THE ARITHMETICAL PHENOMENA OF SYMMETRY IN THE GENETIC CODE WITH THE MODULES OF SERGEI PETOUKHOV

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1. Introduction.

This study describes numerous phenomena of symmetry in the distribution of the amino acids in the genetic code table. These phenomena consist to arithmetical arrangements of sets of modules numbers or/and of protons numbers which are counted in each of the 20 amino acids used by the standard genetic code. The author has already presented numerous phenomena of symmetry about the genetic code in the study "The numeric connections of the genetic code"[1]. In this present article, is specifically investigated the molecular modules system of Professor Sergei Petoukhov.

2. Molecular structure and Petoukhov's structure of the 20 amino acids used in the genetic code.

Petoukhov's structure is an original system describing the living molecular structure. Here is a fragment of the article[2]: S.V.Petoukhov "Genetic Code and the Ancient Chinese "Book Of Changes " "Symmetry: Culture and Science", 1999, vol.10 :

> *…Instead of usual symbols of atoms (in a form of circles with the letters inside) new symbolism will represent each non-hydrogen atom by number of protons of its nucleus. For example, atom of nitrogen will be represented by number 7. If one or several atoms of hydrogen are joined to some non-hydrogen atom, we shall add protons of hydrogen to number of protons of non-hydrogen atom always. Such group of the non-hydrogen atom with its adjoined hydrogen atoms (i.e., "protonated" non-hydrogen atom) will be denote by sum of protons of their nucleuses. For example, amino group NH_2 will be denoted by number 9 which is sum of 7 protons of nitrogen atom and 2 protons of two hydrogen atoms. In such schemes the atoms of hydrogen are not represented independently at all, and their presence at a molecule simply increases general number of protons of the atoms, connected to them directly…*

Molecular structure and Petoukhov's structure of the 20 amino acids (for example here the glycine):

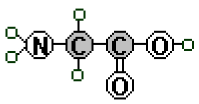
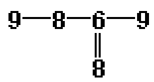
Molecular structure	Petoukhov's structure
	
10 atoms - 40 protons	5 modules - 40 protons

Fig.1. Molecular structure and Petoukhov's structure of the 20 amino acids (inspired by S. Petoukhov's paper)

So, a module is a grouping of one non-hydrogen atom with from 0 to 3 hydrogen atoms. These modules are described by S. Petoukhov in a number from 6 to 9. This number is the quantity of protons inside the module.

In this study, the author (J-Y Boulay) uses a special counting of protons for the proline amino acid. The proline amino acid has a very particular structure. It is the only among all whose radical has an even number of protons. All other amino acids have an odd radical and organized with the common base (39 protons: also odd) form all a complete molecule possessing an even number of protons. The proline should lose a proton (a hydrogen) during its association on the base to form too a molecule in even number of protons. It is also the one amino acid with two electronic liaisons between the radical and the base. In this study, the proline hydrogen atom lost is nevertheless counted. So, in this study, it is counted for the proline 24 protons in the radical zone + 39 protons in the base zone, so a total number of protons equal to 63. This is the total number of protons of the proline radical + the one which is included in the common base of all the amino acids. The counting of modules numbers in the proline is not affected by that.

Depiction of the 20 amino acids which are used in the genetic code (molecular and modular depiction):

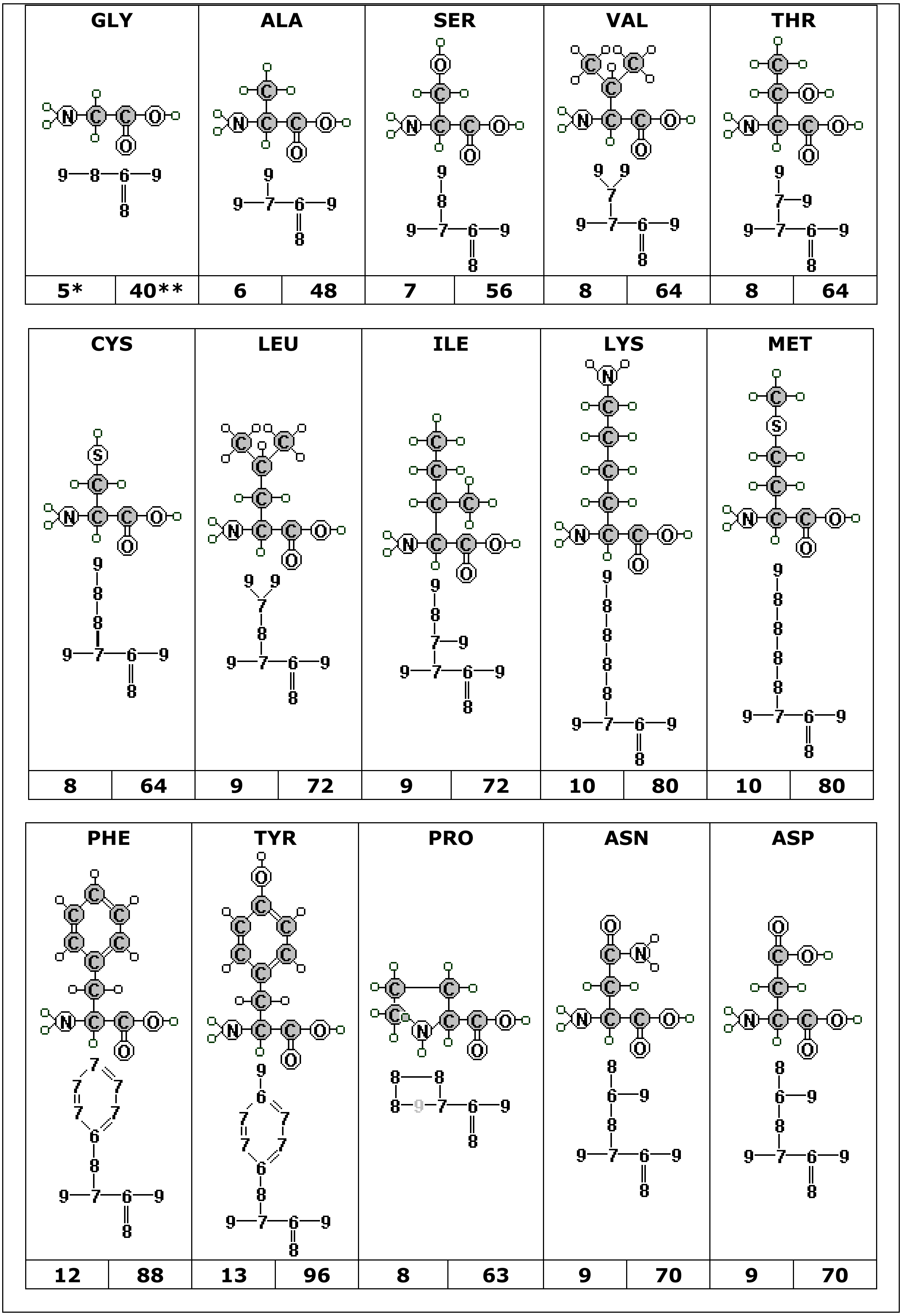


Fig. 2 (inspired by S. Petoukhov's paper). Molecular structure and Petoukhov's structure of the 20 amino acids.
* number of modules and ** number of protons in the amino acid. See the special counting for the proline.

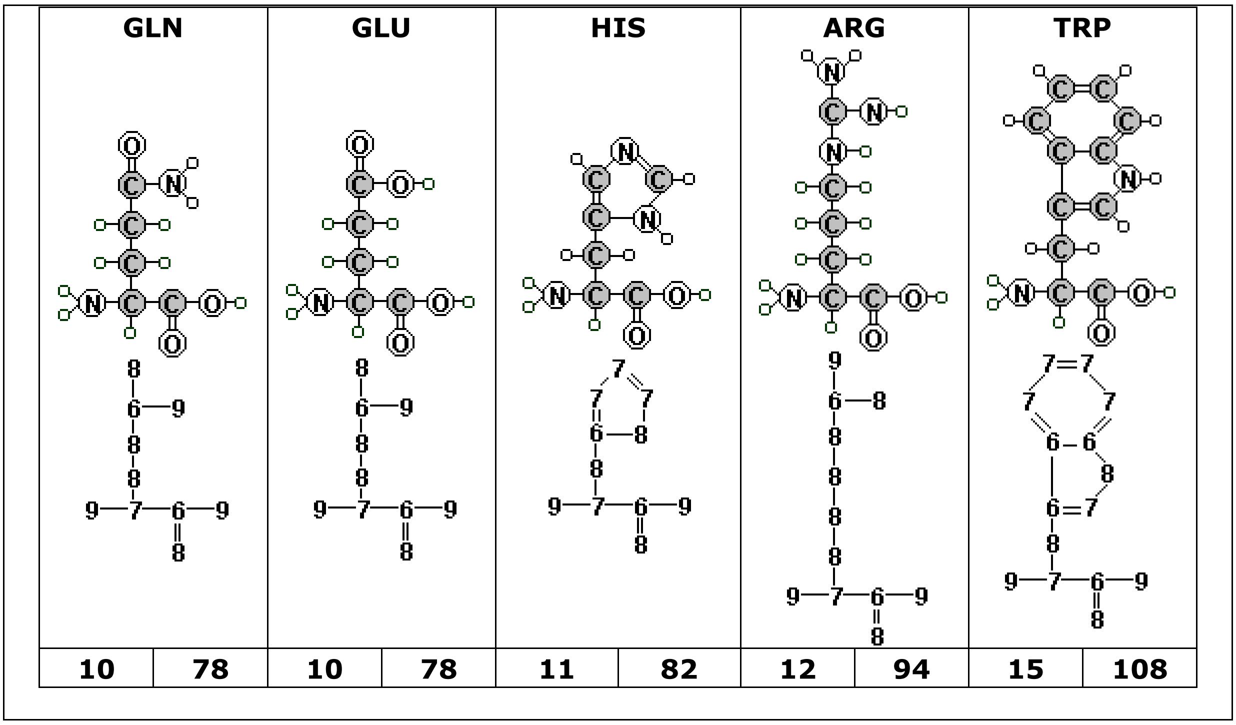


Fig. 2 (continuation). Molecular structure and Petoukhov's structure of the 20 amino acids. (inspired by S. Petoukhov's paper). * number of modules and ** number of protons in the amino acid. See the special counting for the proline.

3. Symmetrical distribution of the modules of S. Petoukhov.

The total modules number of the 64 coded (61 amino acids + 3 stop signals) is equal to 272. It is a multiple of the prime number 17.

The numbers of modules are regularly distributed in the genetic code table. The modules numbers of concentrated sets of from 16 to 2 boxes are all multiples of the prime number 17 and these different counting are systematically proportional to the number of boxes in the genetic code table.

16 boxes = 272

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	TG/AG 15	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

2 boxes = 34

2 boxes = 34

4 boxes = 68

8 boxes = 136

Fig. 3. Distribution of the modules numbers in the genetic code table. The total sums of the same color are all multiples of the prime number 17.

