Volume 10 Number 2 1982 Nucleic Acids Research

Compilation of tRNA sequences

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INTRODUCTION

This compilation presents in a small space the tRNA sequences so far published. The numbering of tRNA^{Phe} from yeast is used (1, Fig. 1) enabling comparisons with the three dimensional structure of tRNA^{Phe}. The secondary structure of tRNAs is indicated by specific underlining. For the nomenclature of rare nucleoside see Table I. Footnotes are numbered according to the coordinates of the corresponding nucleoside and are indicated in the sequence by an asterisk. For technical reasons in 17:1, 20:1, 47:1, etc. the numbers after the colon are replaced by capital letters in alphabetical order.

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 to further references (2,3,4). Suppressor tRNAs are dealt with in an accompanying compilation. The compilers would welcome any information by the readers regarding missing material or erroneous presentation. On the basis of this compilation and numbering system computer printed tRNA presentations are possible.

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Acknowledgements: We thank Mrs. H. Sorhage and Mr. R. Jung for skilfull assistance and the Fonds der Chemischen Industrie for financial support.

0305-1048/82/1002-r001 $2.00/0

Table 1: Nomenclature of Rare Nucleosides (5,6).

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-METHYLCARBAMOYL)THREONINE
A9 = MS2T6A = N-((9-BETA-D-RIBOFURNOSYL-2-METHYLTHIOPURIN-6-YL) CARBAMOYL)THREONINE

G1 = M1G = 1-METHYLGUANOSINE
G2 = M2G = 2-METHYLGUANOSINE
G3 = GM = 2'-O-METHYLGUANOSINE
G4 = M22G = 2,2-DIMETHYLGUANOSINE
G7 = M7G = 7-METHYLGUANOSINE
I1 = M1I = 1-METHYLINOSINE

Q = Q = QUEUOSINE
Q1 = MAN Q = BETA-D-MANNOSYLQUEUOSINE
Q2 = GAL Q = BETA-D-GALACTOSYLQUEUOSINE

Y1 = YW = WYBUTOSINE
Y2 = O2YW = WYBUTOXOSINE

C2 = S2C = 2-THIOCYTIDINE
C3 = CM = 2'O-METHYLCYTIDINE
C4 = AC4C = 4-ACETYLCYTIDINE
C5 = M5C = 5-METHYLCYTIDINE
C6 = M3C = 3-METHYLCYTIDINE

T = T = 5-METHYLURIDINE
T2 = S2T = 5-METHYL-2-THIOURIDINE
T3 = TM = 2'-O-METHYL-5-METHYLURIDINE

F = Ψ = PSEUDOURIDINE
F1 = M1Ψ = 1-METHYLPSEUDOURIDINE
D = D = DIHYDROURIDINE
X = X = 3-(3-AMINO-3-CARBOXYPROPYL)URIDINE, (ACP3)U

