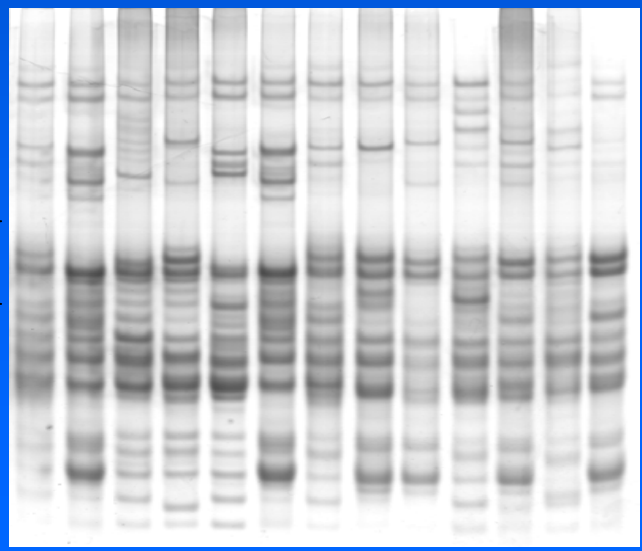
Gli-2 → ω-gliadins, γ-gliadins, β-gliadins, α-gliadins

Glutenins



SDS Page

Gliadins



Acid Page

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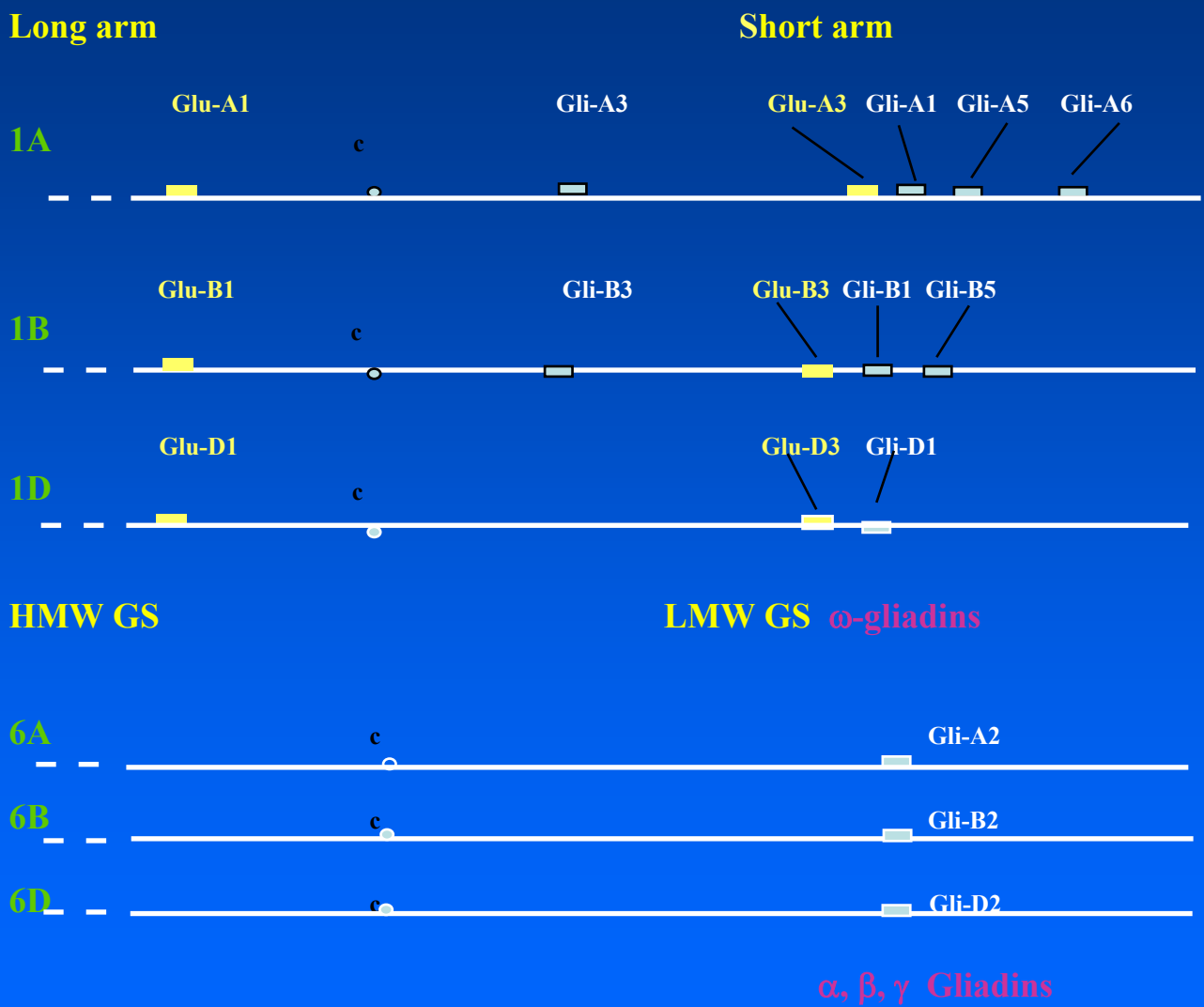
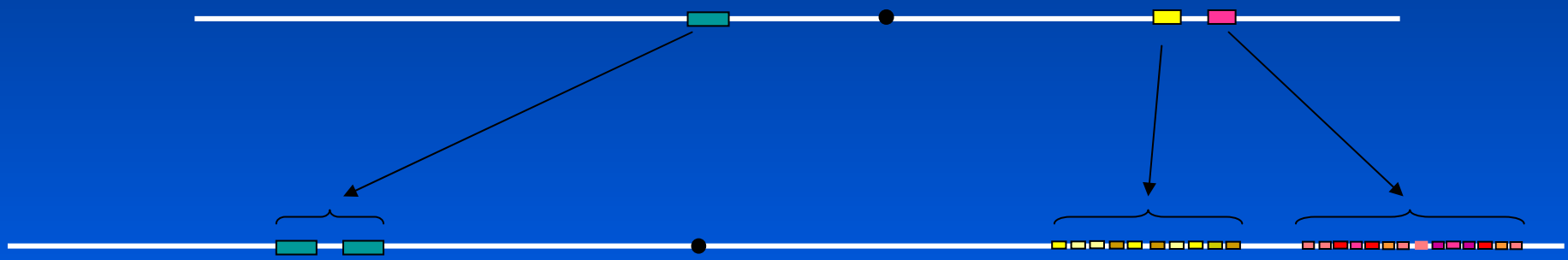
Main locus involved in synthesis of wheat endosperm storage proteins