Many symmetry phenomena appear in the distribution of the modules in the genetic code table. These phenomena are presented directly in tables for a more easy depiction. For example, instead to use the dully words "the amino acids with the first DNA base…" it is used more simply the terms of "first column, second line, etc". The presented tables are compressed tables of the following complete genetic code table (Fig. 4). In this table, for each 64 coded: the DNA triplet, the modules number in the respective amino acid and the amino acid by three letters. Ranks of DNA bases are in the order A⇒T⇒G⇒C (or in the order A⇒G⇒T⇒C). By this same depiction system, all the arithmetical phenomena are quasi presented in this paper.

AAA	10	LYS	TAA	0		GAA	10	GLU	CAA	10	GLN		
AAG	10	LYS	TAG	0		GAG	10	GLU	CAG	10	GLN		
AAT	9	ASN	TAT	13	TYR	GAT	9	ASP	CAT	11	HIS		
AAC	9	ASN	TAC	13	TYR	GAC	9	ASP	CAC	11	HIS		
	38			**26**			**38**			**42**		**144**	**144**
ATA	9	ILE	TTA	9	LEU	GTA	8	VAL	CTA	9	LEU		
ATG	10	MET	TTG	9	LEU	GTG	8	VAL	CTG	9	LEU		
ATT	9	ILE	TTT	12	PHE	GTT	8	VAL	CTT	9	LEU		
ATC	9	ILE	TTC	12	PHE	GTC	8	VAL	CTC	9	LEU		
	37			**42**			**32**			**36**		**147**	**128**
AGA	12	ARG	TGA	0		GGA	5	GLY	CGA	12	ARG		
AGG	12	ARG	TGG	15	TRP	GGG	5	GLY	CGG	12	ARG		
AGT	7	SER	TGT	8	CYS	GGT	5	GLY	CGT	12	ARG		
AGC	7	SER	TGC	8	CYS	GGC	5	GLY	CGC	12	ARG		
	38			**31**			**20**			**48**		**137**	**122**
ACA	8	THR	TCA	7	SER	GCA	6	ALA	CCA	8	PRO		
ACG	8	THR	TCG	7	SER	GCG	6	ALA	CCG	8	PRO		
ACT	8	THR	TCT	7	SER	GCT	6	ALA	CCT	8	PRO		
ACC	8	THR	TCC	7	SER	GCC	6	ALA	CCC	8	PRO		
	32			**28**			**24**			**32**		**116**	**116**
	145			**127**			**114**			**158**		**544**	
	126			**112**			**114**			**158**			**510**

544 = with the rebel group **510 =** without the rebel group

Fig. 4. Distribution of the modules numbers in the genetic code table. In grey it is the rebel group.

The total modules number inside the coded is multiple of the prime number 17. That is with or without **the rebel group**.

with the rebel group	The rebel group only	without the rebel group
544 = 32 x 17	**34** = 2 x 17	**510** = 30 x17

3.1 Depiction of the rebel group.

Systematically, it seems that the coded are identical if the final DNA base of the codon is **either A or G** or if this base is **either T or C**. That excepts for a named group **"the rebel group"**: ATA (ILE), ATG (MET), TGG (TRP) and TGA (STOP).

The rebel group set apart,

codons code for the same coded if and only if

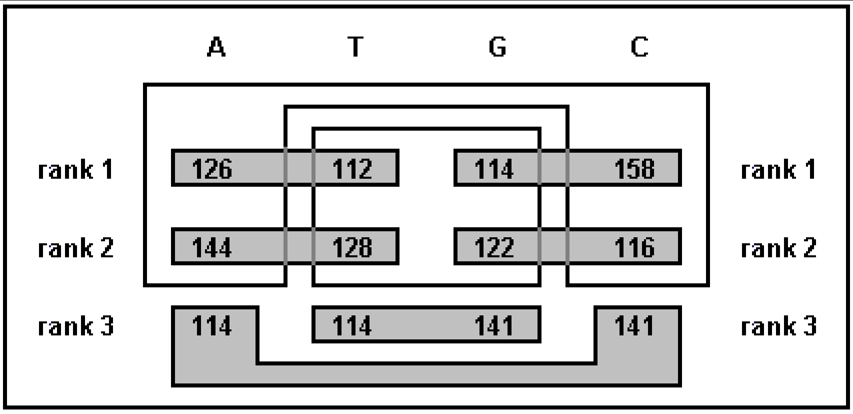
their last base is either A or G

or if their last base is either T or C.

In this group there are four singular coded. In this group there is coded MET, **the methionine**, the fundamental sulphured amino acid (**ATG** is the **initiator codon)**. Also in this group there is coded TRP, **the tryptophan** is the more large protons number coded. Also in this group there is coded **STOP signal**. And in this group there is coded ILE, **the isoleucine** which is the one amino acid inside and outside the rebel group.

The distinction of this set named by the author "the rebel group" is very important because the arithmetical phenomena of symmetry are different and more often very amplified if this set is not counted.

In numerous observations, the apartheid of the rebel group amplifies the arithmetical phenomena of symmetry in the genetic code mechanism. For first example, without the rebel group and in according with the ranks of the DNA bases, the amino acids are symmetrically distributed into sets with modules numbers which are multiples of the prime number 17.



126 + 112 = 238 = **14 x 17**
114 + 158 = 272 = **16 x 17**
144 + 128 = 272 = **16 x 17**
122 + 116 = 238 = **14 x 17**
114 + 141 = 255 = **15 x 17**
114 + 141 = 255 = **15 x 17**

126 + 144 + 158 + 116 = 544 = **32 x 17**
112 + 128 + 114 + 122 = 476 = **28 x 17**

Fig. 5. Symmetrical modules distribution in multiples of the prime number 17 in according with the ranks of the DNA bases (without the rebel group).

3.2 Distribution of the modules numbers in symmetrical sub groups.

3.2a With the rebel group.

In the genetic code table, the total modules sum of the columns 1 and 2 (**145 + 127)** and the total modules sum of the columns 3 and 4 (**114 + 158)** are identical! Their 2 sums are equal to **272 = 16 by 17**. So, this number is equal to 16 boxes by 17 modules.

AA/AG 20	**TA/AG 0**	GA/AG 20	CA/AG 20
AA/TC 18	**TA/TC 26**	GA/TC 18	CA/TC 22
AT/AG 19	**TT/AG 18**	GT/AG 16	CT/AG 18
AT/TC 18	**TT/TC 24**	GT/TC 16	CT/TC 18
AG/AG 24	TG/AG 15	GG/AG 10	CG/AG 24
AG/TC 14	**TG/TC 16**	GG/TC 10	CG/TC 24
AC/AG 16	**TC/AG 14**	GC/AG 12	CC/AG 16
AC/TC 16	**TC/TC 14**	GC/TC 12	CC/TC 16

272 = 2 x 8 x 17

AA/AG 20	TA/AG 0	**GA/AG 20**	**CA/AG 20**
AA/TC 18	TA/TC 26	**GA/TC 18**	**CA/TC 22**
AT/AG 19	TT/AG 18	**GT/AG 16**	**CT/AG 18**
AT/TC 18	TT/TC 24	**GT/TC 16**	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	**CG/AG 24**
AG/TC 14	TG/TC 16	**GG/TC 10**	**CG/TC 24**
AC/AG 16	TC/AG 14	**GC/AG 12**	**CC/AG 16**
AC/TC 16	TC/TC 14	**GC/TC 12**	**CC/TC 16**

272 = 2 x 8 x 17

Fig. 6. Symmetrical and even distribution of the modules in 2 by 2 columns.

The total modules sums of the following chequered configurations (Fig. 7) are also identical!

Their 2 sums are also equal to 272 so equal to 16 times the prime number 17. Thus the modules numbers are regularly distributed inside the 32 boxes of the genetic code table. It is not possible that this perfect distribution is by chance! Numerous other following observations go in this idea.

AA/AG 20	TA/AG 0	**GA/AG 20**	CA/AG 20
AA/TC 18	TA/TC 26	**GA/TC 18**	CA/TC 22
AT/AG 19	**TT/AG 18**	GT/AG 16	**CT/AG 18**
AT/TC 18	**TT/TC 24**	GT/TC 16	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	CG/AG 24
AG/TC 14	TG/TC 16	**GG/TC 10**	CG/TC 24
AC/AG 16	**TC/AG 14**	GC/AG 12	**CC/AG 16**
AC/TC 16	**TC/TC 14**	GC/TC 12	**CC/TC 16**

272 = 2 x 8 x 17

AA/AG 20	**TA/AG 0**	GA/AG 20	**CA/AG 20**
AA/TC 18	**TA/TC 26**	GA/TC 18	**CA/TC 22**
AT/AG 19	TT/AG 18	**GT/AG 16**	CT/AG 18
AT/TC 18	TT/TC 24	**GT/TC 16**	CT/TC 18
AG/AG 24	TG/AG 15	GG/AG 10	**CG/AG 24**
AG/TC 14	**TG/TC 16**	GG/TC 10	**CG/TC 24**
AC/AG 16	TC/AG 14	**GC/AG 12**	CC/AG 16
AC/TC 16	TC/TC 14	**GC/TC 12**	CC/TC 16

272 = 2 x 8 x 17

Fig. 7. Symmetrical and even distribution of the modules in 2 by 2 chequered configurations.

Recall: the total modules sum in the rebel group is equal to **34, so 2 times the prime number 17.**

3.2b Without the rebel group.

In the genetic code table, the total modules sum of the columns 1and 2 (**126 + 112)** and the total modules sum of the lines 3 and 4 (**122 + 116)** are identical! And the sum of the right chequered configuration is also the same.

Also, the total modules sum of the columns 3 and 4 (**114 + 158)** and the total modules sum of the lines 1 and 2 (**144 + 128)** are identical! And the total modules sum of the second chequered configurations is also the same.

