Compilation of tRNA sequences

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INTRODUCTION

This compilation presents in a small space the tRNA sequences so far published covering the literature to about the end of 1983. The numbering derived from $tRNA^{Phe}$ from yeast as adopted in the Cold Spring Harbor Symposium on tRNA, 1979, is used (1, Fig. 1). Different from the originally adopted nomenclature (1) in 17:1, 20:1, 47:1, etc. the numbers after the colon are replaced by capital letters in alphabetical order for technical reasons. The secondary structure of tRNA is indicated by specific underlining. For the nomenclature of rare nucleosides see Table 1 and references 2 and 3; for that of species see the Nucleotide Sequence Data Library of EMBL, Heidelberg. Together with the running number and the species the anticodon sequence (in unmodified state) is given for further identification of the sequences. Footnotes are numbered according to the coordinates of the corresponding nucleoside and are indicated in the sequence by an asterisk. In the case of tRNAs where an aligment is not possible, this fact is indicated in a footnote.

The references are restricted to the citation of the latest publication in those cases, where several papers deal with one sequence. tRNA mutants are not compiled comprehensively (see another compilation within these compilations).

The compilation is deposited with the Nucleotide Sequence Data Library of EMBL and available there on magnetic tape upon request. The compilers would welcome any information regarding missing material or erroneous presentation.

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Table 1: Abbreviations for modified nucleosides

A1	M1A	= 1-METHYLADENOSINE
A2	M2A	= 2-METHYLADENOSINE
A4	I6A	= N6-ISOPENTENYLADENOSINE
A5	MS2I6A	= 2-METHYLTHIO-N6-ISOPENTENYLADENOSINE
A6	M6A	= N6-METHYLADENOSINE
A7	T6A	= N-((9-BETA-D-RIBOFURANOSYLPURINE-6-YL)CARBAMOYL) THREONINE
A8	MT6A	= N-((9-BETA-D-RIBOFURANOSYLPURINE-6-YL)N-METHYL-CARBAMOYL)THREONIN
A9	MS2T6A	= N-((9-BETA-D-RIBOFURANOSYL-2-METHYLTHIOPURIN-6-YL) CARBAMOYL THREONINE
C2	S2C	= 2-THIOCYTIDINE
C3	CM	= 2'O-METHYLCYTIDINE
C4	AC4C	= 4-ACETYLCYTIDINE
C5	M5C	= 5-METHYLCYTIDINE
C6	M3C	= 3-METHYLCYTIDINE
D	D	= DIHYDROURIDINE
F	F	= PSEUDOURIDINE
F1	M1F	= 1-METHYLPSEUDOURIDINE
F3	FM	= 2'-O-METHYLPSEUDOURIDINE
G1	M1G	= 1-METHYLGUANOSINE
G2	M2G	= 2-METHYLGUANOSINE
G3	GM	= 2'-O-METHYLGUANOSINE
G4	M22G	= 2,2-DIMETHYLGUANOSINE
G7	M7G	= 7-METHYLGUANOSINE
G5	M22G	= 2,2,3'-TRIMETHYLGUANOSINE
I	I	= INOSINE
I1	M1I	= 1-METHYLINOSINE
Q	Q	= QUENOSINE
Q1	MAN_Q	= BETA,D-MANNOSYLQUENOSINE
Q2	GAL_Q	= BETA,D-GALACTOSYLQUENOSINE
T1	T	= 5-METHYLURIDINE
T2	S2T	= 5-METHYL-2-THIOURIDINE
T3	TM	= 2'-O-METHYL-5-METHYLURIDINE
U1	MAM5U	= 5-METHYLAMINOMETHYLURIDINE
U2	S2U	= 2-THIOURIDINE
U3	UM	= 2'-O-METHYLURIDINE
U4	S4U	= 4-THIOURIDINE
U7	MCM5U	= 5-METHOXYCARBONYLMETHYLURIDINE
U8	MAM5S2U	= 5-METHYLAMINOMETHYL-2-THIOURIDINE
U9	MCM5S2U	= 5-METHOXYCARBONYLMETHYL-2-THIOURIDINE
V1	O5U	= URIDINE-5-OXYACETIC ACID, (V)
V2	MO5U	= 5-METHOXYURIDINE
V3	MV	= URIDINE-5-OXOACETIC ACID-METHYLESTER
V4	CMNM5U	= 5-CARBOXYMETHYLAMINOMETHYLURIDINE
V5	CMNM5S2U	= 5-CARBOXYMETHYLAMINOMETHYL-2-THIOURIDINE
V6	CHM5U	= 5-(CARBOXYHYDROXYLMETHYL)URIDINE
X	X	= 3-(3-AMINO-3-CARBOXYPROPYL)URIDINE, (ACP3)U
Y1	YW	= WYBUTOSINE
Y2	O2YW	= WYBUTOXOSINE

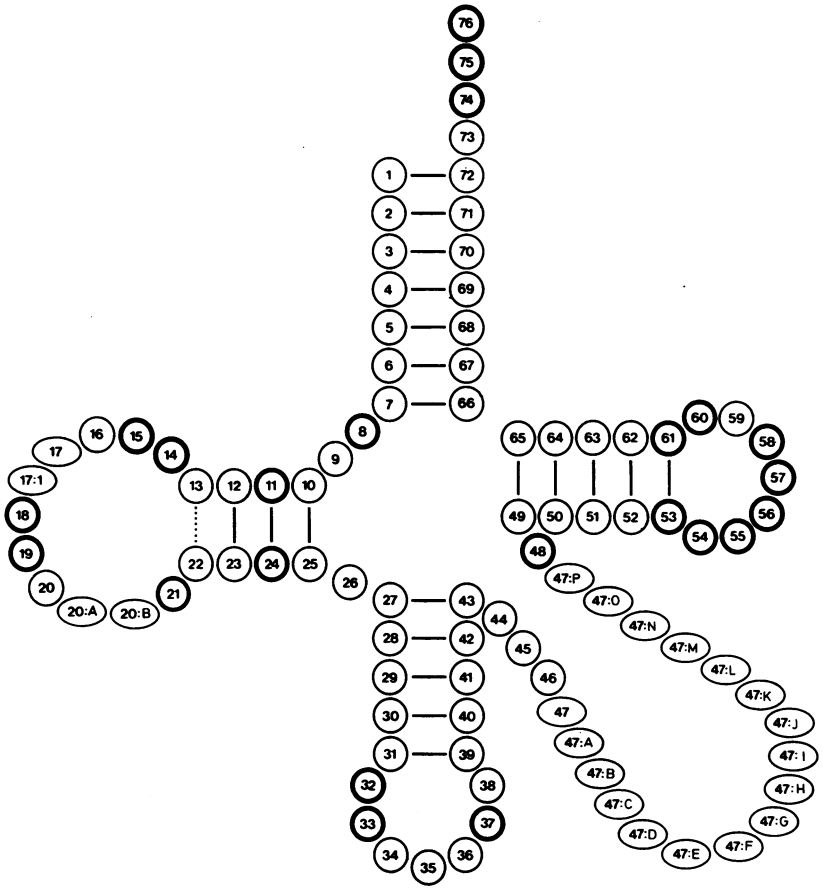
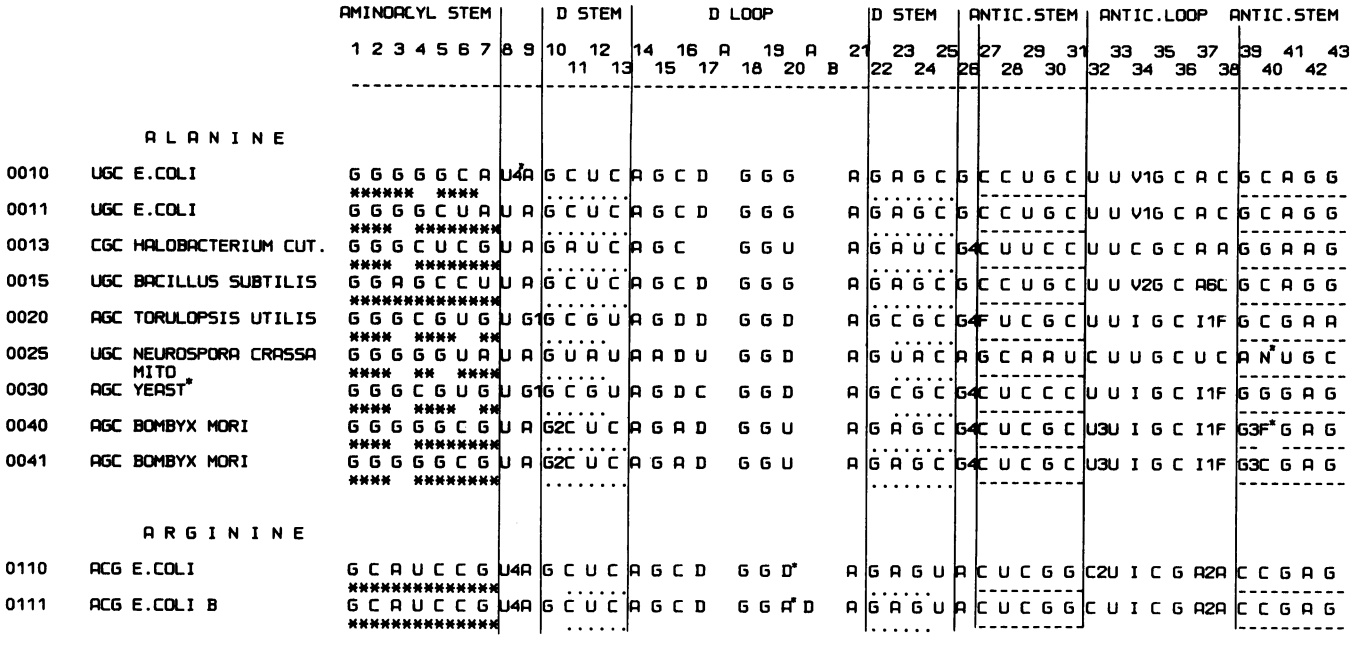


Figure 1: Numbering system of nucleotides in tRNAs according to the numbering of phenylalanine tRNA from yeast. Circles represent nucleotides which are always present; among these, the thick-edged circles denote invariant or semi-invariant nucleotides. Ovals represent nucleotides which are not present in each sequence: these are the nucleotides before the two constant GMP residues (18,19) in the D loop, the nucleotides after these GMP residues, and the nucleotides in the variable loop which may be up to 17 nucleotides.

A nucleotide to be added at a given site is indicated by the number of the preceding nucleotide followed by a colon and a capital letter in alphabetical order. Thus, e.g. 20:A and 20:B mean the first and the second nucleotide after position 20. The absence of a nucleotide is indicated by the absence of a number, e.g. if no residue is found in position 17, the sequence then reads C16-C18. The numbering for the D loop, when one, two or three nucleotides are present each between 15 and 18 or between 19 and 21, ist then 16 and 16, 17 and 16, 17, 17:A or 20 and 20, 20:A and 20, 20:A, 20:B, respectively. When the variable loop is five-membered, the numbering is as in yeast phenylalanine tRNA 44, 45, 46, 47, 48. 47 is eliminated when the variable loop is four-membered. For large variable loops, numbers are added onto 47, e.g. for thirteen nucleotides 44, 45, 46, 47, 47:A, 47:B, 48:C, 47:D, 47:E, 47:F, 47:G, 47:H, 47:I.



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0011 E.LUND,J.E.DAHLBERG(1977) CELL 11, 247-262
0013 X.-R. GU,K.NICOGHOSIAN,R.J.CEDERGREN,J.T.-F.WONG(1983) NUCLEIC ACIDS RES. 11, 5433-5442
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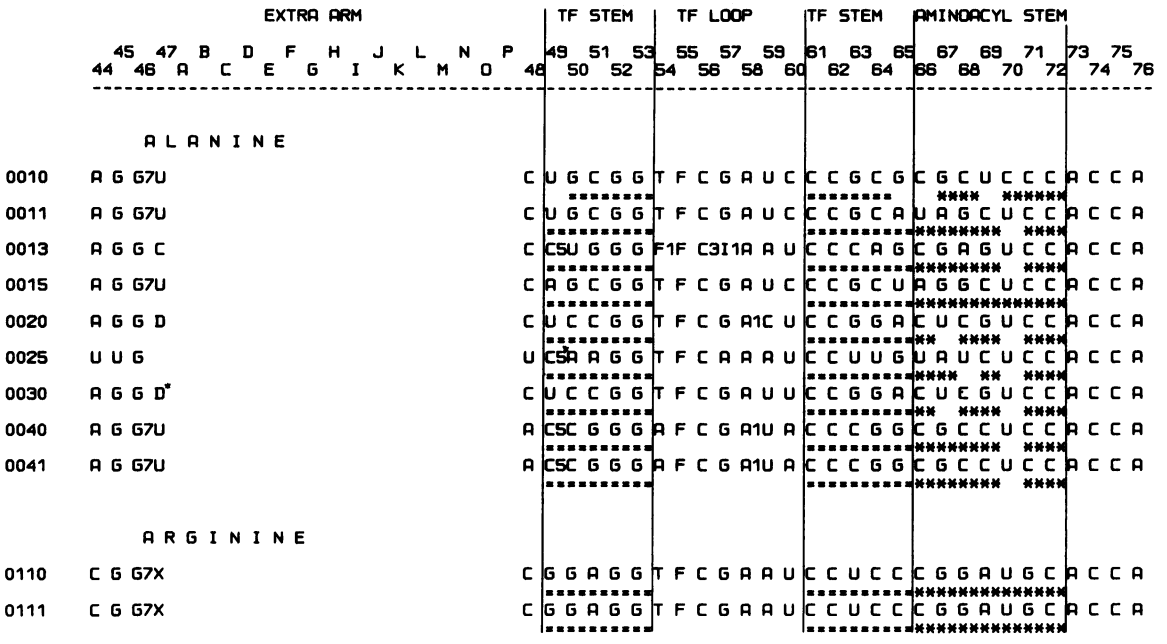

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0025/49 PARTIALLY MODIFIED
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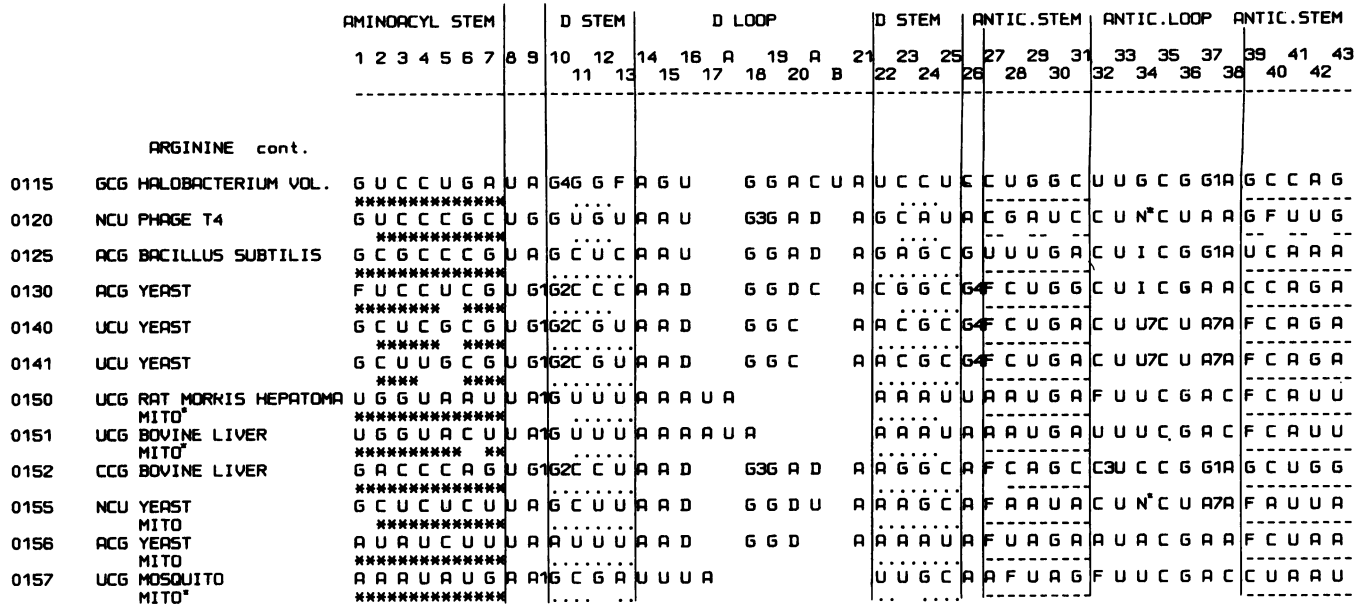
0030/47 PARTIALLY MODIFIED
0040/40 PARTIALLY PSEUDOURIDINE
0110/20 PARTIALLY MODIFIED
0111/20 A PARTIALLY MODIFIED



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0120 G.P.MAZZARA,J.G.SEIDMAN,W.H.MCCLAIN,H.YESIAN,J.ABELSON,C.GUTHRIE(1977) J.BIOL.CHEM. 252, 8245-8253
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0156 G.DIRHEIMER (1983) PERSONAL COMMUNICATION
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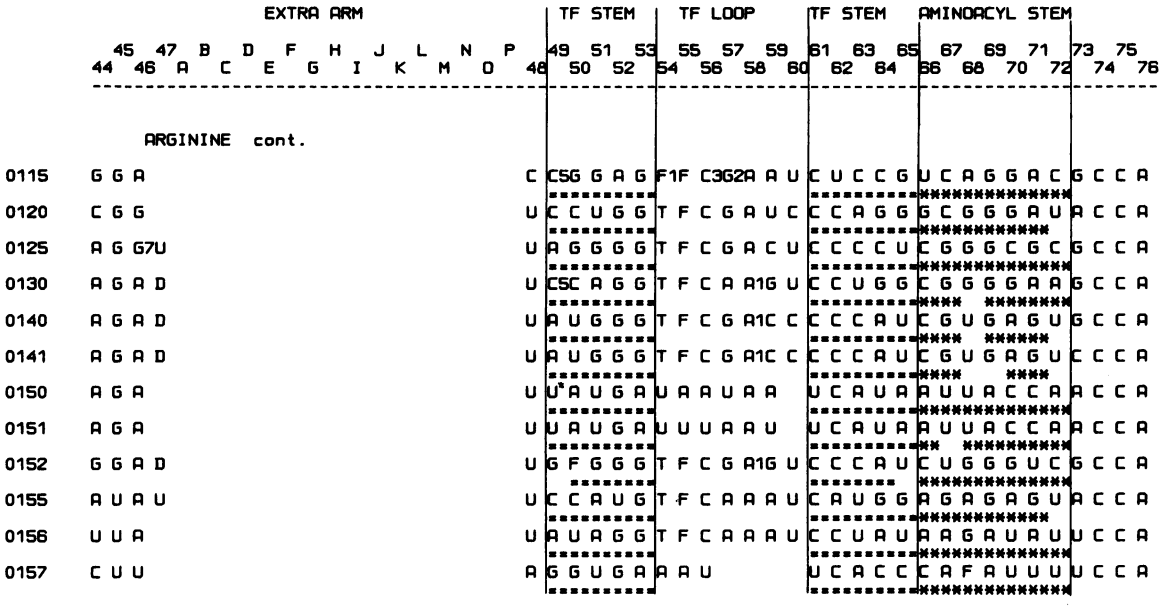

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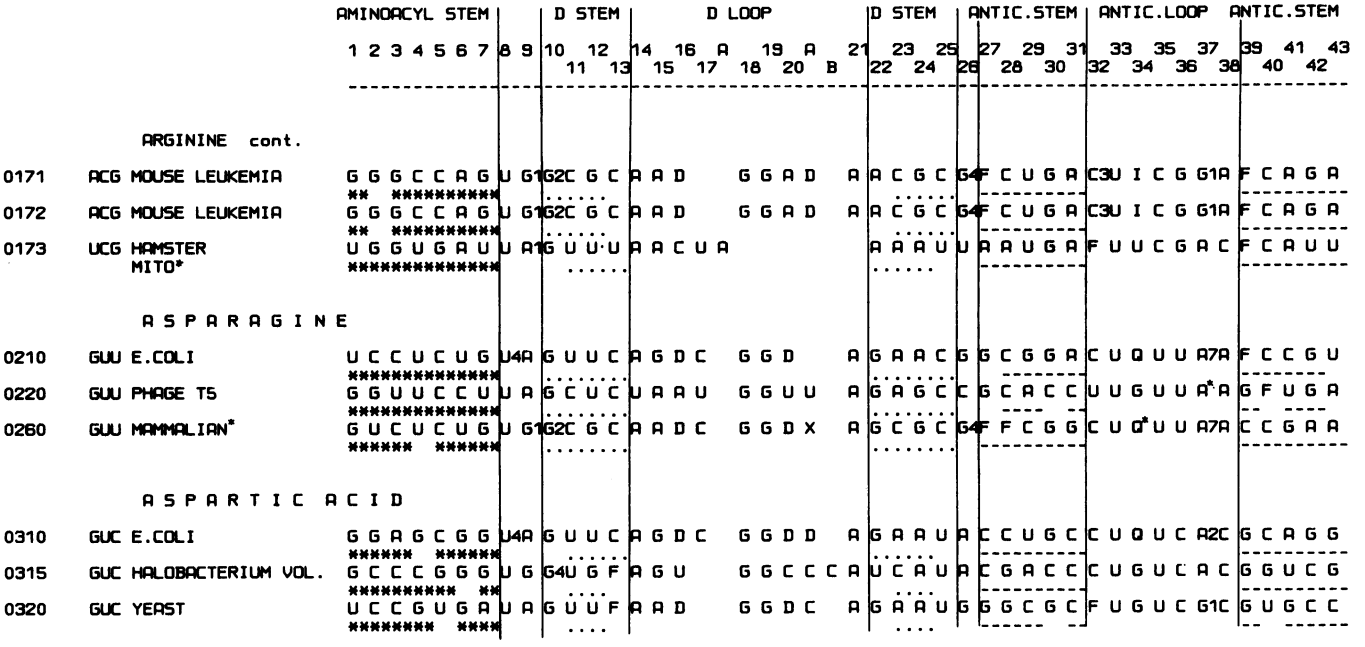
0151/0 ALIGNMENT IS ARBITRARY
0155/34 MODIFIED URIDINE
0157/0 ALIGNMENT IS ARBITRARY



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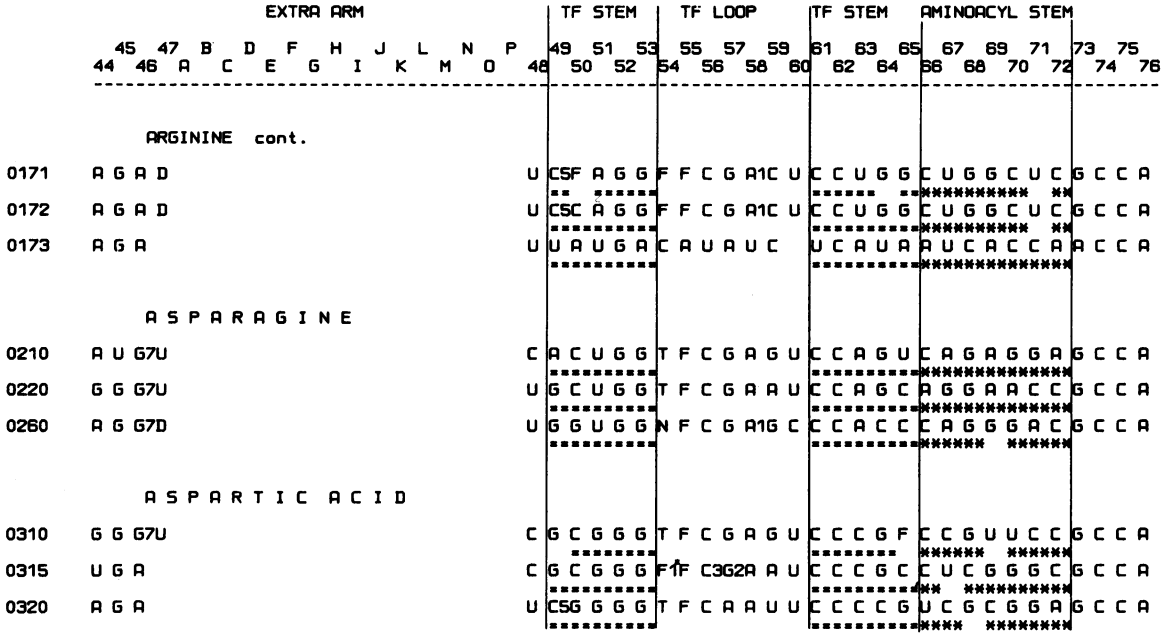

