
Compilation of tRNA sequences

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INTRODUCTION

This compilation presents in a small space the tRNA sequences so far published in order to enable rapid orientation and comparison. The numbering of tRNA^{Phe} from yeast is used as has been done earlier (1) but following the rules proposed by the participants of the Cold Spring Harbor Meeting on tRNA 1978 (2) (Fig. 1). This numbering allows comparisons with the three dimensional structure of tRNA^{Phe}, the only structure known from X-ray analysis. The secondary structure of tRNAs is indicated by specific underlining. In the primary structure a nucleoside followed by a nucleoside in brackets or a modification in brackets denotes that both types of nucleosides can occupy this position. Part of a sequence in brackets designates a piece of sequence not unambiguously analyzed. Rare nucleosides are named according to the IUPAC-IUB rules (for some more complicated rare nucleosides and their identification see Table 1); those with lengthy names are given with the prefix x and specified in the footnotes. Footnotes are numbered according to the coordinates of the corresponding nucleoside and are indicated in the sequence by an asterisk. The references are restricted to the citation of the latest publication in those cases where several papers deal with one sequence. For additional information the reader is referred either to the original literature or to other tRNA sequence compilations (3-7). Mutant tRNAs are dealt with in a separate compilation prepared by J. Celis (see below). The compilers would welcome any information by the readers regarding missing material or erroneous presentation. On the basis of this numbering system computer printed compilations of tRNA sequences in a linear form and in cloverleaf form are in preparation.

1. M. Sprinzl, F. Grüter, D.H. Gauss (1978) Nucleic Acids Research 5, r15-r27.
2. These rules are given with the compilation of tRNA sequences by D.H. Gauss, F. Grüter, M. Sprinzl in J. Abelson, P.R. Schimmel, D. Söll (Ed.) (1979) Cold Spring Harbor Symposia on Quantitative Biology, in press.
3. M.A. Soddy in G.D. Fasman (Ed.), CRC Handbook of Biochemistry and Molecular Biology, 3rd Edition, Nucleic Acids Vol. II, p. 423-456, The Chemical Rubber Company, Cleveland, 1976.
4. G. Dirheimer, J.P. Ebel, J. Bonnet, J. Gangloff, G. Keith, B. Krebs, B. Kuntzel, A. Roy, J. Weissenbach, C. Werner (1972) Biochimie 54, 127-144.
5. N.A. Soddy, B.P. Doctor (1974) Methods Enzymol. 29, 741-756.

Nucleic Acids Research

6. B.G. Barrell, B.F.C. Clark, *Handbook of Nucleic Acid Sequences*, Joynson-Bruvvers Ltd. Oxford, 1974.
7. J. Barciszewski, A.J. Rafalski, *Atlas of Transfer Ribonucleic Acids and Modified Nucleosides*, Poznan, 1978, in press.

Table 1: Names of Some Rare Nucleosides and Citations Regarding their Identification

compare:	M.Y. Feldman (1978) <i>Progr.Biophys.Mol.Biol.</i> <u>32</u> , 83-102; J.P. Goddard (1978) <i>Progr.Biophys.Mol.Biol.</i> <u>32</u> , 233-308; J.A. McCloskey, S. Nishimura (1977) <i>Accounts Chem.Res.</i> <u>10</u> , 403-410.
o^5U	is uridine-5-oxyacetic acid.
mo^5U	is 5-methoxyuridine.
mcm^5U	is 5-methoxycarbonylmethyluridine, B. Kuntzel, J. Weissenbach, R.E. Wolff, T.D. Tumaitis-Kennedy, B.G. Lane, G. Dirheimer (1975) <i>Biochimie</i> <u>57</u> , 61-70.
$\text{mcm}^5\text{s}^2\text{U}$	is 5-methoxycarbonylmethyl-2-thiouridine.
$\text{mam}^5\text{s}^2\text{U}$	is 5-N-methylaminomethyl-2-thiouridine.
i^6A	is N-6-(Δ^2 -isopentenyl)adenosine.
$\text{ms}^2\text{i}^6\text{A}$	is N-6-(Δ^2 -isopentenyl)2-methylthioadenosine, F. Harada, H.J. Gross, F. Kimura, S.H. Chang, S. Nishimura, U.L. RajBhandary (1968) <i>Biochem.Biophys.Res.Commun</i> <u>33</u> , 299-306; Y. Yamada, S. Nishimura, H. Ishikura (1971) <i>Biochim.Biophys.Acta</i> <u>247</u> , 170-174.
t^6A	is N-[9-(β -D-ribofuranosyl)purin-6-ylcarbamoyl]threonine.
mt^6A	is N-[9-(β -D-ribofuranosyl)purin-6-yl-N-methylcarbamoyl]threonine.
Q_{34}	is 7-(4,5-cisdihydroxy-1-cyclopenten-3-ylaminomethyl)-7-deazaguanosine, H. Casai, Z. Ohashi, F. Harada, S. Nishimura, N.J. Oppenheimer, P.F. Crain, J.G. Liehr, D.L. von Minden, J.A. McCloskey (1975) <i>Biochem.</i> <u>14</u> , 4198-4208.
X	is 3-N-(3-amino-3-carboxypropyl)uridine, S. Nishimura, Y. Taya, Y. Kuchino, Z. Ohashi (1974) <i>Biochem.Biophys.Res.Commun.</i> <u>57</u> , 702-708; Z. Ohashi, M. Maeda, J.A. McCloskey, S. Nishimura (1974) <i>Biochem.</i> <u>13</u> , 2620-2625; S. Friedman, H.J. Li, K. Nakanishi, G. van Lear (1974) <i>Biochem.</i> <u>13</u> , 2932-2937.
yW	is wybutoxine, K. Nakanishi, N. Furutachi, M. Funamizu, D. Grunberger, I.B. Weinstein (1970) <i>J.Amer.Chem.Soc.</i> <u>92</u> , 7617-7619.
O_2yW	is wybutoxosine, S.H. Blobstein, D. Grunberger, I.B. Weinstein, K. Nakanishi (1973) <i>Biochem.</i> <u>12</u> , 188-193; A.M. Feinberg, K. Nakanishi, J. Barciszewski, A.J. Rafalski, H. Augustyniak, M. Wiewiórowski (1974) <i>J.Amer.Chem.Soc.</i> <u>96</u> , 7797-7800.
N	is an unknown nucleoside.