AA/AG 20	**TA/AG 0**	GA/AG 20	CA/AG 20
AA/TC 18	**TA/TC 26**	GA/TC 18	CA/TC 22
AT/AG 19	**TT/AG 18**	GT/AG 16	CT/AG 18
AT/TC 18	**TT/TC 24**	GT/TC 16	CT/TC 18
AG/AG 24	TG/AG 15	GG/AG 10	CG/AG 24
AG/TC 14	**TG/TC 16**	GG/TC 10	CG/TC 24
AC/AG 16	**TC/AG 14**	GC/AG 12	CC/AG 16
AC/TC 16	**TC/TC 14**	GC/TC 12	CC/TC 16

238 = 2 x 7 x 17

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	TG/AG 15	**GG/AG 10**	**CG/AG 24**
AG/TC 14	**TG/TC 16**	**GG/TC 10**	**CG/TC 24**
AC/AG 16	**TC/AG 14**	**GC/AG 12**	**CC/AG 16**
AC/TC 16	**TC/TC 14**	**GC/TC 12**	**CC/TC 16**

238 = 2 x 7 x 17

AA/AG 20	**TA/AG 0**	GA/AG 20	**CA/AG 20**
AA/TC 18	**TA/TC 26**	GA/TC 18	**CA/TC 22**
AT/AG 19	TT/AG 18	**GT/AG 16**	CT/AG 18
AT/TC 18	TT/TC 24	**GT/TC 16**	CT/TC 18
AG/AG 24	TG/AG 15	GG/AG 10	**CG/AG 24**
AG/TC 14	**TG/TC 16**	GG/TC 10	**CG/TC 24**
AC/AG 16	TC/AG 14	**GC/AG 12**	CC/AG 16
AC/TC 16	TC/TC 14	**GC/TC 12**	CC/TC 16

238 = 2 x 7 x 17

AA/AG 20	TA/AG 0	**GA/AG 20**	**CA/AG 20**
AA/TC 18	TA/TC 26	**GA/TC 18**	**CA/TC 22**
AT/AG 19	TT/AG 18	**GT/AG 16**	**CT/AG 18**
AT/TC 18	TT/TC 24	**GT/TC 16**	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	**CG/AG 24**
AG/TC 14	TG/TC 16	**GG/TC 10**	**CG/TC 24**
AC/AG 16	TC/AG 14	**GC/AG 12**	**CC/AG 16**
AC/TC 16	TC/TC 14	**GC/TC 12**	**CC/TC 16**

272 = 2 x 8 x 17

AA/AG 20	**TA/AG 0**	**GA/AG 20**	**CA/AG 20**
AA/TC 18	**TA/TC 26**	**GA/TC 18**	**CA/TC 22**
AT/AG 19	**TT/AG 18**	**GT/AG 16**	**CT/AG 18**
AT/TC 18	**TT/TC 24**	**GT/TC 16**	**CT/TC 18**
AG/AG 24	**TG/AG 15**	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

272 = 2 x 8 x 17

AA/AG 20	TA/AG 0	**GA/AG 20**	CA/AG 20
AA/TC 18	TA/TC 26	**GA/TC 18**	CA/TC 22
AT/AG 19	**TT/AG 18**	GT/AG 16	**CT/AG 18**
AT/TC 18	**TT/TC 24**	GT/TC 16	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	CG/AG 24
AG/TC 14	TG/TC 16	**GG/TC 10**	CG/TC 24
AC/AG 16	**TC/AG 14**	GC/AG 12	**CC/AG 16**
AC/TC 16	**TC/TC 14**	GC/TC 12	**CC/TC 16**

272 = 2 x 8 x 17

Fig. 8. Same numbers of modules in 2 times 3 complementary configurations.

3.3 Others progressive sub groups perfectly symmetrical (only in the right configuration):

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	**GT/AG 16**	**CT/AG 18**
AT/TC 18	TT/TC 24	**GT/TC 16**	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	**CG/AG 24**
AG/TC 14	TG/TC 16	**GG/TC 10**	**CG/TC 24**
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

136 = 8 x 17

AA/AG 20	TA/AG 0	**GA/AG 20**	**CA/AG 20**
AA/TC 18	TA/TC 26	**GA/TC 18**	**CA/TC 22**
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	**TG/AG 15**	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	**GC/AG 12**	**CC/AG 16**
AC/TC 16	TC/TC 14	**GC/TC 12**	**CC/TC 16**

136 = 8 x 17

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	**GT/TC 16**	**CT/TC 18**
AG/AG 24	**TG/AG 15**	**GG/AG 10**	**CG/AG 24**
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

16 + 18 = 2 x 17
10 + 24 = 2 x 17

68 = 4 x 17

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	**GT/AG 16**	**CT/AG 18**
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	**TG/AG 15**	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	**GG/TC 10**	**CG/TC 24**
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

16 + 18 = 2 x 17

10 + 24 = 2 x 17

68 = 4 x 17

AA/AG 20	TA/AG 0	GA/AG 20	CA/AG 20
AA/TC 18	TA/TC 26	**GA/TC 18**	**CA/TC 22**
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	**TG/AG 15**	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	**GC/AG 12**	**CC/AG 16**
AC/TC 16	TC/TC 14	GC/TC 12	CC/TC 16

68 = 4 x 17

AA/AG 20	TA/AG 0	**GA/AG 20**	**CA/AG 20**
AA/TC 18	TA/TC 26	GA/TC 18	CA/TC 22
AT/AG 19	TT/AG 18	GT/AG 16	CT/AG 18
AT/TC 18	TT/TC 24	GT/TC 16	CT/TC 18
AG/AG 24	**TG/AG 15**	GG/AG 10	CG/AG 24
AG/TC 14	TG/TC 16	GG/TC 10	CG/TC 24
AC/AG 16	TC/AG 14	GC/AG 12	CC/AG 16
AC/TC 16	TC/TC 14	**GC/TC 12**	**CC/TC 16**

68 = 4 x 17

Fig. 9. Progressive sub configurations perfectly symmetrical. The modules numbers are proportional to the boxes numbers always.

3.4 The 34 great codons-coded

These symmetrical phenomena appear in the observation of modules numbers included in the boxes of 2 coded which have the 2 identical first DNA bases. 30 boxes (by 2 codons) code for 30 coded (1 only coded is by box) and 2 boxes (the rebel group) code for 4 coded (2 coded are by box). So, the number of "great" codons-coded is equal to 34**. This number is equal to 2 times the prime number 17**.

AA/AG LYS	TA/AG STOP	GA/AG GLU	CA/AG GLN
AA/TC ASN	TA/TC TYR	GA/TC ASP	CA/TC HIS
ATA ILE ATG MET	TT/AG LEU	GT/AG VAL	CT/AG LEU
AT/TC ILE	TT/TC PHE	GT/TC VAL	CT/TC LEU
AG/AG ARG	TGA STOP TGG TRP	GG/AG GLY	CG/AG ARG
AG/TC SER	TG/TC CYS	GG/TC GLY	CG/TC ARG
AC/AG THR	TC/AG SER	GC/AG ALA	CC/AG PRO
AC/TC THR	TC/TC SER	GC/TC ALA	CC/TC PRO

Fig.10. The 34 great codons-coded in according to the numbers of Petoukhov's modules.

In parallel of this, the total **protons number**[1] is multiple of the **prime number 13** with 8 boxes (of 4 codons) which code for 1 same coded, 6 boxes (of 4 codons) which code for 2 coded and 2 boxes which code for 3 coded. So, by the study of protons numbers, the number of these "great" codons-coded is equal to 26: **2 times the prime number 13** and the total protons number of all amino acids is multiple of the **prime number 13**.

3.5 Two sets of modules. The 3/2 ratio.

In according to their modules number, the 20 amino acids can be classified in 10 ranks. These 10 ranks are regrouped in two sets

- Set 1 with ranks of modules number from 5 to 9.
- Set 2 with ranks of modules number from 10 to 15.

Set 1 ranks of modules number from 5 to 9				**Set 2** ranks of modules number from 10 to 15			
Rank of the amino acid in according to the modules number	Amino acids	modules number	Total* modules number	Rank of the amino acid in according to the modules number	Amino acids	modules number	Total* modules number
1	GLY	5	20	6	GLU GLN **MET** LYS	10	60
2	ALA	6	24	7	HIS	11	22
3	SER	7	42	8	PHE ARG	12	96
4	PRO VAL THR CYS	8	112	9	TYR	13	26
5	**ILE** LEU ASN ASP	9	108	10	**TRP**	**15**	**15**
Total modules number			**306**	Total modules number			**204**
= 18 x **17**				= 12 x **17**			

Fig. 11. Classification of the 20 amino acids in according to the modules number. The rebel group is not counted. * Total modules number in the complete genetic code, for example, GLY is 4 times coded.

Without the rebel group, these two sets have a total modules number which is multiple of the prime number 17: 18 by 17 modules for the first set and 12 by 17 modules for the second set. The ratio between these two numbers (18/12) is equal to 3/2.

This ratio is not by chance: Sergei Petoukhov has presented this ratio in numerous observations in different papers and for different study aspects of the genetic code. For example[2], the hydrogen bonds number in the DNA is to 3 between the DNA bases G and C and to 2 between the DNA bases A and T. This ratio is too introduced by the author in same following depictions in this present article.

3.6 Connections of the phenomena with the DNA structure.

The total number of protons in the 4 bases of DNA is also multiple of the **prime number 17**.

Numbers of protons in the 4 bases of DNA[2]:

A = 70	T = 66	A + T = **136** = 8 x **17**
G = 78	C = 58	G + C = **136** = 8 x **17**

Total protons number in the 64 codons*: 136 by 3 (triplets) by 64 = 26112

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                                                              A  T  G
                                                              |  |  |
*complete codons (complete DNA coding), for example not just A-T-G but T  A  C
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Protons number in DNA + modules number in the all amino acids are multiple of 17 x 49 (prime number 7^2).
This without or with the rebel group.

Sets quality	Modules in AA (in the 64 coded)	Protons in DNA (in the 64 complete triplets)	Total sums
without rebel group	**510** = **30** x 17 x 1	**24480** = **30** x 17 x 48 = **510** x 48	**24990** = **30** x 17 x 49 = **510** x 49
rebel group only	**34** = **2** x 17 x 1	**1632** = **2** x 17 x 48 = **34** x 48	**1666** = **2** x 17 x 49 = **34** x 49
with rebel group	**544** = **32** x 17 x 1	**26112** = **32** x 17 x 48 = **544** x 48	**26656** = **32** x 17 x 49 = **544** x 49

Fig.13. Counting of modules in amino acids and of protons in DNA.

The same numbers are present in the different counting (modules or protons): **34**, **510** and **544**!

3.7 Similarity between the adenosine triphosphate molecule (ATP) and the rebel group.

The adenosine triphosphate molecule (ATP), this very important molecule used in the translation of the genetic code, has a protons number which is multiple of the prime number 13 and **a modules number which is multiple of the prime number 17**! This is like the total protons number and the total modules number inside all coded. This is also like inside the rebel group.

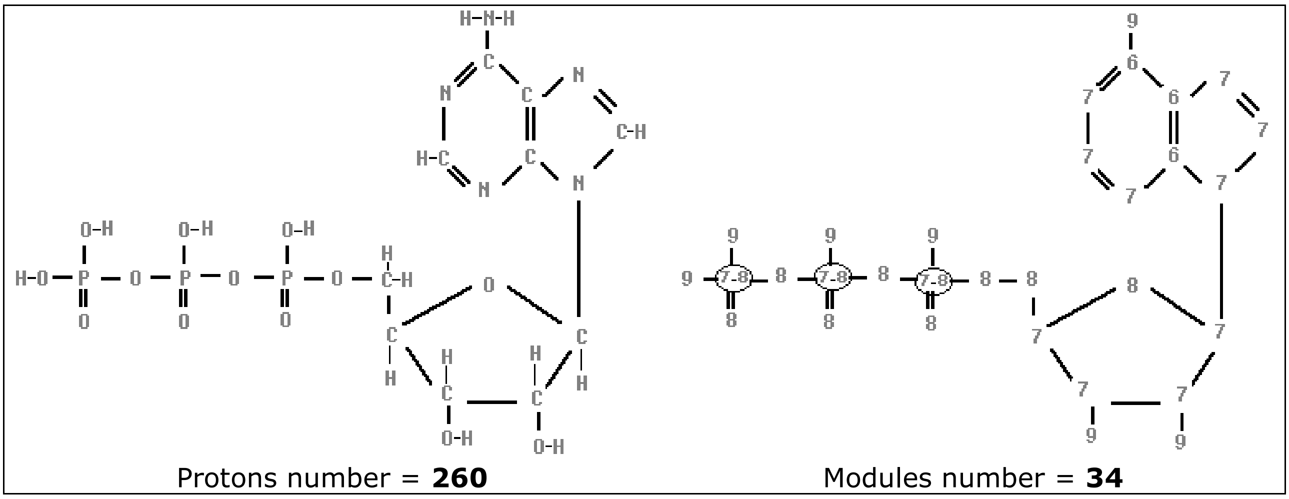


Fig. 14. Molecular structure and Petoukhov's structure of ATP.