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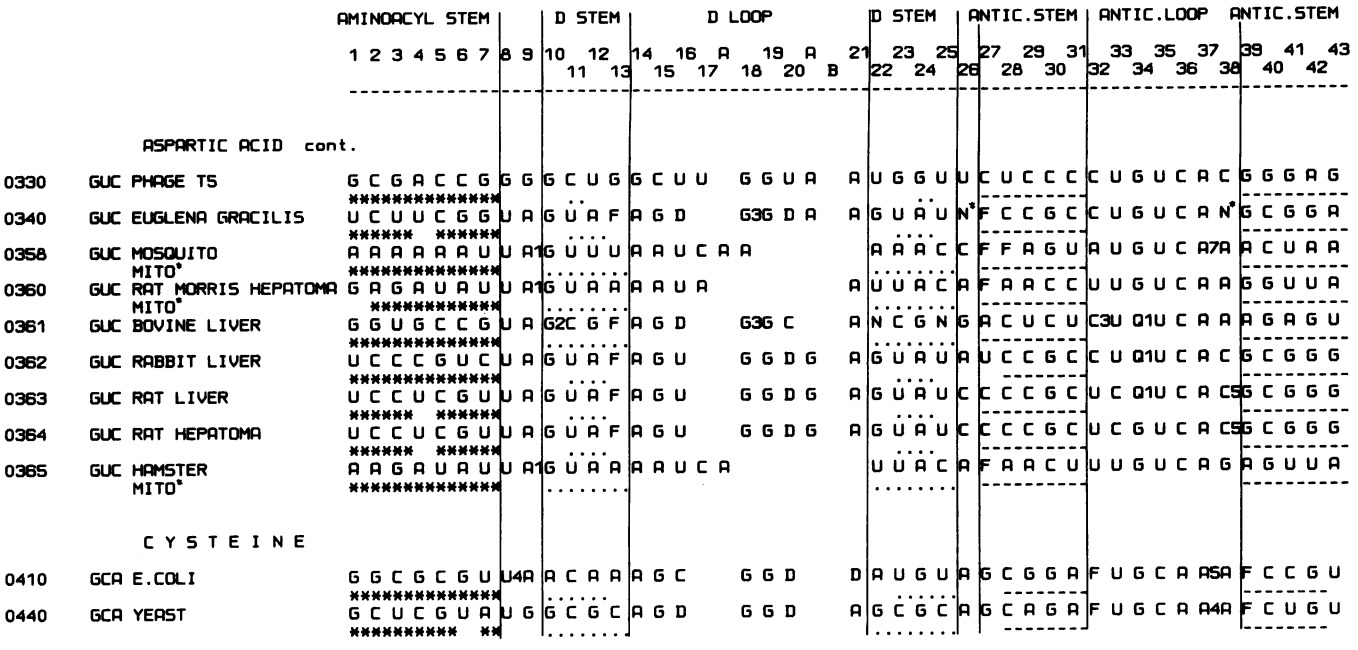
0260/34 IN SARCOMA TRNA G INSTEAD OF Ψ
0315/54 PARTIALLY F



0330 V.M.KRYUKOV, M.G.SCHLYAPNIKOV,S.I.KAZANTSEV,A.V.KALIMAN,V.N.KSENZENKO, A.A.BAYEV, EMBO-FEBS MEETING, STRASBOURG, JULY 1980

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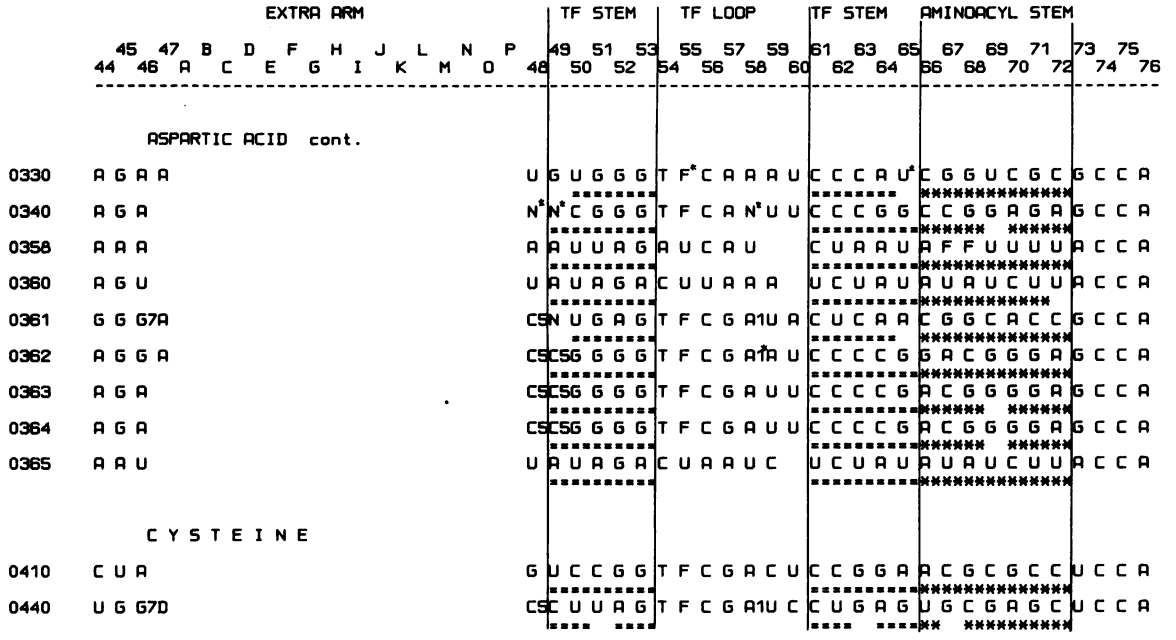
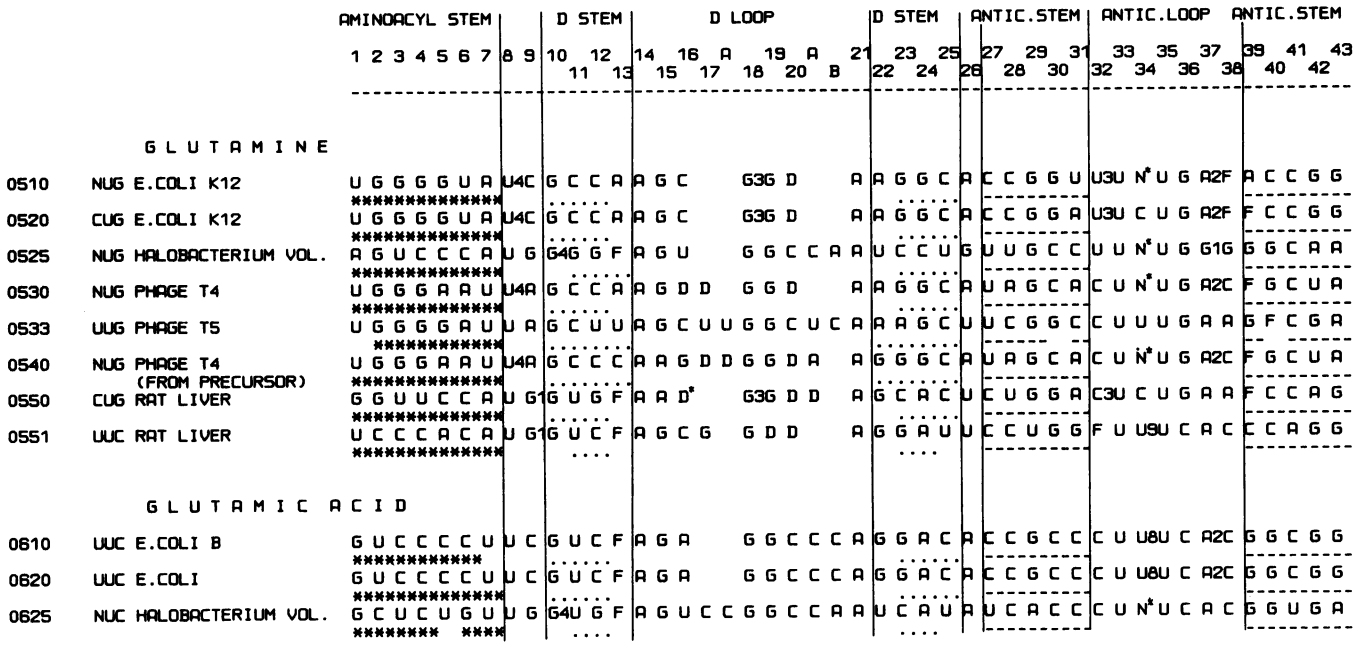


0330/65 30% PSEUDOURIDINE
0330/55 20% URIDINE
0340/26 MODIFIED GUANOSINE
0340/38 MODIFIED CYTIDINE
0340/48 MODIFIED CYTIDINE
0340/49 MODIFIED CYTIDINE

0340/58 MODIFIED ADENOSINE
0358/0 ALIGNMENT IS ARBITRARY
0360/0 MAMMALIAN MITO TRNA CANNOT BE FITTED TO THE GENERALISED CLOVERLEAF ARRANGEMENT
0362/58 PARTIALLY MODIFIED
0365/0 ALIGNMENT IS ARBITRARY



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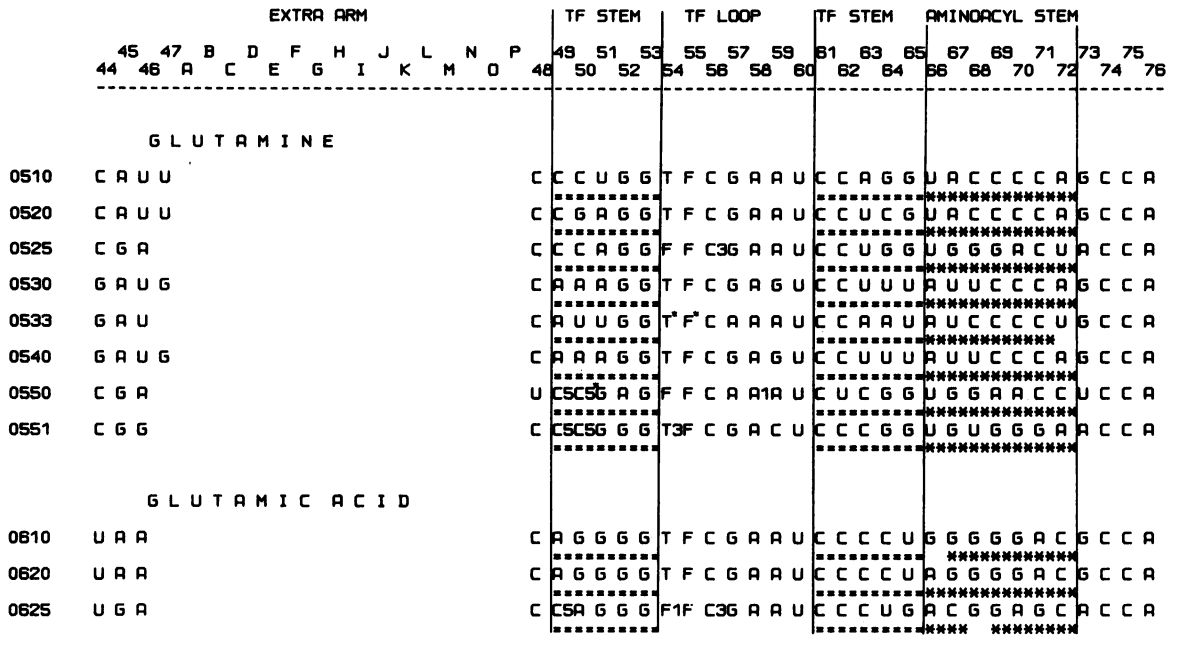
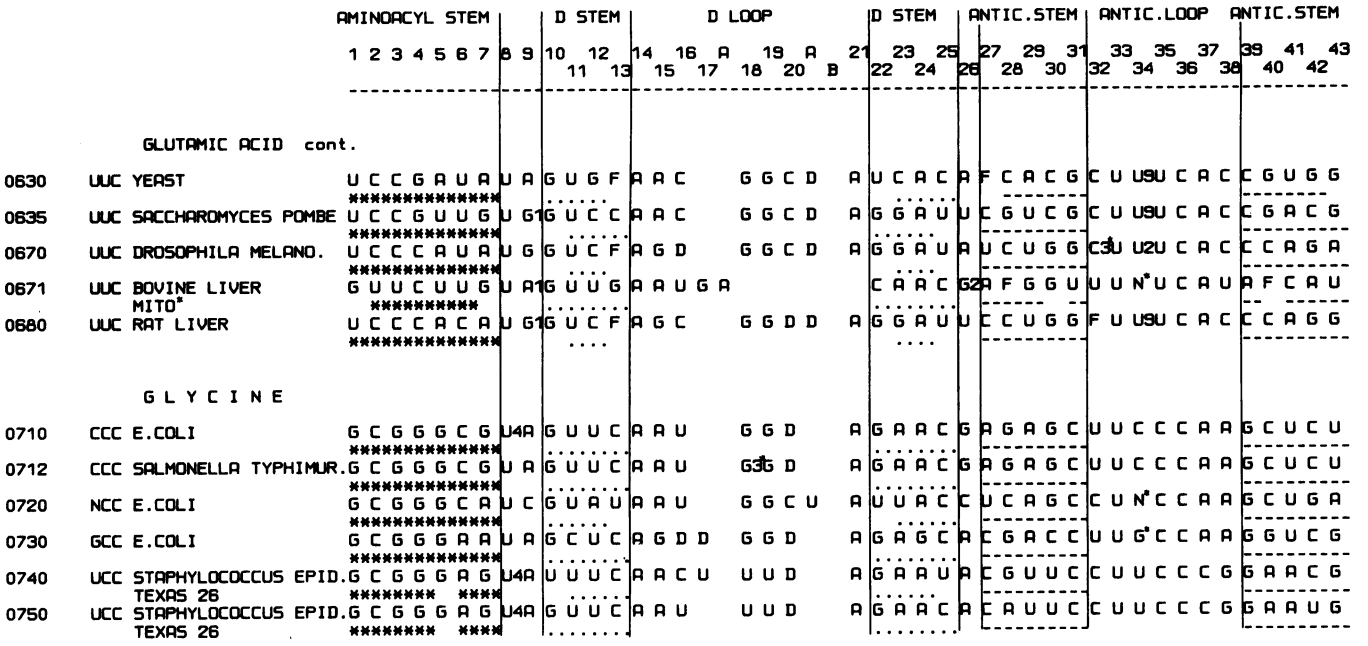


0510/34 N IS A DERIVATIVE OF 2-THIOURIDINE
0525/34 PARTIALLY MODIFIED TO A DERIVATIVE OF CYTIDINE
0530/34 N IS AN UNKNOWN DERIVATIVE OF URIDINE..
0533/54 30% URIDINE
0533/55 30% URIDINE

0540/34 N IS AN UNKNOWN DERIVATIVE OF URIDINE
0550/16 PARTIALLY MODIFIED
0550/50 PARTIALLY MODIFIED
0625/34 PARTIALLY MODIFIED



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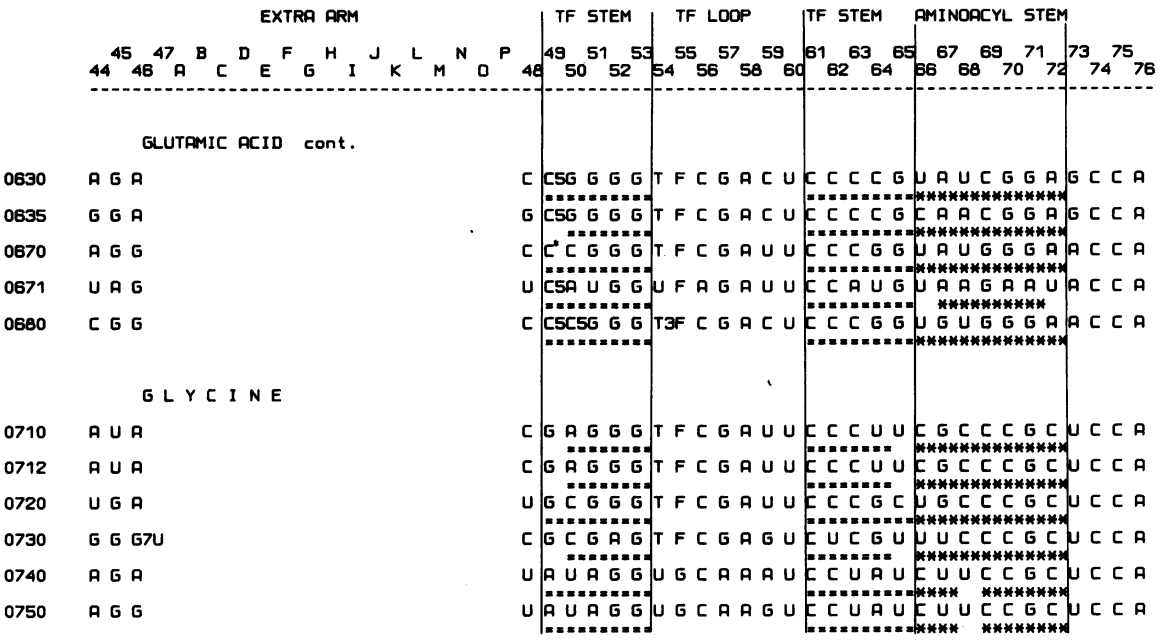

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0670/49 AND OR 50: IN POSITION 49 AND OR 50 M5C IS PRESENT
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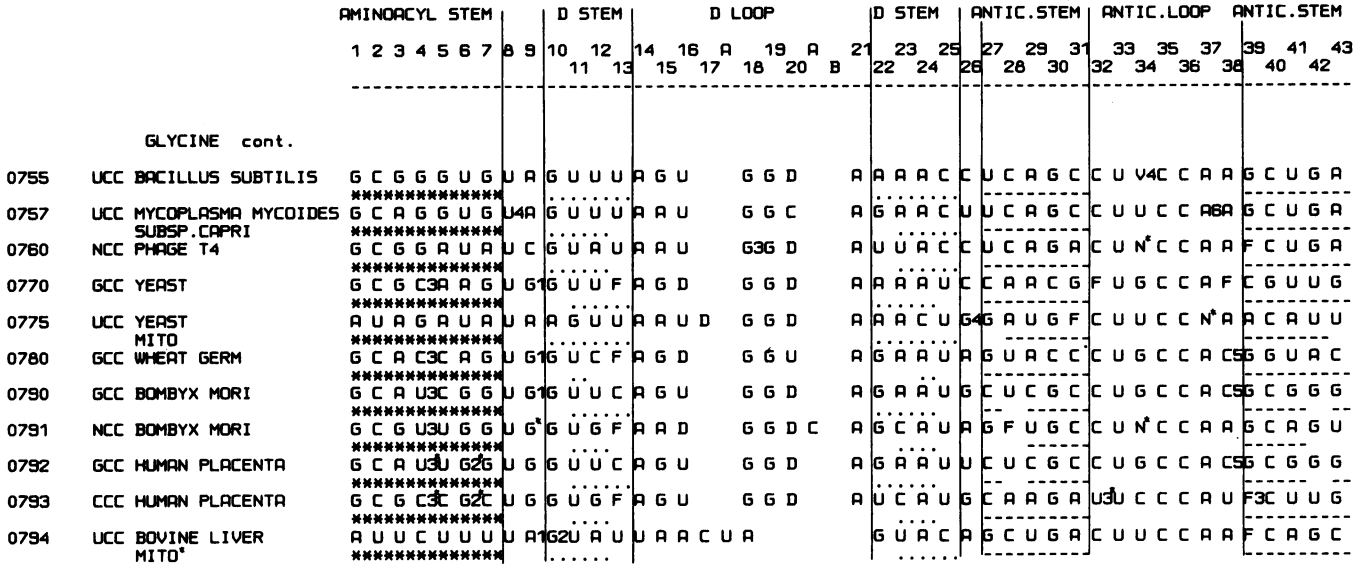

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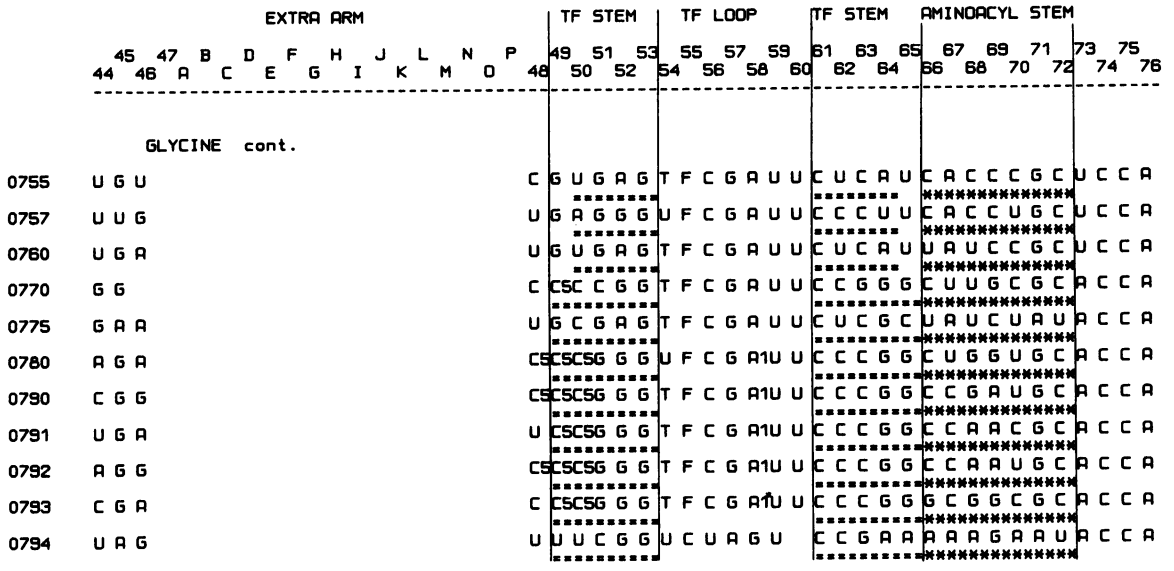
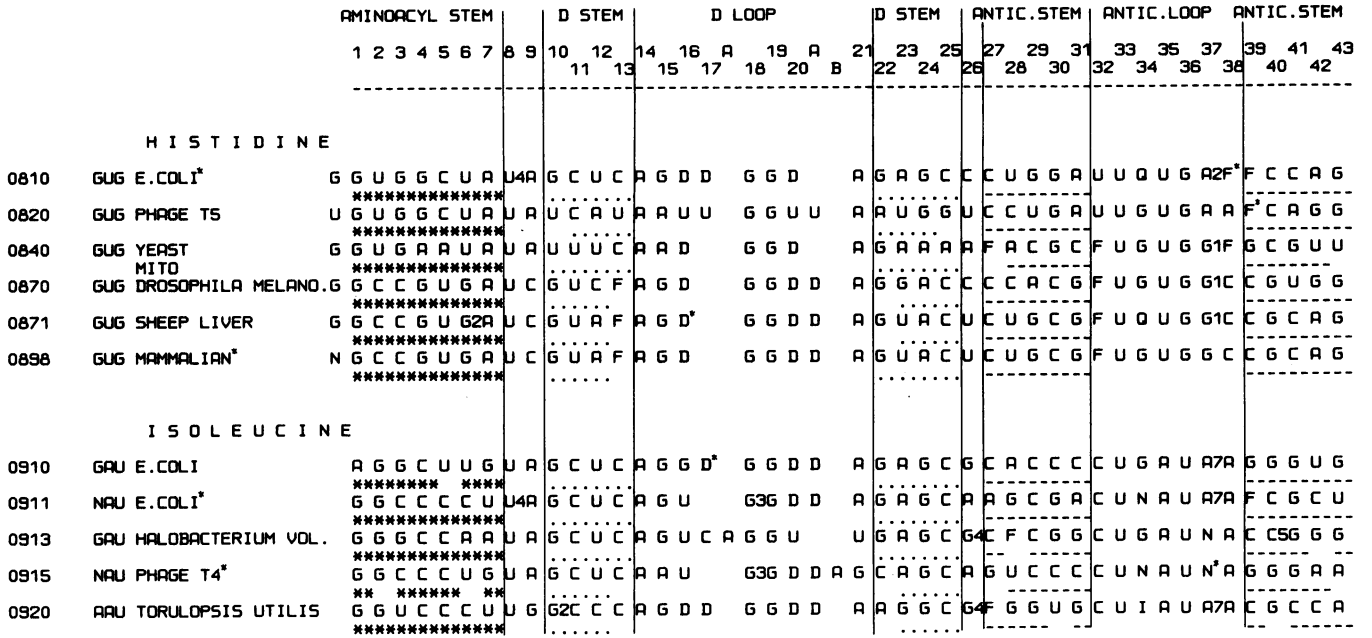
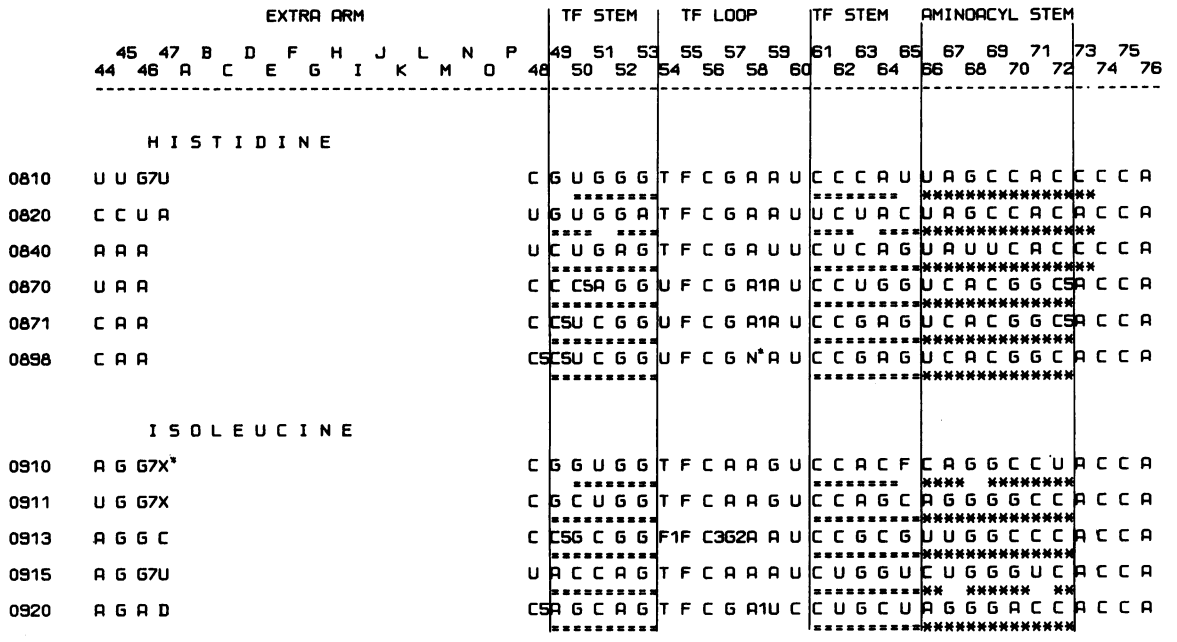
0793 R.C.GUPTA,B.A.ROE,K.RANDERATH(1980) BIOCHEM. 19, 1699-1705
0794 B.A.ROE, J.F.H.WONG, E.Y.CHEN,P. A. ARMSTRONG(1981) PROC.THIRD CLEAVELAND SYMP. A.G.WALTON(ED) ELSEVIER AMSTERDAM