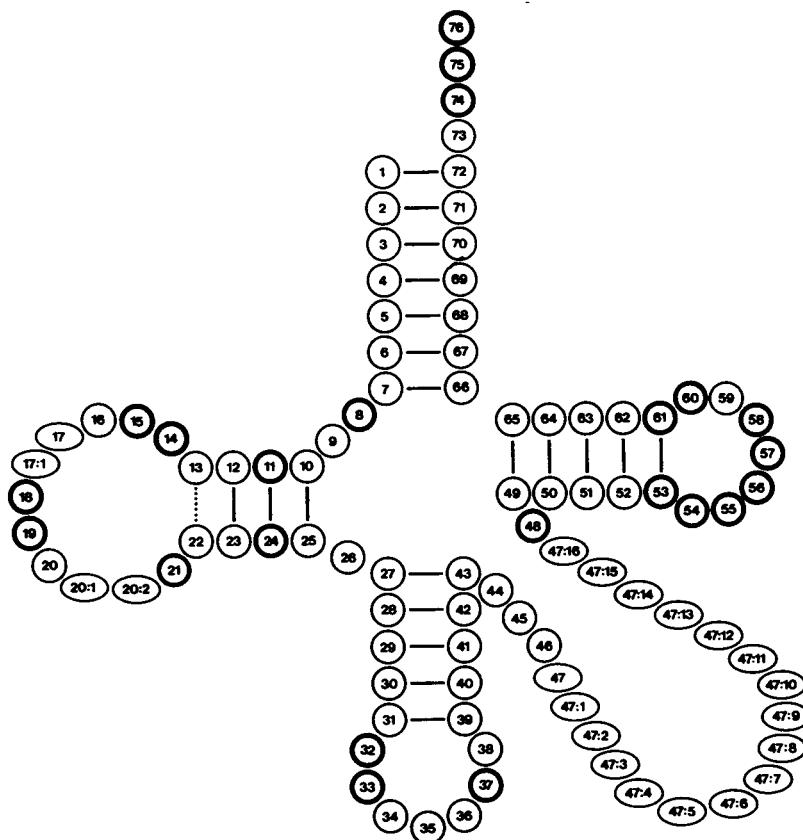


Figure 1: Numbering system of nucleotides in tRNAs according to the numbering of phenylalanine tRNA from yeast. Circles represent nucleotides which are always present; among these, the thick-edged circles denote invariant or semi-invariant nucleotides. Ovals represent nucleotides which are not present 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 further number. Thus, e.g. 20:1 and 20:2 mean the first and 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-G18. The numbering for the D loop, when one, two or three nucleotides are present each between 15 and 18 or between 19 and 21, is then 16 and 16, 17 and 16, 17, 17:1 or 20 and 20, 20:1 and 20, 20:1, 20:2, respectively. When the variable loop is five-membered the numbering is as in yeast phenylalanine tRNA 44, 45, 46, 47, 48. 47 is eliminated as the three dimensional structure of yeast phenylalanine tRNA suggests 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, 47:1, 47:2, 47:3, 47:4, 47:5, 47:6, 47:7, 47:8, 48.

0030/0 Comptare R.W.Holley et al. (1965) Science 147: 1462-1465.

גָּדוֹלָה וְעַמְּדָה (בְּשִׁירָה) בְּרֵבָבָן

0120/34 N is a not identified derivative of uridine.

0121/34 N is a not identified derivative of uridine.

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0140/34 Xu is identified as McM U.

10141/34 xU is identified as mom U.
10260/0 Isolated from rat liver human liver and human placenta

- 03410 G.P.Mazzara, W.H.McClain (1977) *J. Mol. Biol.* **117**:1061-1079.
 03410 N.J.Holmes, G.Attfield (1976) *Biochem.J.* **153**:447-454.
 03410 M.Yaniv, W.R.Folk (1975) *J. Biol.Chem.* **250**, 3423-3553.
 03530 M.H.Comer, W.H.McClain (1974) *J. Mol.Biol.* **90**, 677-689.
 03532 M.M.Comer, K.Foss, W.H.McClain (1975) *J. Mol.Biol.* **99**, 283-293.
 05410 C.Gushrie (1975) *J. Mol.Biol.* **95**, 529-548.
 0610 J.W.Haiberg (1975) *Nucleic Acids Res.* **2**, 469-476.
 0620 Z.Ohashi, F.Nakada, S.Nishizuka (1972) *FEBS-Lett.* **20**, 239-241;
 K.O.Munning, S.H.Chang (1972) *Biochem.Biophys.Res.Commun.*
 0630 T.Kobayashi, T.Irie, M.Yoshida, K.Takeishi, T.Ukita (1974) *Biochim.Biophys.Acta* **368**:181.

		Extra	Arm	Tψ Stem	Tψ Loop	Tψ Stem	Tψ Stem	Aminoacyl Stem
44	45	46	47	47	47	47	47	75
1	2	3	4	5	6	7	8	76
CYSTEINE								
0410	C	U	A	G	G	G	G	65
0440	U	G	mG	D	U	U	U	66
GLUTAMINE								
0510	C	A	U	U	T	C	C	67
0520	C	A	U	U	T	C	C	68
0530	G	A	U	G	T	C	C	69
0531	G	A	U	G	T	C	C	70
0532	G	A	U	G	T	C	C	71
0540	G	A	U	G	T	C	C	72
GLUTAMIC ACID								
0610	U	A	A	T	C	G	A	73
0620	U	A	A	T	C	G	A	74
0630	A	G	A	T	C	C	G	75

20110137 19 ms 216A

20510/24 N 42 24' N

3310/34 N IS likely a derivative of Z-WILHELM.

0530/34 N is an unknown derivative of uridine.

0531/34 N is an unknown derivative of uridine.

0630/34 xU is mcm⁵s²U.

0540/34 N is an unknown derivative of uridine

3348/34

0610/34 Xu 15 Nam S.U. 52

0620/34 xU is mammals.

0630/34 xU is mcm⁵s²U.