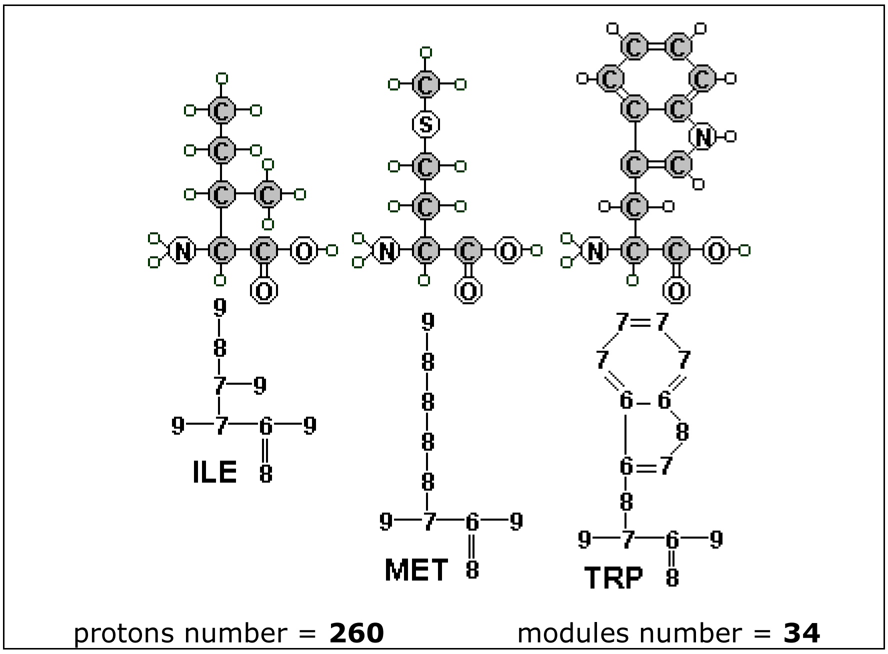


Fig. 15. Molecular structure and Petoukhov's structure of the rebel group. (Pictures inspired by S. Petoukhov's paper)

So, the protons number and the modules number of the ATP molecule and those of the 3 amino acids of the rebel group are identical: **260** protons (20 times prime number 13) and **34** modules (2 times prime number 17).

4. The modules liaisons.

Here are studied the counting of electronic liaisons between Petoukhov's modules of each amino acid. In this counting system, it is not specified the quality of the liaison (one or two electrons in the liaisons are equally considered). So, a twice electronic liaison is counted to one only liaison.

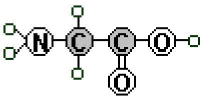
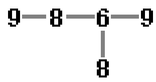
Molecular structure (here the glycine)	Petoukhov's structure (of the glycine)
	
10 atoms (40 protons) 10 electronic liaisons	5 modules (40 protons) **4 modules liaisons**

Fig. 16. Depictions of the electronic liaisons in the amino acids (for example here is the glycine).

For the sulphured amino acids, S. Petoukhov counts two modules in the sulphur atom. Thus one liaison is also counted between the two sulphured modules in the cysteine and in the methionine.

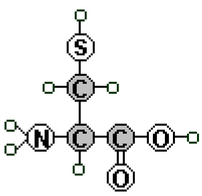
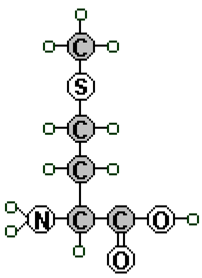
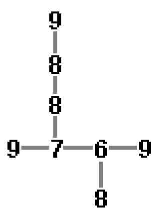
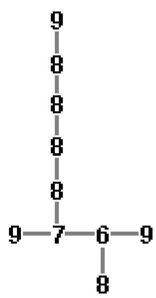
Molecular structure of CYS and MET		Petoukhov's structure of CYS and MET	
			
14 atoms 14 e. liaisons	20 atoms 20 e. liaisons	8 modules **7 modules liaisons**	10 modules **9 modules liaisons**

Fig. 17. Depictions of the electronic liaisons in the 2 sulphured amino acids.

The counting of the modules liaisons in the genetic code table reveals arithmetical phenomena of symmetry. These phenomena are by multiples of prime numbers 11 and 7. Here, DNA bases are in the order A⇒G⇒T⇒C.

AAA	9	LYS	GAA	9	GLU	TAA	0	stop	CAA	9	GLN		
AAG	9	LYS	GAG	9	GLU	TAG	0	stop	CAG	9	GLN		
AAT	8	ASN	GAT	8	ASP	TAT	13	TYR	CAT	11	HIS		
AAC	8	ASN	GAC	8	ASP	TAC	13	TYR	CAC	11	HIS		
	34			34			26			40		134	134
AGA	11	ARG	GGA	4	GLY	TGA	0	stop	CGA	11	ARG		
AGG	11	ARG	GGG	4	GLY	TGG	16	TRP	CGG	11	ARG		
AGT	6	SER	GGT	4	GLY	TGT	7	CYS	CGT	11	ARG		
AGC	6	SER	GGC	4	GLY	TGC	7	CYS	CGC	11	ARG		
	34			16			30			44		124	108
ATA	8	ILE	GTA	7	VAL	TTA	8	LEU	CTA	8	LEU		
ATG	9	MET	GTG	7	VAL	TTG	8	LEU	CTG	8	LEU		
ATT	8	ILE	GTT	7	VAL	TTT	12	PHE	CTT	8	LEU		
ATC	8	ILE	GTC	7	VAL	TTC	12	PHE	CTC	8	LEU		
	33			28			40			32		133	116
ACA	7	THR	GCA	5	ALA	TCA	6	SER	CCA	8	PRO		
ACG	7	THR	GCG	5	ALA	TCG	6	SER	CCG	8	PRO		
ACT	7	THR	GCT	5	ALA	TCT	6	SER	CCT	8	PRO		
ACC	7	THR	GCC	5	ALA	TCC	6	SER	CCC	8	PRO		
	28			20			24			32		104	104
	129			98			120			148		495	
	112			98			104			148			462

With the rebel group: **495** liaisons Without the rebel group: 462 liaisons

Fig. 18. Counting of the modules liaisons in the genetic code table. In grey it is the rebel group.

4.1 High importance to show the rebel group.

With or without the rebel group, the total number of modules liaisons is multiple of the prime number 11:

with the rebel group:	**495** liaisons	= **11** x 45
the rebel group only:	**33** liaisons	= **11** x 3
without the rebel group:	**462** liaisons	= **11 x 7** x 6

This counting has some similarity with the modules counting:

With or without the rebel group, the total number of Petoukhov's modules is multiple of the prime number 17:

with the rebel group:	**544** modules	= **17** x 32
the rebel group only:	**34** modules	= **17** x 2
without the rebel group:	**510** modules	= **17 x 5** x 6

In numerous observations introduced in the study "The numeric connections of the genetic code"[1] the author discovered some similarities with this previous arithmetical phenomenon about the rebel group. For example with the protons counting:

With or without the rebel group, the total number of protons is multiple of the prime number 13. With or without the rebel group, the total number of neutrons is multiple of the prime number 7.

with the rebel group:	**4264** protons	= **13** x 328	**3654** protons	= **7** x 522
the rebel group only:	**260** protons	= **13** x 20	**224** protons	= **7** x 32
without the rebel group:	**4004** protons	= **13** x 308	**3430** protons	= **7** x 490

4.2 Arithmetical phenomena without the rebel group.

Without the rebel group, appear numerous configurations of sets of numbers of modules liaisons which are by multiples of prime numbers 11 and 7.

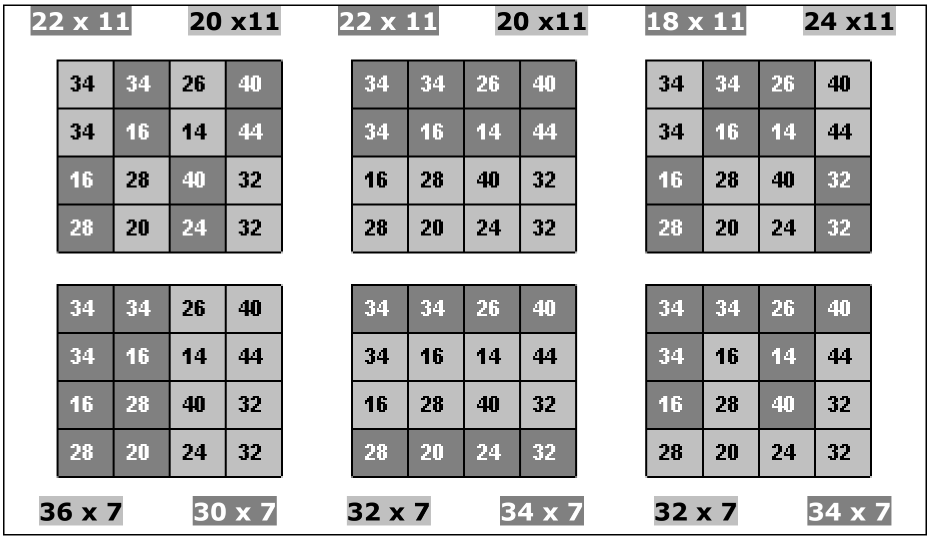


Fig. 19. Configurations of modules liaisons numbers which are multiples of prime numbers 11 and 7. (Compressed genetic code table presented in fig. 18)

In the two last previous configurations appear regular concentrations of 7 multiples from 8 boxes to 1 box.