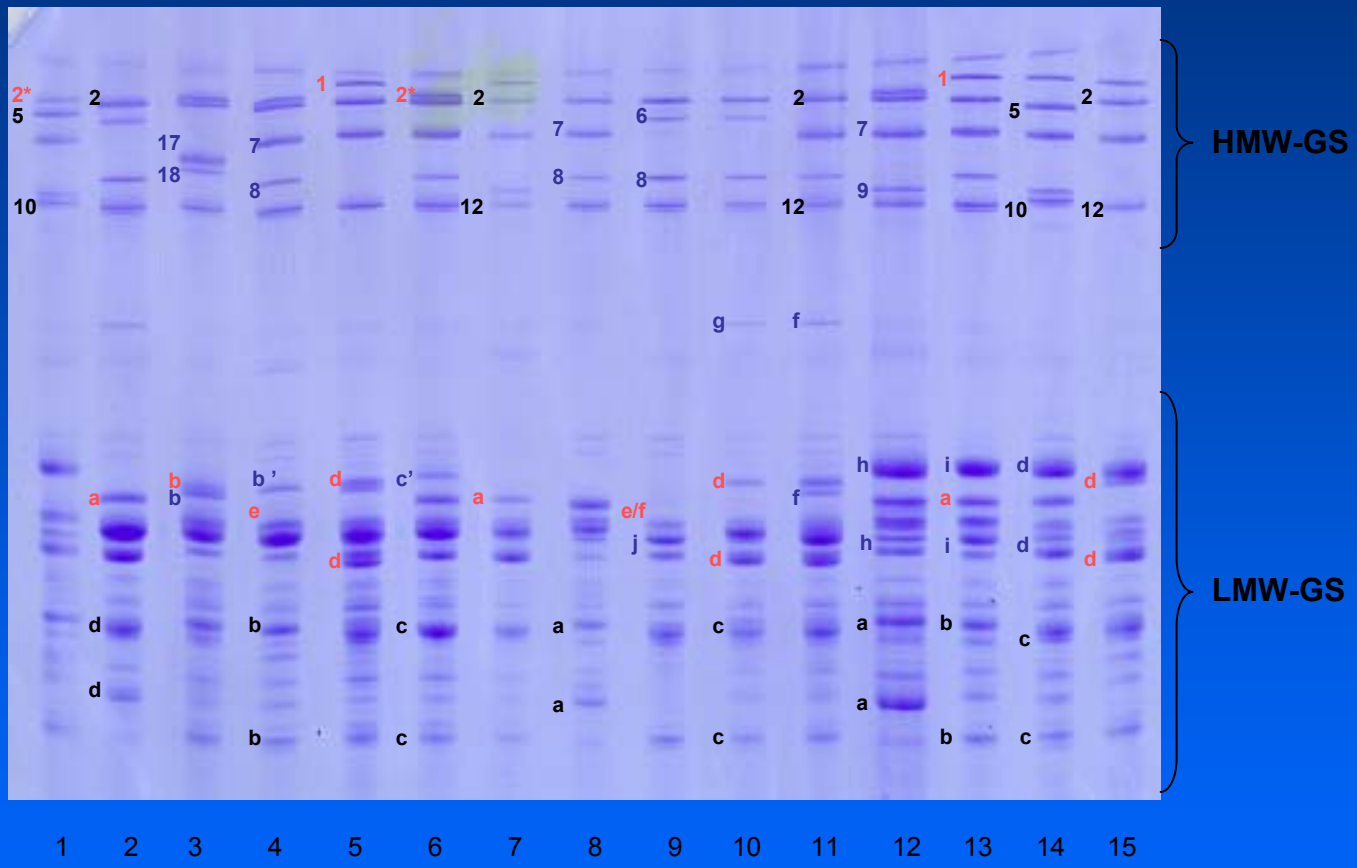
WSPs are encoded by clusters of genes



Glu 1x Glu 1y Glu 3 Gli 1

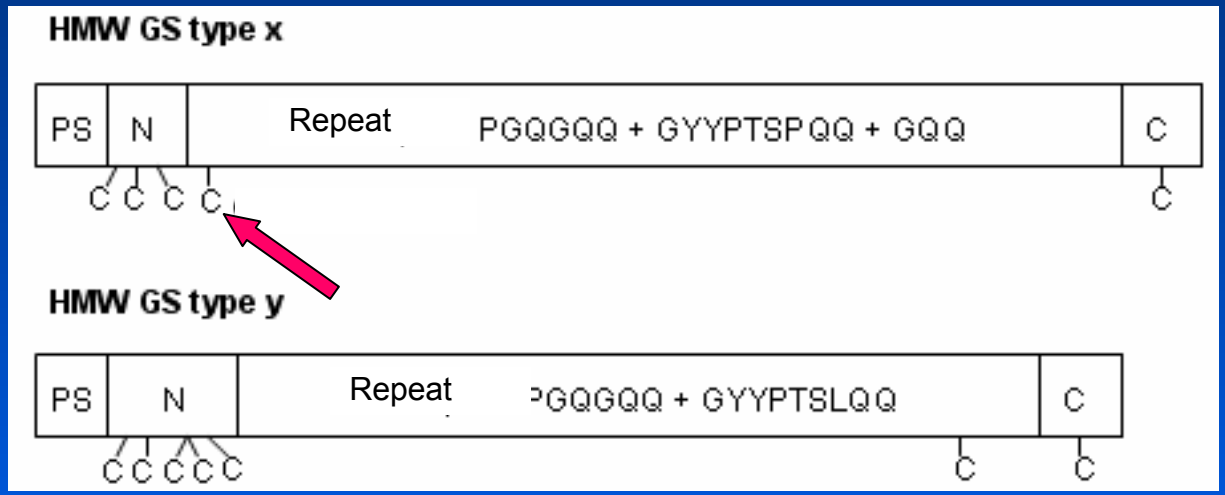
HMW-GS LMW-GS Gliadins

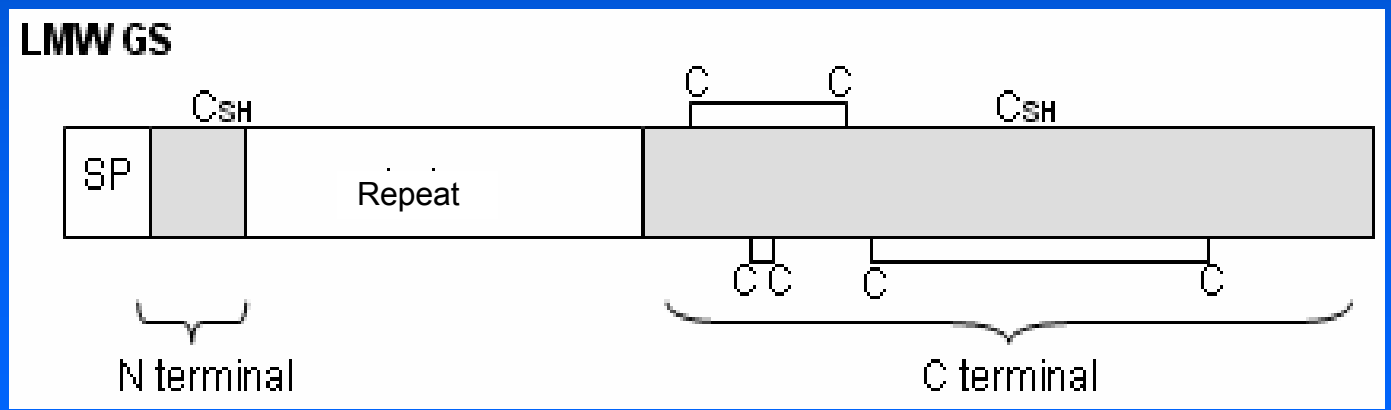
Some alleles of HMW-GS and LMW-GS



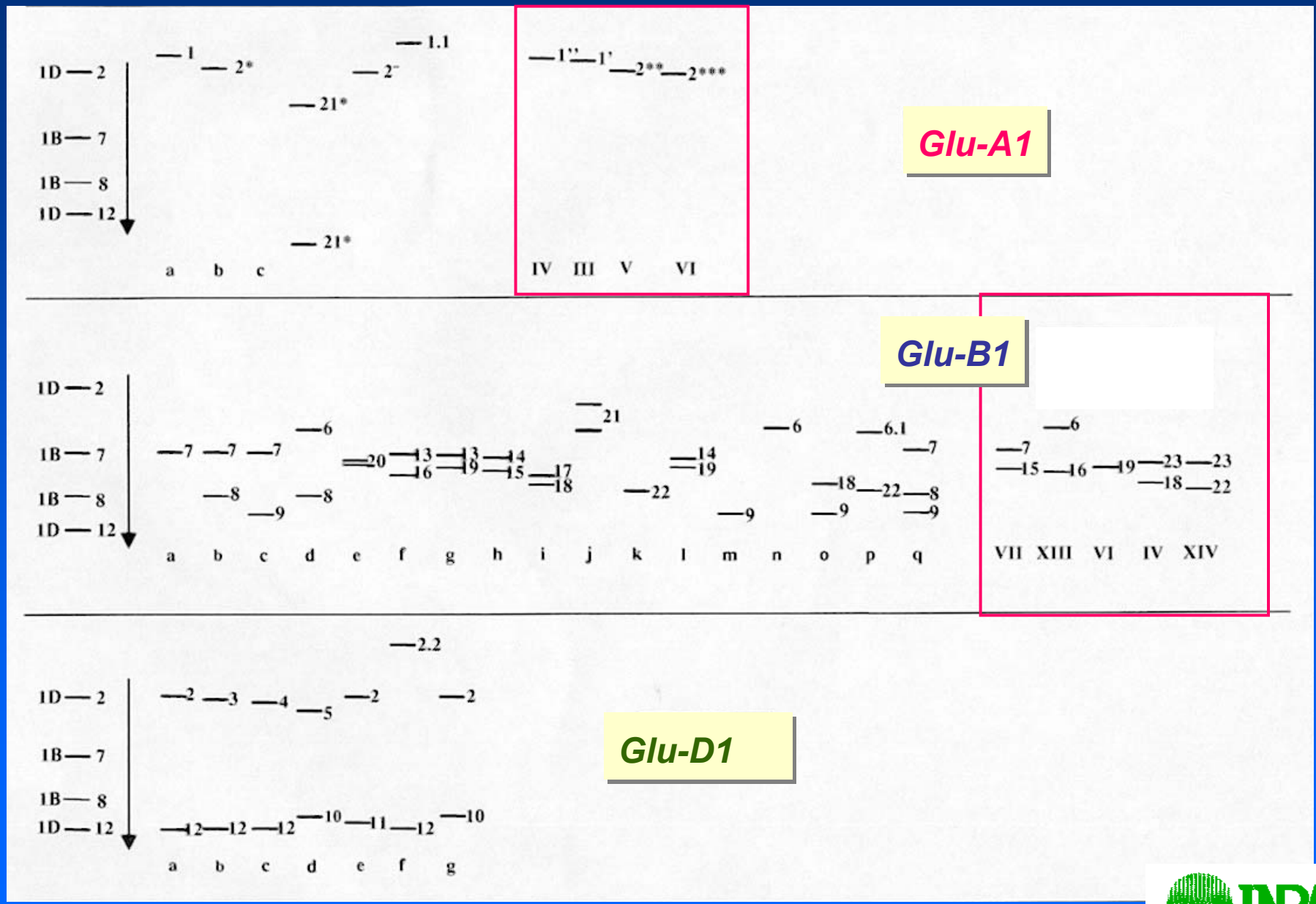
From: Branlard et al. *Genetic Resources and Crop Evolution* 2003, 50, 669-679