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

N = unknown nucleoside

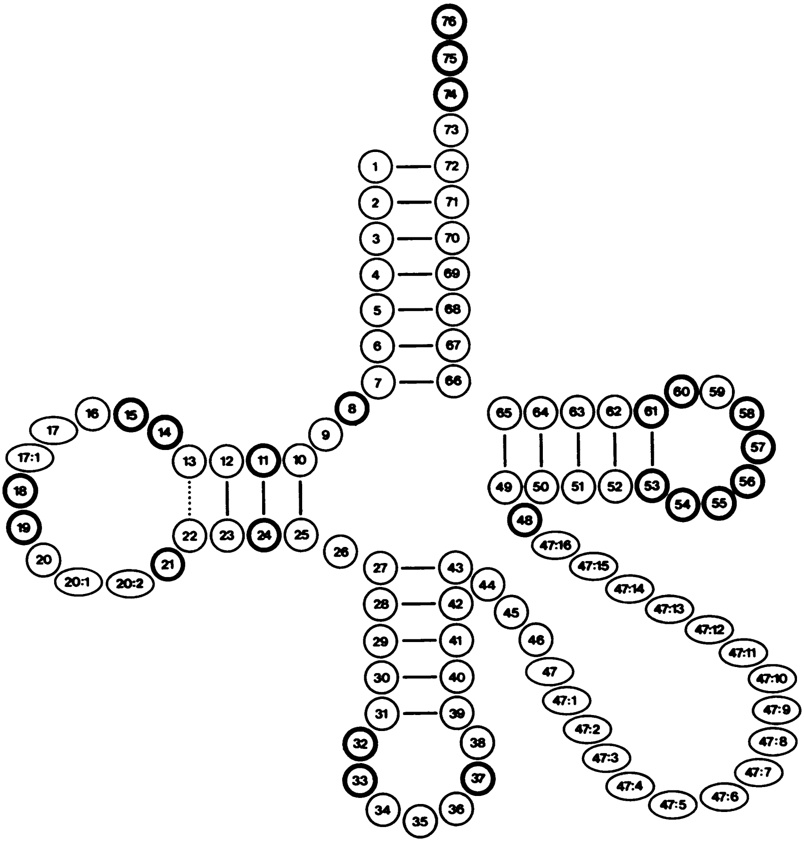

Figure 1: Numbering system of nucleotides in tRNAs according to the numbering of phenylalanine tRNA from yeast. Circles represent nucleotides which are always present; among these, the thick-edged circles denote invariant or semiinvariant nucleotides. Ovals represent nucleotides which are not present 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.

			AMINOACYL STEM 1 2 3 4 5 6 7	8 9	D STEM 10 11 12 13	D LOOP 14 15 16 17 A 18 19 20 A B 21	D STEM 22 23 24 25	26	ANTIC.STEM 27 28 29 30 31	ANTIC.LOOP 32 33 34 35 36 37 38	ANTIC.STEM 39 40 41 42 43
		A L A N I N E									
0010	1A	E.COLI	G G G G G C A ****** ****	*U4A	G C U C	A G C D G G G A	G A G C	G	C C U G C -----------	U U V1G C A C	G C A G G -----------
0011	1B	E.COLI	G G G G C U A **** ********	U A	G C U C	A G C D G G G A	G A G C	G	C C U G C -----------	U U V1G C A C	G C A G G -----------
0015		B.SUBTILIS	G G A G C C U **************	U A	G C U C	A G C D G G G A	G A G C	G	C C U G C -----------	U U V2G C A6C	G C A G G -----------
0020	1	T.UTILIS	G G G C G U G **** **** **	U G1	G C G U	A G D D G G D A	G C G C	G4	F U C G C -----------	U U I G C I1F	G C G A A -----------
0025		N.CRASSA MITO	G G G G G U A **** ** ****	U A	G U A U	A A D U G G D A	G U A C	A	G C A A U -----------	C U U G C U C	A N* U G C -----------
0030*	1	YEAST	G G G C G U G **** **** **	U G1	G C G U	A G D C G G D A	G C G C	G4	C U C C C -----------	U U I G C I1F	G G G A G -----------
0040	1	BOMBYX MORI	G G G G G C G **** ********	U A	G2C U C	A G A D G G U A	G A G C	G4	C U C G C -----------	U3U I G C I1F	G3F* G A G -- ------
0041	2	BOMBYX MORI	G G G G G C G **** ********	U A	G2C U C	A G A D G G U A	G A G C	G4	C U C G C -----------	U3U I G C I1F	G3C G A G -----------

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                        EXTRA ARM                |  TF STEM | TF LOOP     |TF STEM  |AMINOACYL STEM|
          45  47  B   D   F   H   J   L   N   P   49  51  53  55  57  59  61  63  65  67  69  71  73  75
        44  46  A   C   E   G   I   K   M   O   48  50  52  54  56  58  60  62  64  66  68  70  72  74  76
        -------------------------------------------------------------------------------------------------

             A L A N I N E

0010    A G G7U                                 C|U G C G G|T F C G A U C|C C G C G|C G C U C C C|A C C A
                                                 |  =======|             |======== |  **** ******|
0011    A G G7U                                 C|U G C G G|T F C G A U C|C C G C A|U A G C U C C|A C C A
                                                 |=========|             |=========|******** ****|
0015    A G G7U                                 C|A G C G G|T F C G A U C|C C G C U|A G G C U C C|A C C A
                                                 |=========|             |=========|*************|
0020    A G G D                                 C|U C C G G|T F C G A1C U|C C G G A|C U C G U C C|A C C A
                                                 |=*=======|             |=========|**  **** ****|
0025    U U G                                   U|C5A A G G|T F C A A A U|C C U U G|U A U C U C C|A C C A
                                                 |=========|             |=========|****  ** ****|
0030    A G G D*                                C|U C C G G|T F C G A U U|C C G G A|C U C G U C C|A C C A
                                                 |=========|             |=========|**  **** ****|
0040    A G G7U                                 A|C5C G G G|A F C G A1U A|C C C G G|C G C C U C C|A C C A
                                                 |=========|             |=========|******** ****|
0041    A G G7U                                 A|C5C G G G|A F C G A1U A|C C C G G|C G C C U C C|A C C A
                                                 |=========|             |=========|******** ****|