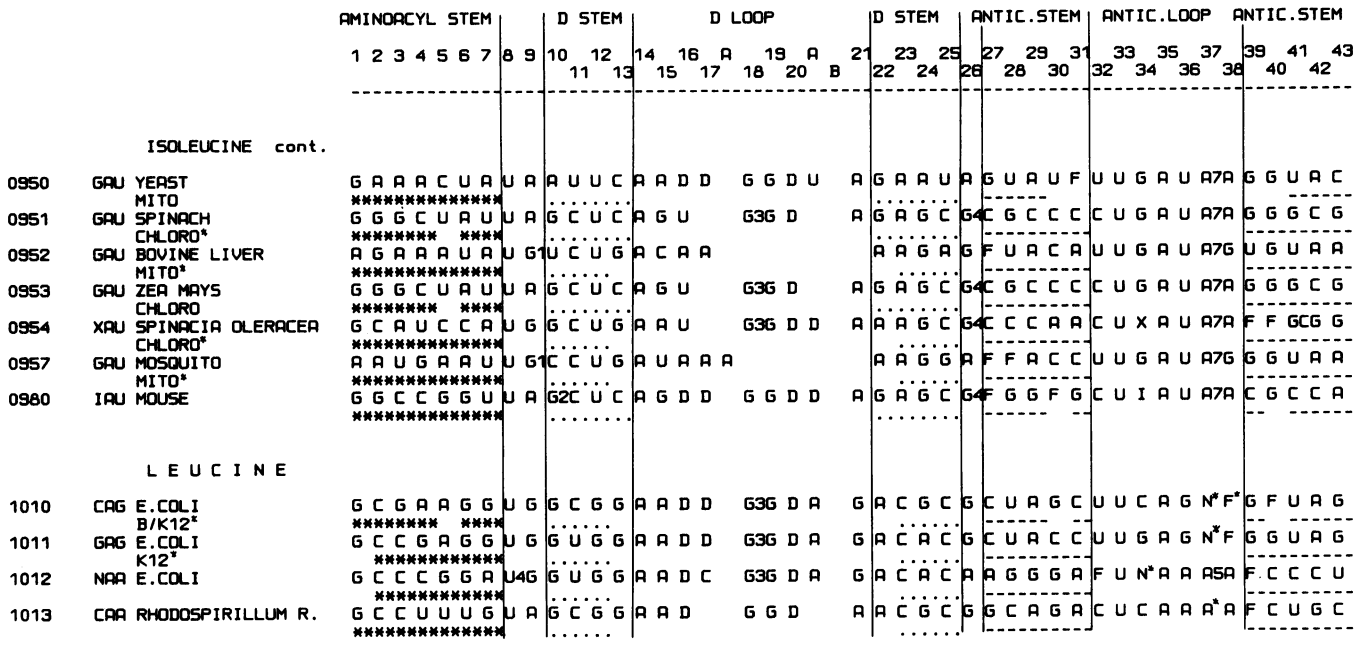
0760/34 PROBABLY RELATED TO MAM5S2U
0775/37 IS I6A OR MS2I6A
0791/9 PARTIALLY MODIFIED
0791/34 N IS CHM5U AND AN ESTER THEREOF; M.KAWAKAMI, K.NISHIO, S.TAKEMURA, T.KONDO, T.GOTO (1979) NUCLEIC ACIDS RES. SYMP. SERIES NO. 6, S.53
0792/4 PARTIALLY MODIFIED
0792/6 PARTIALLY MODIFIED
0793/4 PARTIALLY MODIFIED
0793/6 PARTIALLY MODIFIED
0793/32 PARTIALLY MODIFIED
0793/58 PARTIALLY MODIFIED
0794/0 ALIGNMENT IS ARBITRARY



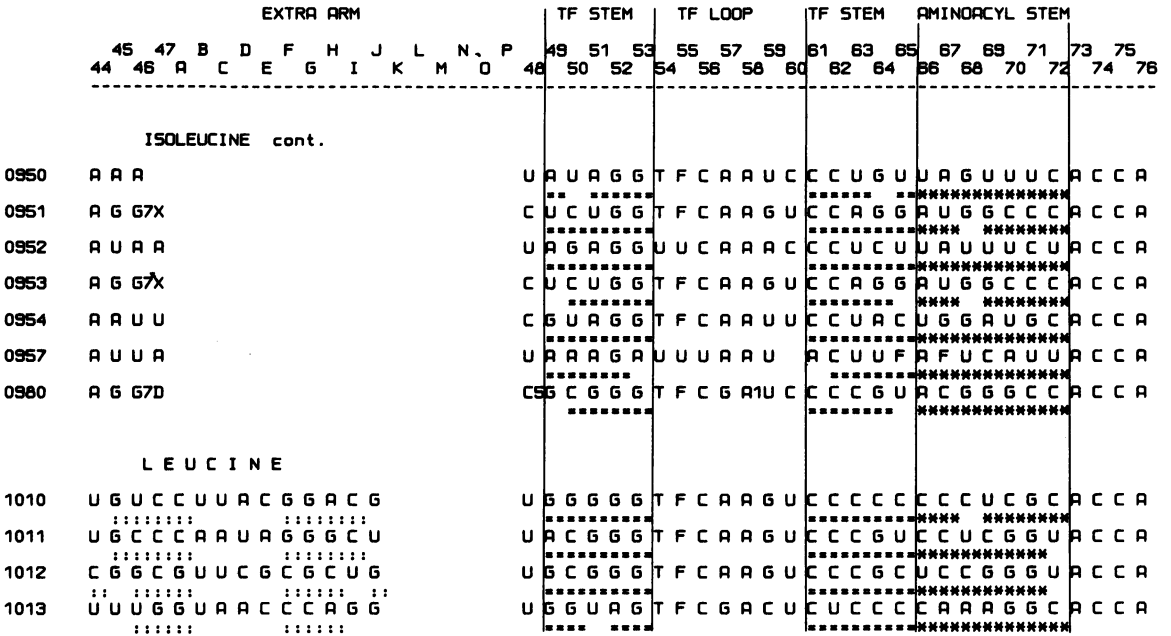
0810 C.E.SINGER,G.R.SMITH(1972) J.BIOL.CHEM. 247, 2989-3000
0820 V.M.KRYUKOV,M.G.SCHLYAPNIKOV,S.I.KAZANTSEV,A.V.KALIMAN,V.N.KSENZENKO, A.A.BAYEV, EMBO-FEBS MEETING, STRASBOURG, JULY 1980
0840 A.P.SIBLER,R.P.MARTIN,G.DIRHEIMER (1979) FEBSLETTERS 107, 182-186
0870 M.ALTWEGG,E.KUBLI(1980) NUCLEIC ACIDS RES. 8, 3259-3262
0871 M.BOISNARD, G.PETRISSANT (1981) FEBS LETTERS 129, 180-184
0898 M.D.ROSA, J.P.HENDRICK,JR., M.R.LERNER, J.A.STEITZ (1983) NUCL. ACIDS RES. 11, 853-870
0910 M.YARUS,B.G.BARELL(1971) BIOCHEM.BIOPHYS.RES.COMMUN. 43, 729-734
0911 Y.KUCHINO,S.WATANABE,F.HARADA,S.NISHIMURA(1980) BIOCHEM.19,2085-2089
0913 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
0915 C.GUTHRIE,M.H.MCCLAIN(1979) BIOCHEM. 18, 3786-3795
0920 S.TAKEMURA,M.MURAKAMI,M.MIYAZAKI(1969) J.BIOCHEM. 65, 553-566



0810/0 IDENTICAL WITH SALMONELLA TYPHIMURIUM
0810/38 + 0810/39 HIS T MUTATION F-38 = U-38, F-39 = U-39. C.E.SINGER, G.R.SMITH, R.CORTESE,B.N.AMES (1972) NATURE NEW BIOLOGY 238, 72-74
0820/39 PARTIALLY MODIFIED
0871/16 PARTIALLY MODIFIED
0898/0 ISOLATED FROM HeLa CELLS;ANTI-Jo-1 ANTIGEN
0898/0 5'TERMINAL NUCLEOTIDE IS A METHYLATED GUANYLIC ACID RESIDUE
0898/58 N IS A MODIFIED NUCLEOTIDE
0910/17 PARTIALLY MODIFIED
0910/47 PROBABLY X
0911/0 DESIGNED AS TRNA-ISOLEUCINE-MINOR
0911/17 PARTIALLY MODIFIED
0915/37 N IS A DERIVATIVE OF ADENOSINE
0915/0 MUTANTS: HA1, C-4 = U-4; HA101, C-4 = U-4, U-71 = C-71; HA103, C-4 = U-4, G-69 = A-69



0950 G.DIRHEIMER (1981) PERSONAL COMMUNICATION
0951 P.GUILLEMAUT, J.H.WEIL (1982) NUCL. ACIDS RES. 10, 1653-1659
0952 B.A.ROE, J.F.H.WONG, E.Y.CHEN,P.A.ARMSTRONG(1981) PROC.THIRD CLEAVELAND SYMP.A.G.WALTON(ED) ELSEVIER AMSTERDAM
0953 P.GUILLEMAUT,J.H.WEIL(1982) NUCL.ACIDS RES. 10, 1653-1659
0954 M.A.FRANCIS,B.S.DUDOCK(1982) J.BIOL.CHEM. 257, 11195-11198
0957 C.C.HSUCHEN, G.R.CLEAVES, D.T.DUBIN (1983) PLASMID 10, 55-65
0980 N.SHINRIKI,K.ISHIZAKI,A.IKEHATA,K.MIURA,T.UEDA,N.KATO,F.HARADA(1981) NUCL.ACIDS RES. SYMP.SER. 10, 211-214
1010 H.U.BLANK,D.SOELL(1971) BIOCHEM.BIOPHYS.RES.COMMUN. 43, 1192-1197 S.K.DUBE,K.A.MARCKER,A.YUDELEVICH(1970) FEBS LETTERS 9, 168-170
1011 H.U.BLANK,D.SOELL(1971) BIOCHEM.BIOPHYS.RES.COMMUN. 43, 1192-1197
1012 Z.YAMAIZUMI,Y.KUCHINO,F.HARADA,S.NISHIMURA,J.A.MCCLOSKEY (1980) J.BIOL.CHEM. 255, 2220-2225
1013 N.NEWHOUSE, K.NICOGHOSIAN, R.J.CEDERGREN (1981) CAN. J. BIOCHEM. 59, 921-932



0951/0 IDENTICAL WITH MAIZE CHLORO TRNA ILE 2
0952/0 ALIGNMENT IS ARBITRARY
0953/46 PARTIALLY MODIFIED
0954/0 ALIGNEMENT IS ARBITRARY
0957/0 ALIGNMENT IS ARBITRARY
1010/0 FOR NUMBERING OF E.COLI LEUCINE TRNAS SEE R.E.HURD,G.T.ROBILLARD, B.A.REID (1977) BIOCHEMISTRY 16, 2095-2100
1010/0 IDENTICAL WITH SALMONELLA TYPHIMURIUM LT2 TRNA LEU 1
1010/37 N IS AN UNKNOWN DERIVATIVE OF GUANOSINE
1010/38 HIS T MUTANT OF SALMONELLA TYPHIMURIUM TRNA LEU 1 HAS F38 = U38 AND F-40 = U-40, H.S.ALLAUDEEN,S.K.YANG,D.SOELL(1972) FEBS LETTERS 28, 205-208
1011/0 FOR NUMBERING OF E.COLI LEUCINE TRNAS SEE R.E.HURD,G.T.ROBILLARD, B.A.REID (1977) BIOCHEMISTRY 16, 2095-2100
1011/37 N IS AN UNKNOWN DERIVATIVE OF GUANOSINE
1012/34 N IS A DERIVATIVE OF ADENOSINE
1013/37 UNKNOWN DERIVATIVE OF ADENOSINE

			AMINOACYL STEM								D STEM			D LOOP									D STEM			ANTIC.STEM				ANTIC.LOOP					ANTIC.STEM		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	A	18	19	20	A	B	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
	LEUCINE cont.																																														
1015	GAG	HALOBACTERIUM VOL.	G	C	G	U	G	G	G	U	A	G	C	C	A	A	N	C	C	A	G	G	C	C	A	A	C	G	G	C	G4	C	A	G	C	G	U	U	G	A	G	G1	G	C5	G	C	U	G
1030	NAA	PHAGE T4	G	C	G	A	G	A	A	U	G	G	U	C	A	A	A	D	D		G3	G	D	A		A	A	G	G	C	A	C	A	G	C	A	C	U	N*	A	A	A	5A	F	G	C	U	G
1031	UAG	PHAGE T5	G	G	G	G	C	U	A	U	G	C	U	G	G	A	A	C	U		G3	G	D	A		G	A	C	A	A	U	A	C	G	G	C	C	U	U	A	G	A	6U	F	C	C	G	U
1040	CAA	YEAST	G	G	U	U	G	U	U	U	G	G2	C	C4	G	A	G	C			G3	G	D	C	D	A	A	G	G	C	G4	C	C	U	G	A	F	U	C5	A	A	G	1C	F	C	A	G	G
1050	UAG	YEAST	G	G	G	A	G	U	U	U	G	G2	C	C4	G	A	G	D			G3	G	D	D	D	A	A	G	G	C	G4	F	C	A	G	A	F	U	U	A	G	G	1C	F	C	U	G	A
1055	NAA	NEUROSPORA CRASSA MITO	A	U	C	C	G	A	G	U	G	A	U	G	G	A	A	D			G	G	D	A		G	A	C	A	U	A	A	C	A	U	G	C	U	N*	A	A	A	A	C	A	U	G	U
1056	UAG	NEUROSPORA CRASSA MITO	A	U	A	G	G	U	G	U	G	C	U	G	G	A	A	D	U		G	G	D	A		G	A	C	A	G	G	U	U	C	C	G	F	U	U	A	G	G1	C	G	G	A	A
1057	CAA	ANACYSTIS NIDUL.	G	G	G	C	A	A	G	U	G	G	C	G	G	A	A	U	D		G	G	D	A		G	A	C	G	C	A	G	C	A	G	A	C	U	C	A	A	N*	A	F	C	U	G	C
1058	CAG	ANACYSTIS NIDUL.	G	C	G	G	A	A	C	U	G	G	C	G	A	A	A	U	D		G	G	D	A		G	A	C	G	C	G	C	U	A	G	A	U	U	C	A	G	G1	F	F	C	U	A	G
1060	CAA	TORULOPSIS UTILIS	G	G	A	U	C	U	U	U	G	G2	C	C4	A	A	G	C			G3	G	D	D	U	A	A	G	G	C	G4	C	U	C	G	A	C3	U	C3	A	A	G	1A	F	C	G	A	G
1073	IAG	CAENORHABDITIS ELEG*	G	G	A	G	A	G	A	U	G	G	C	C4	G	A	G	C			G	G	D	C	U	A	A	G	G	C	G	C	U	G	G	U	U	U	I	A	G	G	C	A	C	C	A	G

1015 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA

1030 T.C.PINKERTON,B.PADDOCK,J.ABELSON(1973) J.BIOL.CHEM. 248, 6348-6365

1031 V.M.KRYUKOV,M.G.SCHLYAPNIKOV,S.I.KAZANTSEV,A.V.KALIMAN,V.N.KSENZENKO, A.A.BAYEV, EMBO-FEBS MEETING, STRASBOURG, JULY 1980

1040 S.H.CHANG,S.KUO,E.HAWKINS,N.R.MILLER (1973) BIOCHEM.BIOPHYS.RES.COMMUN. 51, 951-955

1050 E.RANDERATH,R.C.GUPTA,L.S.Y.CHIA,S.H.CHANG,K.RANDERATH (1979) EUR. J. BIOCHEM. 93, 79-94

1055 J.E.HECKMAN,J.SARNOFF,B.ALZNER-DE WEERD,S.YIN,U.L.RAJBHANDARY(1980) PROC. NATL. ACAD. SCI. USA 77, 3159-3163

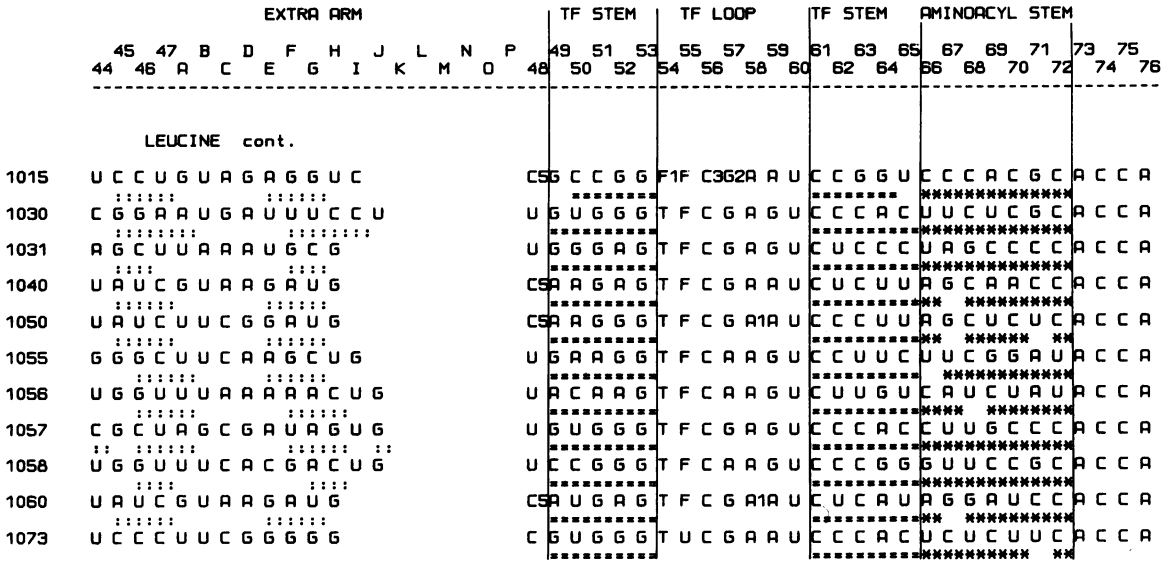
1056 J.E.HECKMAN,J.SARNOFF,B.ALZNER-DE WEERD,S.YIN,U.L.RAJBHANDARY(1980) PROC. NATL. ACAD. SCI. USA 77, 3159-3163