	Aminoacyl Stem	D Stem	D Loop	D Stem	D Loop	D Stem	D Loop	Anticodon Stem	Anticodon Loop	Anticodon Stem	Anticodon Loop
1	2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19 20 20 21	1	2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19 20 20 21	1	2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19 20 20 21	1	2 3 4 5 6 7 8 9	10 11 12 13 14 15 16 17 18 19 20 20 21
GLYCINE											
0710 E.coli 1	G C G G G G G	SUA	G U U C	A A U	G G D	A G A A	G A G A C	U U C C C A A	G C U C A A	G C U C A A	G C U C A A
0711 S.typhimurium	G C G G G G G	SUA	G U U C	A A U	G(m)G D	A G A A	G A G A C	U U C C C A A	G C U C A A	G C U C A A	G C U C A A
0712 S.typhimurium sulf D	G C G G G G G	SUA	G U U C	A A U	G(m)G D	A G A A	G A G A C	U U C C C A A	G C U C A A	G C U C A A	G C U C A A
0720 E.coli 2	G C G G G G C A	U C G U A	U A U	G G C U	A U U A C	C U C A G	C U U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A
0721 TsaA36	G C G G G G C A	U C G U A	U A U	G G C U	A U U A C	C U C A G	C U U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A	G C U C U N(C) C A A
0730 E.coli 3	G C G G G G G A A	U A G C U	A G D D	G G D	A G A G C A	C G A C C	U G * C C A A	G G U C C A A	G G U C C A A	G G U C C A A	G G U C C A A
0731 E.coli sui+ A78	G C G G G G G A A	U A G C U	A G D D	G G D	A G A G C A	C G A C C	U G * C C A A	G G U C C A A	G G U C C A A	G G U C C A A	G G U C C A A
0740 S.epidermidis* 1A	G C G G G G A G	SUA	G U U C	A A C U	U U D	A G A A	U A G A C	U U C C G A A	G A G A C	G A G A C	G A G A C
0750 S.epidermidis* 1B	G C G G G G A G	SUA	G U U C	A A U	U U D	A G A A	U A G A C	U U C C G A A	G A G A C	G A G A C	G A G A C
0760 Phage T4	G C G G G A A A	U C G U A	A A U	G(m)G D	A U U A C	C U C A G	C U U N(A) C A A	G C U C U N(A) C A A	G C U C U N(A) C A A	G C U C U N(A) C A A	G C U C U N(A) C A A
0770 Yeast	G C G G G A A G	U(m)G G	G U U Y	A G D	G G D	A A A A	U C C A C G	U G C C A A	G C U C U G	G C U C U G	G C U C U G
0780 Wheat germ 1	G C A C m C A G	U(m)G G	G U C Y	A G D	G G U	A G A A	U A G Y A C	C U G C C U	G C C A M	G C C A M	G C C A M
0790 Bombyx mori 1	G C A l m C G G	U(m)G G	G U U C	A G U	G G D	A G A A	U G C C C	C U G C C C	G C C A M	G C C A M	G C C A M
0791 Bombyx mori 2	G C G l m U G G	U(m)G G	G U G Y	A D	G G D C	A G C A	U A G Y U G C	C U N C C A A	G C C A G	G C C A G	G C C A G
0792 Human Placenta(GCC)	G C A N U G G	U G(m)G	U U C	A G U	G G D	A G A A	U U C G G C	C U G C C C	G C C A M	G C C G G	G C C G G
0793 Human Placenta(ccc)	G C G C C G C	U G(m)G	U G Y	A G U	G G D	A U C A U G C A A G A N U	U Q U G m A Y * C C A G G	U C C A N U	N C U U G	N C U U G	N C U U G
HISTIDINE											
0810 E.coli* 1	G G U G G C U A	SUA	G C U C	A G D D	G G D	A G A G C	C C U G G A	U Q U G m A Y * C C A G G	U Q U G m A Y * C C A G G	U Q U G m A Y * C C A G G	U Q U G m A Y * C C A G G

- 0710 + 0711 C.W.Hill,G.Combrilato,W.Stainhart,D.L.Riddle,J.Carbon (1973) J.Biol.Chem.248, 4252-4262.
- 0712 D.L.Riddle,J.Carbon (1973) Nature New Biology 242, 230-234.
- 0720 + 0721 J.W.Roberts,J.Carbon (1975) J.Biol.Chem.250, 5530-5541.
- 0730 C.Squires,J.Carbon (1971) Nature New Biology 233, 274-277.
- 0731 J.Carbon,E.W.Plece (1974) J.Mol.Biol.55, 371-391.
- 0740 + 0750 R.J.Roberts (1974) J.Biol.Chem.249, 4787-4796.
- 0760 S.Stahl,G.V.Paddock,J.Abelson (1974) Nucleic Acids Res. 1, 1287-1306; B.G.Bareil,A.R.Coullon,M.W.McClain (1973)

- FEBS-Lett. 37, 64-69.
- 0770 M.Yoshida (1973) Biochem.Biophys.Res.Commun. 50, 779-784.
- 0780 K.B.Marcel,R.E.Magnus,B.S.Dick (1977) Biochemistry 16, 797-806.
- 0790 J.P.Garel,G.Reith (1977) Nature 269, 350-352.
- M.C.Zunica,J.A.Seitz (1977) Nucleic Acids Res. 4, 4175-4196.
- 0791 M.Kawakami,K.Nishio,S.Takemura (1978) FEBS-Lett. 87, 288-290.
- 0792 + 0793 R.C.Gupta,B.A.Roe,K.Randerfer (1978) Cold Spring Harbor Meeting on tRNA Abstracts p.5.
- 0810 C.E.Slinger,J.A.Smith (1972) J.Biol.Chem. 247, 2989-3000.

	Extra Arm																T ^ψ Stem																T ^ψ Loop																T ^ψ Stem																Aminoacyl Stem															
	44	45	46	47	47	47	47	47	47	47	47	47	47	47	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76																																				
GLYCINE	0710	A	U	A													C	G	A	G	G	T	ψ	C	G	A	U																																																					
	0711	A	U	A													C	G	A	G	G	T	ψ	C	G	A	U																																																					
	0712	A	U	A													U	G	C	G	G	T	ψ	C	G	A	U																																																					
	0720	U	G	A													U	G	C	G	G	T	ψ	C	G	A	U																																																					
	0721	U	G	A													U	G	C	G	G	T	ψ	C	G	A	U																																																					
	0730	G	G	m ² U													C	G	C	G	A	G	T	ψ	C	G	A	U																																																				
	0731	G	G	m ² U													C	G	C	G	A	G	T	ψ	C	G	A	U																																																				
	0740	A	G	A													U	A	U	A	G	G	T	ψ	C	G	A	U																																																				
	0750	A	G	G													U	A	U	A	G	G	T	ψ	C	G	A	U																																																				
	0760	U	G	A													U	G	U	G	A	G	T	ψ	C	G	A	U																																																				
	0770	G															C	m ² C	C	G	G	T	ψ	C	G	A	U																																																					
	0780	A	G	A													m ² C	m ² C	G	G	T	ψ	C	G	A	U																																																						
	0790	C	G														m ² C	m ² C	G	G	T	ψ	C	G	A	U																																																						
	0791	U	G	A													U	m ² C	m ² C	G	G	T	ψ	C	G	A	U																																																					
	0792	A	G	G													m ² C	m ² C	G	G	T	ψ	C	G	A	U																																																						
	0793	C	G	A													C	m ² C	m ² C	G	G	T	ψ	C	G	A	U																																																					
HISTIDINE	0810	U	U	m ² U												C	G	U	6	6	6	T	ψ	C	G	A	A	U	C	C	C	A	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C																																

0710/35 Mutation C-35-MU-35; C.W.Hall, G.Combriato, N.Dolph (1974) J.Bacteriol. 117, 351-359.

0720/34 N is an unidentified derivative of uridine.

0721/34 N is an unidentified derivative of uridine.

0724/34 N is probably a derivative of adenosine.

0730/34 Mutation E.coli ins has G-34-U-34.

0731/37 xA is m²A.

0740/0 Staphylococcus epidermidis Texas 26.

0750/0 Staphylococcus epidermidis Texas 26.

0760/34 xU is probably related to m²U.