0010/8  PARTIALLY MODIFIED                                0030/0  COMPARE R.W.HOLLEY ET AL. (1965) SCIENCE 147, 1462-1465
0025/40 N IS A MODIFIED URIDINE                           0030/47 PARTIALLY MODIFIED
0025/49 PARTIALLY MODIFIED                                0040/40 PARTIALLY PSEUDOURIDINE
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                                 AMINOACYL STEM|    | D STEM |        D LOOP        |D STEM  | ANTIC.STEM  | ANTIC.LOOP    ANTIC.STEM
                                 1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37  |39  41  43
                                               |    |  11  13|  15  17  18  20  B   |22  24  |26|  28  30  |32  34  36  38|  40  42
                                 --------------|----|--------|----------------------|--------|--|----------|--------------|----------

            A R G I N I N E                    |    |        |                      |        |  |          |              |

0110   1    E.COLI               G C A U C C G |U4A |G C U C |A G C D   G G D*    A |G A G U |A |C U C G G |C2U I C G A2A |C C G A G
                                 **************|    |  ......|                      |......  |  |----------|              |----------
0111   2    E.COLI               G C A U C C G |U4A |G C U C |A G C D   G G A D*  A |G A G U |A |C U C G G |C U I C G A2A |C C G A G
            B                    **************|    |  ......|                      |......  |  |----------|              |----------
0115        H.VOLCANII           G U C C U G A |U A |G4G G F |A G U     G G A C U A |U C C U |C |C U G G C |U U G C G G1A |G C C A G
            HALOBACTERIUM SP.    **************|    |  ....  |                      |  ....  |  |----------|              |----------
0120        PHAGE T4             G U C C C G C |U G |G U G U |A A U     G3G A D   A |G C A U |A |C G A U C |C U N*C U A A |G F U U G
                                   ************|    |  ....  |                      |  ....  |  |--  --  --|              |--  --  --
0121        PHAGE T4             G U C C C G C |U G |G U G U |A A U     G3G A D   A |G C A U |A |C G A U C |C U N*C A A A |G F U U G
            PSU+ 4 UGA             ************|    |  ....  |                      |  ....  |  |--  --  --|              |--  --  --
0125        B.SUBTILIS           G C G C C C G |U A |G C U C |A A U     G G A D   A |G A G C |G |U U U G A |C U I C G G1A |U C A A A
                                 **************|    |........|                      |........|. |----------|              |----------
0130   2    YEAST                F U C C U C G |U G1|G2C C C |A A D     G G D C   A |C G G C |G4|F C U G G |C U I C G A A |C C A G A
                                 ********  ****|    |......  |                      |  ......|  |----------|              |----------
0140   3A   YEAST                G C U C G C G |U G1|G2C G U |A A D     G G C     A |A C G C |G4|F C U G A |C U U7C U A7A |F C A G A
                                   ******  ****|    |........|                      |........|. |----------|              |----------
0141   3B   YEAST                G C U U G C G |U G1|G2C G U |A A D     G G C     A |A C G C |G4|F C U G A |C U U7C U A7A |F C A G A
                                   ****    ****|    |........|                      |........|. |----------|              |----------
0150*       MORRIS HEPATOMA      U G G U A A U |U A1|G U U U |A A A U A             |A A A U |U |A A U G A |F U U C G A C |F C A U U
            MITO                 **************|    |  ......|                      |......  |  |----------|              |----------
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                       EXTRA ARM                  TF STEM    TF LOOP     TF STEM   AMINOACYL STEM

         45  47  B   D   F   H   J   L   N   P   49  51  53  55  57  59  61  63  65  67  69  71  73  75
       44  46  A   C   E   G   I   K   M   O   48  50  52  54  56  58  60  62  64  66  68  70  72  74  76
       -------------------------------------------------------------------------------------------------

           A R G I N I N E

0110   C G G7X                                 C G G A G G T F C G A A U C C U C C C G G A U G C A C C A
                                                 ==========              ==========**************
0111   C G G7X                                 C G G A G G T F C G A A U C C U C C C G G A U G C A C C A
                                                 ==========              ==========**************
0115   G G A                                   C C5G G A G   F C3G2A A U C U C C G U C A G G A C G C C A
                                                 ==========              ==========**************
0120   C G G                                   U C C U G G T F C G A U C C C A G G G C G G G A U A C C A
                                                 ==========              ==========*************
0121   C G G                                   U C C U G G T F C G A U C C C A G G G C G G G A U A C C A
                                                 ==========              ==========*************
0125   A G G7U                                 U A G G G G T F C G A C U C C C C U C G G G C G C G C C A
                                                 ==========              ==========**************
0130   A G A D                                 U C5C A G G T F C A A1G U C C U G G C G G G G A A G C C A
                                                 ==========              ==========****  ********
0140   A G A D                                 U A U G G G T F C G A1C C C C C A U C G U G A G U G C C A
                                                 ==========              ==========****  ******
0141   A G A D                                 U A U G G G T F C G A1C C C C C A U C G U G A G U C C C A
                                                 ==========              ==========****    ****
0150   A G A                                   U U*A U G A U A A U A A   U C A U A A U U A C C A A C C A
                                                 ==========              ==========**************
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0110/20 PARTIALLY MODIFIED
0111/20 1 (A) PARTIALLY MODIFIED
0120/34 N IS A NOT IDENTIFIED DERIVATIVE OF URIDINE