1057 B.LARUE, N.NEWHOUSE, K.NICOGHOSIAN, R.J.CEDERGREN (1981) J. BIOL. CHEM. 256, 1539-1543

1058 B. LARUE, N.NEWHOUSE, K.NICOGHOSIAN, R.J.CEDERGREN (1981) J. BIOL. CHEM. 256, 1539-1543

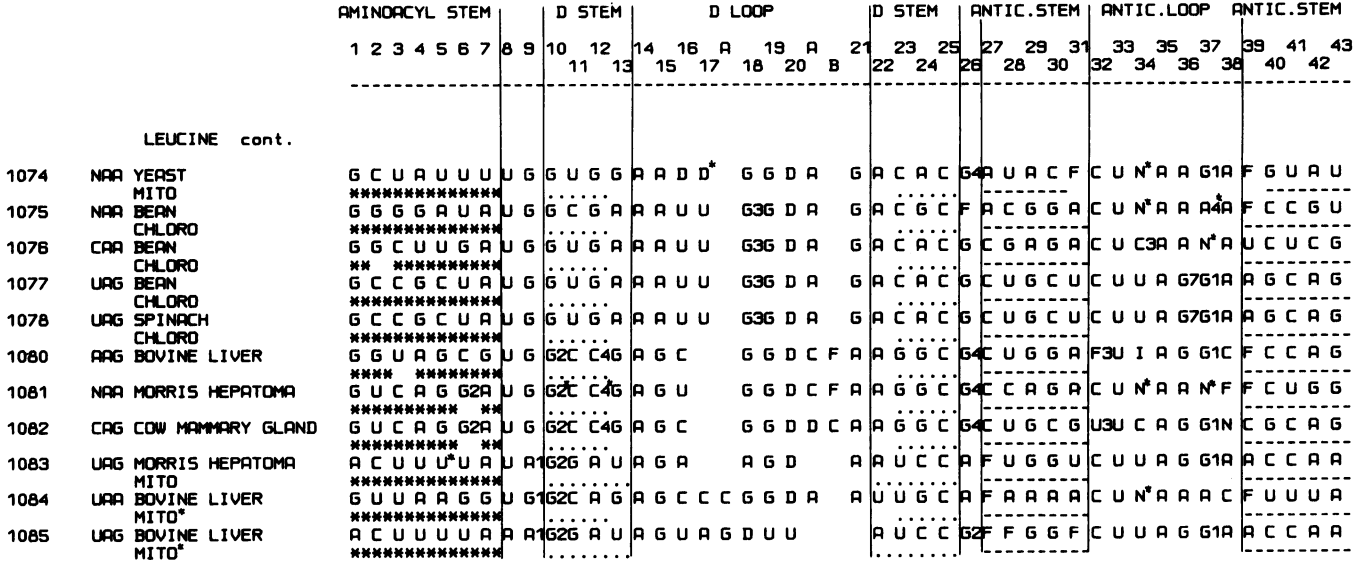
1060 A.MURASUGI,S.TAKEMURA(1978) J.BIOCHEM. 83, 1029-1038

1073 T.A.TRANQUILLA,R.CORTESE,D.MELTON,J.D.SMITH(1983) NUCL.ACIDS RES. 10, 7919-7934



1030/34 N IS A DERIVATIVE OF URIDINE
1055/34 N IS A MODIFIED URIDINE

1057/37 IS A MODIFIED ADENOSINE
1073/0 THE RNA TRANSCRIPT WAS PROCSSED IN XENOPUS OOCYTES



1074 G.DIRHEIMER (1981) PERSONAL COMMUNICATION

1075 M.L.OSORIO-ALMEIDA,P.GUILLEMAUT,G.KEITH,J.CANADAY,J.H.WEIL (1980) BIOCHEM. BIOPHYS. RES. COMMUN. 92, 102-108

1076 M.L.OSORIO-ALMEIDA,P.GUILLEMAUT,G.KEITH,J.CANADAY,J.H.WEIL (1980) BIOCHEM. BIOPHYS. RES. COMMUN. 92, 102-108

1077 M.L.OSORIO-ALMEIDA,P.GUILLEMAUT,G.KEITH,J.CANADAY,J.H.WEIL (1980) BIOCHEM. BIOPHYS. RES. COMMUN. 92, 102-108

1078 J.CANADAY,P.GUILLEMAUT,R.GLOECKLER,J.H.WEIL (1980) PLANT SCIENCE LETTERS 20, 57-62

1080 R.PIRTLE,M.KASHDAN,I.PIRTLE,B.DUDOCK(1980) NUCLEIC ACIDS RES. 8, 805-815

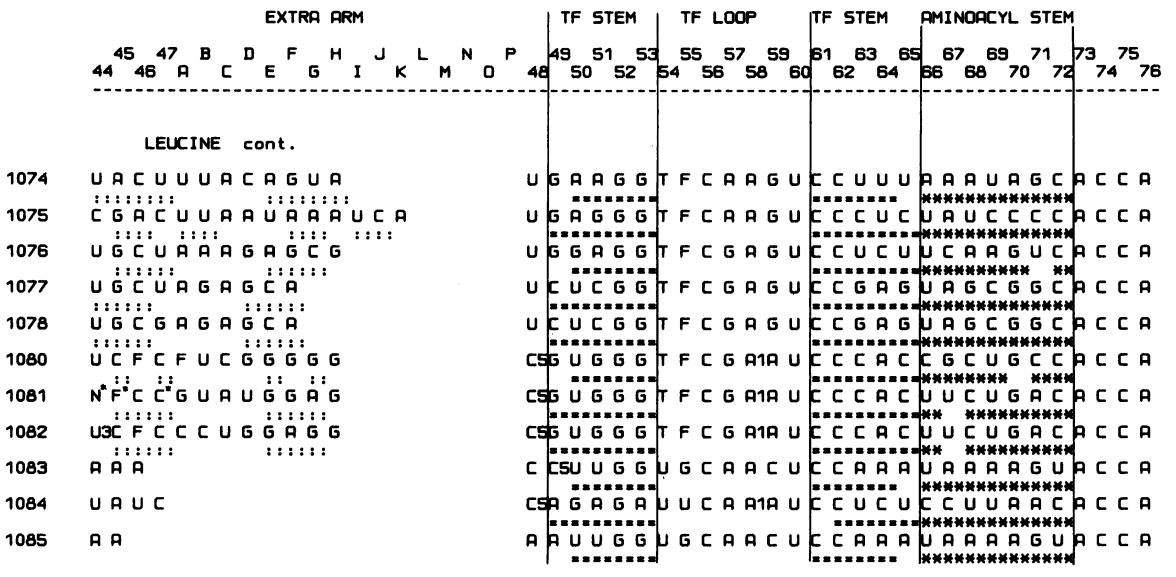
1081 E.RANDERATH,R.C.GUPTA,H.P.MORRIS,K.RANDERATH(1980) BIOCHEMISTRY 19, 3476-3483

1082 M.A.TUKALO,V.V.VLASOV,I.G.VASIL'CHENKO,G.KH.MATSUKA,D.G.KNORRE (1980) DOKL.AKAD.NAUK SSR 253, 253-256 (ENGL. TRANSL. 222-225) M.A.TUKALO, I.G.VASILCHENKO, V.V.VLASOV, G.KH.MATSUKA (1980) UKRAIN. BIOCHIM. Z. 52, 547-550

1083 K.RANDERATH, H.P.AGRAWAL, E.RANDERATH (1981) BIOCHEM. BIOPHYS. RES. COMMUN. 100, 732-737

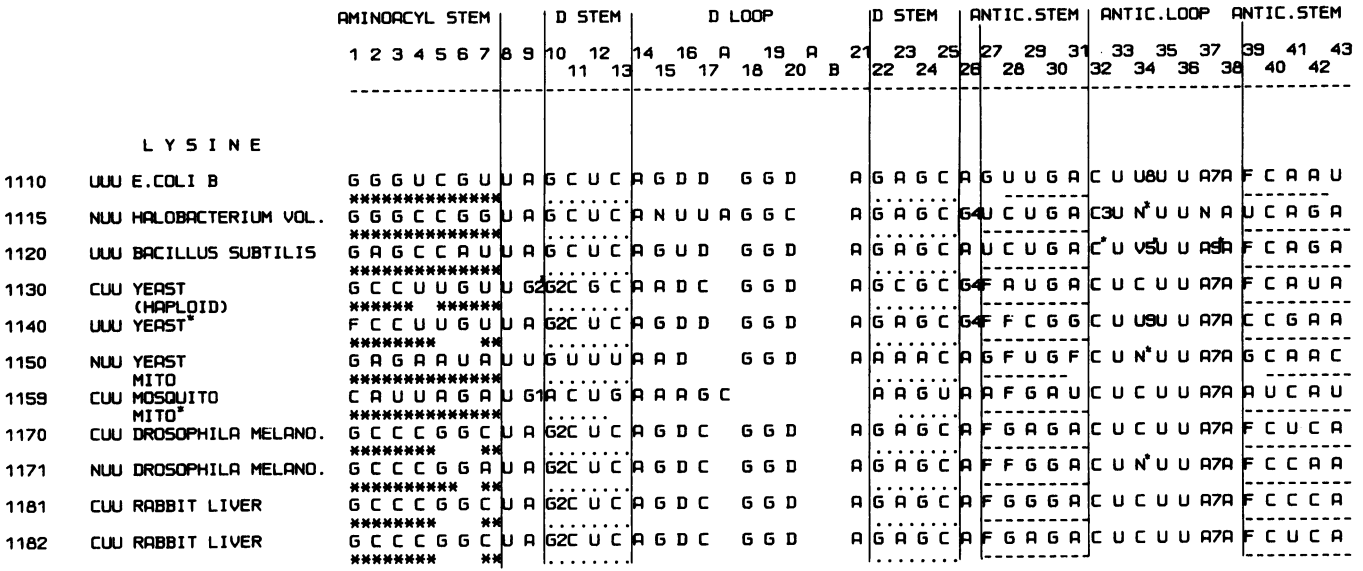
1084 B.A.ROE, J.F.H.WONG, E.Y.CHEN (1982) PERSONAL COMMUNICATION

1085 B.A.ROE, J.F.H.WONG, E.Y.CHEN (1982) PERSONAL COMMUNICATION



1074/17 PARTIALLY MODIFIED
1074/34 MODIFIED URIDINE
1075/34 N IS AN UNKNOWN URIDINE DERIVATIVE
1075/37 IS EITHER I6A OR ZEATIN
1076/37 IS AN UNIDENTIFIED DERIVATIVE OF ADENOSINE
1081/10 PARTIALLY MODIFIED
1081/12 PARTIALLY MODIFIED
1081/34 N IS A DERIVATIVE OF CYTIDINE

1081/37 N IS A DERIVATIVE OF GUANOSINE
1081/44 N IS A DERIVATIVE OF URIDINE
1081/45 PARTIALLY MODIFIED
1081/47 B ISOACCEPTOR HAS ADENOSINE AT THIS POSITION
1083/5 PARTIALLY GUANOSINE
1084/0 ALIGNMENT IS ARBITRARY
1084/34 N IS A MODIFIED URIDINE
1085/0 ALIGNMENT IS ARBITRARY



1110 K.CHAKRABURTTY,A.STEINSCHNEIDER,R.V.CASE,A.H.MEHLER(1975) NUCLEIC ACIDS RES. 2, 2069-2075

1115 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA

1120 Y.YAMADA,H.ISHIKURA(1977) NUCLEIC ACIDS RES. 4, 4291-4303
B.S.VOLD, D.E.KEITH JR., M.BUCK, J.A.MCCLOSKEY, H.PANG (1982) NUCL. ACIDS RES. 10, 3125-3132

1130 S.J.SMITH,H.S.TEH,A.N.LEY,P.D'OBRENAN(1973) J.BIOL.CHEM. 248, 4475-4485

1140 J.T.MADISON,S.J.BOGUSLAWSKI(1974) BIOCHEMISTRY 13, 524-527

1150 G.DIRHEIMER (1983) PERSONAL COMMUNICATION

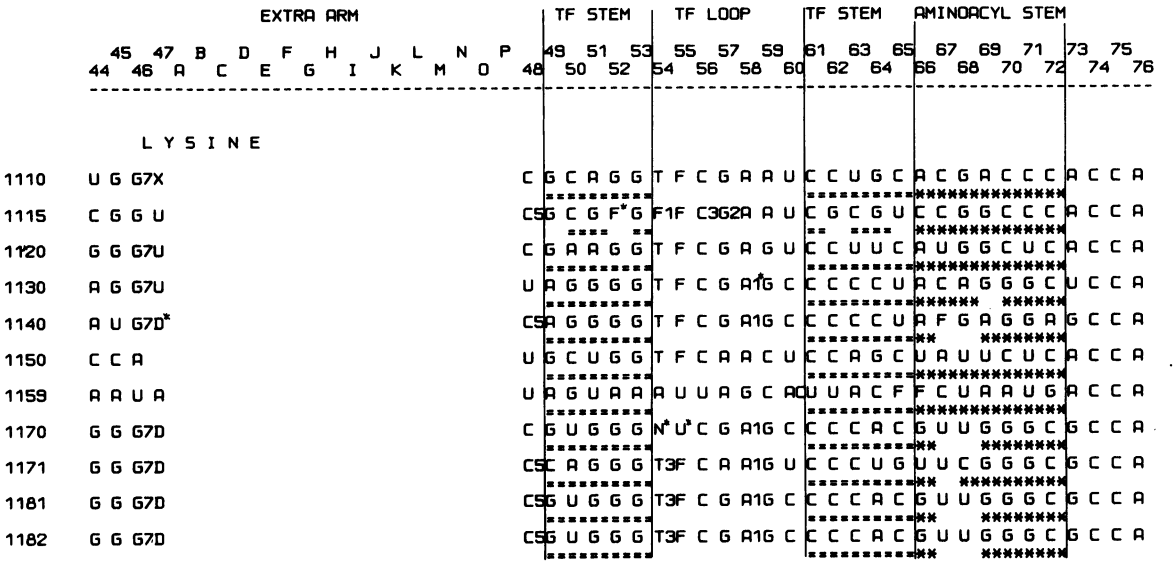
1159 C.-C.HSUCHEN,G.R.CLEAVES,D.T.DUBIN(1983) NUCL.ACIDS RES. 11, 8659-8662

1170 S.SILVERMANN,I.C.GILLAM,G.M.TENER,D.SOELL(1979) NUCLEIC ACIDS RES. 6, 435-442

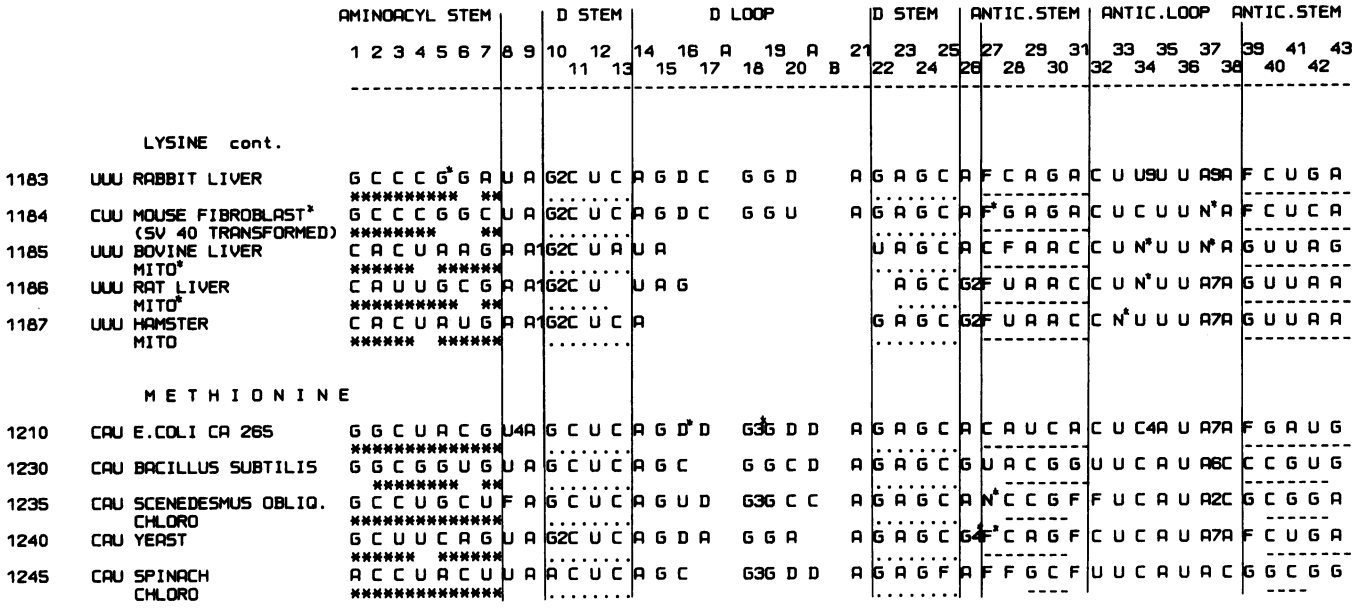
1171 D.L.CRIBBS, I.C.GILLAM, G.M.TENER (1982) NUCL. ACIDS RES. 10, 6393-6399

1181 M.RABA,K.LIMBURG,M.BURGHAGEN,J.R.KATZE,M.SIMSEK,J.E.HECKMAN, U.L.RAJBHANDARY,H.J.GROSS (1979) EUR.J.BIOCHEM. 97 , 305-318

1182 M.RABA,K.LIMBURG,M.BURGHAGEN,J.R.KATZE,M.SIMSEK,J.E.HECKMAN, U.L.RAJBHANDARY,H.J.GROSS (1979) EUR.J.BIOCHEM. 97, 305-318



1115/34 PARTIALLY MODIFIED TO UNIDENTIFIED DERIVATIVE OF CYTIDINE
1115/52 PARTIALLY MODIFIED
1120/32 ONE ISOACCEPTOR (1) HAS AN UNMODIFIED CYTIDINE,THE OTHER ONE (3) A MODIFIED CYTIDINE
1120/34 Y.YAMADA, K.MURAO, H.ISHIKURA (1981) NUCLEIC ACIDS RES. 9, 1933-1939;
1120/37 Y.YAMADA, H.ISHIKURA (1981) J.BIOCHEM. 89, 1589-1591; PARTIALLY MODIFIED
1130/9 PARTIALLY MODIFIED
1130/58 PARTIALLY MODIFIED
1140/0 IS IDENTICAL WITH SACCHAROMYCES CERIVISIAE HAPLOID 2;C.J.SMITH, H.-S.TEH,A.N.LEY,P.D'OBRENAN (1973) J.BIOL.CHEM. 248, 4475-4485
1140/47 PARTIALLY MODIFIED
1150/34 IS A DERIVATIVE OF URIDINE
1159/0 ALIGNMENT IS ARBITRARY
1170/54 N IS VERY LIKELY TM
1170/55 U IS PROBABLY PARTLY MODIFIED TO F
1171/34 N IS PROBABLY MCM5S2U



1183 M.RABA,K.LIMBURG,M.BURGHAGEN,J.R.KATZE,M.SIMSEK,J.E.HECKMAN, U.L.RAJBHANDARY,H.J.GROSS (1979) EUR.J.BIOCHEM. 97, 305-318

1184 M.RABA,K.LIMBURG,M.BURGHAGEN,J.R.KATZE,M.SIMSEK,J.E.HECKMAN, U.L.RAJBHANDARY,H.J.GROSS (1979) EUR.J.BIOCHEM. 97, 305-318

1185 B.A.ROE, J.F.H.WONG, E.Y.CHEN (1982) PERSONAL COMMUNICATION

1186 E.RANDERATH, H.P. AGRAWAL, K.RANDERATH (1981) BIOCHEM. BIOPHYS. RES. COMMUN. 103, 739-744

1187 C.-C.HSUCHEN,G.R.CLEAVES,D.T.DUBIN(1983) NUCL.ACIDS RES. 11, 8659-8662

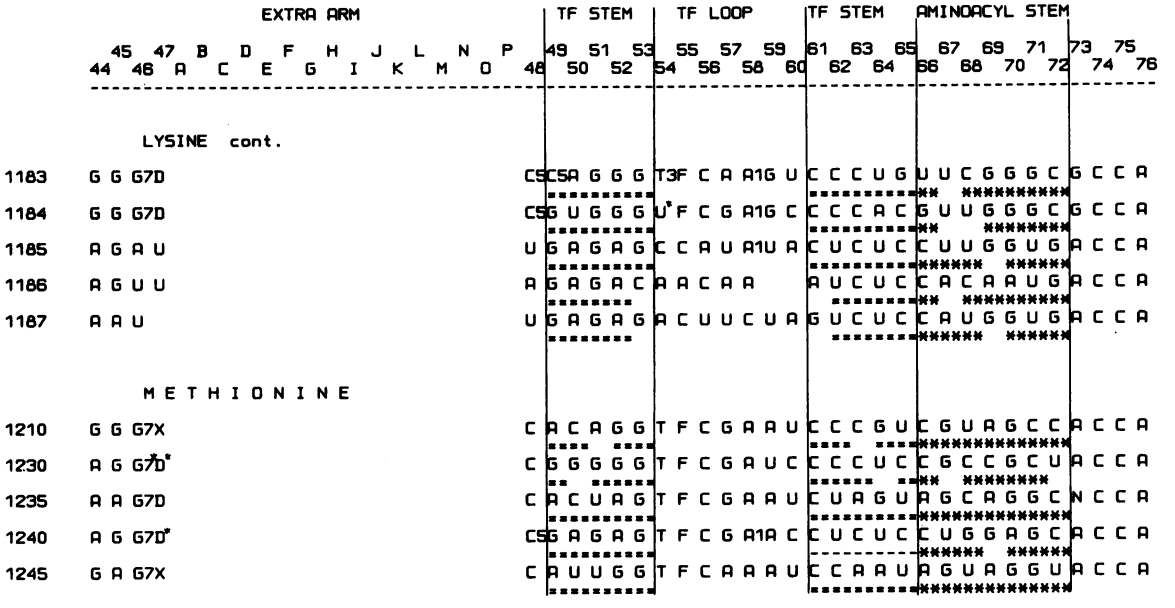
1210 S.CORY,K.A.MARCKER(1970) EUR.J.BIOCHEM. 12, 177-194

1230 Y.YAMADA, H.ISHIKURA (1980) NUCLEIC ACIDS RES. 8, 4517-4520

1235 D.S.JONES (1980) EMBO-FEBS TRNA WORKSHOP, STRASBOURG.

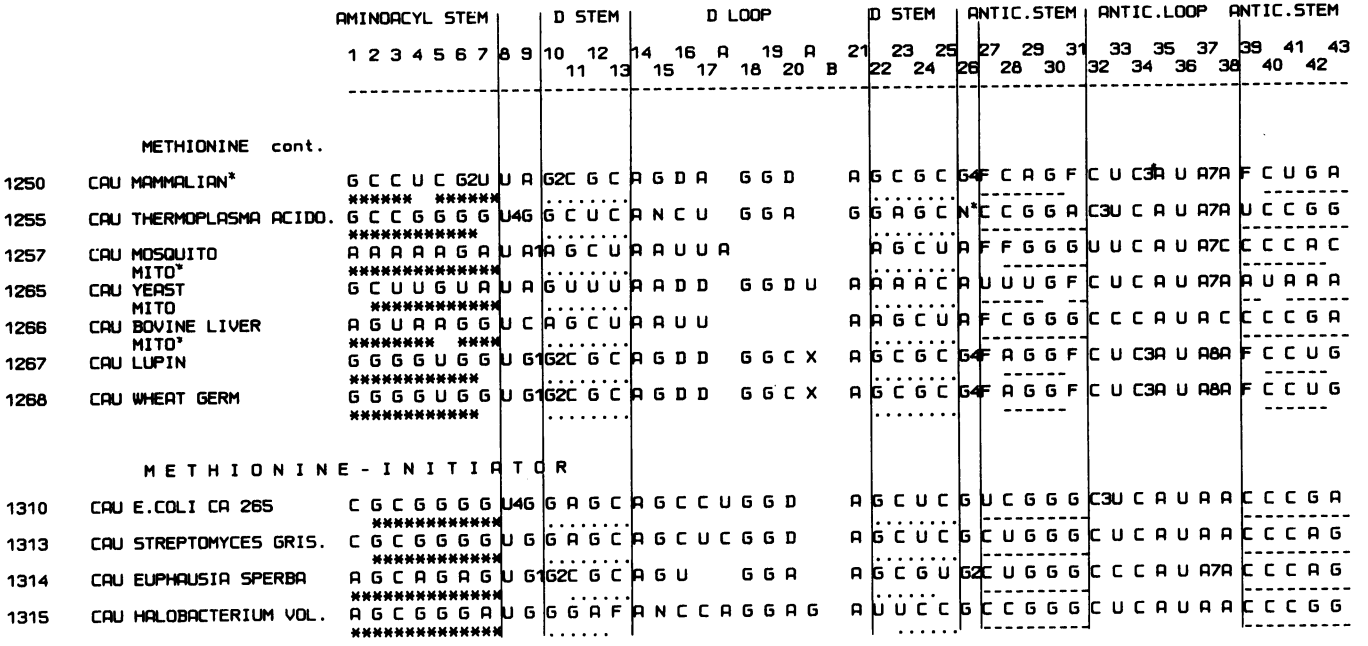
1240 H.GRUHL,H.FELDMANN(1976) EUR.J.BIOCHEM. 68, 209-217
O.KOIWAI,M.MIYAZAKI(1976) J.BIOCHEM. 80, 951-959