0791/34 N contains 2 unknown modified nucleosides. They are probably derivatives of uridine.

0810/0 Identical with *Salmonella typhimurium*.

0810/38 + 0810/39 Hist mutation ψ-38→U-38; ψ-39→U-39; C.E.Singer, G.R.Smith, R.Cortese, B.N.Ames (1972) Nature New Biology 238, 72-74.

Aminoacyl Stem	D Stem												D Loop												D Stem												Anticodon Stem											
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43				
ISOLEUCINE																																																
0910 E.coli 1	A	G	G	C	U	U	G	U	A	G	C	U	C	A	G	D	U	G	D	D	A	G	A	G	C	G	A	S	C	G	U	G	U	G	G	G	U	G	G	U	G							
0920 T.utilis	G	G	U	C	C	C	U	U	G	mG	G	C	C	A	G	D	D	G	D	D	A	A	G	G	C	mG	mG	U	G	U	G	G	U	G	G	U	G	G	U	G								
LEUCINE																																																
1010 E.coli b/K12*	1	G	C	G	A	G	G	U	U	G	G	G	G	A	D	D	Um	G	D	A	G	A	C	G	C	G	C	U	U	C	A	G	N	*	G	*	U	A	G									
1011 E.coli K12*	2	G	C	C	G	A	G	G	U	U	G	G	G	G	A	D	D	Um	G	D	A	G	A	C	C	G	C	G	C	U	U	N	*	G	*	U	A	G										
1012 E.coli 5	G	C	C	C	G	A	G	U	U	G	G	G	G	A	D	C	Um	G	D	A	G	A	C	C	G	C	G	C	U	U	N	*	A	*	U	A	G											
1030 Phage T4	G	C	G	A	G	A	A	U	U	G	G	G	G	A	A	D	D	Um	G	D	A	G	A	G	C	G	C	G	C	U	U	N	A	X	A	*	W	G	C	U	G							
1040 Yeast 3	G	G	U	U	U	U	U	U	U	G	mG	C	mG	G	A	G	C	Um	G	D	D	A	A	G	G	C	mG	mG	U	U	mG	C	U	A	G	C	G	G	U	G								
1050 Yeast	G	G	G	A	G	U	U	U	U	G	mG	C	mG	G	A	G	D	Um	G	D	D	A	A	G	G	C	mG	mG	U	U	A	G	mG	C	U	A	G	C	G	U	G							
1060 T.utilis	G	G	A	U	C	U	U	G	U	G	mG	C	mG	G	A	D	C	Um	G	D	D	A	A	G	G	C	mG	mG	U	U	mG	A	mG	C	U	mG	A	G	G	U	G							
LYSINE																																																
1110 E.coli B	G	G	G	U	C	G	U	A	G	C	U	C	A	G	D	D	Um	G	D	D	A	G	A	G	C	G	A	U	U	Q	A	U	U	Q	A	U	U	Q	A	U	U	Q	A					
1120 Bacillus subtilis	G	A	G	C	C	A	U	U	G	G	C	C	A	G	D	D	Um	G	D	D	A	G	A	G	C	G	A	U	U	N	A	U	C	A	G	A	U	C	A	G	A							
1130 Yeast (haploid) 1	G	C	C	U	U	G	U	U	G	mG	C	mG	G	A	D	C	Um	G	D	D	A	G	A	G	C	G	A	U	U	Q	A	U	C	A	U	A	U	Q	A	U	C	A	G	A				
1140 Yeast *	2	G	C	C	U	U	G	U	G	mG	C	mG	G	A	D	D	Um	G	D	D	A	G	A	G	C	mG	mG	U	U	mG	A	mG	C	U	mG	A	G	G	U	G								

- 0910 M.Varus,B.G.Barrell(1971) Biochem.Biophys.Res.Commun. 43, 729-734.
- 0920 S.Takemura,M.Murakami,M.Miyazaki(1969) J.Biochem. 65, 553-566.
- 1010 H.U.Bank,D.S611(1971) Biochem.Biophys.Res.Commun. 43, 1192-1197.
- 1011 S.K.Dube,K.A.Marcker,A.Yudalevich(1970) FEBS-Lett. 9, 168-170.
- 1011 H.U.Bank,D.S611(1971) Biochem.Biophys.Res.Commun. 43, 1192-1197.
- 1012 Z.Yamazumi,T.Kuchino,F.Narada,S.Nishimura,J.A.McCloskey(1978) Cold Spring Harbor Meeting on tRNA Abstracts, p.4.
- 1030 T.C.Pinkerton,G.Paddock,J.Abelson(1973) J.Biol.Chem. 248, 6349-6365.
- 1040 S.H.Chang,S.Kuo,E.Bawkins,N.R.Miller(1973) Biochem.Biophys.Res.Commun. 51, 951-955.
- 1050 K.Randerath,I.S.Y.Chia,R.C.Gupta,E.Randolph,E.R.Banks,C.K.Brunn, S.H.Chang(1975) Biochem.Biophys.Res.Commun. 63, 157-163.
- 1060 A.Murasugi,S.Takemura(1978) J.Biochem. 83, 1029-1038.
- 1110 K.Chakraburty,A.Steinschneider,R.V.Case,A.H.Mohler(1975) Nucleic Acids Res. 2, 2069-2075.
- 1120 Y.Yamada,H.Ishikura(1977) Nucleic Acids Res. 4, 4291-4303.
- 1130 S.J.Smith,H.S.Ten,A.N.Ley,P.D.O'Bryan(1973) J.Biol.Chem. 248, 4475-4485.
- 1140 J.T.Madison,S.J.Boguslawski(1974) Biochemistry 13, 524-527.

0910/47 Probably X, 3N-(3-amino-3-carboxypropyl)uridine, S.Friedman, H.J.Li,
1030/34 N is an unknown derivative of uridine.

K.Nakanishi, G.van Lear (1974) Biochemistry 13, 2932-2937.
1030/37 xA is ms^{2.6} 1A.

Identical with *Salmonella typhimurium* LT2 tRNA₁.
1010/0 1110/34 xU is man^{5,2}U.

1010/38	His T mutant of <i>Salmonella typhimurium</i> tRNA _{Leu} has ψ-38→U-38 and ψ-39→U-39	1120/34	U is partially
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1010/40	$\Psi-40-\bar{U}-40$, H.S.Allaudeen, S.K.Yang, D.Schill(1972) FEB5-Lett.	28,	205-208.	1120, 5 2-thiouridine. 2-aziridine.
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1120/37 N is an unknown
For numbering of *E. coli* tRNAs see R.E. Hurst, G.T. Robillard,
in *Proc. Roy. Soc. (London)*, **200**, 1974.

1011/0 B.A.Reid(1977) Biochemistry 16, 2095-2100.
1140/0 Is identical w

H.-S.Teh, A.N.I.
1010/37 N is an unknown derivative of quanosine.