Structural diversity of the glutenin subunits

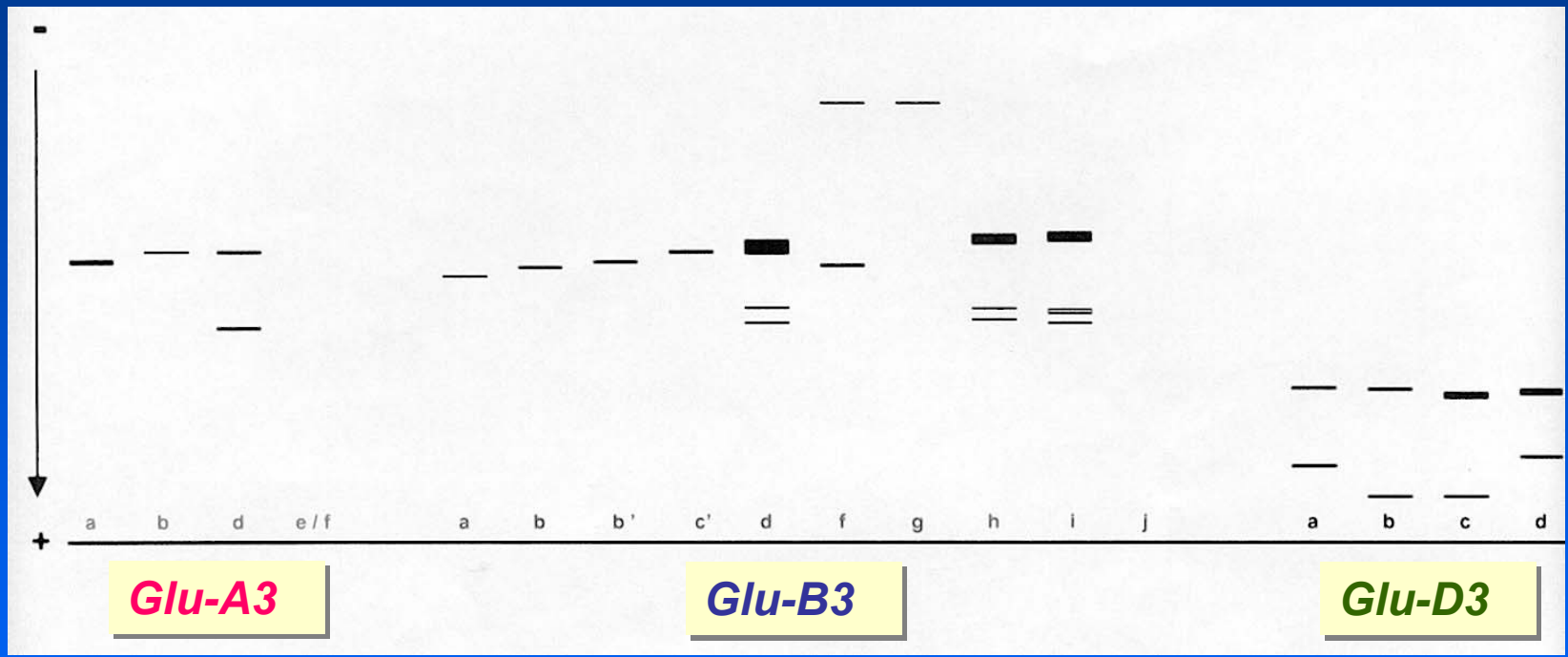




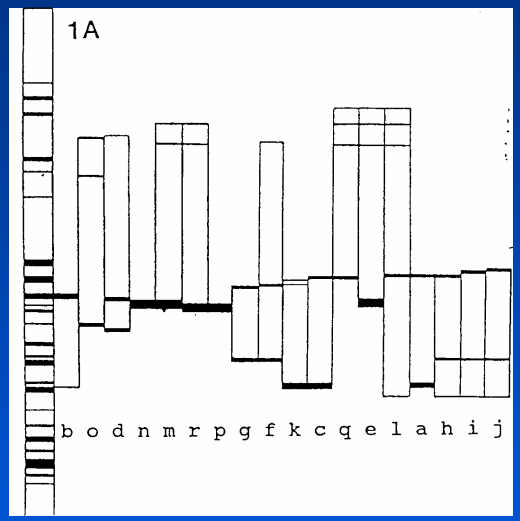
Main alleles encoding HMW-GS

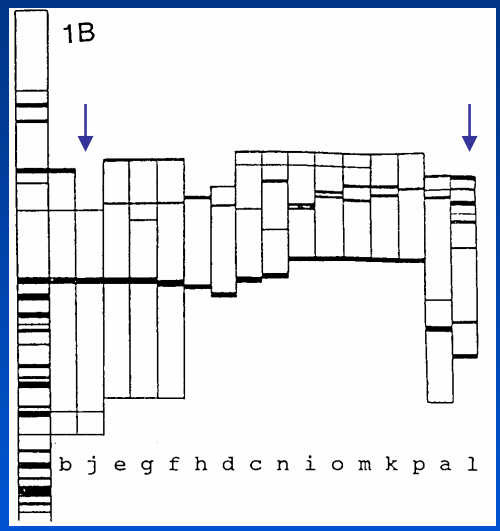


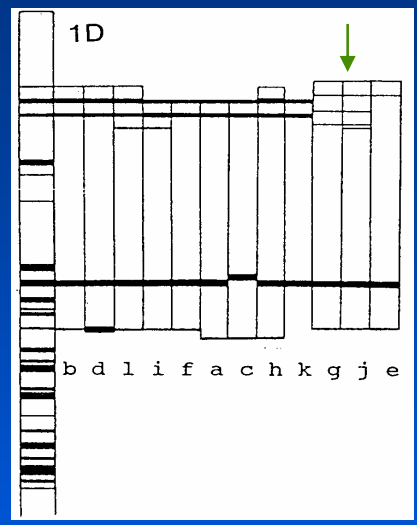
Allelic diversity of the LMW-GS

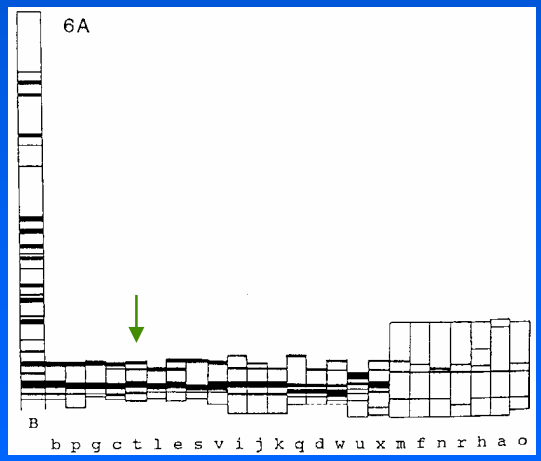


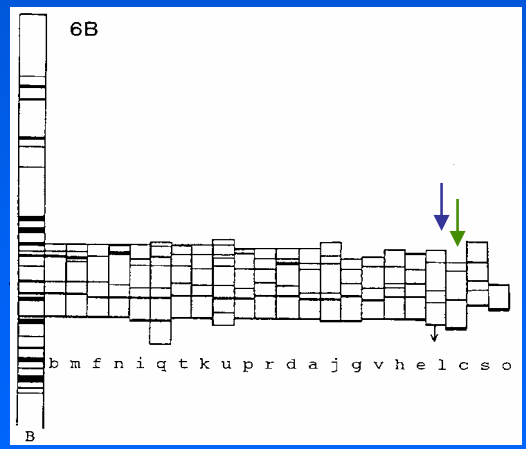
Allelic diversity of Gliadins

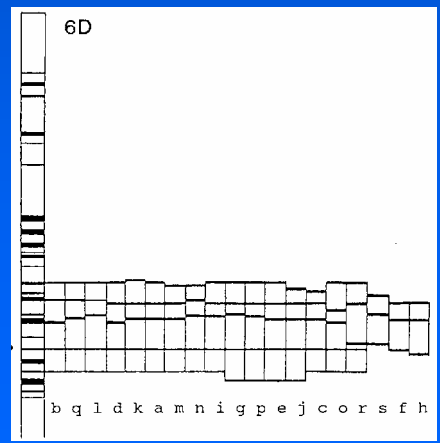






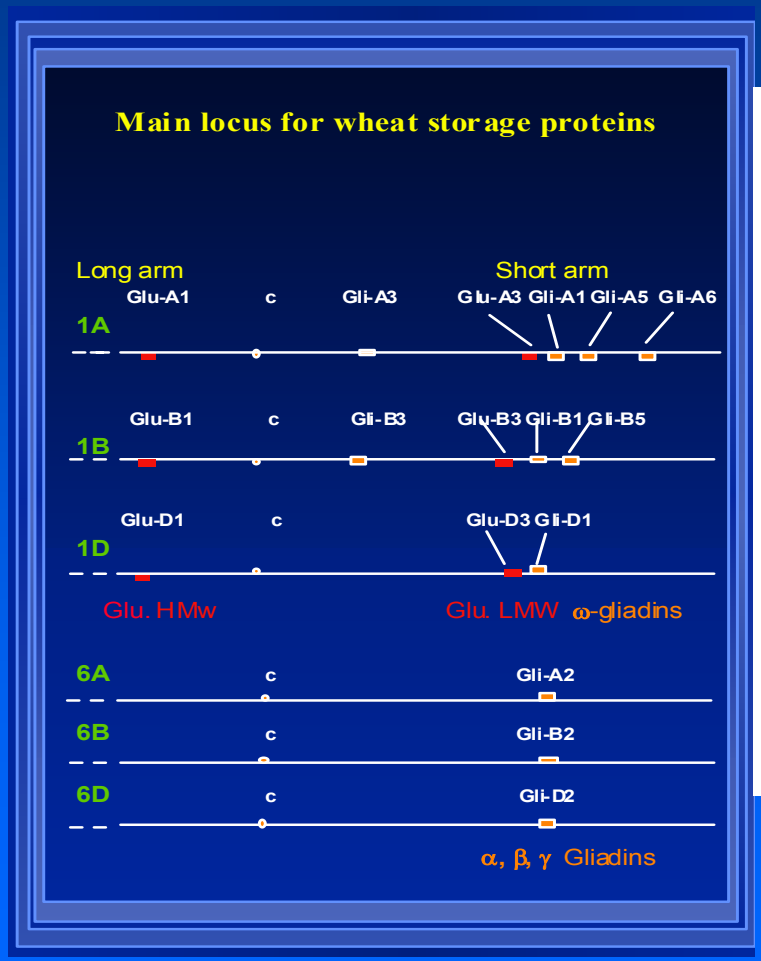






From Metakovsky 1991, J Genet.& Breeding,45, 325-344.

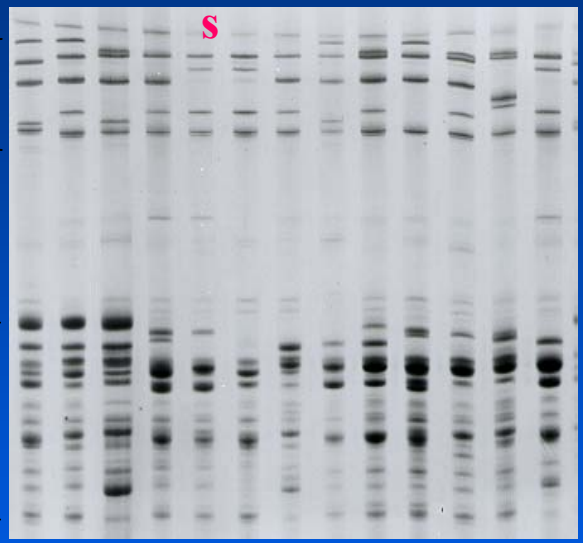
Allelic diversity of wheat storage proteins



Cultivars	HMW-GS			LMW-GS			ω-Gliadins		
	Glu-A1	*Glu-B1*	*Glu-D1*	*Glu-A3*	*Glu-B3*	*Glu-D3*	*Gli-A1*	*Gli-B1*	*Gli-D1*
'Abo'	c	b	d	a	b	c	k	b	b
'Aboukir'	c	b	d	a	g	b	k	f	f
'Aiglon'	c	a	d	ef	g	c	f	e	b
'Albatros'	c	b	a	d	f	c	o	e	b
'Alpe'	b	b	d	a	b	c	b	b	b
'Alto'	c	b	d	a	g	c	k	f	b
'Alvina'	c	b	d	a	c	c	k	b	b
'Ami'	c	b	d	a	c'	c	o	b	b
'Apexal'	c	c	d	a	g	c	b	e	b
'Apollo'	c	d	a	d	j	c	o	l	b
'Apostole'	c	i	a	ef	g	b	b	f	g
'Arbon'	c	d	a	a	b	c	a	b	b
'Arcane'	c	b	a	a	g	b	a	f	f
'Arche'	c	d	a	d	g	c	o	f	b
'Arcole'	c	b	c	d	g	c	o	f	b
'Arfort'	b	i	d	a	b	a	b	b	b
'Aristide'	b	a	d	a	c'	c	b	b	j
'Armada'	c	d	a	ef	f	c	m	g	b
'Arminda'	c	a	a	a	g	c	f	f	b
'Armur'	c	c	d	a	g	c	k	f	b
'Arsenal'	a	d	a	a	g	a	f	e	b

How these Wheat Storage Proteins are assembled ?