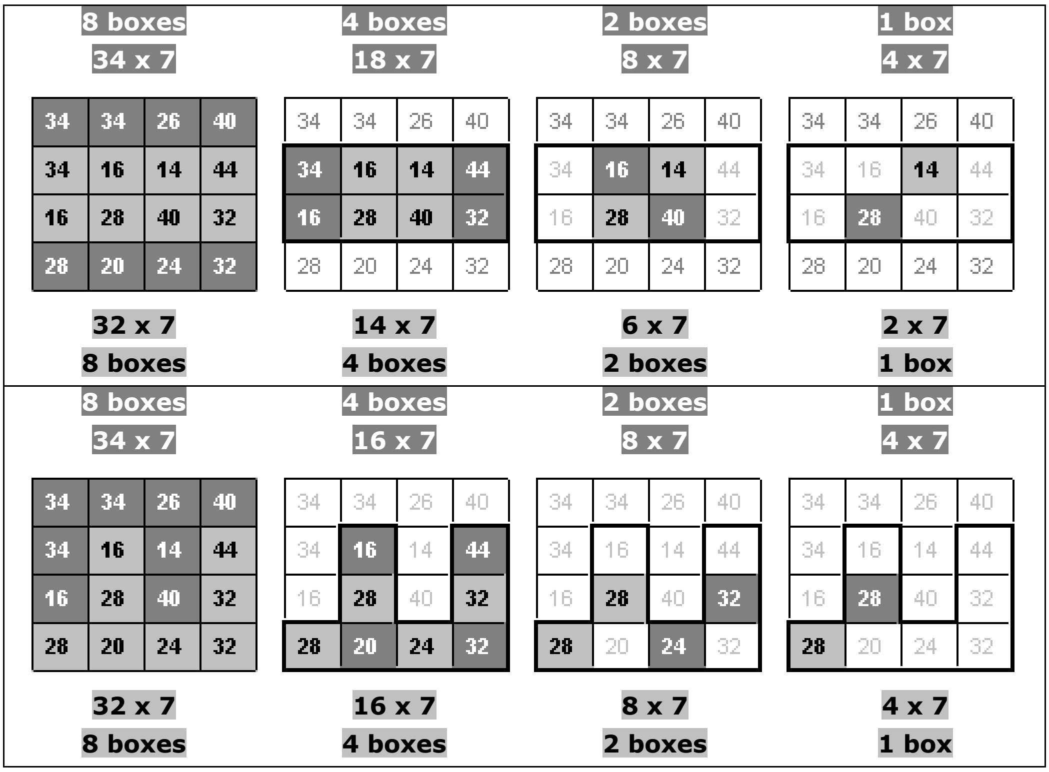


Fig. 20. Regular concentrations of 7 multiples from 8 to 1 box.

This last second configuration is inside the set of 8 boxes which have one only coded amino acid. (See Fig.18)

4.2 Arithmetical phenomena of symmetry by the special Petoukhov's table.

Other symmetrical configurations of 7 multiples appear in another presentation of the genetic code table. These configurations are distributed in the special Petoukhov's table[2]. In this table, codons and anti-codons are symmetrically distributed:

CC 32	**CA 40**	**AC 28**	**AA 34**
CT 32	**CG 44**	**AT 16**	**AG 34**
TC 24	**TA 26**	**GC 20**	**GA 34**
TT 40	**TG 14**	**GT 28**	**GG 16**

Fig. 21. Numbers of modules liaisons in the Petoukhov's table. (Summary of the genetic code table proposed by Petoukhov[2].)

In this table, these configurations consist to associations of one line and one square. These sets of numbers of modules liaisons are by multiples of the prime number 7.

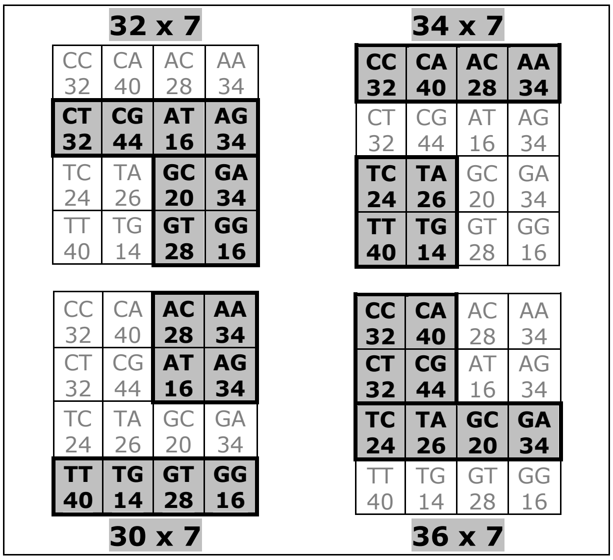


Fig. 22. Associations of one line and one square in the Petoukhov's table.

Inside these configurations, sub configurations are also multiples of the prime number 7 in the Petoukhov's table.

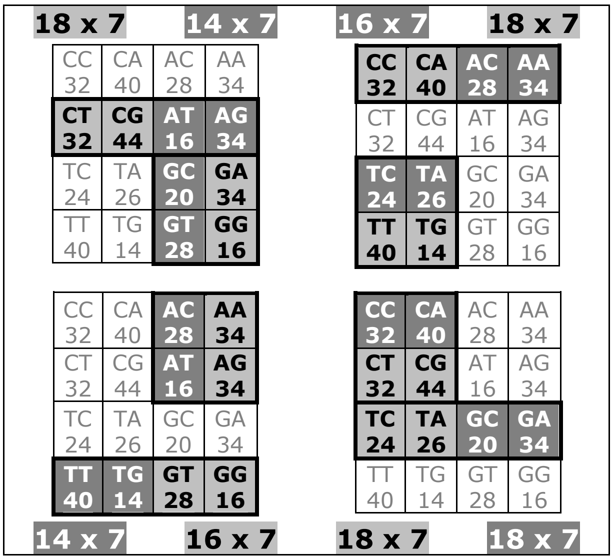


Fig. 23. Sub configurations with multiples of the prime number 7 in the Petoukhov's table.

5. The symmetrical and not symmetrical amino acids.

In different publications, Prof. Sergei Petoukhov has described two sets of amino acids with **a protons number which is multiple of 8 or not multiple of 8**. Here is presented more subtle configurations of 2 times four groups interactively embedded and including other criteria: **symmetrical** or **not symmetrical** radical, **quasi symmetrical** or **not quasi symmetrical** radical and protons number which is **equal** or **not equal** to **8 times the modules number**.

Remark about number 8: The works of the author are more specifically on the relationships between prime numbers and the genetic code. The number 8 is not directly a prime number but it is the prime number $\mathbf{2^{3}}$.

5.1 Distribution of the 20 amino acids in four groups

The 20 amino acids used in the genetic code can be distributed in four groups. These four groups are symmetrical, complementary and interactively embedded. These four groups separate the amino acids with a **protons number which is multiple of 8** from those with a **protons number which is not multiple of 8** and those with an **symmetrical radical** (including the electronic liaisons) from those with an **asymmetrical radical**.

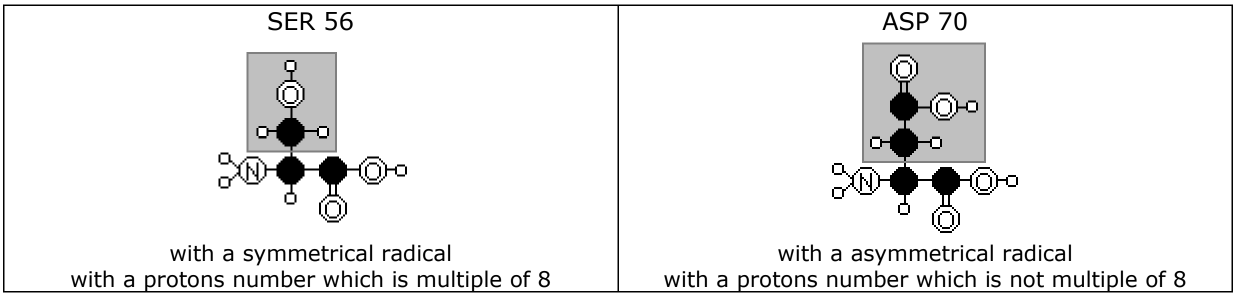


Fig. 24. Four criteria of segregation for the amino acids. (See also Fig.2) (Pictures inspired by S. Petoukhov's paper).

The totality of the amino acids with **a symmetrical radical** is included in the group with **a protons number which is multiple of 8**. And the totality of the amino acids with **a protons number which is not multiple of 8** is included in the group with **an asymmetrical radical**. The number of amino acids inside the respective opposed groups is identical and asymmetrically distributed.

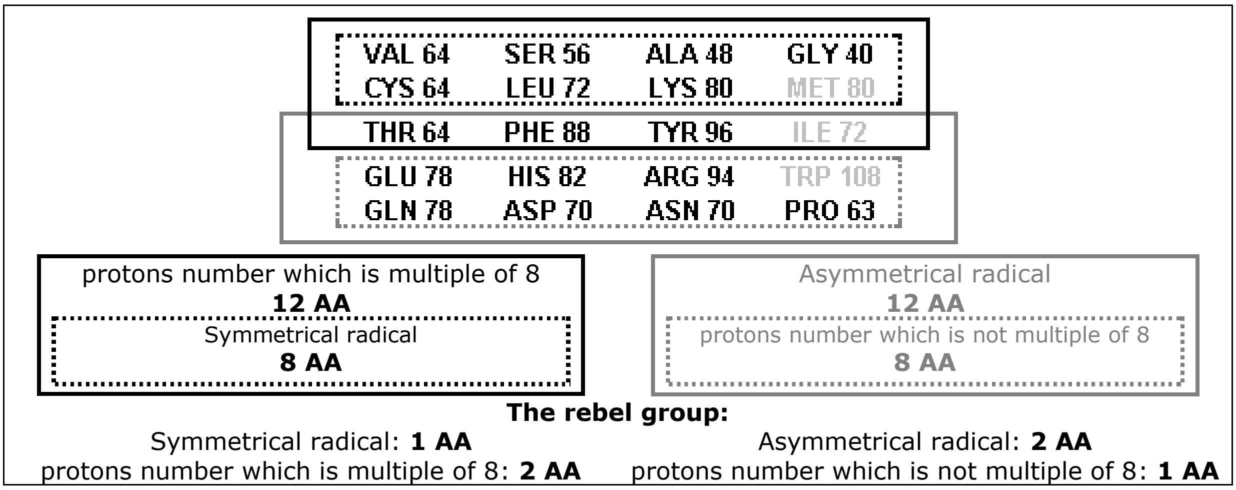


Fig. 25. Symmetrical distribution of the 20 AA. The number after each AA is its protons number. (See also Fig.2)

These different sets have for respective ratio 12/8 so the ratio 3/2 which is present in numerous arithmetic aspects about the genetic code. This ratio is introduced by S. Petoukhov[2] and by Shcherbak[3] in his nucleons study.

Not by chance, the rebel group is also symmetrically distributed. The isoleucine is the only amino acid of the rebel group also present out this rebel group and, not by chance, it is in the centre of this symmetrical distribution of the 20 amino acids separated in four interactive groups: **symmetrical radical** or **not symmetrical radical** and protons number which is **multiple of 8** or **not multiple of 8**.