	Aminoacyl Stem	D Stem	D Loop	D Stem		Anticodon Stem		Anticodon Loop																							
				14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38			
METHIONINE-INITIATOR																															
1210 E. coli CA 265	G G C U A C G	S U A	G C U C	A G D(U) D	G(m) G D D	A G A G C	C A U C A	C U a C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G		
1240 Yeast 3	G C U U C A G	U A m G C U C	A G	A G D A	G G A	A G A G C	C A U C A	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G	C U C A U t A	A G A U G		
1250 Mammalian*	G C C U C m G U	A m G C G C		A G D A	G G D	A G C G C																									
1310 E. coli CA 265	C G C G G G G	S U G	G A G C	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1320 Thermus thermophilic	G C G G G G G	S U G	G A G C	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1330 Bacillus subtilis	C G C G G G G	U G G G G G	G A G C	A G U U C G G D	A G U U C G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1340 Anacystis nidulans	C G C G G G G	S U G	G A G C	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1350 Mycoplasma	C G C G G G G	S U A	G A G C	A G U D(U)	A G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1360 <i>Neurospora crassa</i>	U G C G G G A	U A U U G U A D	A G C U G C A	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G
1370 <i>Neurospora crassa</i>	A G C U G C A	A m G C G C A	A G C U G C A	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	
1375 Wheat germ	A U C A G A Q	U m G m G C G C	A G C U G C A	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	
1380 Yeast	A G C C G C G C G	U m G m G C G C	A G C U G C A	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	
1390 Mammalian*	A G C A G A G	U m G m G C G C	A G C U G C A	A G C C U G G D	A G C C U G G D	A G C U S	G U C G G	G m U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	G U C G G	

- 1210 S.Cory K.A.Marchker (1970) Eur.J.Biochem. 12, 177-194.
- 1240 H.Groth, H.Feldmann (1976) Eur.J.Biochem. 68, 209-217;
- O.Koswai,M.Miyazaki (1976) J.Biochem. 80, 951-959.
- 1250 P.W.Piper (1975) Eur.J.Biochem. 51, 283-293;
- G.Petrisant,M.Boisnard (1974) Biochimie 56, 787-789.
- 1310 S.K.Dube,K.A.Marchker (1969) Eur.J.Biochem. 8, 256-262.
- K.Watahiko,T.Oshima,S.Mishimura (1976) Nucleic Acids Res. 3, 1703-1713.
- Y.Yanada,H.Ishikura (1975) FEBS-Lett. 54, 155-158.
- B.Escarot-Charrrier,R.J.Cederberg (1978) FEBS-Lett. 63, 287-290.
- R.T.Walker,U.L.RajBhandary (1978) Nucleic Acids Res. 5, 57-70.
- 1360 J.E.Hochman,L.I.Hocher, S.D.Schwartzbach,W.E.Barnett, B.Baumstark, U.L.RajBhandary (1978) Cell 12, 83-95.
- A.M.Gillum,L.I.Hocher,M.Silberklang,S.D.Schwartzbach,U.L.RajBhandary, W.E.Barnett (1978) Nucleic Acids Res. 4, 4109-4131.
- H.P.Ghosh,K.Ghosh,M.Simsek,U.L.RajBhandary (1978) Cold Spring Harbor Meeting on tRNA, Abstracts p.6.
- M.Simsek,U.L.RajBhandary (1972) Biochem.Biophys.Res.Commun. 49, 508-515.
- M.Simsek,U.L.RajBhandary,M.Boisnard,G.Petrisant (1974) Nature 247, 518-520;
- A.M.Gillum,N.Urguhart,M.Smith,U.L.RajBhandary (1975) Cell 6, 395-405;
- P.W.Piper,B.P.C.Clark (1974) Eur.J.Biochem. 45, 589-600;
- M.Nezne,A.Mazabraud,H.Denis,G.Petrisant,M.Boisnard (1975) Eur.J.Biochem. 60, 295-302.

	Extra Arm												T _ψ Stem												T _ψ Loop												T _ψ Stem															
	44	45	46	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	
METHIONINE	G	G	m ⁷ G X																																																	
	1210	A	G m ⁷ G D(U)																																																	
	1240	A	G m ⁷ G D																																																	
	1250	A	G m ⁷ G D																																																	
METHIONINE-INITIATOR																																																				
	1310	A	G m ⁷ G U																																																	
	1320	A	G m ⁷ G U																																																	
	1330	A	G G U																																																	
	1340	A	G m ⁷ G U																																																	
	1350	A	G G C																																																	
	1360	U	G A																																																	
	1370	A	G m ⁷ G U(U)																																																	
	1375	A	G m ⁷ G D																																																	
	1380	A	U m ⁷ G D																																																	
	1390	A	G m ⁷ G D																																																	
	1250/0																																																			
	1310/46																																																			
	1320/0																																																			
	1330/0																																																			
	1340/0																																																			
	1350/0																																																			
	1360/38																																																			
	1370/28																																																			

- Mouse myeloma and rabbit liver.
- ⁷C-46-46 in the minor species of tRNA Met from E. coli, S. K. Dubois, K.A. Marcher, 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.
- N is most probably pseudouridine.
- N is an unidentified derivative of pyrimidine.
- 1370/0 N is an unidentified derivative of guanosine.
- 1375/65 N is probably a modified derivative of guanosine.
- 1380/64 N is an unidentified derivative of adenosine.
- 1380/65 N is an unidentified derivative of guanosine.
- Rabbit liver, sheep mammary glands, salmon testes, salmon liver, human placenta, mouse myeloma cells, oocytes and somatic cells of Xenopus laevis.