1245 R.PIRTLE, J.CALAGAN, I.PIRTLE, M.KASHDAN, H.VREMAN, B.DUDOCK (1981) NUCLEIC ACIDS RES. 9, 183-188

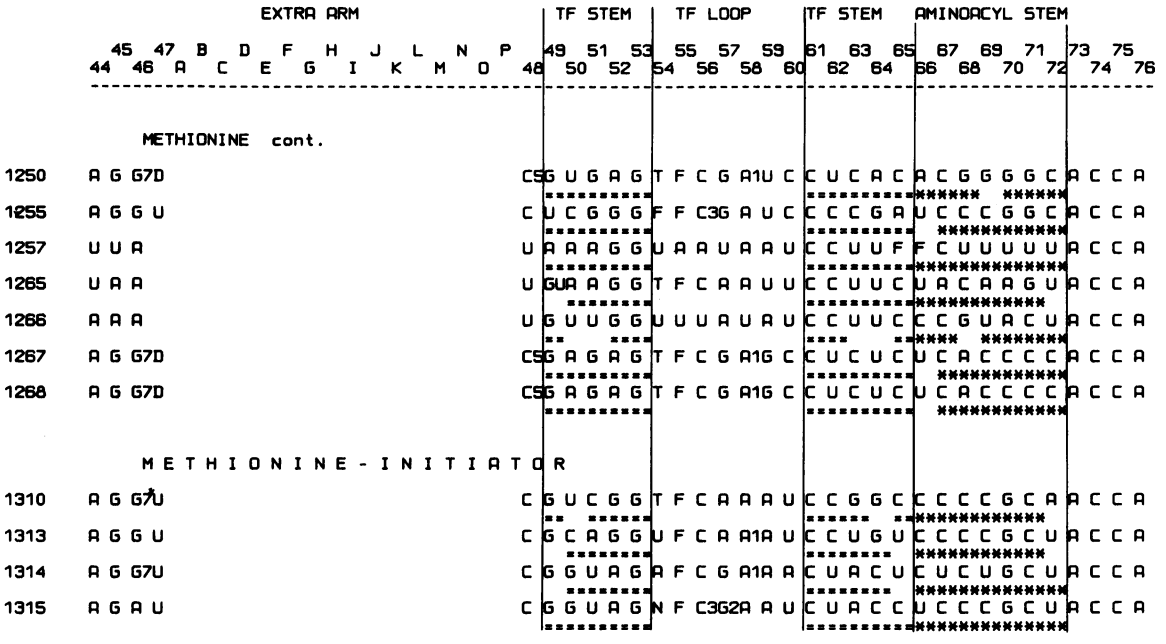


1184/27 PARTIALLY MODIFIED
1184/37 N IS PROBABLY A PRECURSOR OF T6A
1184/54 CONTAINS U, T, TM AND F
1185/0 ALIGNMENT IS ARBITRARY
1185/34 N IS A MODIFIED URIDINE
1185/37 N IS A MODIFIED ADENOSINE
1186/0 ALIGNMENT IS ARBITRARY
1186/34 N IS A DERIVATIVE OF URIDINE
1187/33 HYPERMODIFIED DERIVATIVE OF URIDINE

1210/16 PARTIALLY MODIFIED
1210/18 PARTIALLY MODIFIED
1230/46 PARTIALLY MODIFIED
1230/47 PARTIALLY MODIFIED
1235/27 N IS A MODIFIED URIDINE.
1240/26 PARTIALLY MODIFIED
1240/27 PARTIALLY MODIFIED
1240/47 PARTIALLY MODIFIED

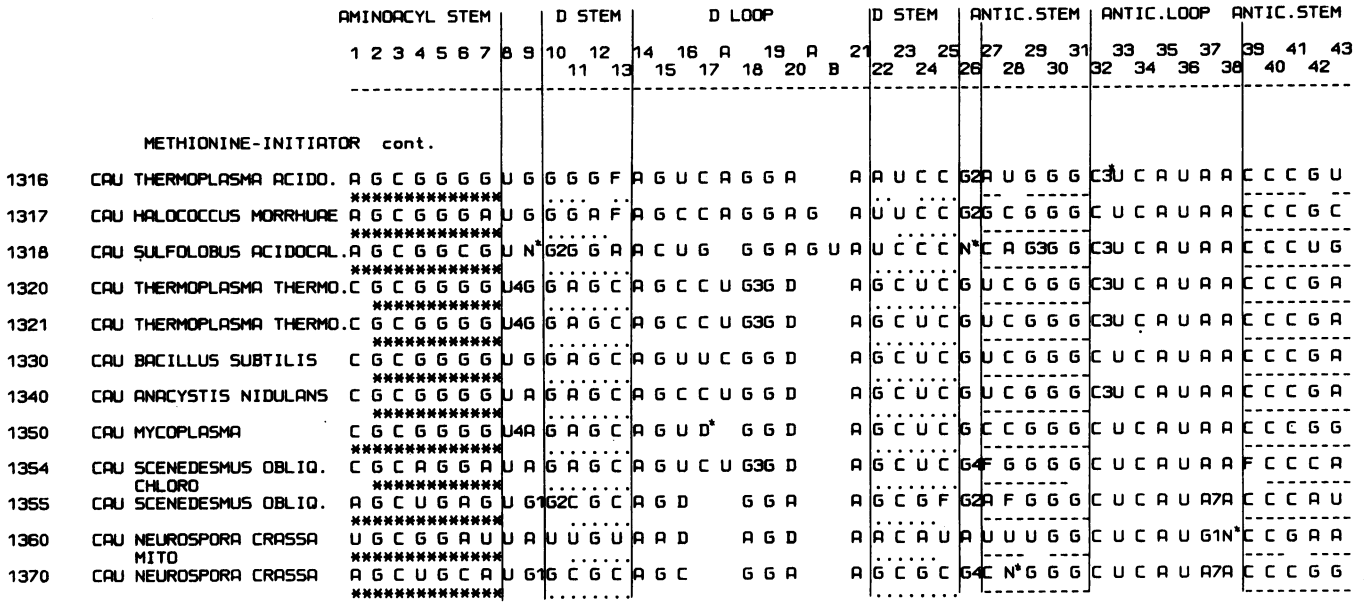


1250 P.W.PIPER(1975) EUR.J.BIOCHEM. 51, 283-293
G.PETRISSANT,M.BOISNARD(1974) BIOCHIMIE 56, 787-789
1255 M.W.KILPATRICK, R.T.WALKER (1981) NUCLEIC ACIDS RES. 9, 4387-4390
1257 D.T.DUBIN (1983) PERSONAL COMMUNICATION
1265 G.DIRHEIMER (1981) PERSONAL COMMUNICATION
1266 R.A.ROE, J.F.H.WONG, E.Y.CHEN (1982) PERSONAL COMMUNICATION
1267 T.ZWIERZYNSKI, A.J.RAFALSKI, K.GULEWICZ, W.KRZYZOSIAK (1983) PERSONAL COMMUNICATION
1268 M.BARCISZEWSKA,G.DIRHEIMER,G.KEITH(1983) BIOCHEM.BIOPHYS.RES.COM. 114 1161-1168
1310 S.K.DUBE,K.A.MARCKER(1969) EUR.J.BIOCHEM. 8, 256-262
1313 Y.KUCHINO, I.YAMAMOTO, S.NISHIMURA (1982) NUCL. ACIDS RES. 10, 6671-6674
1314 K.WATANABE, K.ASAI, T.OSHIMA, Y.KUCHINO (1981) J. BIOCHEM. 90, 1259-1266
1315 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA



1250/0 MOUSE MYELOMA AND RABBIT LIVER
1250/34 PARTIALLY MODIFIED
1255/26 IS A DERIVATIVE OF GUANOSINE
1257/0 THIS SPECIES MAY ALSO FUNCTION AS INITIATOR TRNA; ALIGNMENT IS ARBITRARY

1266/0 ALIGNMENT IS ARBITRARY
1310/46 M7G46 = A46 IN THE MINOR SPECIES OF TRNA F-MET FROM E.COLI,S.K.DUBE, K.A.MARCKER,B.F.C.CLARK,S.CORY (1968) NATURE 218, 231-233; B.Z.EGAN,J.F.WEISS,A.D.KELMERS (1973) BIOCHEM.BIOPHYS.RES.COMMUN. 55, 320-327



1316 Y.KUCHINO, M.IHARA, Y.YABUSAKI, S.NISHIMURA (1982) NATURE 298, 684-685

1317 Y.KUCHINO, M.IHARA, Y.YABUSAKI, S.NISHIMURA (1982) NATURE 298, 684-685

1318 Y.KUCHINO, M.IHARA, Y.YABUSAKI, S.NISHIMURA (1982) NATURE 298, 684-685

1320 K.WATANABE,Y.KUCHINO,Z.YAMAIZUMI,M.KATO,T.OSHIMA,S.NISHIMURA (1979) J. BIOCHEM. 86, 893-905

1321 K.WATANABE,Y.KUCHINO,Z.YAMAIZUMI,M.KATO,T.OSHIMA,S.NISHIMURA(1979) J.BIOCHEM. 86, 893-905

1330 Y.YAMADA, Y.KUCHINO, H.ISHIKURA (1980) J.BIOCHEM.87, 1261-1269

1340 B.ECAROT-CHARRIER,R.J.CEDERGREN(1976) FEBS LETTERS 63, 287-290

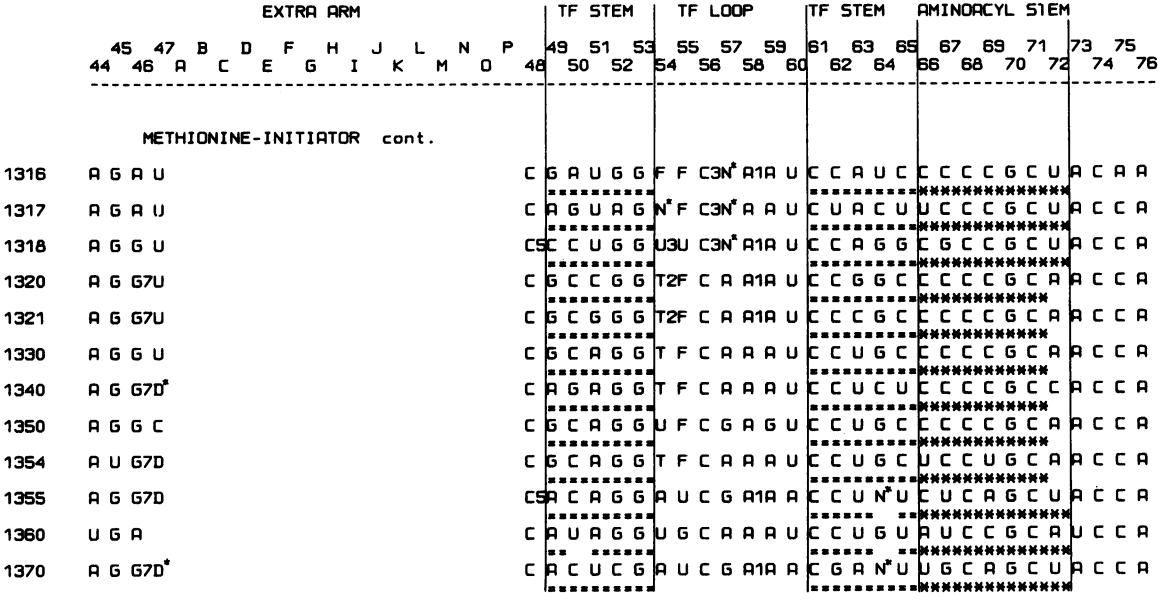
1350 R.T.WALKER,U.L.RAJBHANDARY(1978) NUCLEIC ACIDS RES. 5, 57-70

1354 J.M.MCCOY, D.S.JONES (1980) NUCLEIC ACIDS RES. 8, 5089-5093

1355 P.O.OLINS,D.S.JONES(1980) NUCLEIC ACIDS RES. 8, 715-729

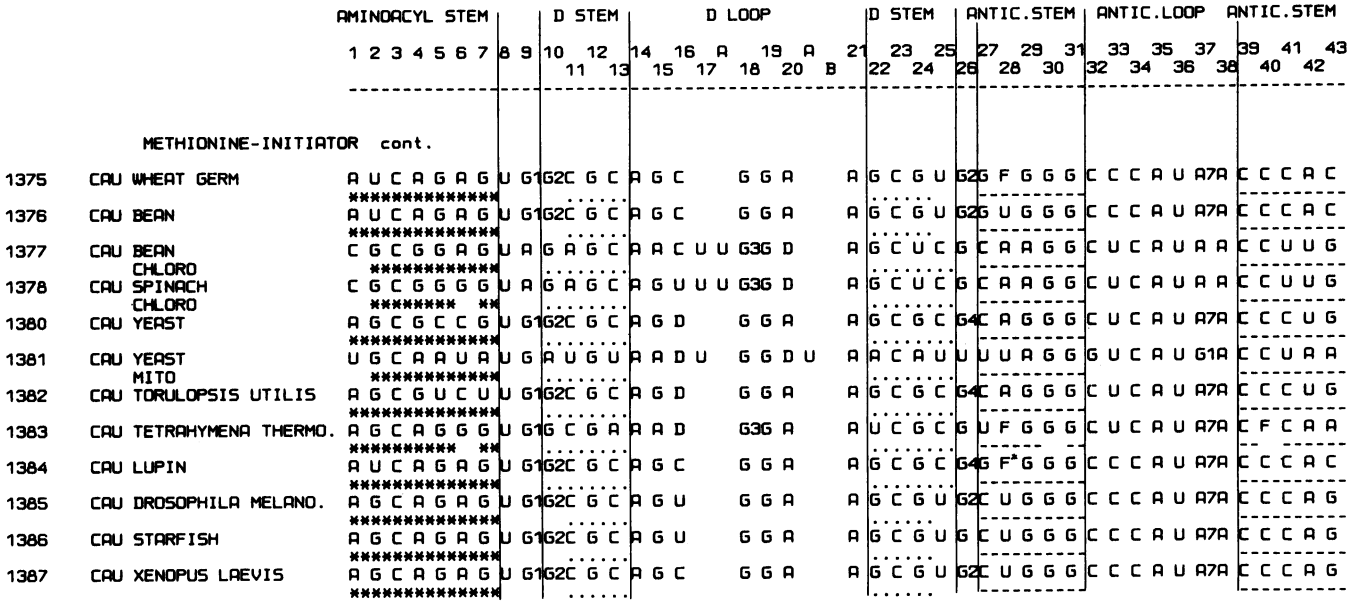
1360 J.E.HECKMAN,L.I.HECKER,S.D.SCHWARTZBACH,W.E.BARNETT,B.BAUMSTARK, U.L.RAJBHANDARY(1978) CELL 13, 83-95

1370 A.M.GILLUM,L.I.HECKER,M.SILBERKLANG,S.D.SCHWARTZBACH,U.L.RAJBHANDARY, W.E.BARNETT(1977) NUCLEIC ACIDS RES. 4, 4109-4131



1316/32 PARTIALLY MODIFIED
1316/57 N IS PRESUMABLY INOSINE
1317/54 N IS PRESUMABLY 1-METHYLPSEUDOURIDINE
1317/57 N IS PRESUMABLY 1-METHYLINOSINE
1318/9 N IS A MODIFIED NUCLEOTIDE
1318/26 N IS A DERIVATIVE OF GUANOSINE, PRESUMABLY 2,2,2'-TRIMETHYL-GUANOSINE, M22GM
1318/57 N IS PRESUMABLY 1-METHYLINOSINE

1340/47 PARTIALLY MODIFIED
1350/17 PARTIALLY MODIFIED
1355/64 POSITION 64 IS PROBABLY OCCUPIED BY GM
1360/38 N IS MOST PROBABLY PSEUDOURIDINE
1370/28 N IS A DERIVATIVE OF PYRIMIDINE
1370/47 PARTIALLY MODIFIED TO D
1370/64 N IS A DERIVATIVE OF GUANOSINE



1375 H.P.GHOSH, K.GHOSH, M. SIMSEK, U.L.RAJBHANDARY (1982) NUCL. ACIDS RES. 10, 3241-3247

1376 J.CANADAY,P.GUILLEMAUT,J.H.WEIL(1980) NUCLEIC ACIDS RES. 8, 999-1008

1377 J.CANADAY,P.GUILLEMAUT,J.H.WEIL(1980) NUCLEIC ACIDS RES. 8, 999-1008

1378 J.L.CALAGAN, R.M.PIRTLE, I.L.PIRTLE, M.A.KASHDAN, H.J. VREMAN, B.S. DUDOCK (1980) J. BIOL. CHEM. 255, 9981-9984

1380 M.SIMSEK,U.L.RAJBHANDARY(1972) BIOCHEM.BIOPHYS.RES.COMMUN. 49, 508-515; N.BEAUCHEMIN, R.CEDERGREN (1982) PERS. COMMUNICATION

1381 J.CANADAY,G.DIRHEIMER,R.P.MARTIN(1980) NUCLEIC ACIDS RES. 8 1445-1457

1382 S,YAMASHIRO-MATSUMURA,S.TAKEMURA(1979) J.BIOCHEM. 86, 335-346

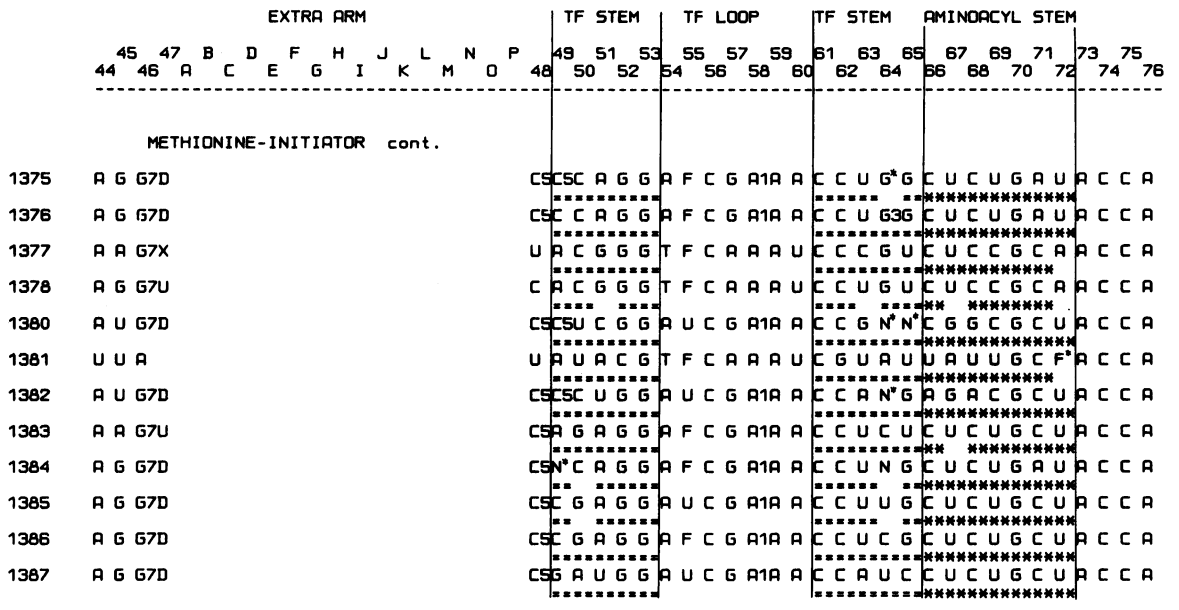
1383 Y.KUCHINO, T.MITA, S.NISHIMURA (1981) NUCLEIC ACIDS RES. 9, 4557-4562

1384 T.ZWIERZYNSKI, A.J.RAFALSKI, K.GULEWICZ, W.KRZYZOSIAK (1983) PERSONAL COMMUNICATION

1385 S,SILVERMAN,J.HECKMAN,G.J.COWLING,A.D.DELANEY,R.J.DUNN,I.C.GILLAM, G.M.TENER,D.SOELL, U.L.RAJBHANDARY(1979) NUCLEIC ACIDS RES. 6 , 421-433

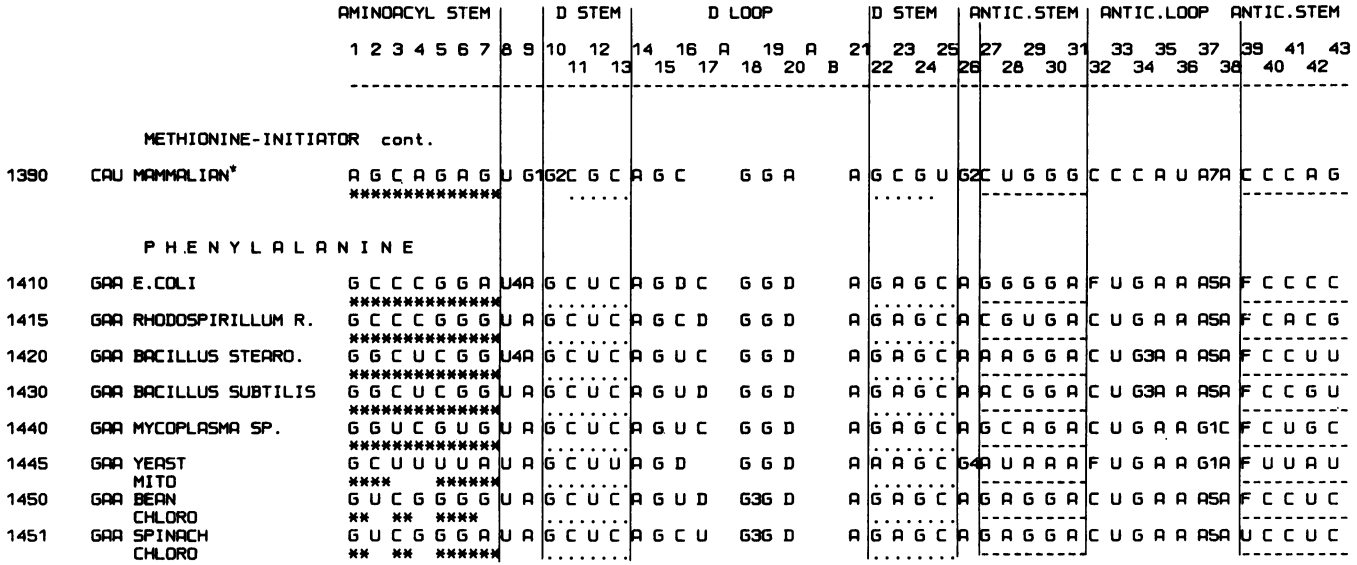
1386 Y.KUCHINO,M.KATO,H.SUGISAKI,S.NISHIMURA(1979) NUCLEIC ACIDS RES.6,3459-3469

1387 R.A.KOSKI,S.G.CLARKSON(1982) BIOL.CHEM. 257, 4514-4521 M.WEGNEZ,A.MAZABRAUD,H.DENIS,G.PETRISSANT,M.BOINARD(1975) EUR.J.BIOCHEM. 60, 295-302



1375/64 IS AN UNKNOWN GUANOSINE DERIVATIVE
1380/64 N IS A DERIVATIVE OF ADENOSINE
1380/65 N IS A DERIVATIVE OF GUANOSINE
1381/72 PARTIALLY MODIFIED

1382/64 N IS A DERIVATIVE OF GUANOSINE
1384/28 PARTIALLY MODIFIED
1384/49 DERIVATIVE OF CYTIDINE



1390 M.SIMSEK,U.L.RAJBHANDARY,M.BOISNARD,G.PETRISSANT(1974) NATURE 247,518-52
A.M.GILLUM,N.URQUHART,M.SMITH,U.L.RAJBHANDARY(1975) CELL 6, 395-405
A.M.GILLUM,B.A.ROE,M.P.J.S.ANANDARAJ,U.L.RAJBHANDARY (1975) CELL 6, 407-413
P.W.PIPER,B.F.C.CLARK(1974) EUR.J.BIOCHEM. 45, 589-600
M.WEGNEZ,A.NAZABRAUD,H.DENIS,G.PETRISSANT,M.BOISNARD (1975) EUR.J.BIOCHEM. 60, 295-302