5.2 Phenomena of multiples of the prime numbers 7, 11 and 13 by sets of protons counting.

Without the rebel group, the interaction between the group of AA with **symmetric radical** and this with **not symmetric radical** reveals arithmetical phenomena of symmetry. These phenomena are by sets of protons counting which are multiples of prime numbers **7**, **11** and **13**. The group of AA with **symmetrical radical** and the group with **not symmetric radical** have each a total protons number which is multiple of the prime number 13. The following tables are summaries of the genetic code table. Here, DNA bases are in the order A⇒G⇒T⇒C:

AA with not symmetrical radical

	A	G	T	C
A	140	296	192	320
G	188			376
T	144		176	
C	256			252

2340 = **13** x 4 x 45

AA with symmetrical radical

	A	G	T	C
A	**160**			
G	**112**	**160**	**128**	
T		**256**	**144**	**288**
C		**192**	**224**	

1664 = **13** x 4 x 32

Fig. 26. Distribution of protons numbers into two sets which are multiples of the prime number 13. (See fig. 2 and fig. 4).

The difference between these two values (2340 – **1664**) is equal to 4 by **13²**! Inside these two sets appear symmetrical sub sets interactively embedded which form news sets of multiples of prime numbers 7, 11 and 13.

symmetrical radical				not symmetrical radical			
160				140	296	192	320
112	**160**	128		188			376
	256	144	288	**144**		**176**	
	192	224		**256**			**252**

1708 = **7** x 4 x 61

symmetrical radical				not symmetrical radical			
160				140	296	**192**	**320**
112	**160**	**128**		188			**376**
	256	144	288	144		**176**	
	192	224		256			**252**

1876 = **7** x 4 x 67

symmetrical radical				not symmetrical radical			
160				**140**	**296**	**192**	**320**
112	160	**128**		**188**			**376**
	256	**144**	**288**	144		176	
	192	**224**		256			252

2296 = **7** x 4 x 82

symmetrical radical				not symmetrical radical			
160				**140**	**296**	192	320
112	160	128		**188**			376
	256	**144**	**288**	**144**		176	
	192	**224**		**256**			252

2128 = **7** x 4 x 76

symmetrical radical				not symmetrical radical			
160				**140**	**296**	**192**	**320**
112	**160**	128		**188**			**376**
	256	144	288	144		176	
	192	224		256			252

2392 = **13** x 4 x 46

symmetrical radical				not symmetrical radical			
160				140	296	**192**	**320**
112	160	128		188			**376**
	256	**144**	**288**	144		**176**	
	192	**224**		256			**252**

2420 = **11** x 4 x 55

symmetrical radical				not symmetrical radical			
160				140	296	192	320
112	160	**128**		188			376
	256	**144**	**288**	**144**		**176**	
	192	**224**		**256**			**252**

1612 = **13** x 4 x 31

symmetrical radical				not symmetrical radical			
160				**140**	**296**	192	320
112	**160**	**128**		**188**			376
	256	144	288	**144**		176	
	192	224		**256**			252

1584 = **11** x 4 x 36

Fig. 27. Distribution of protons numbers inside interactively embedded sub sets which form news sets of multiples of prime numbers 7, 11 and 13.

In similar organisations appear others symmetrical phenomena of multiples of prime number 11 and/or 13.

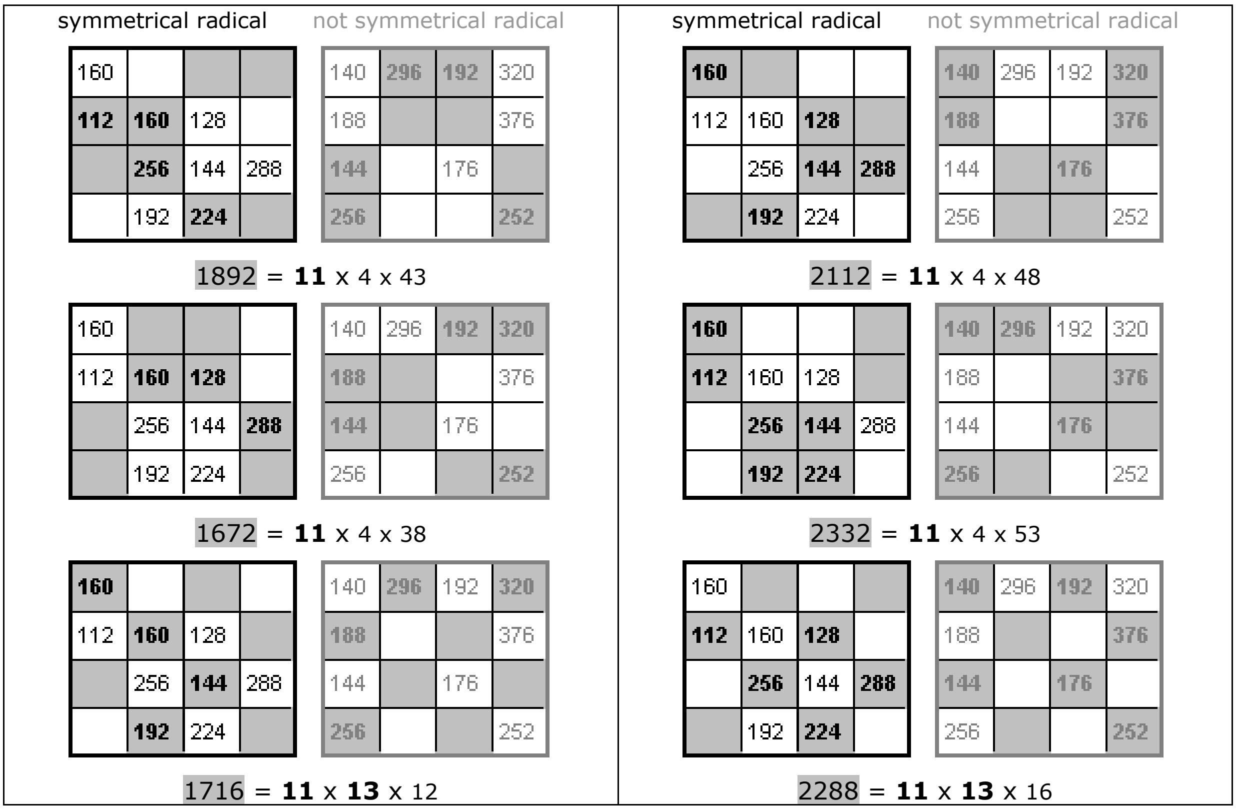


Fig. 28. Distribution of protons numbers into sub sets interactively embedded which form news sets of multiples of prime numbers 11 and/or 13.

5. 3 Distribution of the 20 amino acids in four another groups.

Four news other sets appear by little modification of the previous criteria. These four sets (very little different of the four previous studied) separate the AA with a protons number which is **equal to 8 times the modules number** from those with a protons number which is **not equal to 8 times the modules number** and those with a **symmetrical** or a **quasi symmetrical** radical from those with an **asymmetrical radical**.

In only two AA, in the phenylalanine and in the tyrosine, the radical is quasi symmetrical. Just the electronic liaisons are not symmetrical. The protons numbers of these two AA are multiple of 8 but are not equal to 8 times their modules number. In these two AA are juxtaposed two intricate phenomena: protons number which is multiple of 8 but not equal to 8 times their modules number and quasi symmetrical radical but not exactly symmetrical radical. Also, in only two other AA, in the isoleucine and in the threonine are juxtaposed two other phenomena: protons number which is multiple to 8 times their modules number but not symmetrical radical.

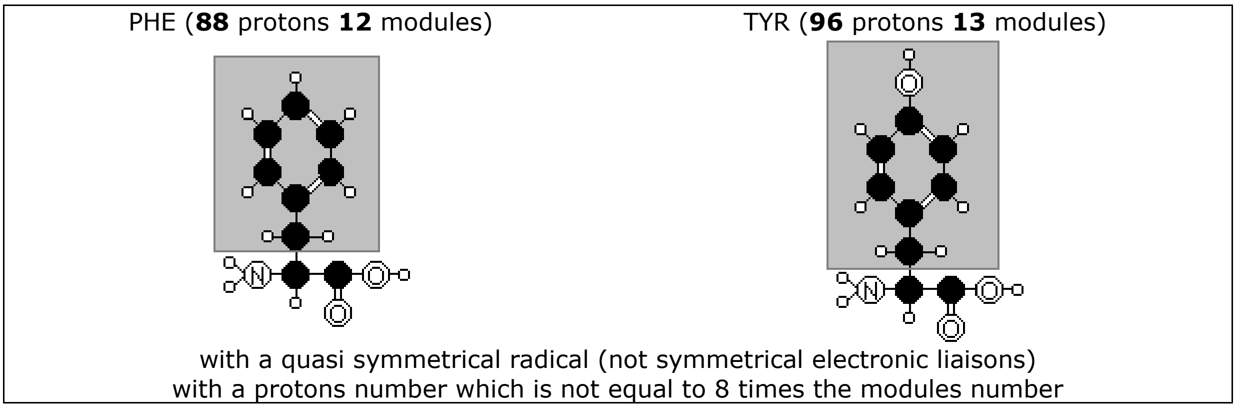


Fig. 29a. Particularities of the phenylalanine and the tyrosine (pictures inspired by S. Petoukhov's paper).

ILE (72 protons 9 modules) THR (64 protons 8 modules)

with a not symmetrical radical
with a protons number which is equal to 8 times the modules number

Fig. 29b. Particularities of the isoleucine and the threonine. (Pictures inspired by S. Petoukhov's paper)

These new criteria reveal four news sets with always the same number of amino acids: 10 amino acids in each set. Associations of two opposed sets have a protons number which is multiple of the prime number 13.

Symmetrical or **quasi symmetrical** radical: **10 AA**	VAL 64/8 SER 56/7 ALA 48/6 GLY 40/5 CYS 64/8 LEU 72/9 LYS 80/10 MET 80/10 THR 64/8 PHE 88/12 TYR 96/13 ILE 72/9 GLU 78/10 HIS 82/11 ARG 94/12 TRP 108/15 GLN 78/10 ASP 70/9 ASN 70/9 PRO 63/8	Protons number which is **not equal** to 8 times the modules number: **10 AA**
2112 protons	4160 = **13** x 8 x 40 protons	2048 protons
Protons number which is **equal** to 8 times the modules number: **10 AA**	VAL 64/8 SER 56/7 ALA 48/6 GLY 40/5 CYS 64/8 LEU 72/9 LYS 80/10 MET 80/10 THR 64/8 PHE 88/12 TYR 96/13 ILE 72/9 GLU 78/10 HIS 82/11 ARG 94/12 TRP 108/15 GLN 78/10 ASP 70/9 ASN 70/9 PRO 63/8	**Asymmetrical** radical: **10 AA**
2216 protons	4368 = **13** x 8 x 42 protons	2152 protons

The rebel group: MET80/10 ILE72/9 TRP108/15

Symmetrical or **quasi symmetrical** radical: **1 AA.** Protons number which is **equal** to 8 times the modules number: **2 AA.**	**Asymmetrical** radical: **2 AA.** Protons number which is **not equal** to 8 times the modules number: **1 AA.**

Fig. 30. 4 sets of 10 amino acids by criteria of radical symmetry and modules number (protons number/modules number).

5.4 Phenomena of multiples of prime number 7, 11 and 13.

The total protons number of the 64 coded of the genetic code is multiple of prime number 13. The total protons number of these previously described interactive sets is also multiple of the prime number 13.