0121/34 N IS A NOT IDENTIFIED DERIVATIVE OF URIDINE
0150/0 ALIGNMENT IS ARBITRARY
0150/49 PARTIALLY G

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                                AMINOACYL STEM |    | D STEM  |       D LOOP            |D STEM  | ANTIC.STEM | ANTIC.LOOP    ANTIC.STEM
                                1 2 3 4 5 6 7  |8 9 |10   12  |14  16  A   19  A    21 | 23  25 |27  29  31 | 33  35  37 |39  41  43
                                               |    |   11  13| 15  17  18  20  B     |22  24  |26  28  30 |32  34  36  38| 40  42
                                ---------------|----|---------|-----------------------|--------|-|----------|-------------|----------

               ARGININE  cont.

0155           YEAST            G C U C U C U  |U A |G C U U  |A A D     G G D U   A  |A A G C |A|F A A U A |C U N*C U A7A|F A U U A
               MITO               ************ |    |.........|                       |........| |----------|             |----------
0171     1     MOUSE LEUKEMIA   G G G C C A G  |U G1|G2C G C  |A A D     G G A D   A  |A C G C |G4F C U G A |C3U I C G G1A|F C A G A
                                **  ********** |    |......   |                       |  ......| |----------|             |----------
0172     2     MOUSE LEUKEMIA   G G G C C A G  |U G1|G2C G C  |A A D     G G A D   A  |A C G C |G4F C U G A |C3U I C G G1A|F C A G A
                                **  ********** |    |......   |                       |  ......| |----------|             |----------

               A S P A R A G I N E

0210           E.COLI           U C C U C U G  |U4A |G U U C  |A G D C   G G D     A  |G A A C |G|G C G G A |C U Q U U A7A|F C C G U
                                ************** |    |.........|                       |........| |  --------|             |--------
0220           PHAGE T5         G G U U C C U  |U A |G C U C  |U A A U   G G U U   A  |G A G C |C|G C A C C |U U G U U A*A|G F U G A
                                ************** |    |.........|                       |........| |  ----  --|             |--  ----
0260*          MAMMALIAN        G U C U C U G  |U G1|G2C G C  |A A D C   G G D X   A  |G C G C |G4F F C G G |C U Q*U U A7A|C C G A A
                                ******  ****** |    |.........|                       |........| |----------|             |----------

               A S P A R T I C   A C I D

0310     1     E.COLI           G G A G C G G  |U4A |G U U C  |A G D C   G G D D   A  |G A A U |A|C C U G C |C U Q U C A2C|G C A G G
                                ******  ****** |    |   ......|                       |......  | |----------|             |----------
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                         EXTRA ARM                        | TF STEM  | TF LOOP      | TF STEM  |AMINOACYL STEM|
          45  47  B   D   F   H   J   L   N   P   |49  51  53|   55  57  59 |61  63  65|   67  69  71 |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        -------------------------------------------------------------------------------------------------------

              ARGININE  cont.

0155    A U A U                                 U |C C A U G |T F C A A A U |C A U G G |A G A G A G U |A C C A
                                                  |==========|              |==========|************* |
0171    A G A D                                 U |C5F A G G |F F C G A1C U |C C U G G |C U G G C U C |G C C A
                                                  |==  ======|              |======  ==|**********  **|
0172    A G A D                                 U |C5C A G G |F F C G A1C U |C C U G G |C U G G C U C |G C C A
                                                  |==========|              |==========|**********  **|

              A S P A R A G I N E

0210    A U G7U                                 C |A C U G G |T F C G A G U |C C A G U |C A G A G G A |G C C A
                                                  |==========|              |==========|**************|
0220    G G G7U                                 U |G C U G G |T F C G A A U |C C A G C |A G G A.A C C |G C C A
                                                  |==========|              |==========|**************|
0260    A G G7D                                 U |G G U G G |N F C G A1G C |C C A C C |C A G G G A C |G C C A
                                                  |==========|              |==========|******  ******|