Glutenins

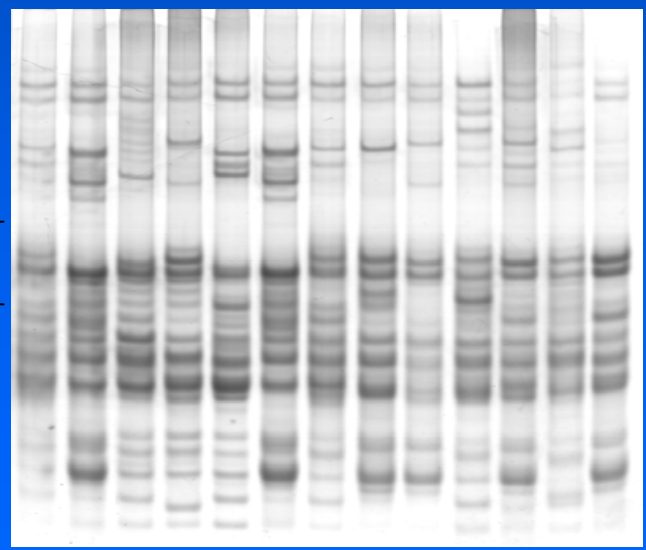


HMW-GS

LMW-GS

- SDS Page +

Gliadins



ω-gliadins

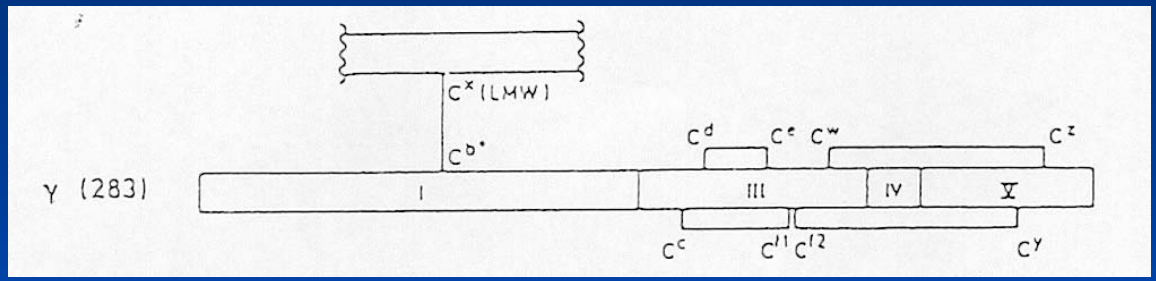
γ-gliadins

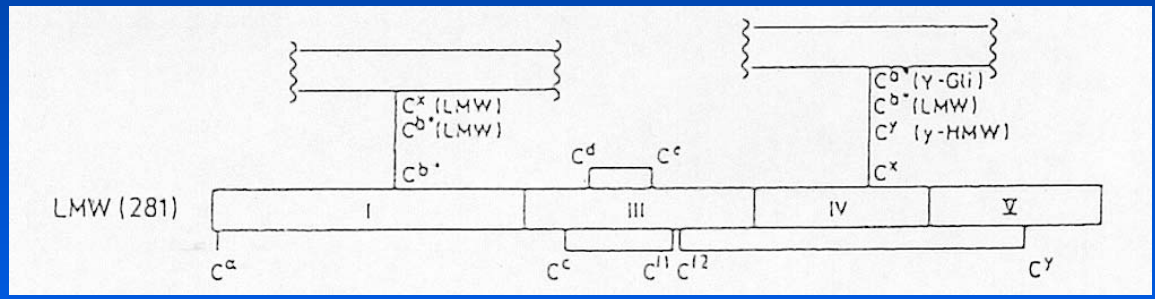
β-gliadins

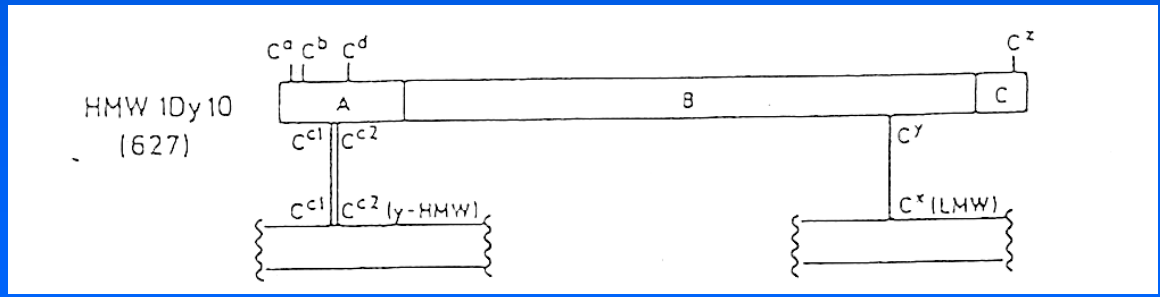
α-gliadins

+ Acid Page -

Covalent SS links between wheat storage proteins







From Köhler P. Belitz H. Wieser H 1993 Z. Lebensm. Unters. Forsch 196,239-247

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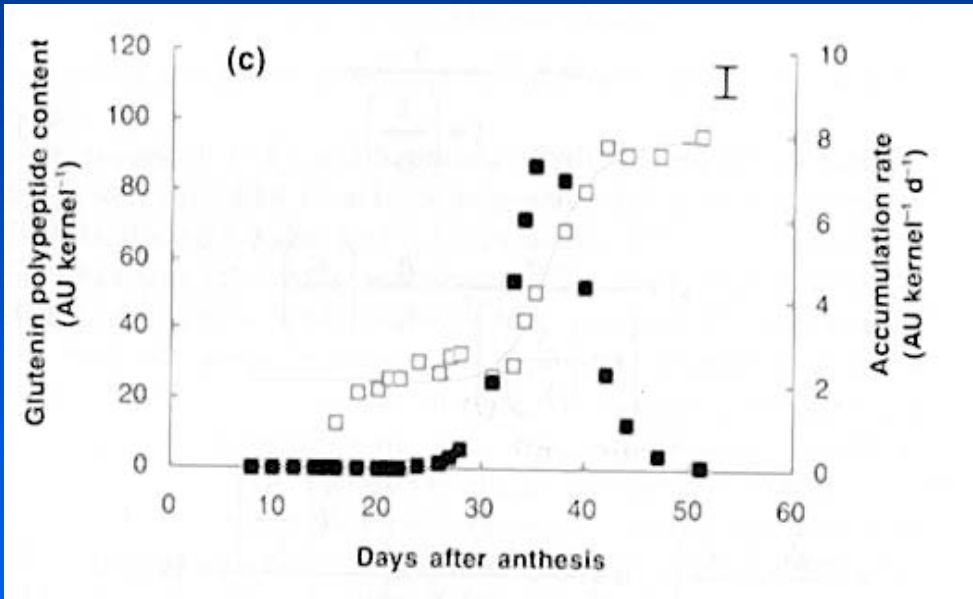
SDS insoluble glutenin polymer formation in developing grains of wheat, (cv: Soissons)



From Carceller JL, Aussenac T., Aust. J. Plant Physiol 2001, 28; 193-201

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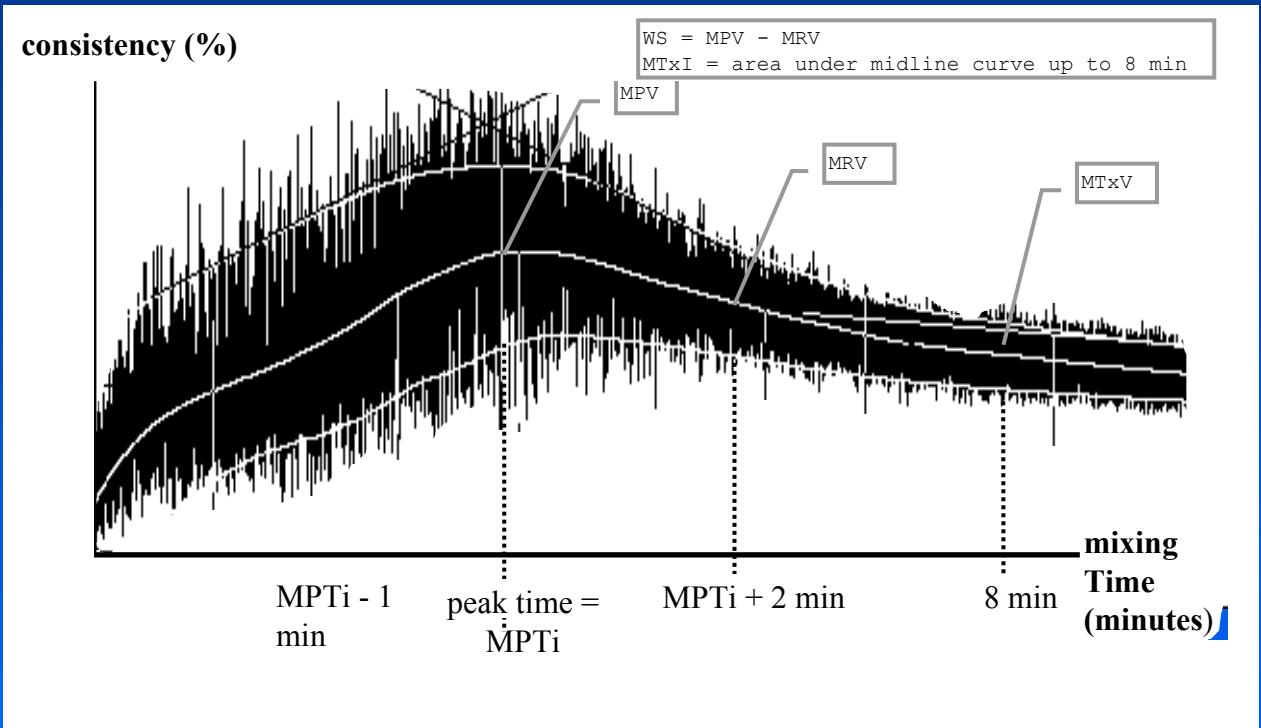
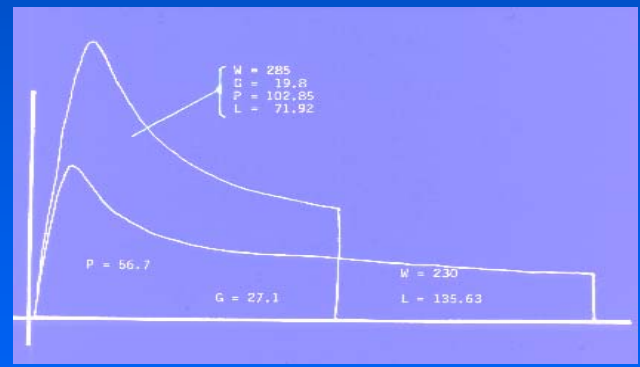
Wheat gluten proteins as part of the bread making quality

Mixographe


consistency (%)
WS = MPV - MRV
MTxI = area under midline curve up to 8 min
MPV
MRV
MTxV
mixing Time (minutes)
MPTi - 1 min
peak time = MPTi
MPTi + 2 min
8 min

Comparison of alleles effects for phenotypic values of dough strength

Locus	Strength
GluA1	2* = 1 > null
GluB1	17-18 ≥ 13-16 ≥ 7-9 = 7-8 ≥ 7 = 6-8
GluD1	5-10 ≥ 3-12 = 2-12 ≥ 4-12
GluA3	a = d = f ≥ e
GluB3	b' ≥ d = c = c' = b = g > i > f ≥ j
GluD3	a ≥ b = d = c
GliA2	t ≥ k = r = f = g = j ≥ l = b = p
GliB2	m >b ≥ r ≥ h = o = g ≥ ae = l = ac
GliD2	m = e ≥ a = h = v = g = n



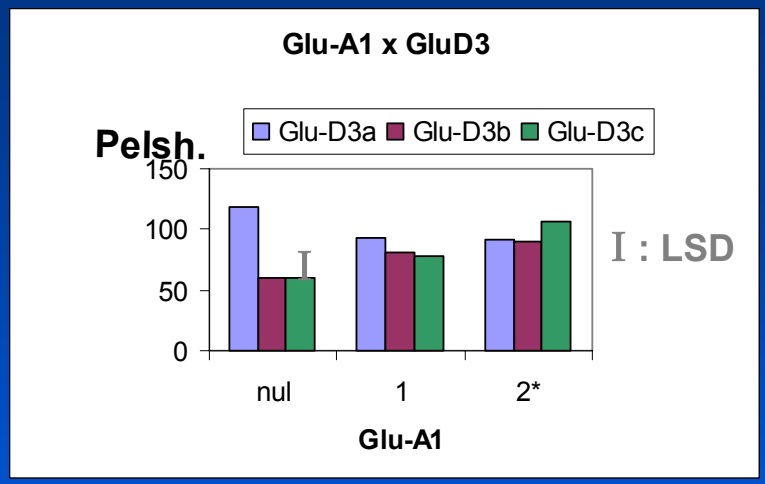
Comparison of alleles effects for phenotypic values of dough extensibility

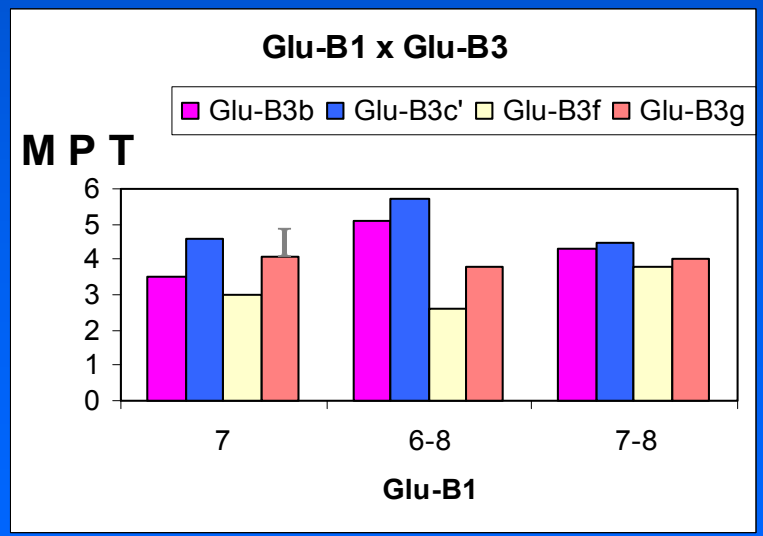
Locus	Extensibility
GluA1	nsd
GluB1	13-16 ≥ 7-8 = 7-9 = 17-18 ≥ 7 ≥ 6-8
GluD1	nsd
GluA3	d = a = f ≥ e
GluB3	i ≥ b' ≥ c = c' = g > b = f = d > j
GluD3	nsd
GliA2	b = t ≥ k = g = l ≥ p = r = f = j
GliB2	ae ≥ m ≥ g = o = h = ac ≥ b = r = l
GliD2	nsd