Symmetrical or **quasi symmetrical** radical
And
Protons number which is **not equal** to 8 times the modules number

160		192	
112	160	128	
80	256	320	288
	192	224	

140	296	192	320
188		108	376
		176	
			252

4160 = **13** x 8 x 40

Protons number which is **equal** to 8 times the modules number
And
Asymmetrical radical

160			
112	160	128	
296	256	144	288
256	192	224	

140	296		320
188		108	376
216			
256			252

4368 = **13** x 8 x 42

Fig. 31. Distribution of the protons number into 2 times 2 sets of 10 amino acids by criteria of radical symmetry and modules number. (Compressed genetic code table with DNA bases in the order A⇒G⇒T⇒C).

By superposition of the set with protons number which is **equal to 8 times the modules number** and the set with **asymmetrical radical** appear others arithmetical phenomena of multiples of prime numbers 7, 11 and 13.

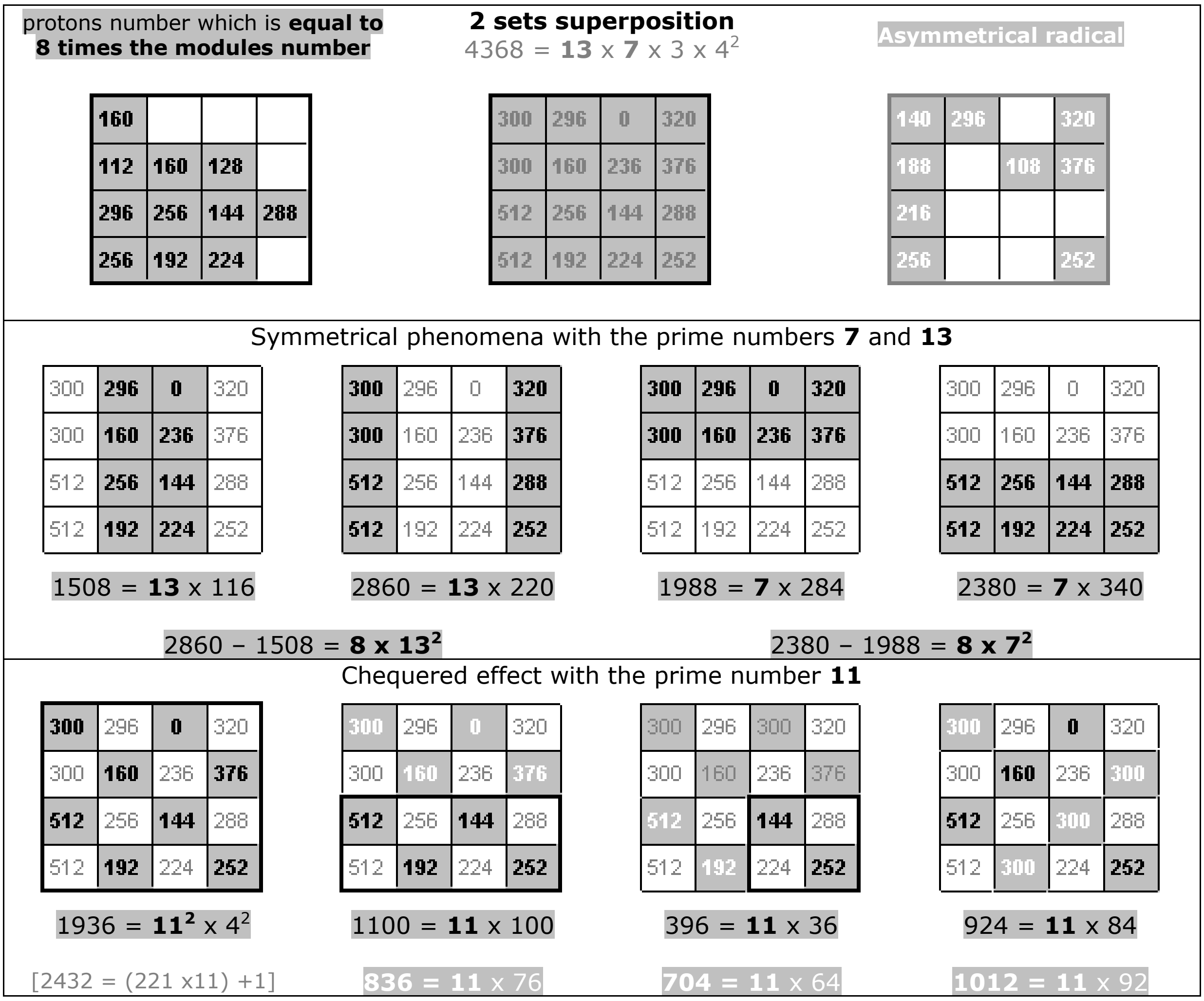


Fig. 32. Distribution of the protons number with superposition of the set of protons number which is equal to 8 times the modules number and of the set of asymmetrical radical.

6. Two sets of modules: The matrix of the modules.

In according to their protons number and to their modules number the 20 amino acids can be separated in two sets. These two sets separate the amino acids with a protons number which is equal to 8 times their modules number to those with a protons number which is not equal to 8 times their modules number.

Amino acid	Modules number in according to the quality of module (protons number of:)				Modules number	Protons number
	6	7	8	9		
GLY	1	0	2	2	5	40
ALA	1	1	1	3	6	48
SER	1	1	2	3	7	56
VAL	1	2	1	4	8	64
THR	1	2	1	4	8	64
CYS	1	1	3	3	8	64
LEU	1	2	2	4	9	72
ILE	1	2	2	4	9	72
LYS	1	1	5	3	10	80
MET	1	1	5	3	10	80

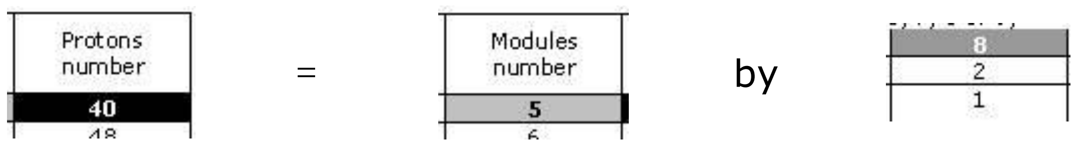
Fig. 33. SET 1: amino acids with a protons number which is equal to 8 times their modules number.

Amino acid	**Modules number in according to the quality of module (protons number of 6, 7, 8 or 9)**				**Modules number**	**Protons number**
	6	**7**	**8**	**9**		
PHE	2	6	2	2	12	88
TYR	3	5	2	3	13	96
PRO	1	1	4	2	8	63
ASN	2	1	3	3	9	70
ASP	2	1	3	3	9	70
GLN	2	1	4	3	10	78
GLU	2	1	4	3	10	78
HIS	2	4	3	2	11	82
ARG	2	1	6	3	12	94
TRP	4	6	3	2	15	108

Fig. 34. SET 2: amino acids with a protons number which is not equal to 8 times their modules number.

In the first set, the protons number of each amino acid is an exact multiple of the modules number. The protons number of each amino acid is equal to 8 times the value of the modules number. More precisely, **the protons number** is equal to the value of **the modules number** by **the third value** of the four different qualities of modules (modules of 6, 7, 8 and 9 protons):

Amino acid	Modules number in according to the quality of module (protons number of 6, 7, 8 or 9)				Modules number	Protons number
	6	7	8	9		
GLY	1	0	2	2	**5**	**40**
ALA	1	1	1	3	6	48

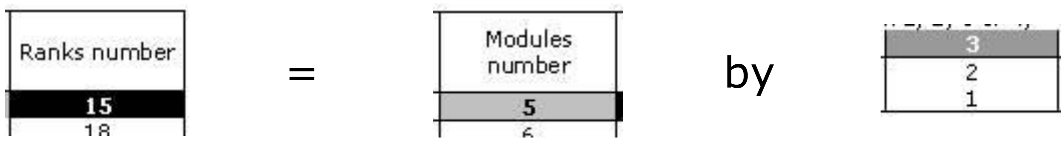


Protons number = Modules number by the third value of the 4 different qualities of modules

Fig.35. Arithmetical mechanism of relationship between the protons number and the modules number in the first set.

If the values of the quality of the modules are modified by all other values of an other set of numbers which have a regular sequence, the same phenomenon is preserved. For example, if the values 6-7-8-9 are changed by the values 1-2-3-4, the final value is equal to the value of the modules number by the third value (here this value is 3) of the four different qualities of modules:

Amino acid	Modules number in according to the quality of Module (for example: rank 1, 2, 3 or 4)				Modules number	Ranks number
	1	2	3	4		
GLY	1	0	2	2	**5**	**15**
ALA	1	1	1	3	6	18



Ranks number = Modules number by the third value of the 4 different qualities of modules

Fig. 36. Arithmetical mechanism of relationship between protons number and quality of modules number in the first set.

This arithmetical phenomenon appears only in the first set. This arithmetical phenomenon appears not in the second set:

SET 1: AA with a protons number which is **equal to 8 times their modules number**						
Amino acid	**Modules number in according to the quality of module (rank 1, 2, 3 or 4)**				**modules number**	**Ranks numbers**
	1	**2**	**3**	**4**		
GLY	1	0	2	2	5	15
ALA	1	1	1	3	6	18
SER	1	1	2	3	7	21
VAL	1	2	1	4	8	24
THR	1	2	1	4	8	24
CYS	1	1	3	3	8	24
LEU	1	2	2	4	9	27
ILE	1	2	2	4	9	27
LYS	1	1	5	3	10	30
MET	1	1	5	3	10	30
SET 2: AA with a protons number which is **not equal to 8 times their modules number**						
Amino acid	**Modules number in according to the quality of module (rank 1, 2, 3 or 4)**				**Modules number**	**Ranks numbers**
	1	**2**	**3**	**4**		
PHE	2	6	2	2	12	28
TYR	3	5	2	3	13	31
PRO	1	1	4	2	8	23
ASN	2	1	3	3	9	25
ASP	2	1	3	3	9	25
GLN	2	1	4	3	10	28
GLU	2	1	4	3	10	28
HIS	2	4	3	2	11	27
ARG	2	1	6	3	12	34
TRP	4	6	3	2	15	33

Fig. 37. Set 1 and Set 2 : only in the first set, the final value is equal to the value of the modules number by the third value (here this value is 3) of the four different qualities of modules.

6.1 The matrix of the modules.

The set 1, this of the amino acids with a protons number which is equal to 8 times their modules number, is constrained by these two rules:

First rule: the number of **module by 6** (first module quality) is always equal to 1 only.

Second rule: the number of **module by 9** (fourth module quality) is always equal to the number of **module by 7** (second module quality) + **2**.

Amino acid	Modules number in according to the quality of module (protons number of 6, 7, 8 or 9)				Modules number	Protons number
	6	7	8	9		
GLY	**1**	**0**	2	**2**	5	40
ALA	**1**	**1**	1	**3**	6	48

the number of **module by 6** (first module quality) is always equal to 1 only.
The number of **module by 9** (fourth module quality) is always equal to
the number of **module by 7** (second nodule quality) + **2**.