1410 B.G.BARRELL,F.SANGER(1969) FEBS LETTERS 3, 275-278

1415 N.NEWHOUSE, K.NICOGHOSIAN, R.J.CEDERGREN (1981) CAN. J. BIOCHEM. 59, 921-932

1420 G.KEITH,C.GUERRRIER-TAKADA,H.GROSJEAN,G.DIRHEIMER (1977) FEBS LETTERS 84, 241-244

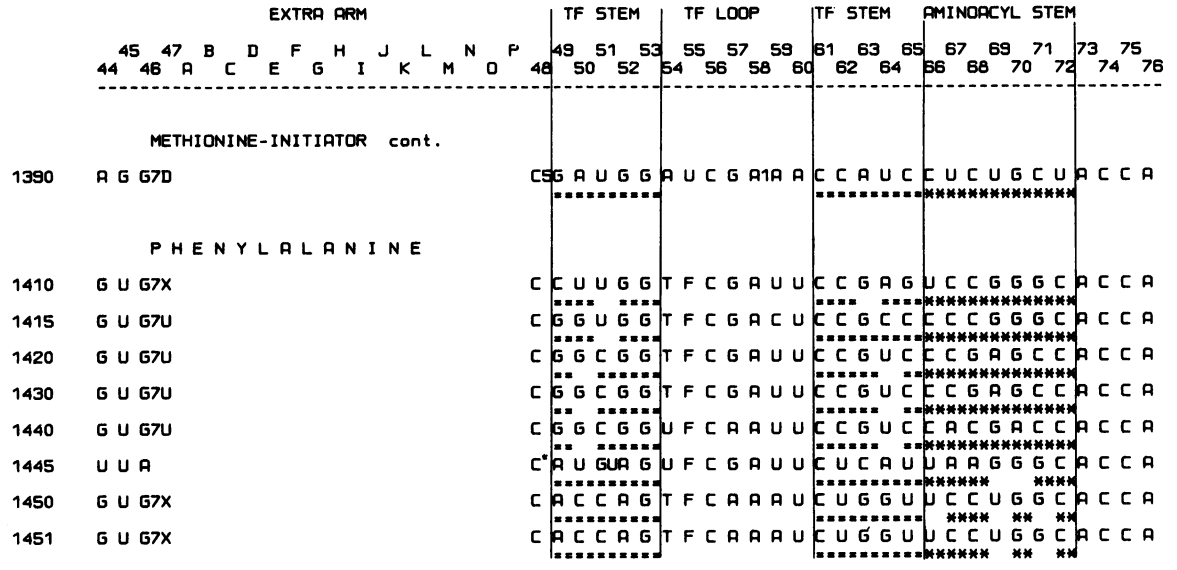
1430 H.ARNOLD, G.KEITH(1977) NUCLEIC ACIDS RES. 4, 2821-2829

1440 M.E.KIMBALL,K.S.SZETO,D.SOELL(1974) NUCLEIC ACIDS RES. 1, 1721-1732

1445 R.P.MARTIN, A.P.SIBLER, J.M.SCHNELLER, G.KEITH, A.J.C.STAHL, G.DIRHEIMER (1978) NUCLEIC ACIDS RES. 5, 4579-4592

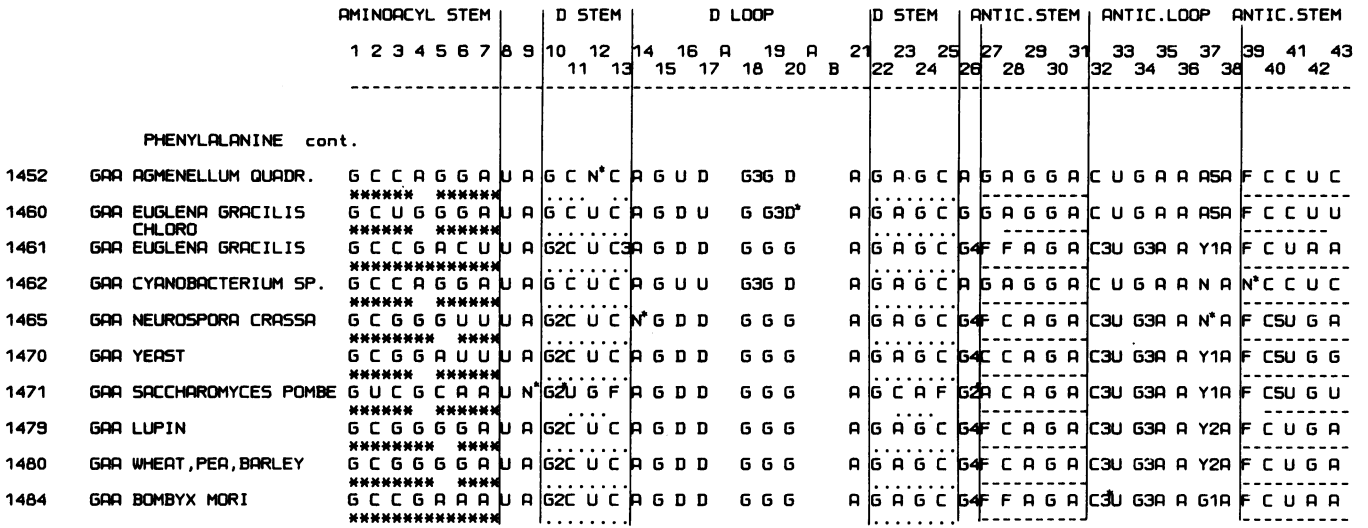
1450 P.GUILLEMAUT,G.KEITH(1977) FEBS LETTERS 84, 351-356

1451 J.CANADAY, P.GUILLEMAUT, R.GLOECKLER, J.-H.WEIL (1980) PLANT SCIENCE LETTERS 20, 57-62



1390/0 RABBIT LIVER,SHEEP MAMMARY GLANDS,SALMON TESTES,SALMON LIVER,HUMAN PLACENTA,MOUSE MYELOMA CELLS,OOCYTES AND SOMATIC CELLS OF XENOPUS LAEVIS

1445/48 FOR ALTERNATIVE ALIGNMENT SEE NUCLEIC ACIDS RES. 5, P.4587



1452 L.I.HECKER, W.E.BARNETT, F.K.LIN, T.D.FURR, J.E.HECKMAN, U.L.RAJBAHANDARY, S.H.CHANG (1982) NUCL. ACIDS RES. 10, 6433-6440

1460 S.H.CHANG,L.HECKER,M.SILBERKLANG,C.K.BRUM,W.E.BARNETT,U.L.RAJBHANDARY (1976) CELL 9, 717-724

1461 S.H.CHANG,L.I.HECKER,C.K.BRUM,J.J.SCHNABEL,J.E.HECKMAN,M.SILBERKLANG, U.L.RAJBHANDARY,W.E.BARNETT (1981) NUCLEIC ACIDS RES. 9, 3199-3204

1462 S.H.CHANG,F.K.LIN,L.I.HECKER,J.E.HECKMAN,U.L.RAJBHANDARY, W.E.BARNETT(1978) COLD SPRING HARBOR MEETING ON T-RNA,ABSTRACTS,P.45

1465 B.ALZNER-DE WEERD,L.J.HECKER,W.E.BARNETT,U.L.RAJBHANDARY(1980) NUCLEIC ACIDS RES. 8, 1023-1032

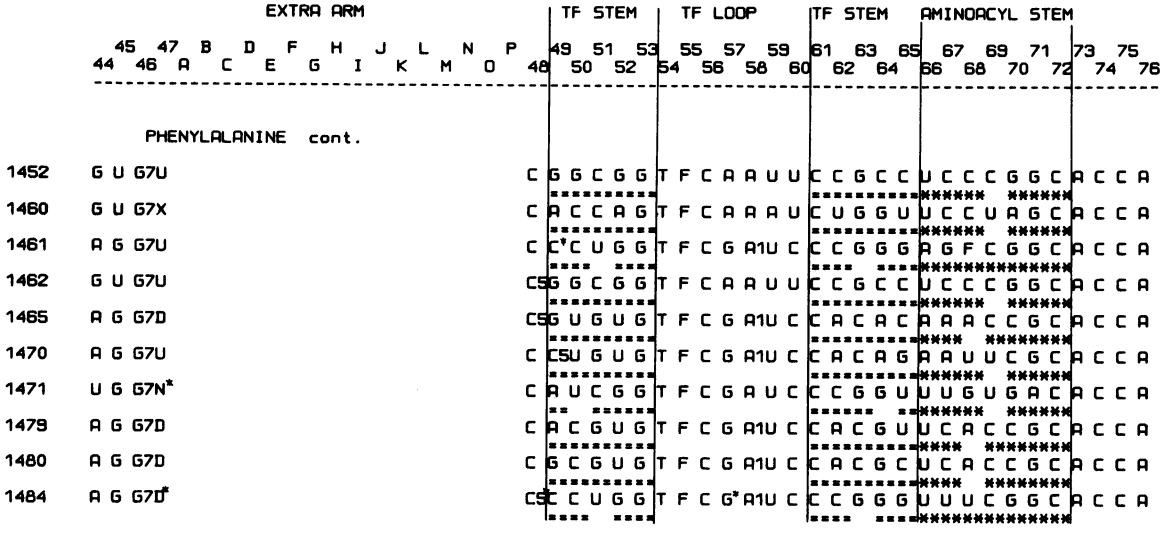
1470 U.L.RAJBHANDARY,S.H.CHANG(1968) J. BIOL. CHEM. 243, 598-608
P.E.NIELSEN,V.LEICK(1982) BIOCHEM.BIOPHYS.RES.COMM. 106, 179-185

1471 T.MCCUTCHAN,S.SILVERMAN,J,KOHLI,D.SOELL(1978) BIOCHEMISTRY 17, 1622-1628

1479 A.J.RAFALSKI, J.BARCISZEWSKI, K.GULEWICZ, Y.T.TWARDOWSKI, G.KEITH (1977) ACTA BIOCH. POLONICA 24, 301-318

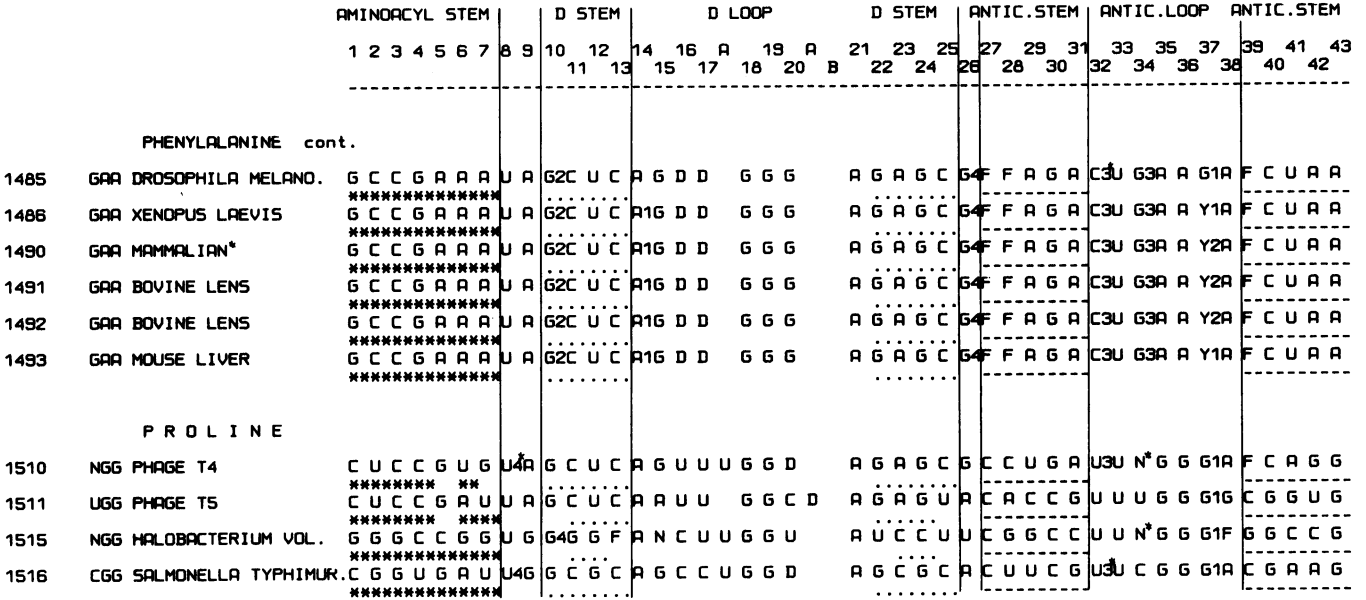
1480 B.S.DUDOCK, G.KATZ (1969) J.BIOL.CHEM. 244, 3069-3074;
G.A.EVERETT, J.T.MADISON (1976) BIOCHEMISTRY 15, 1016-1021;
J.M.WOWER, Z.A.JANOWICZ, J.AUGUSTYNIAK (1979) ACTA BIOCH. POLONICA 26, 369-381

1484 G.KEITH, G.DIRHEIMER (1980) BIOCHEM. AND BIOPHYS. RES. COMMUN. 92, 109-115

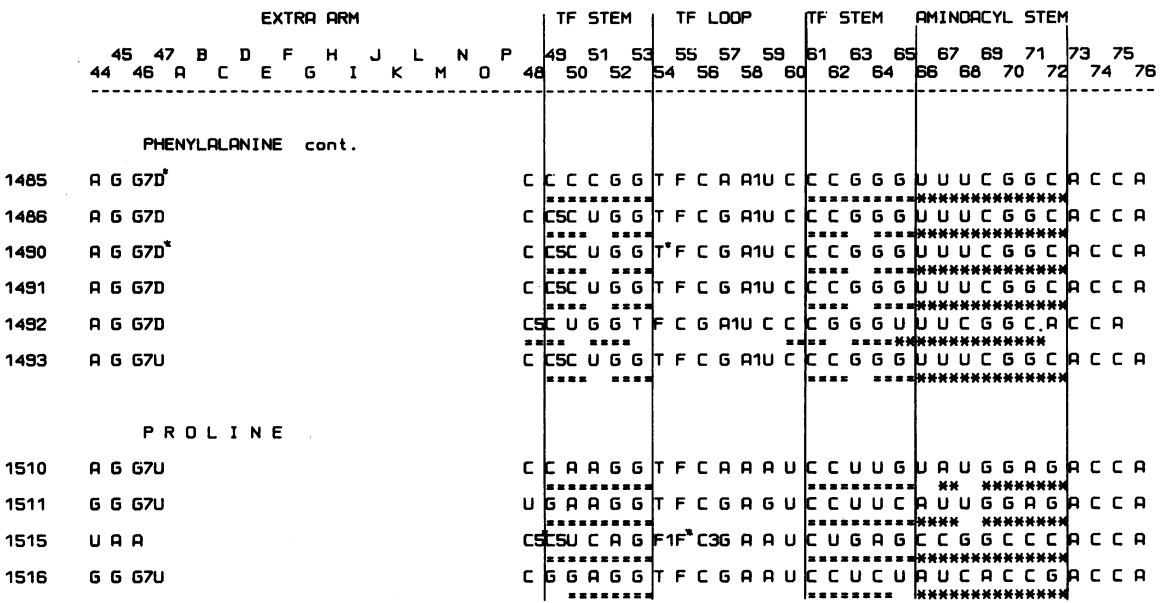


1452/12 N IS A DERIVATIVE OF URIDINE
1460/20 PARTIALLY MODIFIED TO D
1461/49 PROBABLY A DERIVATIVE OF CYTIDINE
1462/39 N IS PROBABLY A DERIVATIVE OF URIDINE
1465/14 N IS A DERIVATIVE OF ADENOSINE
1465/37 N IS A DERIVATIVE OF Y
1471/9 N IS A DERIVATIVE OF GUANOSINE

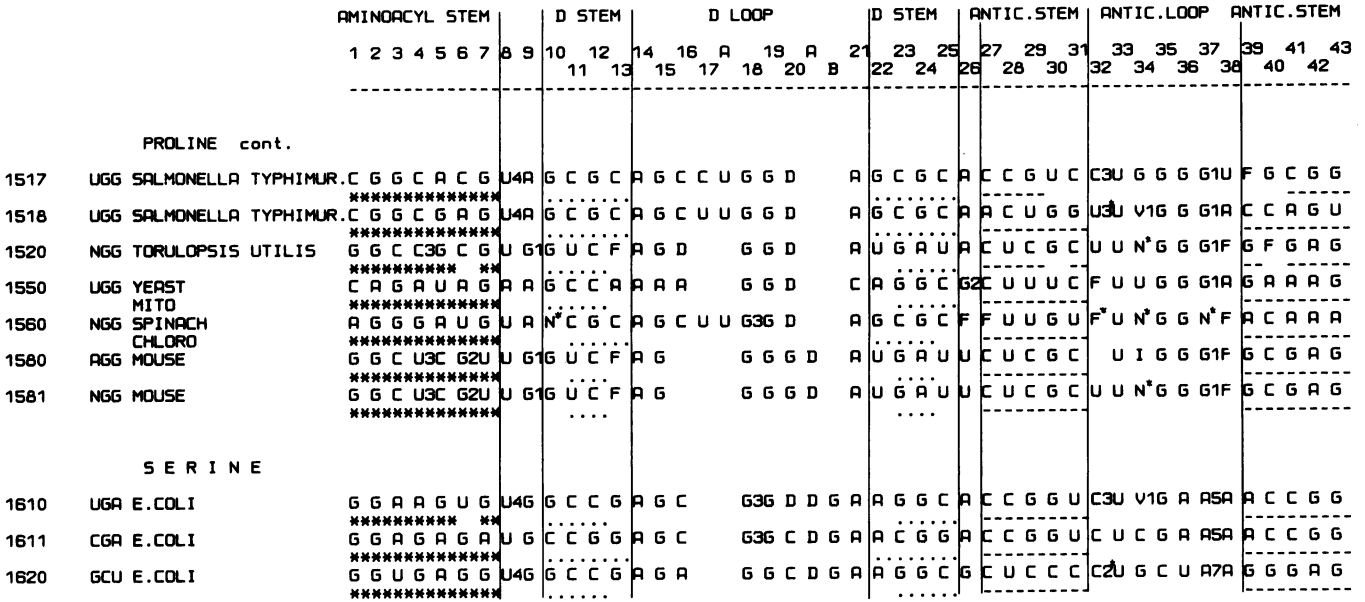
1471/10 IS PROBABLY M2G
1471/26 IS PROBABLY M2G
1471/47 N IS PROBABLY A DERIVATIVE OF URIDINE
1484/32 PARTIALLY MODIFIED
1484/47 PARTIALLY MODIFIED
1484/48 MODIFICATION EITHER IN POSITION 48 OR 49
1484/57 MINOR SPECIES HAS A57



1485 M.ALTWEGG,E.KUBLI(1979) NUCLEIC ACIDS RES. 7, 93-105
1486 A.MAZABRAUD(1982) BIOCHIMIE 64, 955-960
1490 B.A.ROE,M.P.J.S.ANANDARAJ,L.S.Y.CHIA,E.RANDERATH,R.C.GUPTA,K.RANDERATH (1975) BIOCHEM.BIOPHYS.RES.COMMUN. 66, 1097-1105
G.KEITH,G.DIRHEIMER(1978) BIOCHIM. BIOPHYS. ACTA 517, 133-149
1491 F.-K.LIN,T.D.FURR,S.H.CHANG,J.HORWITZ,P.F.AGRIS,B.J.ORTWERTH(1980) J.BIOL.CHEM. 255, 6020-6023
1492 F.K.LIN,T.D.FURR,S.H.CHANG,J.HORWITZ,P.F.AGRIS,B.J.ORTWERTH(1980) J.BIOL.CHEM. 255, 6020-6023
1493 Y.KUCHINO,E.BORECK,D.GRUNBERGER,J.F.MUSHINSKI,S.NISHIMURA(1982) NUCL.ACIDS RES. 10,6421-6432
1510 J.G.SEIDMAN,B.G.BARELL,W.H.MC CLAIN(1975)J. MOL. BIOL. 99, 733-760
1511 V.M.KRYUKOV,M.G.SCHLYAPNIKOV,S.I.KAZANTSEV,A.V.KALIMAN,V.N.KSENZENKO, A.A.BAYEV, EMBO-FEBS MEETING, STRASBOURG, JULY 1980
1515 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
1516 Y.KUCHINO,Y.YABUSAKI,F.MORI,S.NISHIMURA(1984) NUCLEIC ACIDS RES. IN PRESS



1485/32 PARTIALLY MODIFIED
1485/47 PARTIALLY MODIFIED
1490/0 RABBIT LIVER,CALF LIVER,BOVINE LIVER AND HUMAN PLACENTA
1490/47 PARTIALLY MODIFIED
1490/54 CONTENT OF T IS DIFFERENT FOR DIFFERENT SPECIES. PARTIALLY U
1510/8 PARTIALLY MODIFIED
1510/34 N IS A DERIVATIVE OF URIDINE
1515/34 PARTIALLY MODIFIED TO UNIDENTIFIED DERIVATIVE OF CYTIDINE
1515/38 PARTIALLY MODIFIED
1515/48 PARTIALLY MODIFIED
1515/55 PARTIALLY MODIFIED
1516/32 PARTIALLY MODIFIED



1517 Y.KUCHINO,Y.YABUSAKI,F.MORI,S.NISHIMURA(1984) NUCLEIC ACIDS RES. IN PRESS

1518 Y.KUCHINO,Y.YABUSAKI,F,MORI,S.NISHIMURA(1984) NUCLEIC ACIDS RES. IN PRESS

1520 K.OGAWA, M.KAWAKAMI, Y.SHIMIZU, S.TAKEMURA (1982) J. BIOCHEM. 91, 1241-1248

1550 G.DIRHEIMER (1983) PERSONAL COMMUNICATION

1560 M.FRANCIS, M.A.KASHDAN, H.SPROUSE, L.OTIS, B.DUDOCK (1981) NUCL. ACIDS RES. 10, 2755-2758

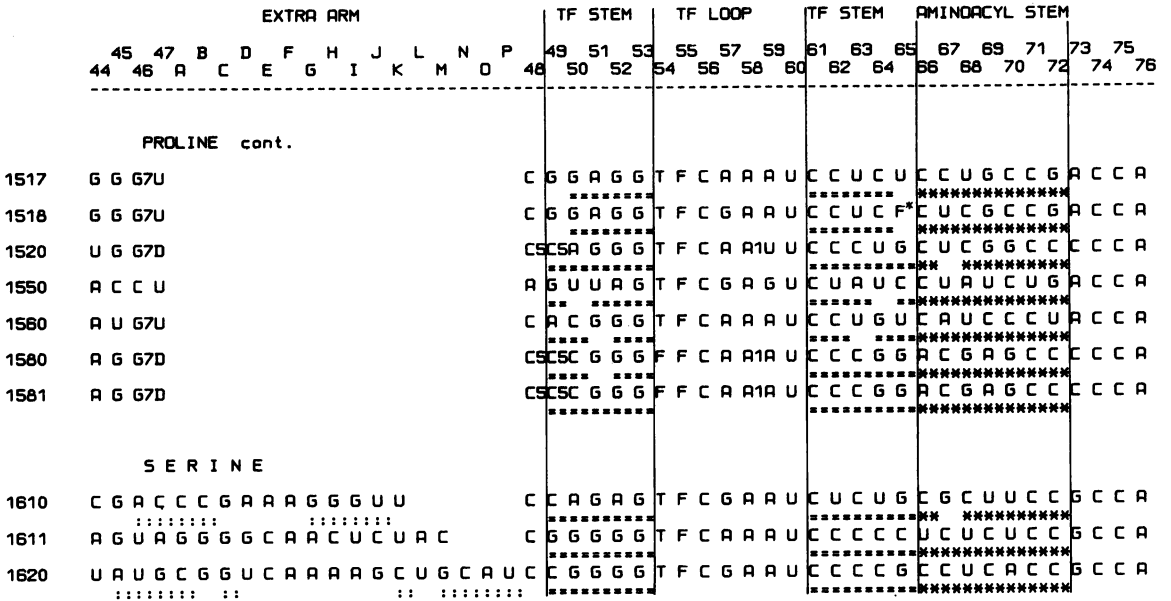
1580 N.SHINRIKI,K.ISHIZAKI,A.IKEHATA,K.MIURA,T.UEDA,N.KATO,F.HARADA(1981) NUCL.ACIDS RES. SYMP.SER. 10, 211-214

1581 N.SHINRIKI,K.ISHIZAKI,A.IKEHATA,K.MIURA,T.UEDA,N.KATO,F.HARADA(1981) NUCL.ACIDS RES. SYMP.SER. 10, 211-214

1610 H.ISHIKURA,Y.YAMADA,S.NISHIMURA(1971) FEBS LETTERS 16, 68-70
Y.YAMADA,H.ISHIKURA(1975) BIOCHIM.BIOPHYS.ACTA 402, 285-287