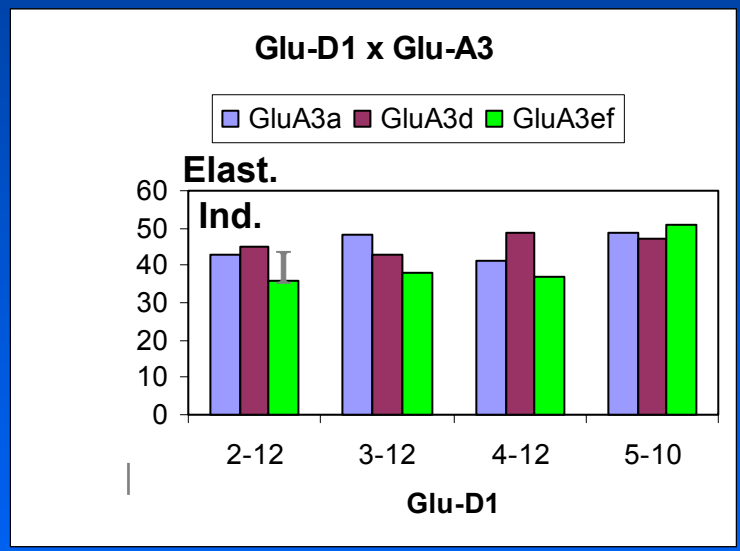
(nsd: not significantly different)

From: Branlard G.,Dardevet M., Saccomano R., Lagoutte F., Gourdon J. Euphytica, 2001, 119, 59-67

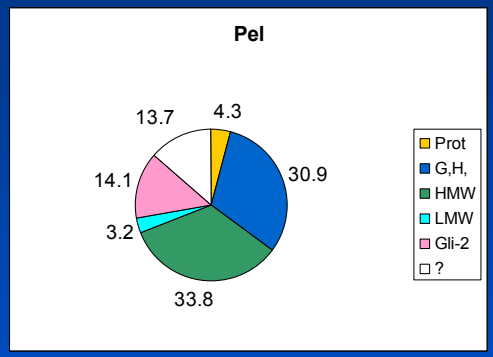
Interactions between Glu-1 and Glu-3 loci

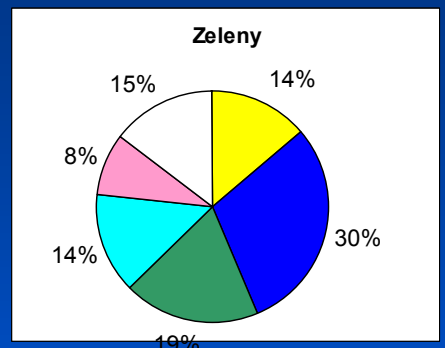


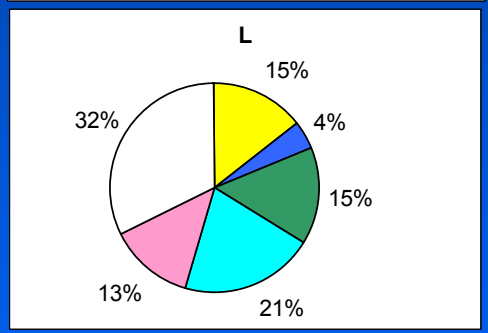


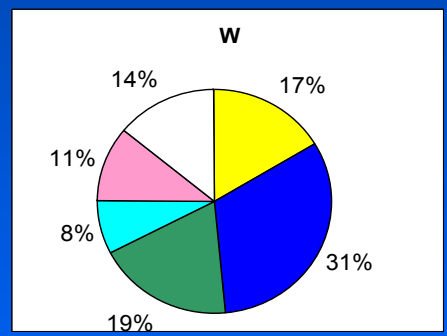


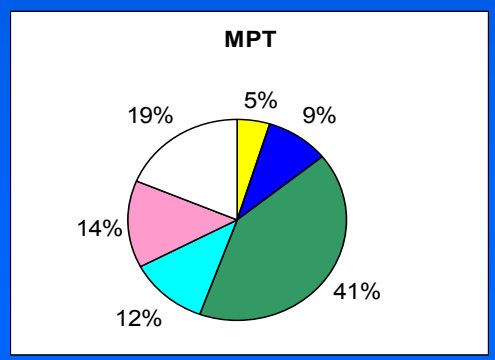
Part (R^2) of Protein content, G. Hardness, HMW, LMW GS and α, β, γ-gliadins in the genotypic variations of six bread wheat quality parameters

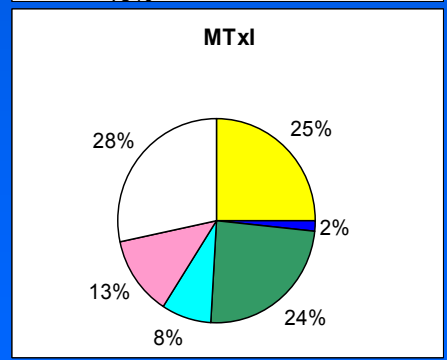












From: Branlard G.,Dardevet M., Saccomano R., Lagoutte F., Gourdon J. Euphytica, 2001, 119, 59-67

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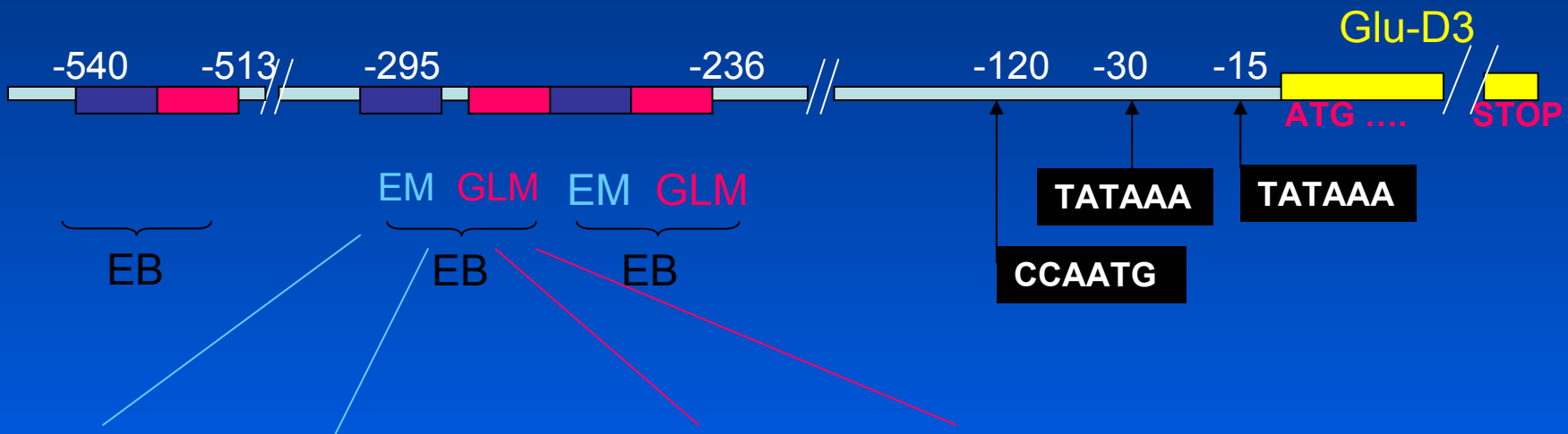
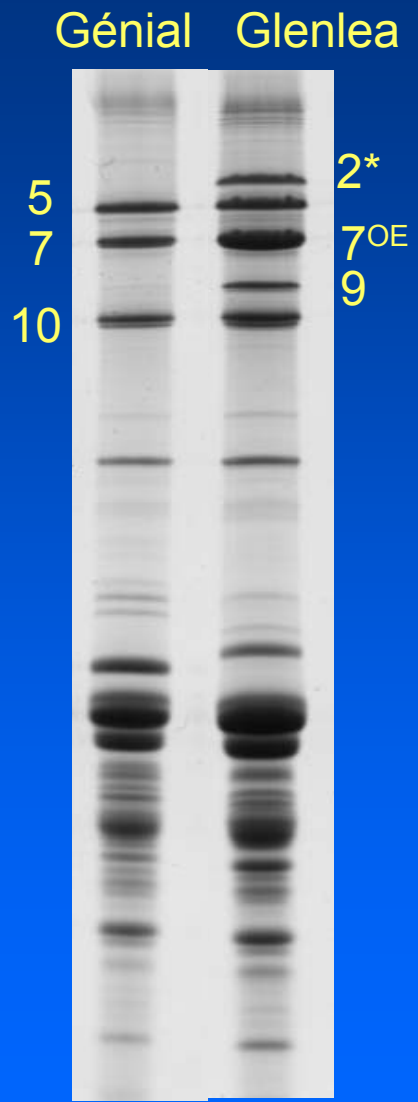
Regulation of the expression

Promoter region of the LMW-GS Glu-3D



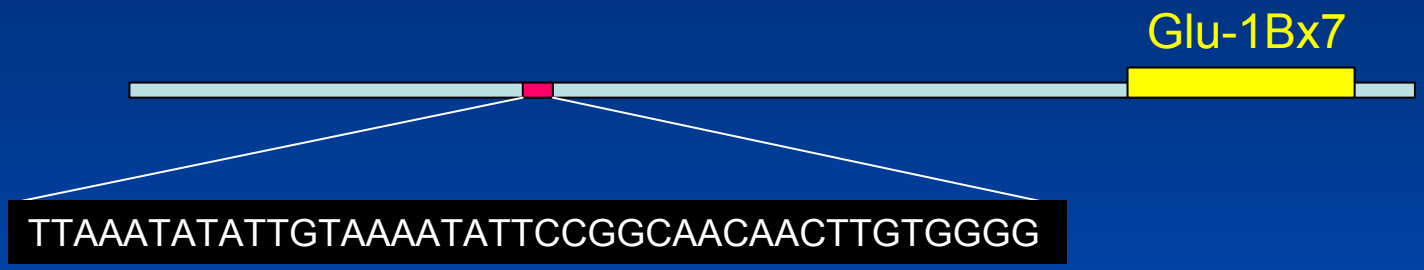
TGTAAAGTGATACTATCTTGATAAGTGTGTGACATGTAAAGTTAATAAGGTGAGTCATA

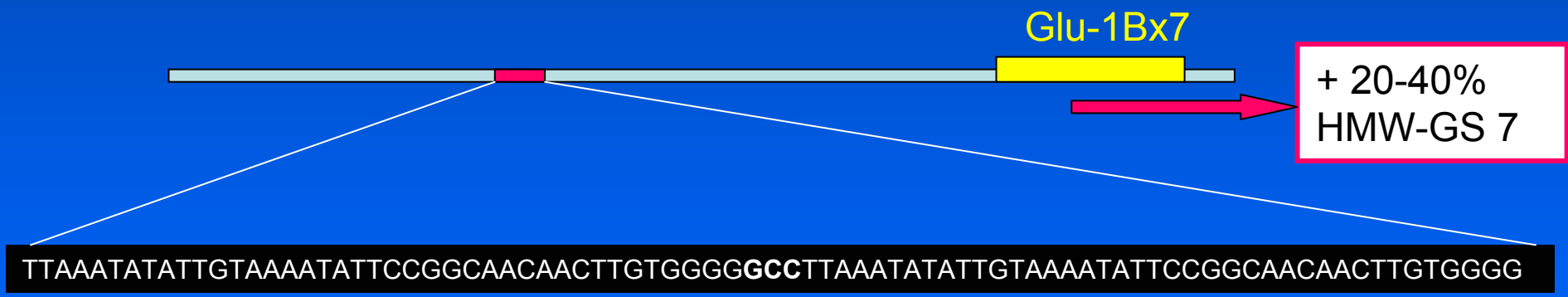
Quantitative variation of some HMW-GS



Regulation of the expression:

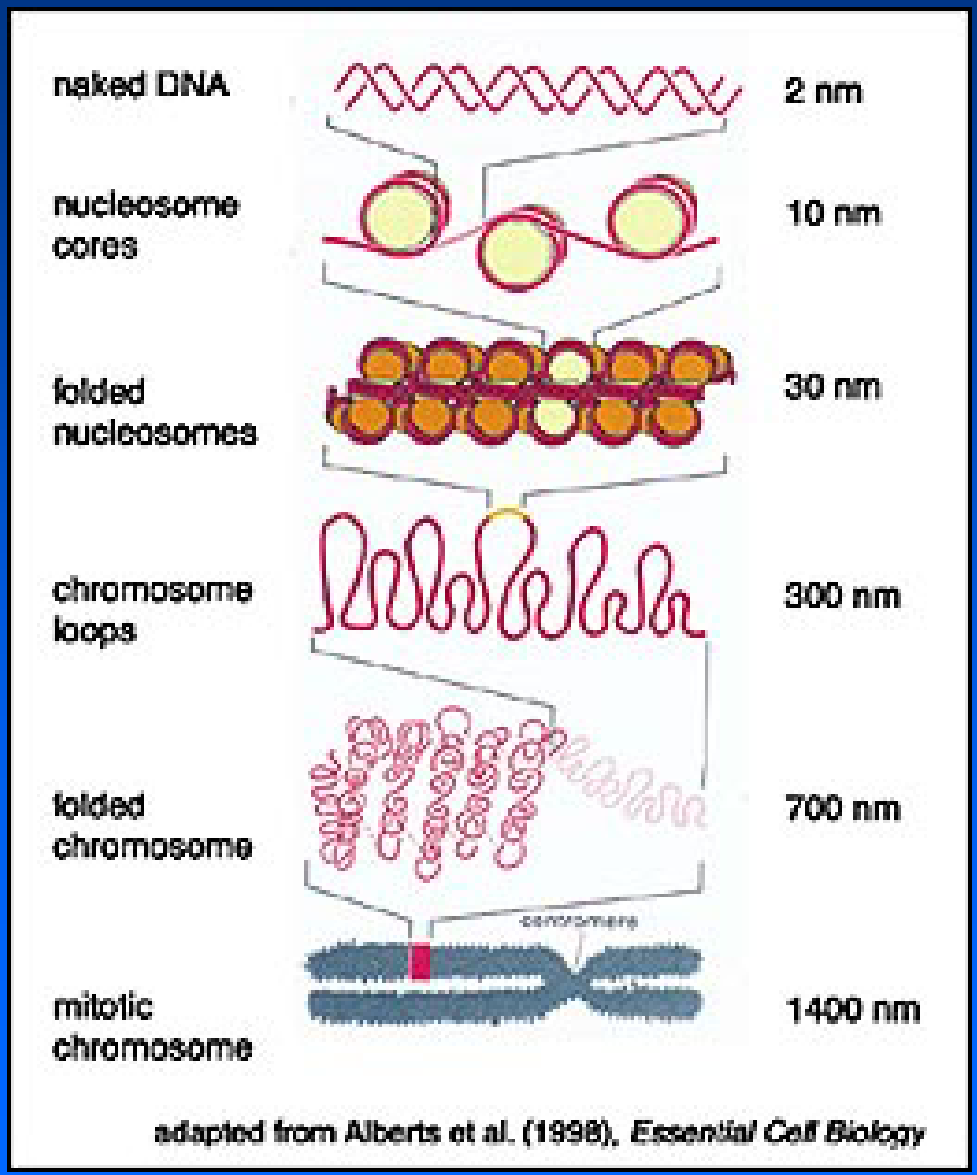
Duplication of a sequence in promoter region





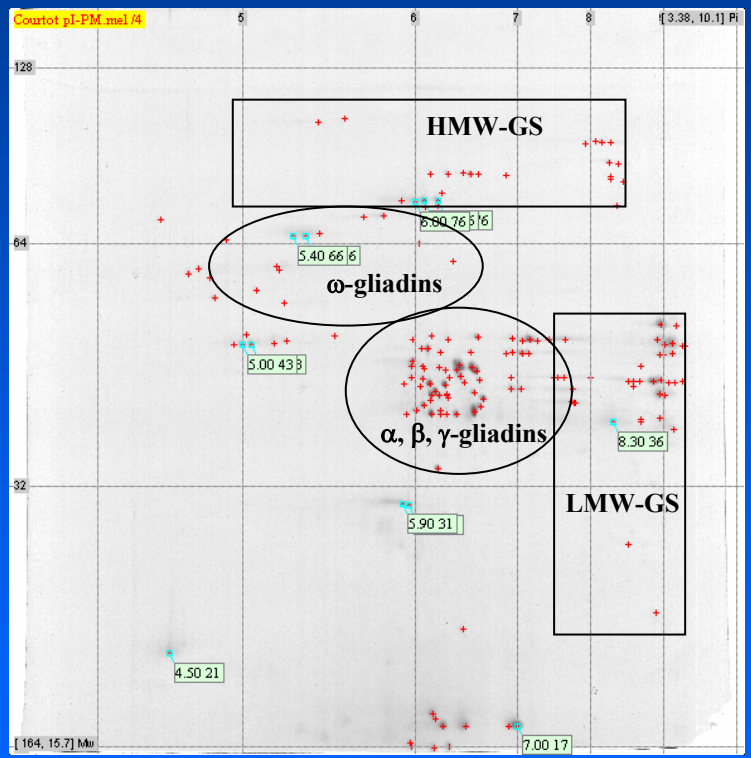
From :Juhász, G á rdonyi, Tamás, Bedõ. 2003, Xth Int Wheat Genet Symp. Paestum, Italy 1348-1350

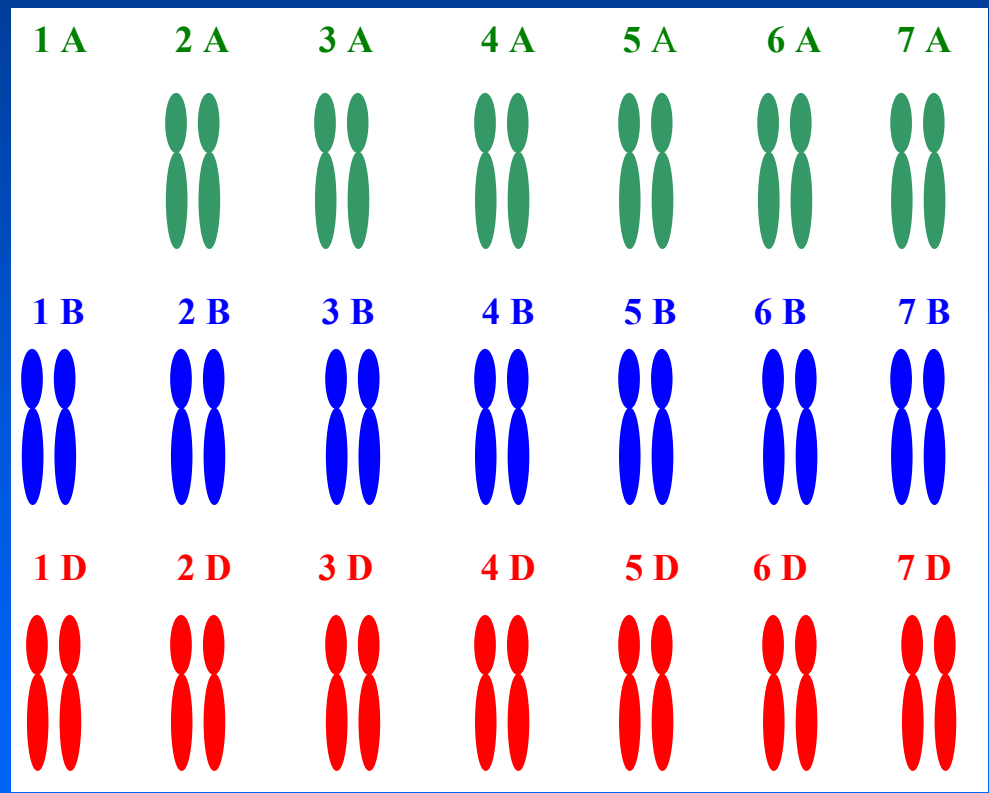
Regulation of the expression



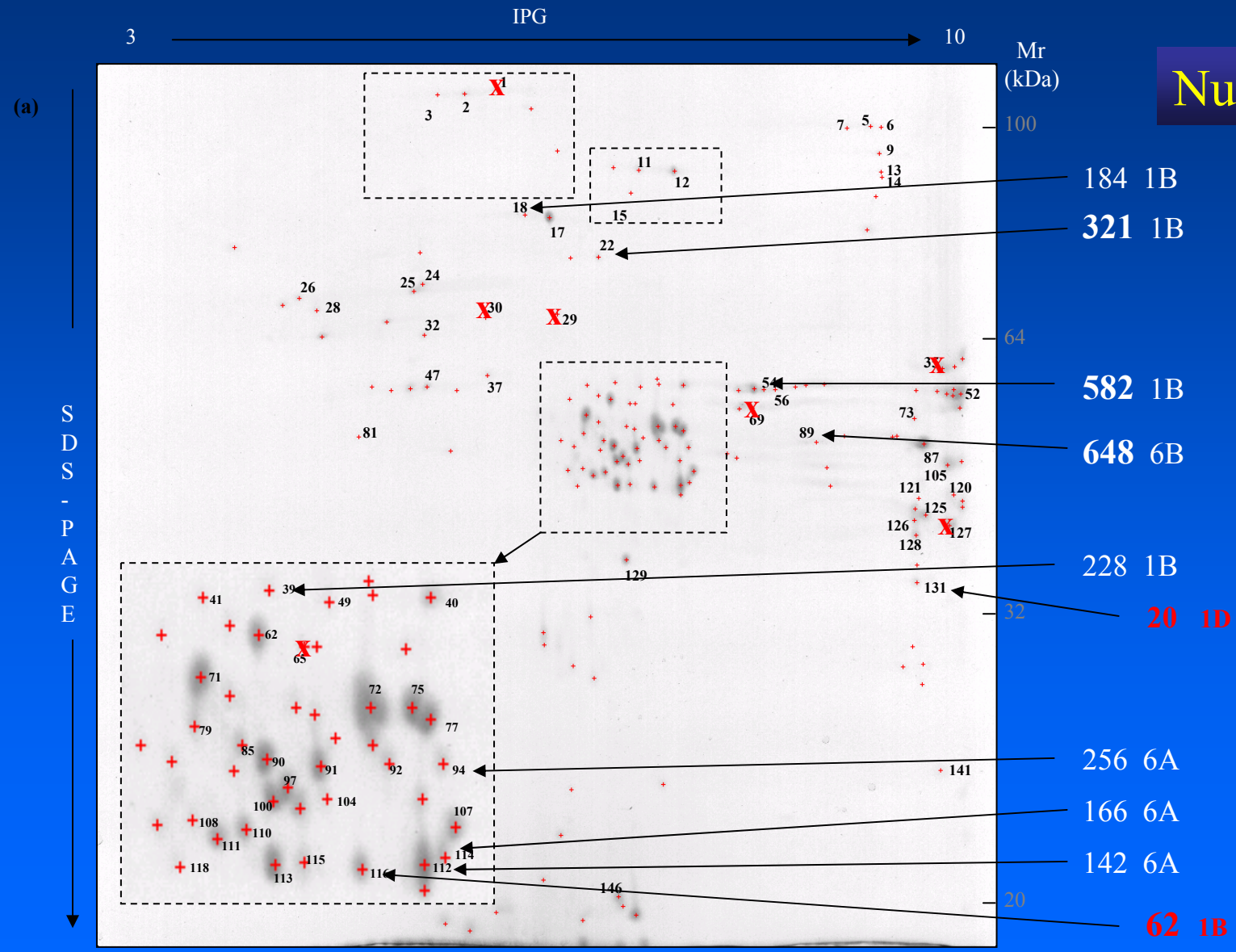
Regulation of the quantitative expression of the different loci

interactions between chromosomes (homologous and homeologous)