Fig. 38. Arithmetical rules of the matrix of the modules for the first set (protons number which is equal to 8 times their modules number).

So, if the values of the module quality are modified by all other values of an other set of numbers which have a regular sequence, the same phenomenon is also observed only in the first set.

This is a very intricate phenomena and this, added to the other arithmetical phenomena here previously presented demonstrates that the genetic code is a very mathematical sophisticated organisation of the living matter.

7. Study of the modules with a protons number which is multiple of 8.

7. 1 Specificity of the proline.

Recall: In this study, the author uses a special counting for the proline with a hydrogen atom counted in more. So the quality of the proline modules is different to the standard counting used by S. Petoukhov.

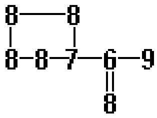
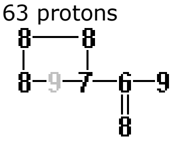
Petoukhov's depiction of the proline Molecular structure: 62 protons	Boulay's depiction of the proline Molecular structure: 63 protons
Modular structure : 	Modular structure : 
8 modules with 5 by 8 protons	8 modules with 4 by 8 protons

Fig. 39. Petoukhov's depiction of the proline and special Boulay's depiction of the proline.

This special depiction of the proline is more detailed in the article "The proline hypothesis"[4]. In this article the author proposes an original idea to explain the numerous arithmetical phenomena of symmetry used by the genetic code mechanism. The author proposes a hypothesis that a neutron could behave like a proton. In this event, the counting of the particles in the carbon atom where is located this singularity gives 5 neutrons and 7 protons including 6 protons to be counted for the radical and 1 proton for the base of the proline amino acid.

7.2 Arithmetical phenomena of symmetry by multiples of prime numbers 7 and 13.

In the Petoukhov' structure, there are four qualities of modules in according to their protons number: modules of 6, 7, 8 or 9 protons. The counting of the modules numbers which are by 8 protons reveals arithmetical phenomena of symmetry in the genetic code table. These phenomena are by multiples of prime numbers 7 and 13.

AAA	5	LYS	GAA	4	GLU	TAA	0	stop	CAA	4	GLN	
AAG	5	LYS	GAG	4	GLU	TAG	0	stop	CAG	4	GLN	
AAT	3	ASN	GAT	3	ASP	TAT	2	TYR	CAT	3	HIS	
AAC	3	ASN	GAC	3	ASP	TAC	2	TYR	CAC	3	HIS	
	16			14			4			14		48
AGA	6	ARG	GGA	2	GLY	**TGA**	0	**stop**	CGA	6	ARG	
AGG	6	ARG	GGG	2	GLY	**TGG**	3	**TRP**	CGG	6	ARG	
AGT	2	SER	GGT	2	GLY	TGT	3	CYS	CGT	6	ARG	
AGC	2	SER	GGC	2	GLY	TGC	3	CYS	CGC	6	ARG	
	16			8			9			24		57
ATA	2	**ILE**	GTA	1	VAL	TTA	2	LEU	CTA	2	LEU	
ATG	5	**MET**	GTG	1	VAL	TTG	2	LEU	CTG	2	LEU	
ATT	2	ILE	GTT	1	VAL	TTT	2	PHE	CTT	2	LEU	
ATC	2	ILE	GTC	1	VAL	TTC	2	PHE	CTC	2	LEU	
	11			4			8			8		31
ACA	1	THR	GCA	1	ALA	TCA	2	SER	CCA	4	PRO	
ACG	1	THR	GCG	1	ALA	TCG	2	SER	CCG	4	PRO	
ACT	1	THR	GCT	1	ALA	TCT	2	SER	CCT	4	PRO	
ACC	1	THR	GCC	1	ALA	TCC	2	SER	CCC	4	PRO	
	4			4			8			16		32
	47			30			29			62		168

168 = 3 x 8 x 7

Fig. 40. Counting of the modules with a protons number which is multiples of 8. For example, GLY has 2 modules by 8 protons. (See also Fig. 2).

Configurations of multiples of the prime number 7:

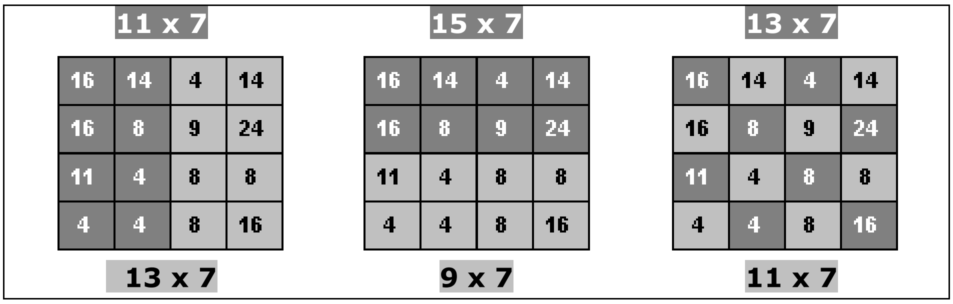


Fig. 41. 3 configurations of multiples of the prime number 7 with the modules by 8 protons. (Tables are compressed tables of Fig. 40)

In the chequered configuration which is to multiple of 13 by 7, regular sub configurations of the prime number 13 multiples appear:

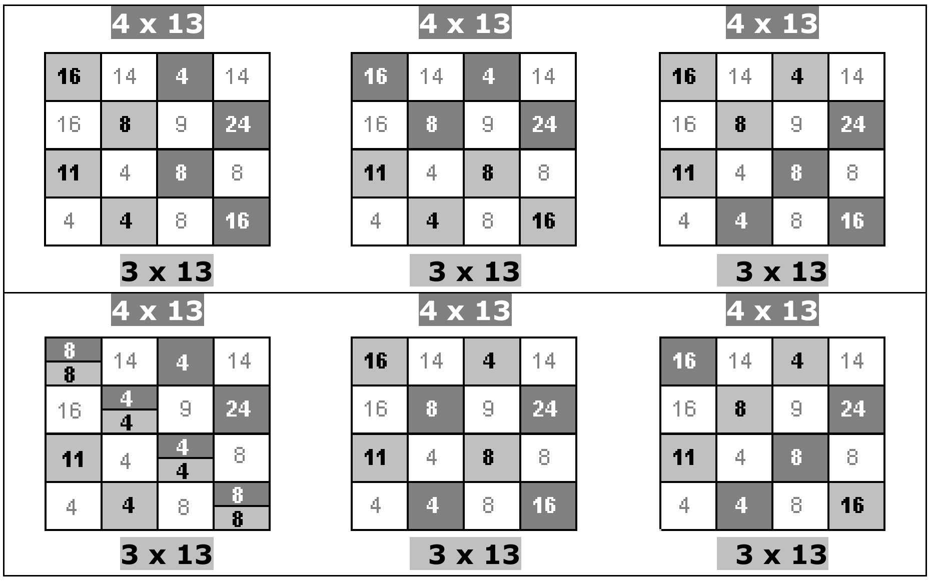


Fig. 42. Sub configurations of multiples of the prime number 13 in the chequered configuration.

In all these latest sub configurations, the values are identical: **4 x 13** and **3 x 13**

In all these configurations, the four individual values of the four boxes are also identical. For a sub configuration, the four values are ever the same:

16 **8** **11** **4**

And for another sub configuration, the four other values are ever the same:

4 **24** **8** **16**

These two set of 4 values are always present in the numerous possible configurations. Configurations are vertical, horizontal and diagonal. But these configurations are also sub vertical (alternated vertically), sub horizontal and sub diagonal with the same values:

4 x 13 and 3 x 13

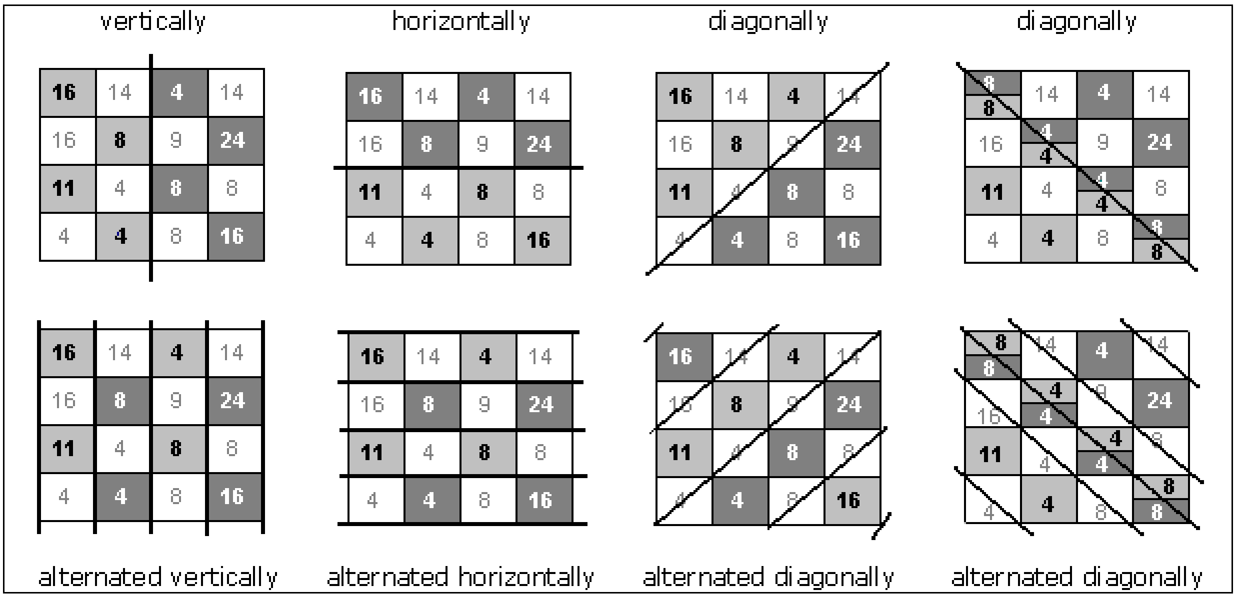


Fig .43. Vertical, horizontal and diagonal configurations by multiples of the prime number 13: (4 x 13) and (3 x 13).

Conclusion.

It is not possible that these very organized phenomena here presented are by chance in the genetic code. The author thinks that these arithmetical arrangements are obligatory constraints linked to the origin of the Universe. These phenomena are also linked to the mathematics Universe and more especially with the prime numbers field. The author thinks so that the standard genetic code is not a product of the evolution but an obliged way for the living World. The exceptional structure of the proline amino acid is a very important investigation field. The proline is certainly a key and even "The" key of the sophisticated genetic code.

Also, the specificity and the segregation of "the rebel group" revealed by the author is a fundamental subject in the study of the genetic code.

Last but not least, the structure in modules proposed by Sergei Petoukhov to describe the living molecules is a real and very interesting field of investigation in the study of the genetic code.

In summary, the arithmetical study of the genetic code should be greatly considered in a new true science.

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