Aminoacyl Stem		D Stem		D Loop		D Stem		Anticodon Stem		Anticodon Loop		anticodon Stem		anticodon Loop																												
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
PHENYLALANINE																																										
10	E. coli	6	C	C	C	G	G	A	S ^U	A	G	C	U	C	A	G	D	C	G	D	A	G	C	A	G	G	A	U	G	A	A	S ^A	U	C	C	C	C					
20	B. starothermophilus	6	G	C	U	C	G	G	S ^U	A	G	C	U	C	A	G	U	C	G	D	A	G	C	A	A	G	G	A	U	C	C	U	Y	C	C	U	Y	C	U			
30	Bacillus subtilis	6	G	C	U	C	G	G	U	A	G	C	U	C	A	G	U	D	G	D	A	G	C	A	C	G	G	A	U	C	C	U	Y	C	C	U	Y	C	U			
40	Mycoplasma	6	G	U	C	G	U	G	U	A	G	C	U	C	A	G	U	C	G	D	A	G	C	A	G	G	A	U	C	C	U	Y	C	C	U	Y	C	U				
50	Bean chloroplast	6	T	U	G	G	A	A	G	C	U	C	A	G	C	A	G	U	D	G	D	A	G	C	A	G	G	A	U	C	C	U	Y	C	C	U	Y	C	U			
60	Euiglena grac. chloro.	6	C	U	G	G	A	A	U	A	G	C	U	C	A	G	D	U	G	U(D)	A	G	G	C	G	G	G	A	U	C	C	U	Y	C	C	U	Y	C	U			
61	Euiglena grac. cyto.	6	C	C	G	A	C	U	U	A	mG	C	U	C	A	mG	G	A	G	D	G	G	A	G	G	G	A	mG	Y	A	G	A	U	U	U	U	U	U	U			
62	Blue green algae	6	C	C	A	G	G	A	U	A	G	C	U	C	A	G	U	U	G	D	G	G	A	G	G	G	A	U	U	U	U	U	U	U	U	U	U	U				
70	Yeast	6	C	G	G	A	U	U	A	mG	C	U	A	mG	C	A	G	D	D	G	G	A	G	G	G	A	U	U	U	U	U	U	U	U	U	U	U	U				
71	S. pombe	6	U	C	G	C	A	A	U	N ^U	G	Y	A	G	D	D	G	G	G	G	A	G	A	Y	mG	A	C	A	G	A	U	U	U	U	U	U	U					
80	Wheat, pea, lupin	6	C	G	G	A	A	U	mG	C	U	A	G	C	A	G	D	D	G	G	A	G	G	G	A	mG	Y	A	G	A	U	U	U	U	U	U	U					
90	Mammalian*	6	C	C	G	A	A	U	mG	C	U	A	mG	C	A	mG	D	D	G	G	A	G	G	G	A	mG	Y	A	G	A	U	U	U	U	U	U	U					
10	Phage T4	C	U	C	G	U	G	S ^U	A	G	C	U	C	A	G	U	U	U	G	D	A	G	G	C	C	C	U	U	N	G	G	mG	A	U	U	U	U	U				

- 410 B.G.Barrell,F.Sanger(1969). FEBS-Lett. 3, 275-278.

420 G.Keith,J.Guerrier-Takada,H.Grossman,G.Dirksen(1977) FEBS-Lett. 84, 241-244.

430 H.Arnode, G.Keith(1977). Nucleic Acids Res. 4, 2821-2839.

440 M.E.Kimball,K.S.Szeto,S.Boil(1974) Nucleic Acids Res. 1, 1721-1732.

450 P.Guillemant,G.Keith(1977) FEBS-Lett. 84, 351-356.

460 S.H.Chang,L.H.Cheever,M.Sberck,ang,C.K.Brun,W.E.Barnett,U.L.RajBhandary (1976) Cell 9, 71-72.

461 S.H.Chang,C.K.Brun,J.J.Schnabel,J.E.Heckman,U.L.RajBhandary,W.E.Barnett (1978) Fed. Proc. 37, 1768-1768.

462 S.H.Chang,F.K.Lin,L.I.Hecker,J.E.Heckman,U.L.RajBhandary,W.E.Barnett (1978) Cold Spring Harbor Meeting on RNA Abstracts p.45.

470 U.L.RajBhandary,S.H.Chang(1968) J.Biol.Chem. 243, 598-608.

1471 T.McCutchan,S.Silverman,J.Kohli,D.Sail(1978) Biochemistry 17, 1622-1628.

1480 B.S.Uddock,G.K.(1969) J.Biol.Chem. 244, 3059-3061.

1481 G.A.Everett,J.T.Madison(1976) Biochemistry 15, 1016-1021;

1482 A.J.Rafalski,J.Barciszewski,K.Gulewicz,T.Wardowski,J.Kieft(1977) Acta Bioc.Polonica 24, 301-318.

1490 G.Keith,G.Ditheimer(1978) Biochim.Biophys.Acta 517, 133-149;

1491 B.A.Roe,M.P.J.S.AnandaraJ.L.S.W.Chia,E.Randerath,R.C.Gupta,K.Randerath (1975) Biochim.Biophys.Res.Commun. 66, 1097-1105.

1510 J.G.Selman,B.G.Barrell,W.H.McClain(1975) J.Mol.Biol. 99, 733-760.

PHENYLALANINE												PROLINE																											
Extra Arm						T Ψ Stem						T Ψ Loop						T Ψ Stem																					
44	45	46	47	47	47	47	47	47	47	47	47	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16																								
1410	G	U	mG	X			C	U	U	6	6	T	T	C	C	G	A	G	U	C	C	G	G	G	G	C	A	C	C	A	A	A	A	A	A	A	A		
1420	G	U	mG	U			C	G	G	C	C	G	T	T	C	C	G	A	U	U	C	C	G	A	G	C	C	A	A	A	A	A	A	A	A	A	A		
1430	G	U	mG	U			C	G	G	C	G	G	T	T	C	G	A	U	U	C	C	G	A	G	C	C	A	A	A	A	A	A	A	A	A	A			
1440	G	U	mG	U			C	G	G	C	G	G	U	U	C	C	G	A	U	U	C	C	G	A	G	C	C	A	A	A	A	A	A	A	A	A			
1450	C	U	mG	X			C	A	C	C	A	G	T	T	C	C	G	A	U	U	C	C	G	A	G	C	C	A	A	A	A	A	A	A	A	A			
1460	G	U	mG	X			C	A	C	C	A	G	T	T	C	C	G	A	U	U	C	C	G	A	G	C	C	A	A	A	A	A	A	A	A	A			
1461	A	G	mG	D*			C	C	C	U	G	G	T	T	C	G	mA	U	U	C	C	G	G	G	G	C	C	A	A	A	A	A	A	A	A	A			
1462	G	U	mG	U			mC	G	G	C	G	G	T	T	C	A	A	U	U	C	C	G	G	G	G	C	C	A	A	A	A	A	A	A	A	A			
1470	A	G	mG	U			C	mC	U	G	U	G	T	T	C	G	mA	U	U	C	C	G	A	G	A	A	U	U	U	U	U	U	U	U	U				
1471	U	G	mG	D*			C	A	U	C	G	G	T	T	C	C	G	G	T	T	C	C	G	G	G	G	C	C	A	A	A	A	A	A	A	A	A		
1480	A	G	mG	D			C	G	C	G	U	G	T	T	C	G	mA	U	U	C	C	G	G	G	G	C	C	A	A	A	A	A	A	A	A	A			
1490	A	G	mG	D			C	mC	C	U	G	G	T	T	C	G	mA	U	U	C	C	G	G	G	G	C	C	A	A	A	A	A	A	A	A	A			
1510	A	G	mG	U			C	C	A	A	G	G	T	T	C	C	U	U	G	U	U	G	U	U	G	G	G	G	C	C	A	A	A	A	A	A			

1410/37 xA 1s ms²₁⁶A.

1430/37

1420/31 2,6

1430/37

1450/37 XA 18 ms 1 A.

1460/37 XA is ms² 1⁸ A.