1611 D.A.STEEGE(1983) NUCL.ACIDS RES. 11,3823-3832

1620 Y.YAMADA,H.ISHIKURA(1973) FEBS LETTERS 29, 231-234
D.ISH-HOROWICZ,B.F.C.CLARK(1973) J.BIOL.CHEM. 248, 6663-6673



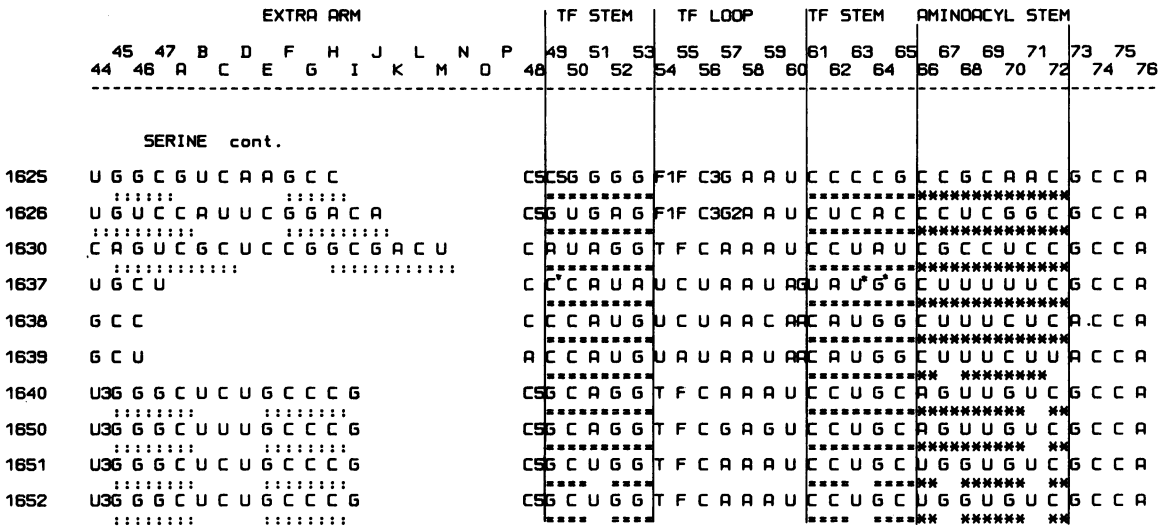
1518/32 PARTIALLY MODIFIED
1518/65 PARTIALLY MODIFIED

1520/34 N IS A DERIVATIVE OF URIDINE
1560/10 N IS A DERIVATIVE OF GUANOSINE

1560/32 PARTIALLY MODIFIED
1560/34 N IS A DERIVATIVE OF URIDINE
1560/37 N IS A DERIVATIVE OF ADENOSINE
1581/34 N IS MOST LIKELY A U DERIVATIVE
1620/32 IN THE POSITION 32 IS MOST PROBABLY 2-THIOCYTIDINE

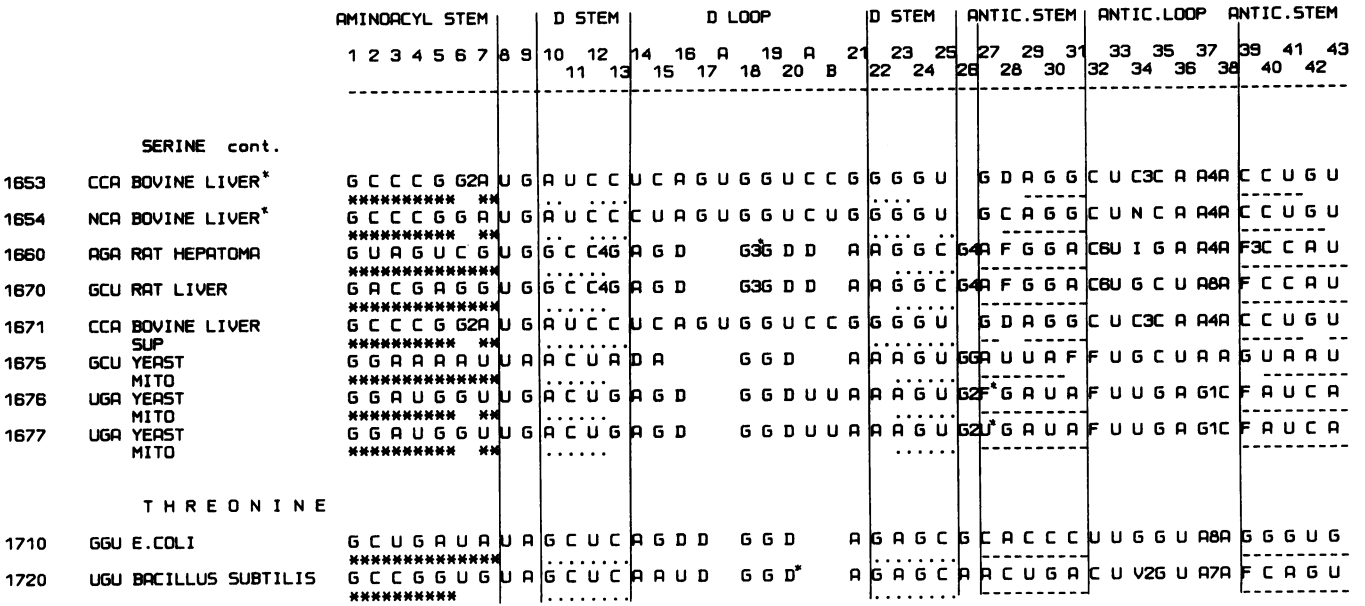
			AMINOACYL STEM								D STEM		D LOOP							D STEM			ANTIC.STEM			ANTIC.LOOP				ANTIC.STEM		
			1	2	3	4	5	6	7	8	9	10 11 12 13	14	15	16	17	A 18	19 20	A B	21	22	23 24	25	26	27	28	29 30	31	32	33	34	35 36 37 38	39	40	41 42	43
	SERINE cont.																																		
1625	GCU	HALOBACTERIUM VOL.	G	U	U	G	C	G	G	U	A	G C C A	A	N	C	C	U	G	G C C C A		A	G	G C	G4	C	U	G	G	G	U	U	G C U N A	C	U	C A G
1626	NGA	HALOBACTERIUM VOL.	G	C	C	G	A	G	G	U	A	G C C F	A	N	C	C	C	G	G C C A		A	G	G C	G4	G	U	A	G	A	U	U	N* G A A A	F	C	U A C
1630	NGA	PHAGE T4	G	G	A	G	G	C	G	U4G		G C A G	A	G	U		G3G	D	D U A		A	U	G C	A	C	C	G	G	U	C3U	N	G A	A5A	A	C	C G G
1637	GCU	BOVINE MITO*	G	A	A	A	A	A	G	U	A	U G C													A	A	G	A	A	C	U	G C U	A7A	U	U	C U A
1638	GCU	HUMAN MITO#	G	A	G	A	A	A	G	C	U	C A C													A	A	G	A	A	C	U	G C U	A7A	C	U	C A U
1639	GCU	HAMSTER MITO*	G	A	G	A	A	U	G	U	A			U	G									C	A	A	G	A	G	C	U	G C U	A7A	C	U	C C U
1640	AGA	YEAST	G	G	C	A	A	C	U	U	G	G C C4G	A	G	D		G3G	D	D	A	A	G	G C	G4	A	A	A	G	A	F	U	I G A	A4A	F	C	U U U
1650	AGA	YEAST	G	G	C	A	A	C	U	U	G	G C C4G	A	G	D		G3G	D	D	A	A	G	G C	G4	A	A	A	G	A	F	U	I G A	A4A	F	C	U U U
1651	NGA	YEAST	G	G	C	A	C	U	A	U	G	G C C4G	A	G	D		G3G	D	D	A	A	G	G C	G4	A	C	A	G	A	N*	U	N G A	A4A	F	C	U G U
1652	NGA	YEAST	G	G	C	A	C	U	A	U	G	G C C4G	A	G	D		G3G	D	D	A	A	G	G C	G4	A	C	A	G	A	N*	U	N* G A	A4A	F	C	U G U

1625 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
1626 R.GUPTA (1981), PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
1630 W.H.MC CLAIN,B.G.BARRELL,J.G.SEIDMAN(1975) J.MOL.BIOL. 99, 717-732
1637 P.ARCARI, G.G.BROWNLEE (1980) NUCLEIC ACIDS RES. 8, 5207-5212
M.H.L. DEBRUIJN, P.H.SCHREIER, I.C.EPERON, G.G.BARREL, E.Y.CHEN, P.W.ARMSTRONG, J.H.F.WONG, B.A.ROE (1980) NUCLEIC ACIDS RES. 8, 5213-5222
B.A.ROE, J.F.H.WONG, E.Y.CHEN,P.A.ARMSTRONG(1981) PROC.THIRD CLEAVELAND SYMP.A.G.WALTON(ED) ELSEVIER AMSTERDAM
1638 M.H.L. DEBRUIJN, P.H.SCHREIER, I.C.EPERON, B.G.BARREL, E.Y.CHEN, P.W.ARMSTRONG, J.H.F.WONG, B.A.ROE (1980) NUCLEIC ACIDS RES. 8, 5213-5222
1639 D.T.DUBIN (1982) PERSONAL COMMUNICATION
1640 H.G.ZACHAU,D.DUETTING,H.FELDMANN(1966) HOPPE-SELYER'S Z.PHYSIOL.CHEM. 347, 212-235
1650 H.G.ZACHAU,D.DUETTING,H.FELDMANN(1966) HOPPE-SELYER'S Z.PHYSIOL.CHEM. 347, 212-235
1651 P.W.PIPER(1978) J.MOL.BIOL. 122, 217-235
T.ETCHEVERRY,D.COLBY,C.GUTHRIE(1979),CELL 18, 11-26
M.V.OLSON, G.S.PAGE, A.SENTENAC, P.W.PIPER, M.WORTHINGTON, R.B.WEISS, B.D.HALL (1981) NATURE 291, 464-469
1652 P.W.PIPER(1978) J.MOL.BIOL. 122, 217-235
T.ETCHEVERRY, D.COLBY, C.GUTHRIE(1979), CELL 18, 11-26
M.V.OLSON, G.S.PAGE, A.SENTENAC, P.W.PIPER, M.WORTHINGTON, R.B.WEISS, B.D.HALL (1981) NATURE 291, 464-469



1626/34 PARTIALLY MODIFIED TO UNIDENTIFIED DERIVATIVE OF CYTIDINE
1637/0 COMPARE R.J.BAER, D.T.DUBIN (1980) NUCLEIC ACIDS RES. 8, 3603-3610
1637/63 DEBRUIJN ET AL. FOUND G-U INSTEAD OF U-G
1637/64 DEBRUIJN ET AL. FOUND G-U INSTEAD OF U-G
1637/49 WAS REPORTED TO BE M5C IN ROE ET AL.

1638/0 COMPARE R.J.BAER,D.T.DUBIN (1980) NUCLEIC ACIDS RES. 8, 3603-3610
1639/0 SEE ALSO R.J.BAER,D.T.DUBIN(1980) NUCL.ACIDS RES. 8, 3603-3610
1651/32 N IS PROBABLY 3-METHYLCYTOSINE
1652/32 N IS PROBABLY 3-METHYLCYTOSINE
1652/34 N IS A MODIFIED URIDINE



1653 D.HATFIELD, A.DIAMOND, B.DUDOCK (1982) PROC. NATL. ACAD. SCI. USA 79, 6215-6219

1654 D.HATFIELD, A.DIAMOND, B.DUDOCK (1982) PROC. NATL. ACAD. SCI. USA 79, 6215-6219

1660 T.GINSBERG,H.ROGG,M.STAEHELIN(1971) EUR.J.BIOCHEM. 21, 249-257
E.RANDERATH, A.S.GOPALAKRISHNAN, R.C.GUPTA, H.P.AGRAWAL, K.RANDERATH (1981) CANCER RES. 41, 2863-2867.

1670 H.ROGG,P.MUELLER,M.STAEHELIN(1975) EUR.J.BIOCHEM. 53, 115-127

1671 A.DIAMOND, B.DUDOCK, D.HATFIELD (1981) CELL 25, 497-506

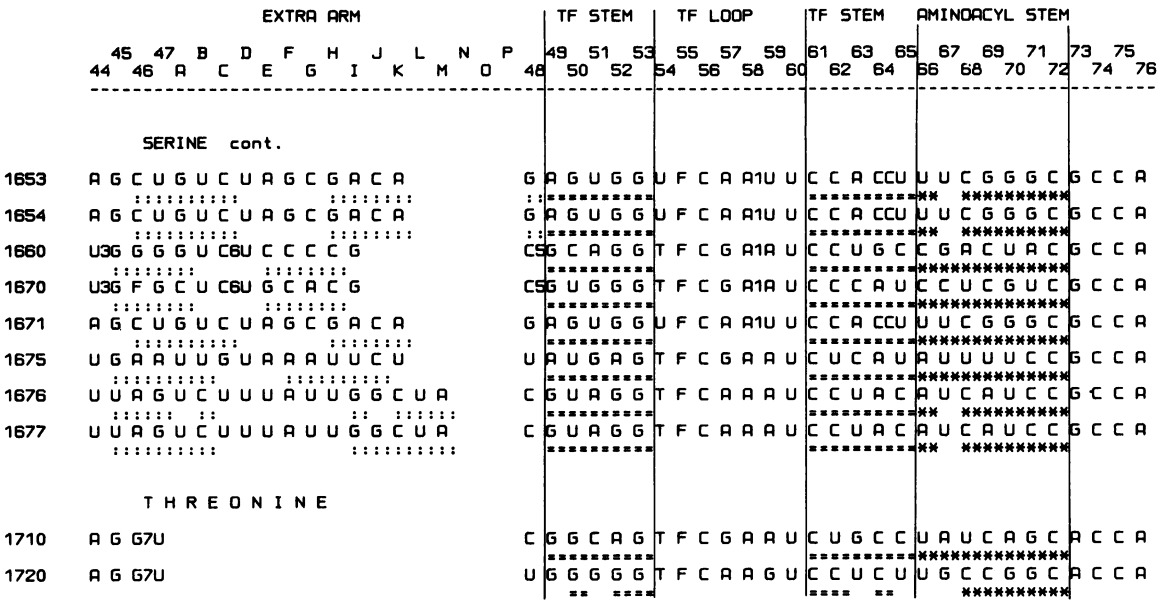
1675 R.MARTIN, A.-P.SIBLER, G.DIRHEIMER (1982) BIOCHIMIE 64, 1073-1079

1676 R.MARTIN, A.-P.SIBLER, G.DIRHEIMER (1982) BIOCHIMIE 64, 1073-1079

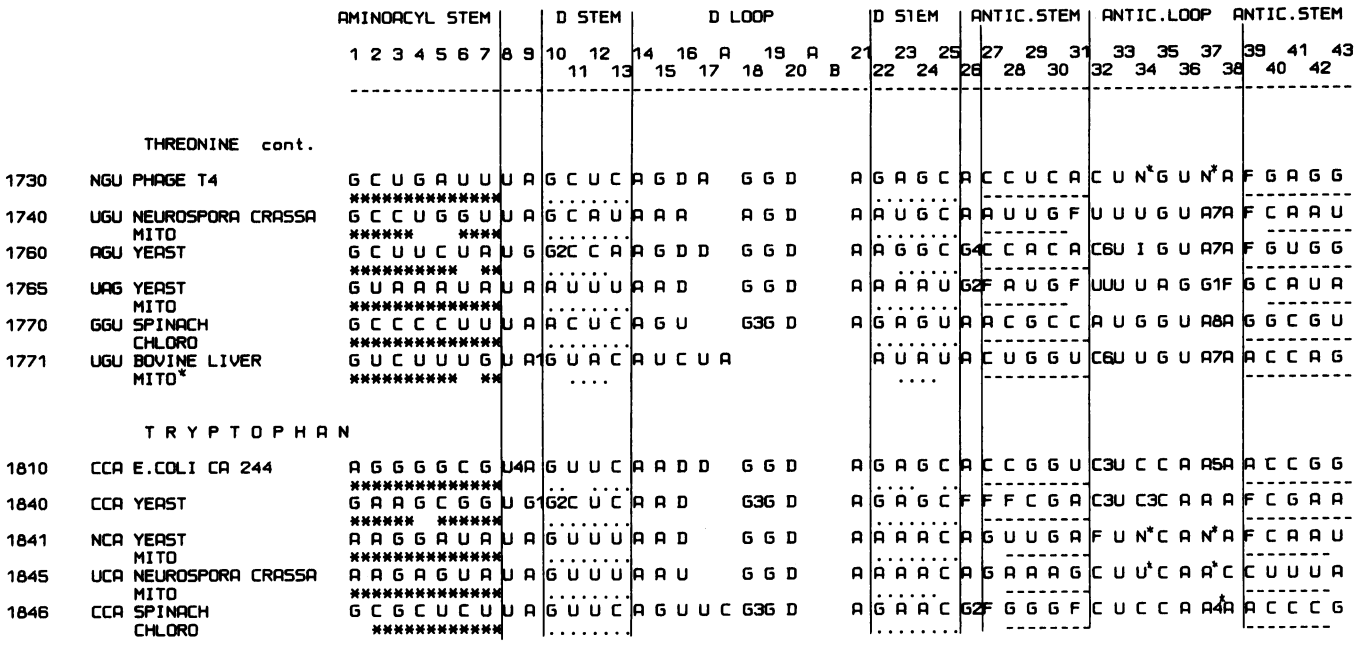
1677 R.MARTIN, A.-P.SIBLER, G.DIRHEIMER (1982) BIOCHIMIE 64, 1073-1079

1710 L.CLARKE,J.CARBON(1974) J.BIOL.CHEM. 249, 6874-6885

1720 T.HASEGAWA,H.ISHIKURA(1978) NUCLEIC ACIDS RES. 5, 537-548



1653/0 CAN BE PHOSPHORYLATED TO PHOSPHOSERYL-TRNA; UGA SUPPRESSOR
1654/0 CAN BE PHOSPHORYLATED TO PHOSPHOSERYL TRNA; UGA-SUPPRESSOR
1660/18 HEPATOMA LACKS MODIFICATION
1676/27 PARTIALLY MODIFIED
1677/27 PARTIALLY MODIFIED
1720/20 PARTIALLY MODIFIED



1730 C.GUTHRIE,C.A.SCHOLLA,H.YESIAN,J.ABELSON(1978) NUCLEIC ACIDS RES. 5, 1833-1844

1740 J.E.HECKMAN,J.SARNOFF,B.ALZNER-DE WEERD,S.YIN,U.L.RAJBHANDARY(1980) PROC. NATL. ACAD. SCI. USA 77, 3159-3163

1760 J.WEISSENBACH,I.KIRALY,G.DIRHEIMER(1977) BIOCHIMIE 59, 381-391

1765 A.P.SIBLER, G.DIRHEIMER, R.P.MARTIN (1981) FEBS LETTERS 132, 344-348

1770 M.A.KASHDAN, R.M.PIRTLE, I.L.PIRTLE,J.L.CALAGAN, H.J.VREMAN, B.S.DUDOCK (1980) J. BIOL. CHEM. 255, 8831-8835

1771 B.A.ROE, J.F.H.WONG, E.Y.CHEN (1982) PERSONAL COMMUNICATION

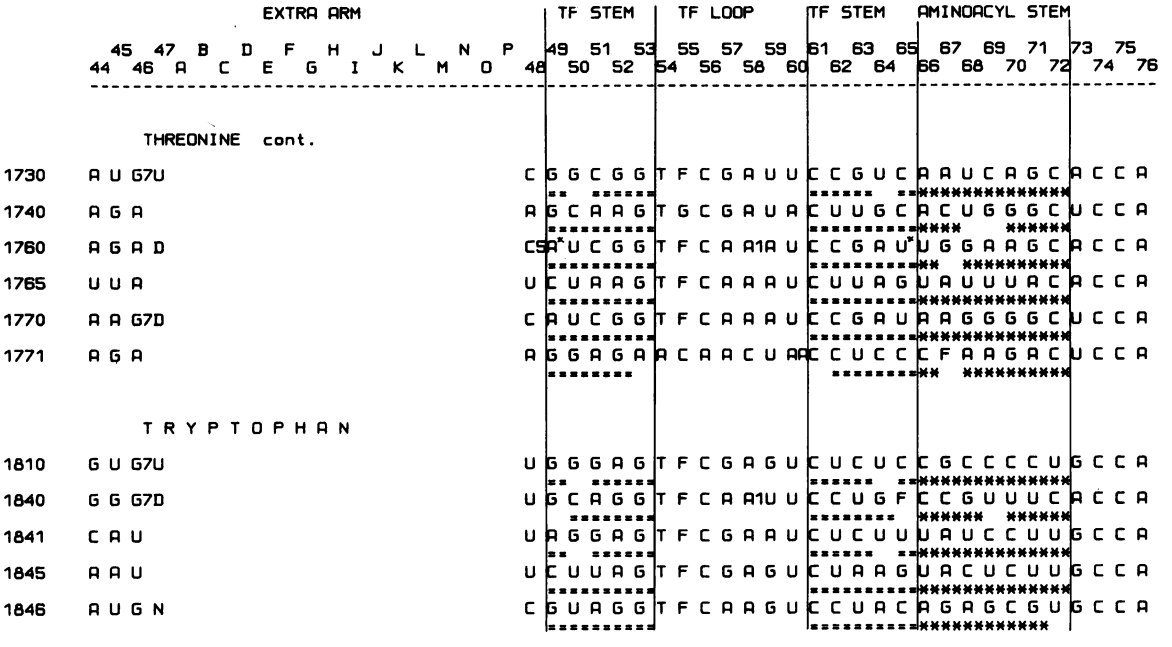
1810 D.HIRSH(1971) J.MOL.BIOL. 58, 439-458

1840 G.KEITH,A.ROY,J.P.EBEL,G.DIRHEIMER(1972) BIOCHIMIE 54, 1405-1426

1841 A.P.SIBLER,R.BORDONNE,G.DIRHEIMER,R.MARTIN(1980) COMP.REND.ACAD.SCI. D. 290, 695-698

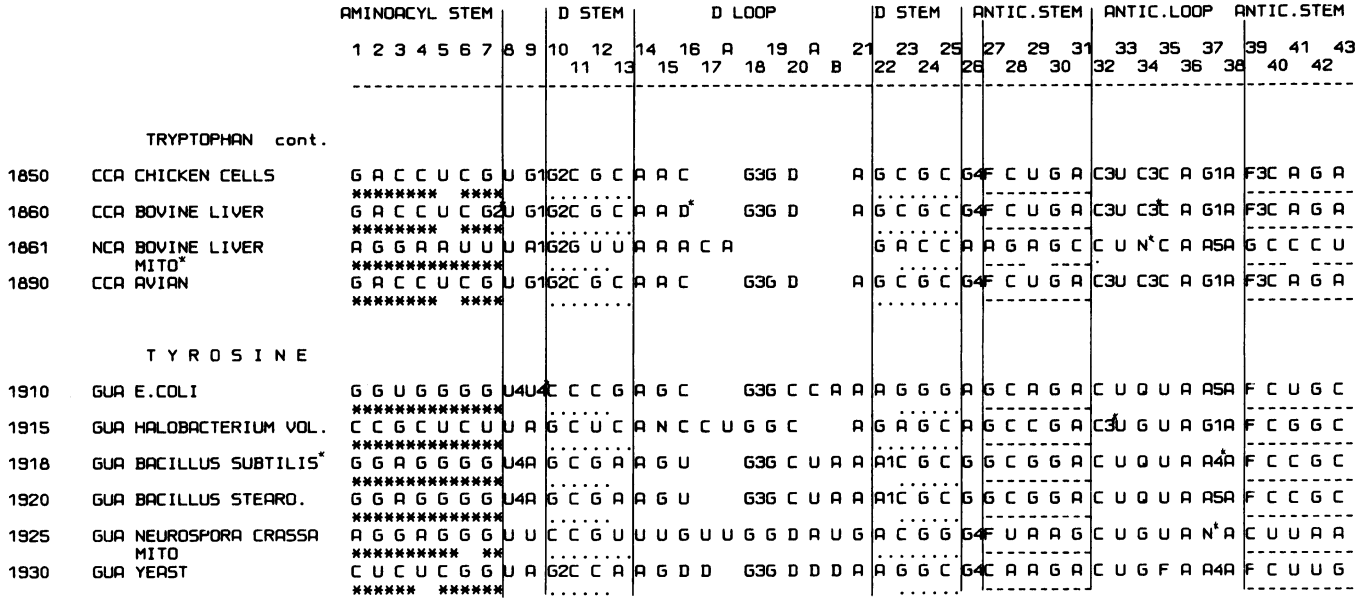
1845 J.E.HECKMAN,J.SARNOFF,B.ALZNER-DE WEERD,S.YIN,U.L.RAJBHANDARY(1980) PROC. NATL. ACAD. SCI. USA 77, 3159-3163