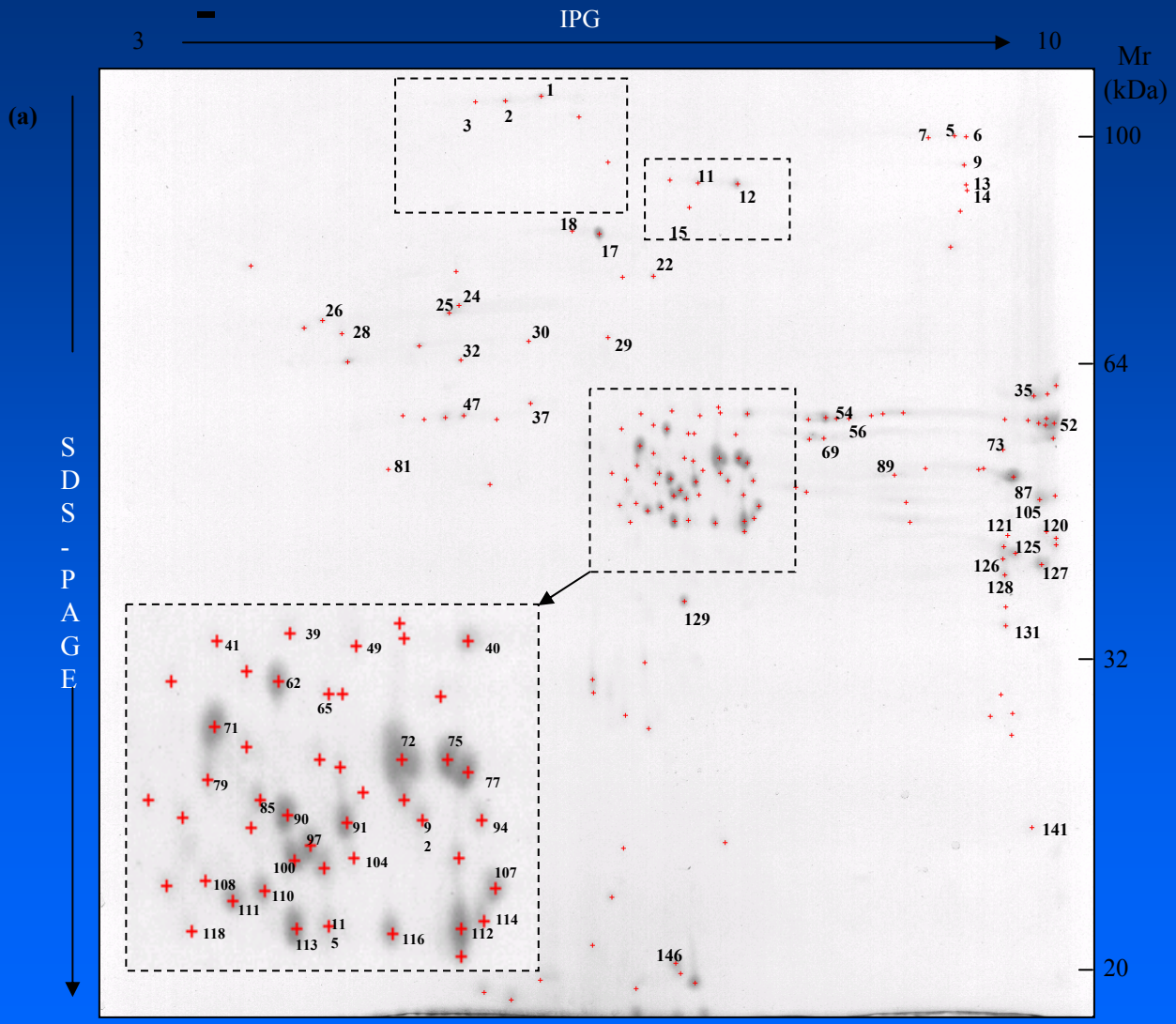


Regulation of the quantitative expression of the different loci
interactions between homeologous chromosomes. cv Courtot



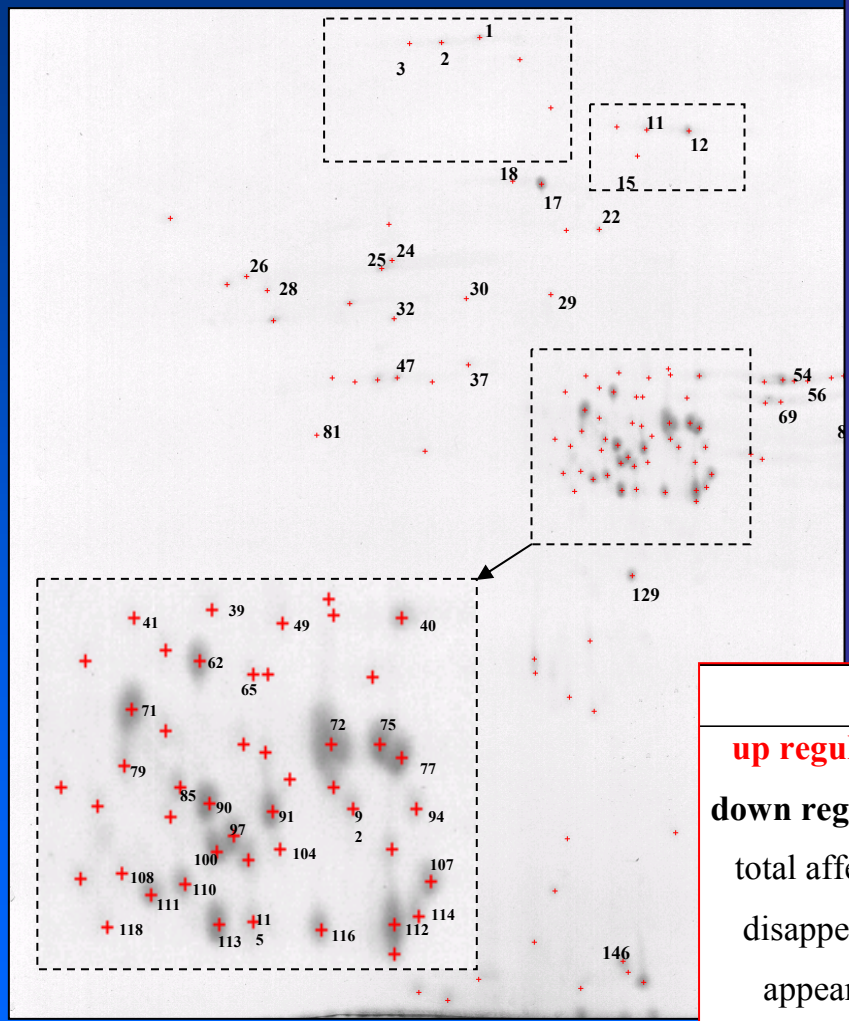
Regulation of the quantitative expression of the different loci

interactions between homolgous chr and homeologous chr.

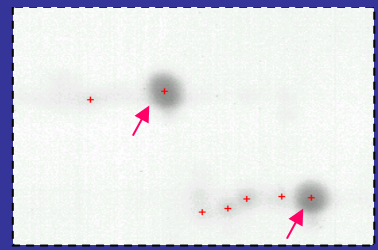


Dumur J, Jahier J, Bancel E, Laurière M, Bernard M, Branlard G 2004, Proteomics, 4, 2685-2695

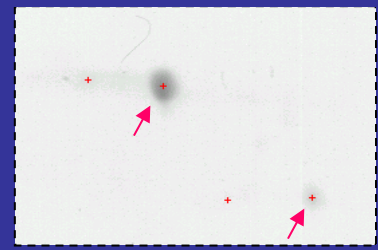
Regulation of the quantitative expression of the different loci
interactions between homolgous chr and homeologous chr.



Quantitiative differences

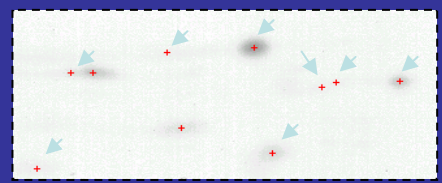


Courtot Nulli1D

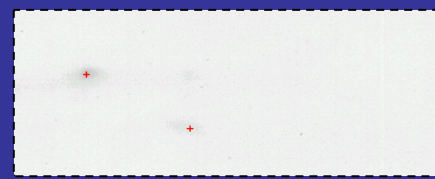


Courtot Normal

Qualitative differences



Courtot Nulli1D



Courtot Normal

	Null-1A	Null-1B	Null-1D	M-1A	M-1B	M-1D
up regulated	**8**	**15**	**14**	**17**	**16**	**26**
down regulated	**2**	**10**	**5**	**17**	**12**	**19**
total affected	10	25	19	**34**	**28**	**45**
disappeared	13	32	24	0	0	0
appeared	0	0	13	0	0	0

Dumur J, Jahier J, Bancel E, Laurière M, Bernard M, Branlard G 2004, Proteomics, 4, 2685-2695

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Effect of nullisomy and monosomy on the amount of wheat storage proteins as compared to the normal cultivar Courtot

Protein Class	Nullisomic 40 ch	Monosomic 41ch	Courtot 42 ch
HMW-GS	NS	↑	=
LMW-GS	↓	↓	=
Gliadins	NS	NS	=
Gliadins / Glutenins	↑	NS	=