1461/47 Xu is probably

1462/39 Xu is probably

1471/9 N 18 and unidentified

1471/10 Is probably m_G^2

11/21/26 18 probable 26

14/1/20 3:58:14 PM G.

14/14/ x0 is probably a derivative of uridine.

1480/49 The Lupinus luteus sequence has mainly

1480/65 The *Lupinus luteus* sequence has mainly

1490/0 Rabbit liver,calf liver,bovine liver an

1490/54 Content of T is different for different

1510/34 N is an unidentified derivative of uridine

1510/34 N 16 an unidentified derivative of uridine

	Aminoacyl Stem:							D Stem							D Loop							D Stem							Anticodon Stem																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	
SERINE																																													
1610 E.coli 1	G	G	A	A	G	U	G	S ^U	G	G	C	C	G	A	G	C	Gm	G	D	D	G	A	G	G	C	A	C	C	G	G	G	G	G	G	G	G	G	G	G	G					
1620 E.coli 3	G	G	U	G	A	G	G	S ^U	G	G	C	C	G	A	G	A	G	G	C	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G	G	G	G						
1630 Phage T4	G	G	A	G	G	G	G	S ^U	G	G	C	A	G	A	G	U	G	G	C	D	D	U	A	U	G	C	U	T	A	A	G	G	G	G	G	G	G	G							
1631 Phage T4 ^{7am}	G	G	A	G	G	G	G	S ^U	G	G	C	A	G	A	G	U	G	G	C	D	D	U	A	U	G	C	U	X	A	A	C	C	G	G	G	G	G								
1640 Yeast 1	G	G	C	A	C	U	U	G	G	C	A	G	G	A	D	G	Gm	G	D	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G	G								
1650 Yeast 2	G	G	C	A	C	U	U	G	G	C	A	G	G	A	D	G	Gm	G	D	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G	G								
1651 Yeast(UUC)*	G	G	C	A	C	U	U	G	G	C	A	G	G	A	D	G	Gm	G	D	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G	G								
1660 Rat liver 1	G	U	A	G	C	A	G	U	G	G	C	A	G	G	A	D	G	Gm	G	D	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G								
1670 Rat liver 3	G	A	C	G	A	G	G	U	G	G	C	A	G	G	A	D	G	Gm	G	D	D	G	A	G	G	C	G	G	G	G	G	G	G	G	G	G	G								
THREONINE																																													
1710 E.coli	G	C	U	G	A	A	A	U	A	G	C	U	C	A	D	D	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G								
1720 Bacillus subtilis	G	C	C	G	G	U	G	U	A	G	C	U	C	A	U	U	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G								
1730 Phage T4	G	C	U	G	A	U	U	U	A	G	C	U	C	A	G	D	A	G	G	D	D	G	G	D	D	G	G	N*	U	N*	A	U	U	G	G	G	G								
1760 Yeast 1a, 1b	G	C	U	U	C	U	A	U	G	mG	C	C	A	A	G	D	D	G	G	D	D	G	G	D	D	G	G	C	C	A	A	A	A	U	U	G	G	G							
TRYPTOPHAN																																													
1810 E.coli CR244	A	G	G	G	G	G	G	S ^U	G	G	U	U	C	A	D	D	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G	G							
1811 E.coli+ UGA	A	G	G	G	G	G	G	S ^U	A	G	U	U	C	A	D	D	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G								
1812 Psu+ 7am	A	G	G	G	G	G	G	S ^U	A	G	U	U	C	A	D	D	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G								
1813 Psu+ 7oc	A	G	G	G	G	G	G	S ^U	A	G	U	U	C	A	D	D	G	G	D	D	G	G	D	D	G	G	C	C	G	G	G	G	G	G	G	G	G								
1840 Yeast	G	A	A	G	C	G	G	U ^m	G	mG	mG	C	U	C	A	D	D	Gm	G	D	D	G	G	D	D	G	G	C	C	G	G	A	A	A	A	A	A								
1850 Chicken cells*	G	A	C	C	U	C	G	U ^m	G	mG	mG	C	U	C	A	C	D	Gm	G	D	D	G	G	D	D	G	G	C	C	G	G	A	A	A	A	A	A								
1860 Bovines liver	G	A	C	C	U	C	G	U ^m	G	mG	mG	C	U	C	A	D[C]	Gm	G	D	D	G	G	D	D	G	G	C	C	G	G	A	A	A	A	A	A									
1810 H.Ishikura,Y.Yamada,S.Nishimura(1971) FEBS-Lett. 16, 69-70;																																													
1820 Y.Yamada,H.Ishikura(1975) Biochim.Biophys.Acta 402, 285-287.																																													
1820 Y.Yamada,H.Ishikura(1973) FEBS-Lett. 29, 231-234;																																													
1820 Y.Yamada,H.Ishikura,B.F.C.Clark(1973) J.Biol.Chem. 248, 6663-6673.																																													
1830 W.H.McClein,C.Guthrie,B.J.Barrow,J.W.Seidman(1973) J.Mol.Biol. 99, 717-732.																																													
1840 H.G.Zachau D.Dötting H.Friedmann(1966) Hoppe-Seyler's Z. Physiol.Chem. 347, 212-235.																																													
1850 P.W.Piper(1973) J.Mol.Biol. 122, 217-235.																																													
1860 T.Ginsberg,H.Rogg,M.Staelelin(1971) Eur.J.Biochem. 21, 249-257.																																													
1860 H.Rogg,P.Müller,M.Staelelin(1975) Eur.J.Biochem. 53, 115-127.																																													
1860 L.Clarke,J.Carbon(1974) J.Biol.Chem. 249, 6874-6885.																																													
1870 T.Hasegawa,H.Ishikura(1978) Nucleic Acids Res. 5, 537-548.																																													
1870 C.Kothiyal,C.A.Schollia,H.Yestian,J.Abelson(1978) Nucleic Acids Res. 5, 1833-1844.																																													
1870 J.Weissenbach,I.Kiraly,G.Dürheimer(1977) Biochimica 59, 381-391.																																													
1870 W.H.Hirsch(1971) J.Mol.Biol. 58, 439-458.																																													
1870 D.Hirsch(1971) J.Mol.Biol. 59, 1811.																																													
1870 G.Dürheimer(1971) J.Mol.Biol. 59, 1812.																																													
1870 G.Dürheimer(1971) J.Mol.Biol. 59, 1813.																																													
1870 M.Yaniv,W.R.Folk,P.Berg,L.Soll,J.Mol.Biol. 59, 1405-1426.																																													
1870 G.Kelth,A.Rey,J.P.Ebel,G.Dürheimer(1972) Biochimica 54, 245-260.																																													
1870 F.Harada,R.C.Sawyer,J.E.Dahlberg(1973) J.Biol.Chem. 250, 3487-3497.																																													
1870 M.Fournier,J.Labouesse,G.Dürheimer(1974) Biochimica 54, 221, 198-208.																																													