1846 J.CANADAY, P.GUILLEMAUT, R.GLOECKLER, J.-H.WEIL (1981) NUCLEIC ACIDS RES 9, 47-53

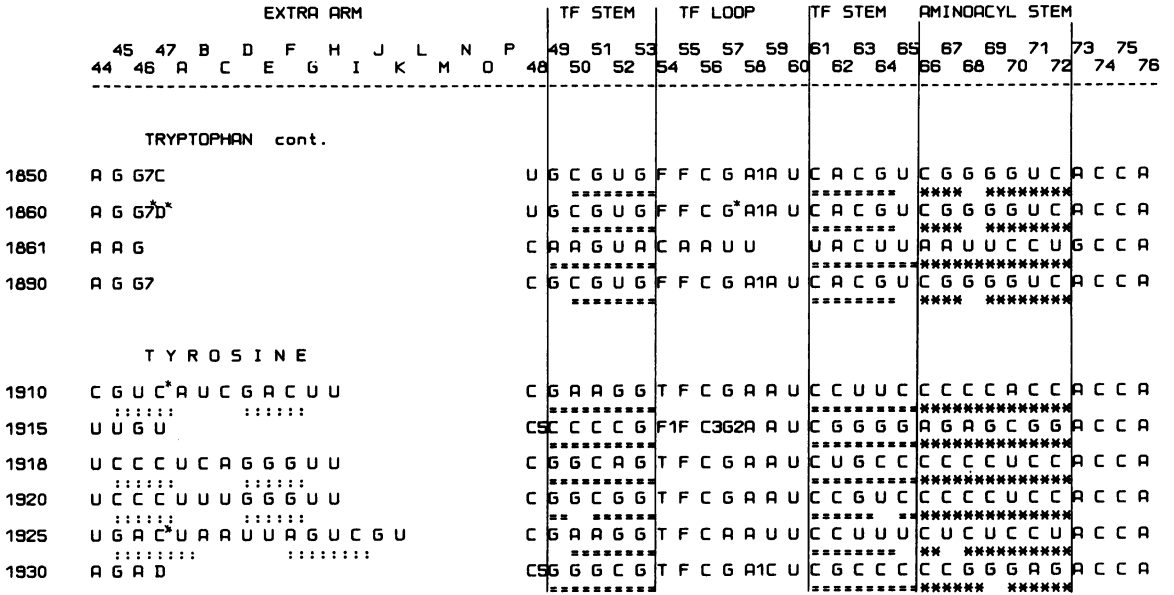


1730/34 N IS A DERIVATIVE OF URIDINE
1730/37 N IS A DERIVATIVE OF ADENOSINE
1760/49 IN OTHER ISOACCEPTOR G
1760/65 IN OTHER ISOACCEPTOR C
1771/0 ALIGNMENT IS ARBITRARY

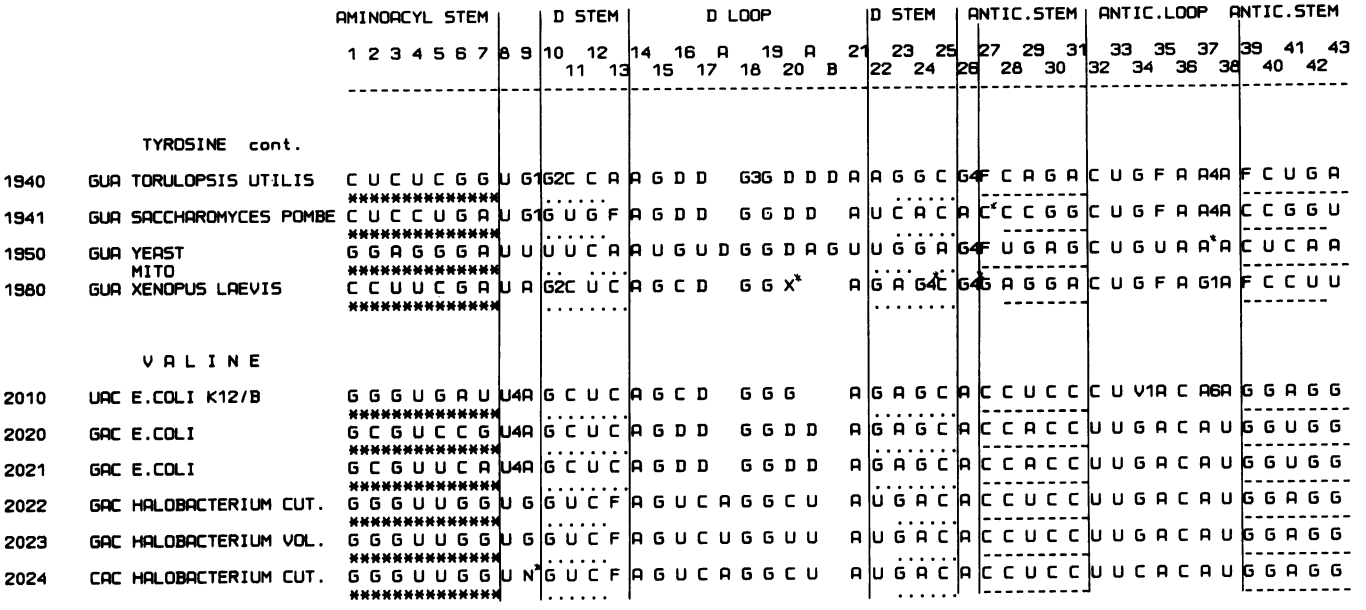
1841/34 MODIFIED URIDINE
1841/37 I6A OR MS2I6A
1845/34 MODIFIED DERIVATIVE OF URIDINE
1845/37 MODIFIED DERIVATIVE OF ADENOSINE
1846/37 I6A OR MS2I6A



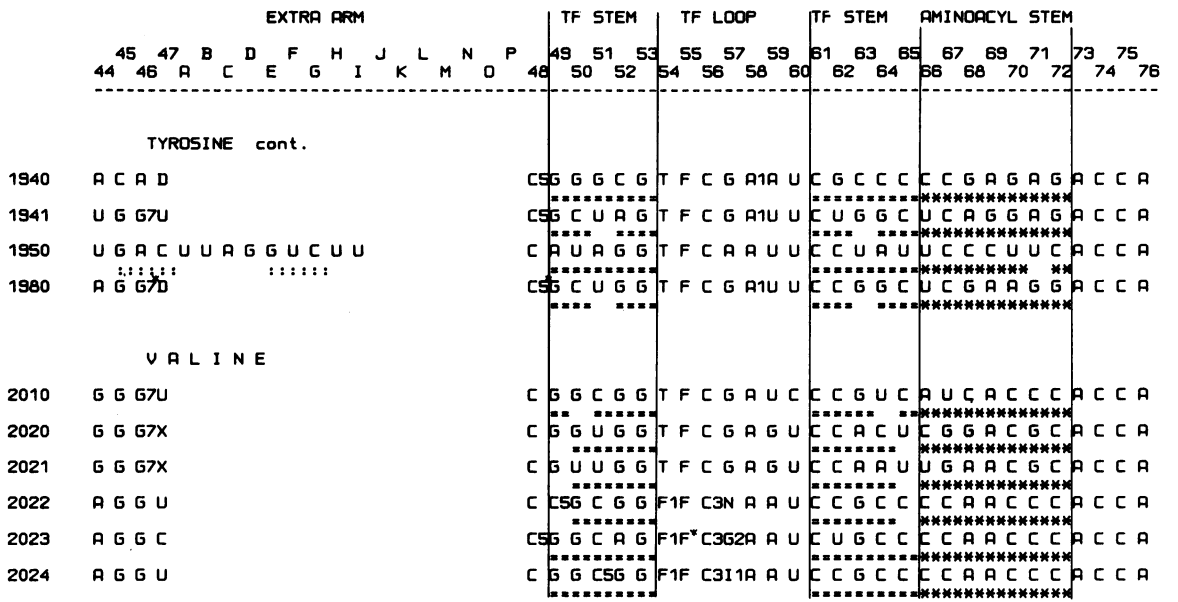
1850 F.HARADA,R.C.SAWYER,J.E.DAHLBERG(1975) J.BIOL.CHEM. 250, 3487-3497
1860 M.FOURNIER,J.LABOUESSE,G.DIRHEIMER,C.FIX,G.KEITH (1978) BIOCHIM. BIOPHYS. ACTA 521, 198-208
1861 B.A.ROE, J.F.H.WONG, E.Y.CHEN,P.A.ARMSTRONG(1981) PROC.THIRD CLEAVELAND SYMP. A.G.WALTON(ED) ELSEVIER AMSTERDAM
1890 J.C.HU,J.E.DAHLBERG(1983) NUCL.ACIDS RES. 11,4823-4833
1910 H.M.GOODMAN,J.ABELSON,A.LANDY,S.BRENNER,J.D.SMITH(1968), NATURE 217, 1019-1024
1915 R.GUPTA (1981), PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
1918 B.MENICHI,H.H.ARNOLD,T.HEYMAN,G.DIRHEIMER,G.KEITH(1980) BIOCHEM. BIOPHYS. RES. COMMUN. 95, 461-467
1920 R.S.BROWN,J.R.RUBIN,D.RHODES,H.GUILLEY,A.SIMONCSITS,G.G.BROWNLEE (1978) NUCLEIC ACIDS RES. 5, 23-36
1925 J.E.HECKMAN,B.ALZNER-DE WEERD,U.L.RAJBHANDARY(1979) PROC.NATL.ACAD. SCI.USA 76, 717-721
1930 J.T.MADISON,H.-K.KUNG(1967) J.BIOL.CHEM. 242, 1324-1330



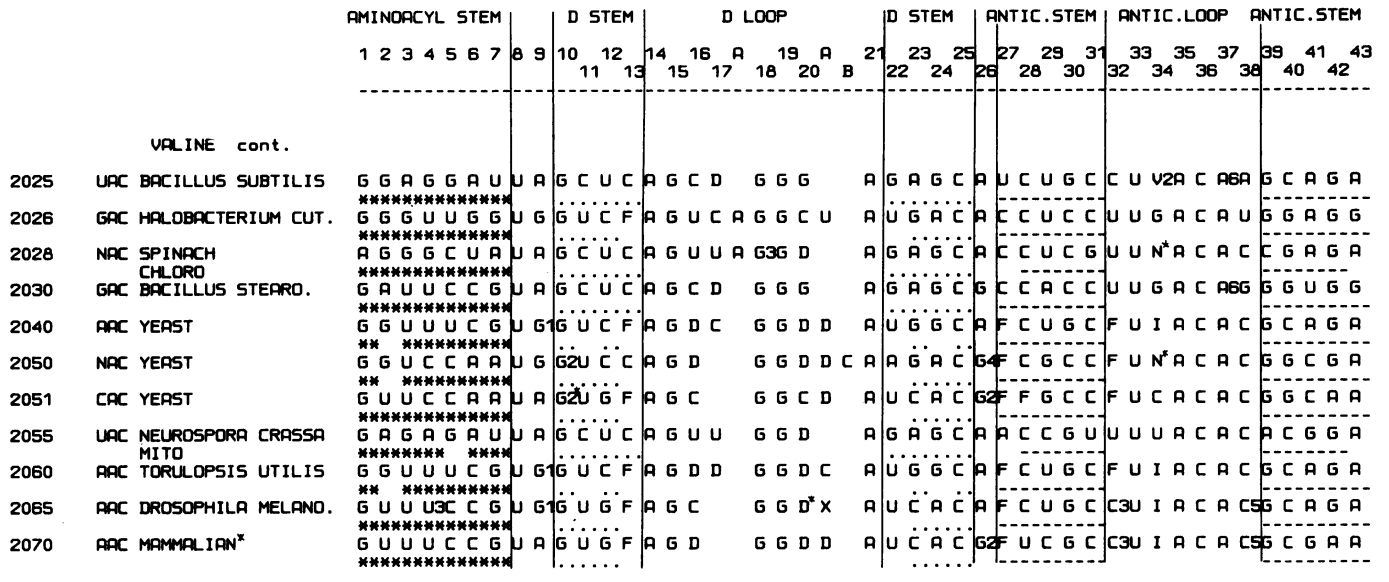
1850/0 THE SEQUENCE WAS DETERMINED ON PRIMER RNA FOR INITIATION OF IN VITRO ROUS-SARCOMA VIRUS DNA SYNTHESIS. TRNA-TRP FROM CHICKEN CELLS HAS AN IDENTICAL COMPOSITION. L.C.WATERS,W.-K.YANG (1975) J.BIOL.CHEM. 250, 6627-6629; COMPARE ALSO B.CORDELL ET AL. (1980) J. BIOL. CHEM. 255, 9358-9368
1860/7 PARTIALLY MODIFIED
1860/16 PARTIALLY C
1860/34 PARTIALLY MODIFIED
1860/46 PARTIALLY MODOFIED
1860/47 PARTIALLY C
1860/57 PARTIALLY A
1861/0 ALIGNMENT IS ARBITRARY
1861/34 N IS A MODIFIED URIDINE
1910/9 U IS PROBABLY MODIFIED TO S4U
1910/47 B PARTIALLY C
1910/47 C PARTIALLY A
1915/32 PARTIALLY MODIFIED
1918/0 SEE FOOTNOTE 37
1918/37 IN THE SPECIES 2 MS2I6A AT THIS POSITION
1925/37 N IS PROBABLY ISOPENTENYL ADENOSINE
1925/47 I OR 48: ONE OF CYTIDINES IS MODIFIED TO M5C



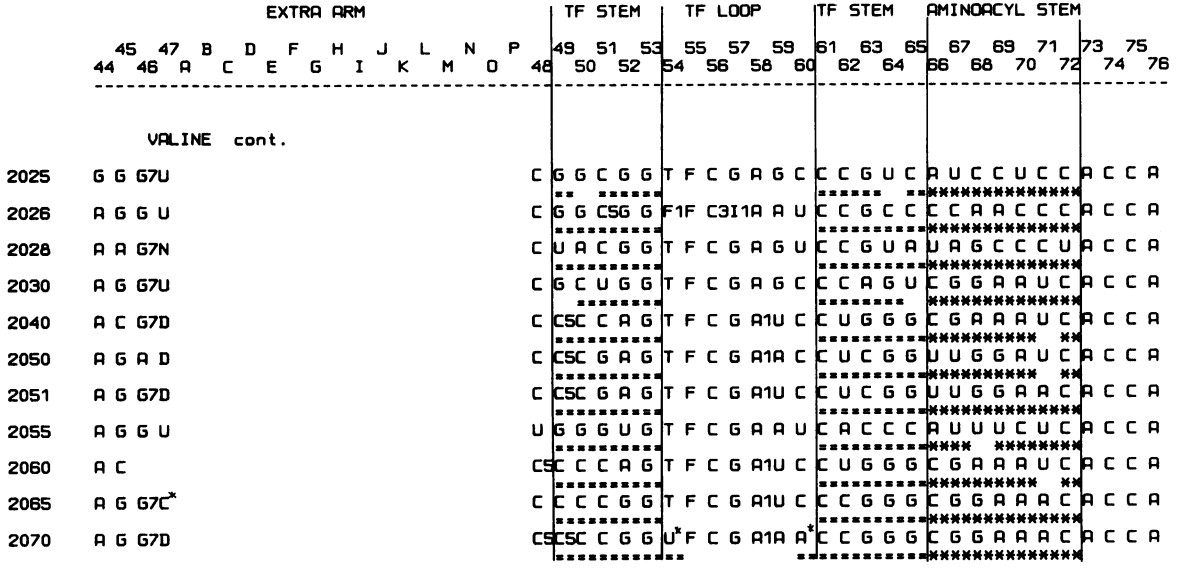
1940 S.HASHIMOTO,S.TAKEMURA,M.MIYAZAKI(1972) J.BIOCHEM. 72, 123-134
1941 G.VOEGELI(1979), NUCLEIC ACIDS RES. 7, 1059-1065
1950 A.P.SILBER,G.DIRHEIMER,R.P.MARTIN(1983) FEBS LETTERS 152, 153-156
1980 W.FILIPOWICZ,A.J.SHATKIN(1983) CELL 32, 547-557
F.A.LASKI,A.Z.FIRE,U.L.RAJBHANDARY,P.A.SHARP(1983) J.BIOL.CHEM. 258 11974-11980
F.MUELLER,S.G.CLARKSON(1980) CELL 19, 345-348
2010 M.YANIV,B.G.BARRELL(1969) NATURE 222, 278-279
F.KIMURA,F.HARADA,S.NISHIMURA(1971) BIOCHEMISTRY 10, 3277-3283
2020 M.YANIV,B.G.BARELL(1971) NATURE NEW BIOL. 233, 113-114
2021 M.YANIV,B.G.BARREL(1971) NATURE NEW BIOL. 233, 113-114
2022 X.-R.GU, K.NICOGHOSIAN, R.J.CEDERGREN, J.TZE-FEI WONG (1983) NUCL. ACIDS RES. 11, 5433-5442
2023 R.GUPTA (1981) PH.D. THESIS, UNIVERSITY OF ILLINOIS, URBANA
2024 X.-R.GU, K.NICOGHOSIAN, R.J.CEDERGREN, J.TZE-FEI WONG (1983) NUCL. ACIDS RES. 11, 5433-5442



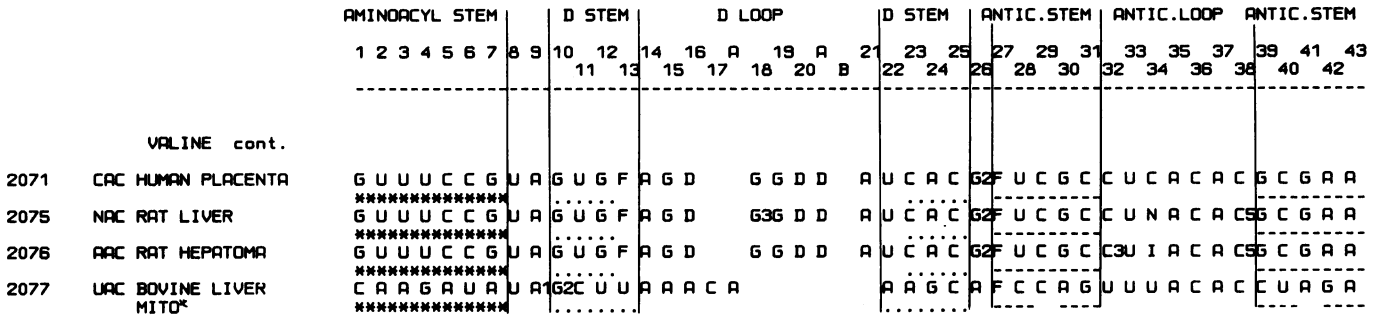
1941/27 F IN 20% OF THE TRNA
1950/37 ADENOSINE IS MODIFIED TO I6A OR MS2I6A
1980/20 PARTIALLY MODIFIED
1980/24 PARTIALLY MODIFIED
1980/26 PARTIALLY MODIFIED
1980/46 PARTIALLY MODIFIED
1980/48 PARTIALLY MODIFIED
2023/55 PARTIALLY MODIFIED
2024/9 probably M1G



2025 K.MURAO, T.HASEGAWA, H.ISHIKURA (1982) NUCL. ACIDS RES. 10, 715-718
2026 X.-R.GU,K.NICOGHOSIAN,R.J.CEDERGREN,J.TZE-FEI WONG (1983) NUCL.ACIDS RES. 11, 5433-5442
2028 H.M.SPROUSE, M.KASHDAN, L.OTIS, B.DUDOCK (1981) NUCLEIC ACIDS RES. 9, 2543-2547
2030 C.TAKADA-GUERRIER,H.GROSJEAN,G.DIRHEIMER,G.KEITH (1976) FEBS LETTERS 62, 1-3
2040 J.BONNET,J.P.EBEL,G.DIRHEIMER,L.P.SHERSHNEVA,A.I.KRUTILINA, T.V.VENKSTERN,A.A.BAYEV(1974) BIOCHIMIE 56, 1211-1213
2050 V.D.AXEL'ROD,V.M.KRYUKOV,S.N.ISAENKO,A.A.BAYEV(1974) FEBS LETTERS 45, 333-336
2051 V.G.GORBULEV,V.D.AXEL'ROD,A.A.BAYEV(1977) NUCLEIC ACIDS RES. 4, 3239-3258
2055 J.E.HECKMAN,J.SARNOFF,B.ALZNER-DE WEERD,S.YIN,U.L.RAJBHANDARY(1980) PROC. NATL. ACAD. SCI. USA 77, 3159-3163
2060 T.MIZUTANI,M.MIYAZAKI,S.TAKEMURA(1968) J.BIOCHEM. 64, 839-848
2065 W.R.ADDISON, I.C.GILLAM, G.M.TENER (1982) J. BIOL. CHEM. 257, 674-677
2070 P.W.PIPER(1975) EUR.J.BIOCHEM. 51, 295-304
P.JANK,N.SHINDA-OKADA,S.NISHIMURA,H.J.GROSS(1977) NUCLEIC ACIDS RES. 4, 1999-2008



2028/34 N IS A DERIVATIVE OF URIDINE
2050/34 N IS A DERIVATIVE OF URIDINE
2051/10 PARTIALLY MODIFIED
2065/20 A PARTIALLY MODIFIED
2065/47 ONE OF THE CYTIDINE RESIDUES BETWEEN POSITIONS 47 AND 51 IS PROBABLY MODIFIED TO 5-METHYLCYTIDINE
2070/0 MOUSE MYELOMA,RABBIT LIVER AND HUMAN PLACENTA 1A, IN THE LATTER CASE C-32 AND C-38 ARE UNMODIFIED
2070/54 THE U-54 - A-60 BASE PAIR WAS DETECTED BY P.JANK,D.RIESNER,
2070/60 H.J.GROSS (1977) NUCLEIC ACIDS RES. 4, 2009-2020

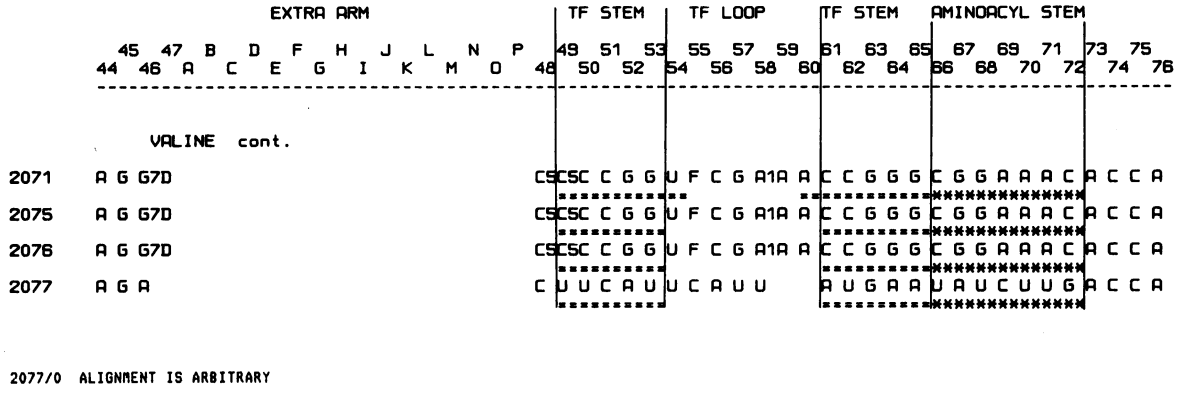


2071 E.Y.CHEN,B.A.ROE(1977) BIOCHEM.BIOPHYS.RES.COMMUN. 78, 631-640

2075 N.SHINDO-OKADA, Y.KUCHINO, F.HARADA, N.OKADA, S.NISHIMURA (1981) J.BIOCHEM. 90, 535-544

2076 N.SHINDO-OKADA, Y.KUCHINO, F.HARADA, N.OKADA, S.NISHIMURA (1981) J.BIOCHEM. 90, 535-544

2077 B.A.ROE, J.F.H.WONG, E.Y.CHEN,P.A.ARMSTRONG(1981) PROC.THIRD CLEAVELAND SYMP. A.G.WALTON(ED) ELSEVIER AMSTERDAM



2077/0 ALIGNMENT IS ARBITRARY