From Dumur J. *et al*. Proteomics, 2004, 4, 2685-2695

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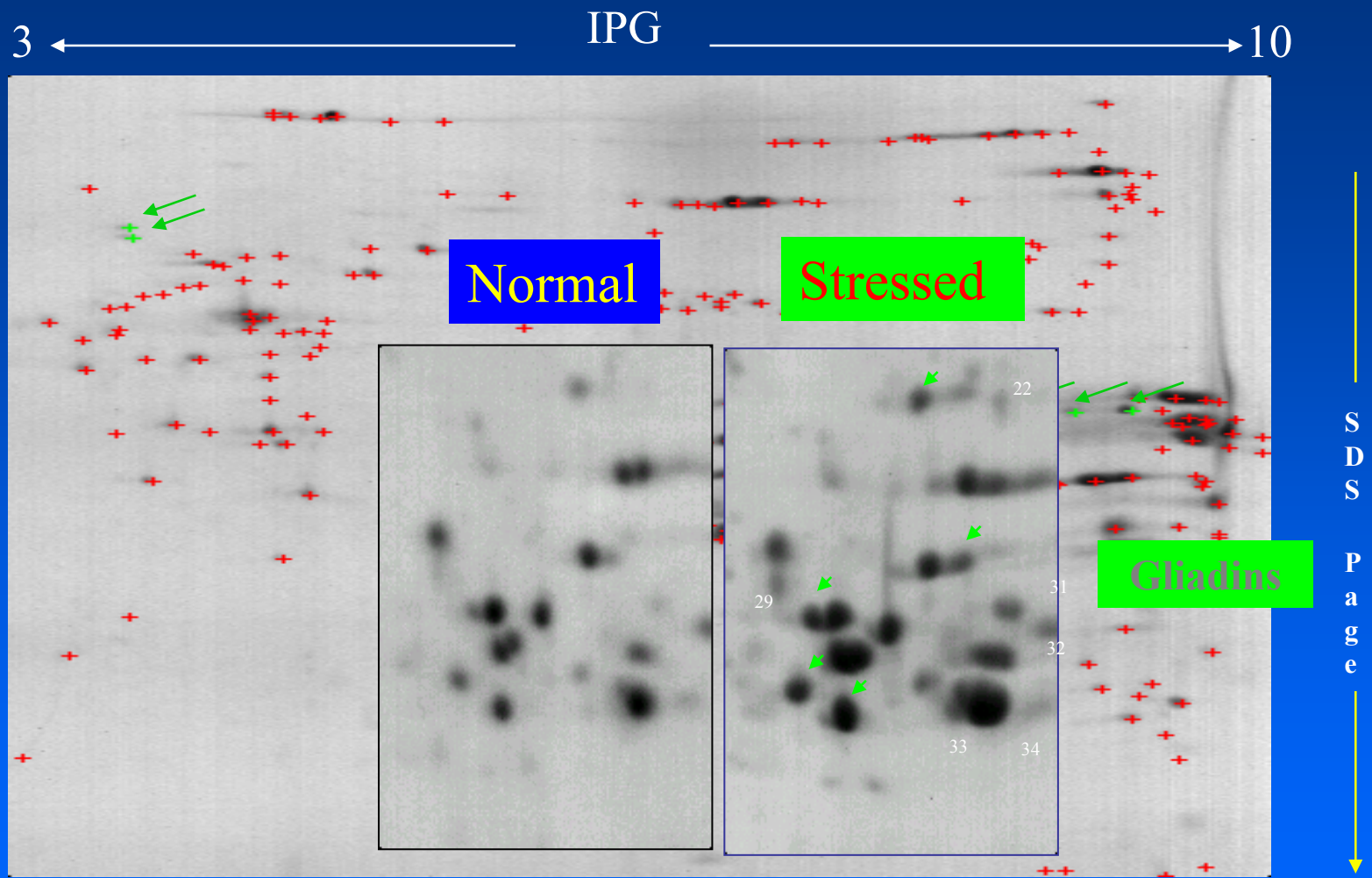
Effect of warm temperature on wheat proteome at kernel maturity on cv Thésée



Majoul T., **Bancel E.**, **Triboï E.**, **Ben Hamida J.**, **Branlard G.** Proteomics 2003, 3, 175-183

Genetic determination of protein quality in wheat grain

Genetic aspects of wheat storage proteins

Wheat storage proteins and quality

Quantitative variations of wheat storage proteins

Some other proteins involved in quality

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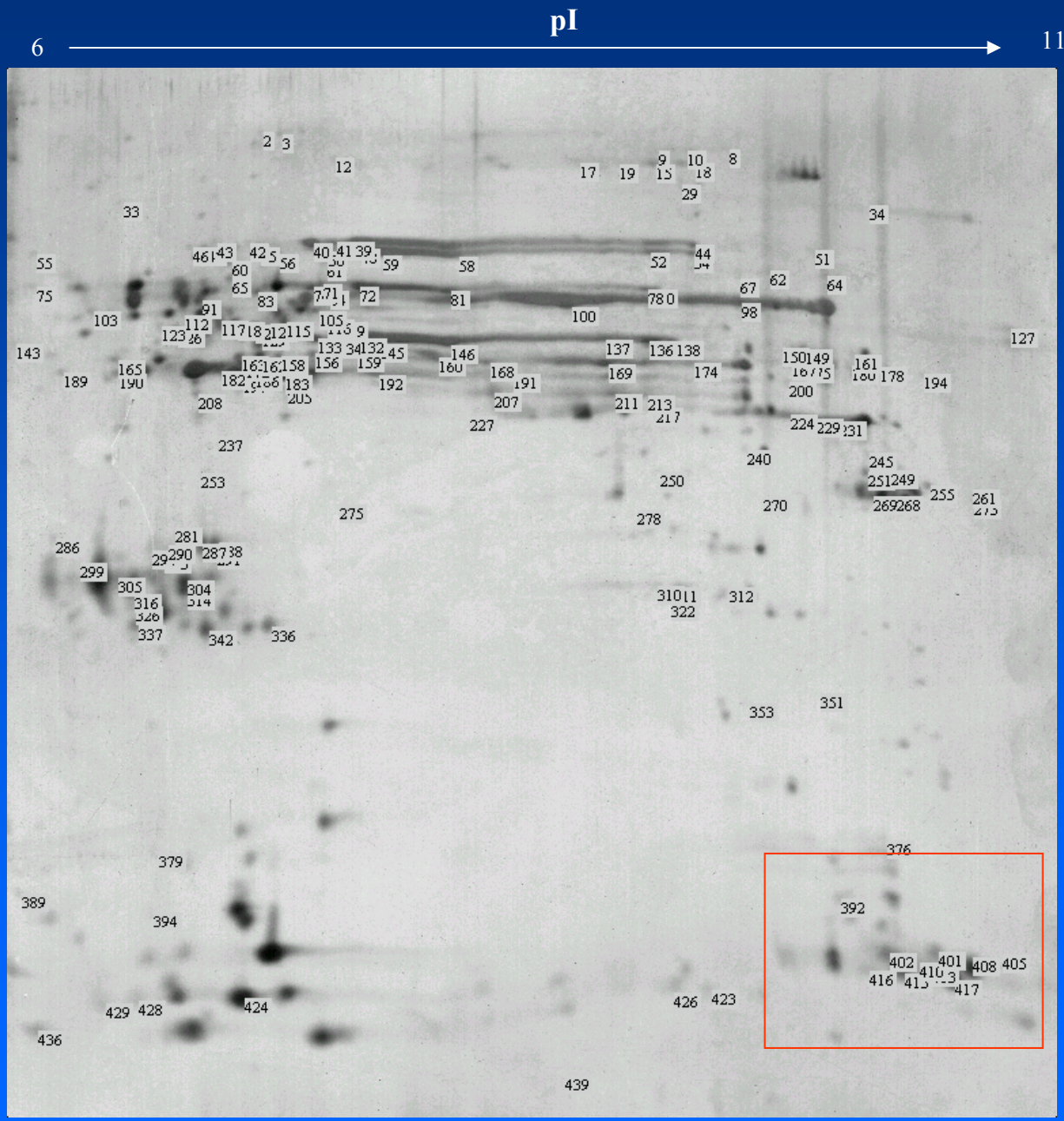
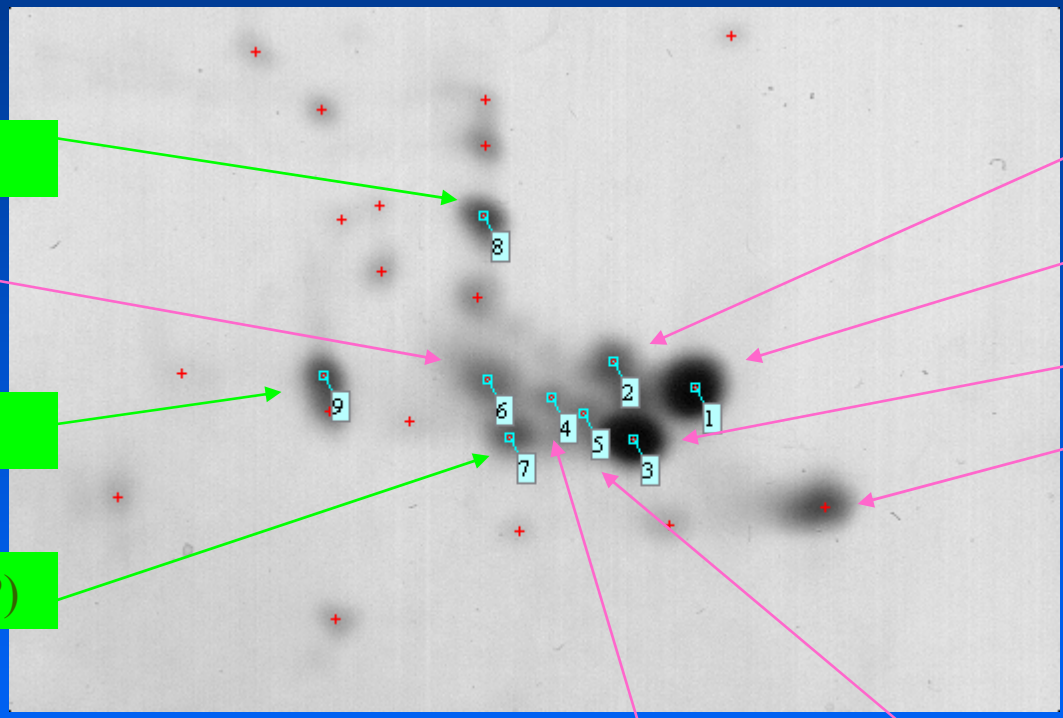
Amphiphilic proteins of Synthetic and Opata



D'après Amiour N., Merlino M;, Leroy P., Branlard G. Proteomics, 2002, 2, 632-641

Identification of the proteins in the puroindoline zone



From : Branlard G., Amiour N., Igrejas G., Gaborit T., Herbette S., Dardevet M., Marion D. Proteomics 2003, 3, 168-174

Conclusion

Wheat Storage Proteins like many plant characters are inherited by families of multigenes.

A very large diversity of WSP has been described, rending more complicated the search of associations between all the different combinations of alleles and technological properties.

The use of the known alleles of glutenins and gliadins allow today to create wheats suitable for the main uses

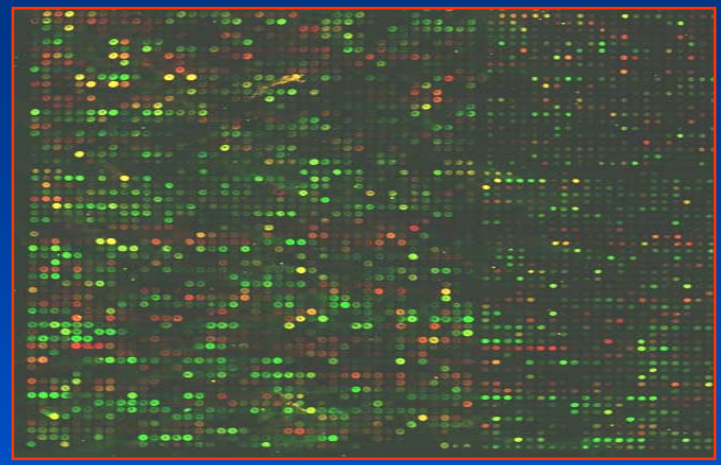
Accumulation of the grain components and particularly WSP are continually influenced by changing environment.

Today the major criticism on the wheat varieties is not the lack of quality but rather their environmental instability.

Question: How to find-out the key genes that govern the kernel protein content for future quality wheat ?

Micro-array provides a complex picture of the numerous DNA sequences which could be directly or not associated to the character

Micro-array is a bottom-up approach for studying gene expression



Proteomic approach is an unavoidable tool for studies on:

- gene expression, functional genomic, gene regulations
- relation between genotype and phenotype
- etc...

Proteomic is the top-down approach particularly useful for studies on plant physiology and environmental influence

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