	Aminoacyl Stem	D Stem	D Loop	D Stem	Anticodon Stem	Anticodon Loop	Anticodon Stem
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 1 2	1	26 27 28 29 30 31	26 27 28 29 30 31	32 33 34 35 36 37 38 39 40 41 42 43		
TYROSINE							
1910 E. coli	G G U G G G G S'U	C C C G A G C	Gm G C C A A G G G	G C A G A C U Q U A Y A*	W C U G C		
1911 E. coli ⁺ 3am	G G U G G G G S'U	C C C G A G C	Gm G C C A A G G G	C U C U X A* A	W C U G C		
1912 A2 psu+ 3oc	G G U G G G G S'U	C C C G A G C	Gm G C C A A G G G	C U U X A* A	W C U G C		
1920 B. stearothermophilus	G A G G G G S'U A	G C G G A G U	Gm G C U A A A G G G	C U Q U A X A*	W C C G C		
1930 Yeast	C U C U C G G G U A	mG C C A A D D	Gm G D D D A A G G G	C U G G Y A A A	W C U G C		
1931 Yeast	C U C U C G G G U A	mG C C A A D D	Gm G D D D A A G G G	C U C Y A A A	W C U G C		
1940 T. utilis	C U C U C G G G U m'G C C A	A G D D	Gm G D D D A A G G G	C U G G Y A A A	W C U G C		
VALINE							
2010 E.coli K12,B 1	G G G U G A U S'U A	G C U C G S'U A	G G G A G C D	G G G A G C A C C U S'U A C m A	G G A G G G		
2020 E.coli 2a	G C G U C C G S'U A	G C U C G S'U A	G D D D	G D D D A G G G C	A C C A U G G G		
2021 E.coli 2b	G C G U U C A S'U A	G C U C G S'U A	G D D D	G D D D A G G G C	A C C A U G G G		
2030 B. stearothermophilus	G A U U C C G U A	G C U C G S'U A	G G C D	G G G A G C G C C U A C m A G	G G G G G		
2040 Yeast 1	G G U U U C G G m'G U C	A G D C	G D D D A U G G C	G G G A G C G C C U I A C A C G C A G A			
2050 Yeast 2a	G G U U C C A A U G m'G U C C A G D	G D D D C A A G A C	G D D D C A A G A C	W C G C C C V U N* A C A C G G C G A			
2051 Yeast 2b	G U U C C A A U A m'G U C C A G D	G D D D C A U C A C	G D D D C A U C A C	W C G C C C V U I A C A C G G C A A			
2060 T. utilis	G G U U C C G U A G U G G A G D D	G D D D A U C A C	G D D D A U C A C	W C G C A V U C U G C A C G G C A A			
2070 Mammalian*	G G U U C C G U A G U G G A G D D	G D D D A U C A C	G D D D A U C A C	W C G C A V U C U G C A C G G C A A			
2071 Human Placenta 1b	G G U U C C G U A G U G G A G D D	G D D D A U C A C	G D D D A U C A C	W C G C A V U C U G C A C G G C A A			
1910 + 1911 H. M. Goodman, J. Abelson, A. Landy, S. Brenner, J.D. Smith (1968) Nature 217, 1019-1024.							
1912 S. Altman, S. Brenner, J.D. Smith (1971) J. Mol. Biol. 56, 195-197.							
1920 R.S.Brown, J.R.Rubin, D.Rhodes, H.Guilliey, A.Simonson, G.C.Brownlee (1978) Nucleic Acids Res. 5, 23-36.							
1930 J.T. Madison, H. K. Kung (1967) J. Biol. Chem. 242, 1324-1330.							
1931 P.W.Piper, M. Wasserstein, F. Englehardt, K. Kaltori, J.F. Cells, J.Zeuthen, S.Lieberman, F. Sherman (1976) Nature 262, 757-761.							
1940 S. Hashimoto, S. Takekura, M. Miyazaki (1972) J. Biochem. 72, 123-134.							
2010 M. Yaniv, B.G.Barrel (1969) Nature 221, 278-279.							
F. Kimura, F. Harada, S.Nishimura (1971) Biochemistry 10, 3277-3283.							
2020 + 2021 M. Yaniv, B.G.Barrel (1971) Nature New Biol. 233, 113-114.							
2030 C.Takada-Guerrier, H.Grosjean, G.Dirheimer, G.Keith (1976) FEBS-Lett. 62, 1-3.							
2040 J. Bonnet, J.-P. Ebé, G.Dirheimer, L.P.Sherstnev, A.I.Krutilina, T.V.Venketan, A.A.Bayev (1974) Biochimie 56, 1211-1213.							
2050 V.D.Axel rod, V.D.Gorbunov, V.D.Axel rod, A.A.Bayev (1977) Nucleic Acids Res. 4, 45, 333-336.							
2051 V.G.Gorbunov, V.D.Axel rod, A.A.Bayev (1977) Nucleic Acids Res. 4, 3259-3256.							
2060 T.W.Brown, M.Miyazaki, S.Takekura (1968) J. Biochem. 51, 295-304;							
2070 P.Jant, N.Shinda-Okada, S.Nishimura, H.J.Grossi (1977) Nucleic Acids Res., 5, 1999-2009.							
2071 E.Y.Chen, B.A.Roe (1977) Biochem.Biophys.Res.Commun. 78, 631-640.							

		Extra Arm	T ^Y Stem	T ^Y Loop	T ^Y Stem	Aminocyl Stem
44	45	46	47	47	47	75
1	2	3	4	5	6	7
1910	C	G	U	C	A	U
1911	C	G	U	C	G	A
1912	C	G	U	C	A	C
1920	U	C	C	U	U	G
1930	A	G	A	D		
1931	A	G	A	D		
1940	A	C	A	D		
1950	C	G	A	A	G	T
1951	C	G	A	A	G	T
1952	C	G	A	A	G	T
1953	C	G	A	G	G	T
1954	C	G	G	G	G	T
1955	mC	G	G	C	G	T
1956	mC	G	G	C	G	T
1957	mC	G	G	C	G	T
1958	mC	G	G	C	G	T
1959	mC	G	G	C	G	T
1960	5'	mC	G	C	G	T
2010	G	G	mG	U		
2020	G	G	mG	X		
2021	G	G	mG	X		
2030	A	G	mG	U		
2040	A	C	mG	D		
2050	A	G	A	D		
2051	A	G	mG	D		
2060	A	C				
2070	A	G	mG	D		
2071	A	G	mG	D		

1910/37 xA is ms²₁A
1911/37 xA is ms²₆iA.

1912/34 Uridine may b...

441-448.

1912/37 xA is ms²i⁶A.

1920/37 xA is ms²i⁶A.

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2050/34 N is an unknown derivative of uridine.

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,
2070/60 D.Riesner, H.J.Gross (1977) Nucleic Acids Res. 4, 2009-2020.