              A S P A R T I C   A C I D

0310    G G G7U                                 C |G C G G G |T F C G A G U |C C C G F |C C G U U C C |G C C A
                                                  |  ========|              |========  |******  ******|
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0155/34 MODIFIED URIDINE
0220/37 DERIVATIVE OF ADENOSINE

0260/0 ISOLATED FROM RAT LIVER, HUMAN LIVER, HUMAN PLACENTA, AND SARCOMA
0260/34 IN SARCOMA TRNA G INSTEAD OF Q

```
                               AMINOACYL STEM|    | D STEM  |        D LOOP         |D STEM  |  ANTIC.STEM |  ANTIC.LOOP   ANTIC.STEM
                               1 2 3 4 5 6 7 |8 9 |10  12   |14  16  A   19  A   21 |  23  25|  |27  29  31|  33  35  37  |39  41  43
                                             |    |  11  13 |  15  17  18  20  B    |22  24  |26|  28  30  |32  34  36  38|  40  42
                               --------------|----|---------|-----------------------|--------|--|----------|--------------|----------

            ASPARTIC ACID  cont.

0315        H.VOLCANII         G C C C G G G |U G |G4U G F  |A G U     G G C C C A  |U C A U |A |C G A C C |C U G U C A C |G G U C G
            HALOBACTERIUM SP.  **********  **|    |  ....   |                       |  ....  |  |----------|              |---------
0320        YEAST              U C C G U G A |U A |G U U F  |A A D     G G D C   A  |G A A U |G |G G C G C |F U G U C G1C |G U G C C
                               ********  ****|    |  ....   |                       |  ....  |  |------  --|              |--  -----
0330        PHAGE T5           G C G A C C G |G G |G C U G  |G C U U   G G U A   A  |U G G U |U |C U C C C |C U G U C A C |G G G A G
                               **************|    |  ..     |                       |    ..  |  |----------|              |---------
0340        EUGLENA GRACILIS   U C U U C G G |U A |G U A F  |A G D     G3G D A   A  |G U A U |N*|F C C G C |C U G U C A N*|G C G G A
                               ******  ******|    |  ....   |                       |  ....  |  |----------|              |---------
0360*   GUC MORRIS HEPATOMA    G A G A U A U |U A1|G U A A  |A A U A             A  |U U A C |A |F A A C C |U U G U C A A |G G U U A
            MITO                 ************|    |.........|                       |........|  |----------|              |---------
0361        BOVINE LIVER       G G U G C C G |U A |G2C G F  |A G D     G3G C     A  |N C G N |G |A C U C U |C3U Q1U C A A |A G A G U
                               **************|    |........ |                       |........|  |----------|              |---------


            C Y S T E I N E

0410        E.COLI             G G C G C G U |U4A |A C A A  |A G C     G G D     D  |A U G U |A |G C G G A |F U G C A A5A |F C C G U
                               **************|    |......   |                       |......  |  |  --------|              |--------
0440        YEAST              G C U C G U A |U G |G C G C  |A G D     G G D     A  |G C G C |A |G C A G A |F U G C A A4A |F C U G U
                               **********  **|    |........ |                       |........|  |  --------|              |--------
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                    EXTRA ARM                          | TF STEM  | TF LOOP       |TF STEM   |AMINOACYL STEM|
         45  47  B   D   F   H   J   L   N   P         |49  51  53| 55  57  59    |61  63  65| 67  69  71   |73  75
       44  46  A   C   E   G   I   K   M   O         48| 50  52   |54  56  58  60 | 62  64   |66  68  70  72| 74  76
       --------------------------------------------------------------------------------------------------------------

         ASPARTIC ACID  cont.

0315   U G A                                         C |G C G G G |F*1F C3G2A A U |C C C G C |C U C G G G C |G C C A
                                                       |==========|               |==========|**  **********|
0320   A G A                                         U |C5G G G G |T F C A A U U  |C C C C G |U C G C G G A |G C C A
                                                       |==========|               |==========|****  ********|
0330   A G A A                                       U |G U G G G |T F* C A A A U |C C C A U*|C G G U C G C |G C C A
                                                       |  ========|               |========  |**************|
0340   A G A                                         N*|N* C G G G|T F C A N* U U |C C C G G |C C G G A G A |G C C A
                                                       |==========|               |==========|******  ******|
0360   A G U                                         U |A U A G A |C U U A A A    |U C U A U |A U A U C U U |A C C A
                                                       |==========|               |==========|************  |
0361   G G G7A                                       C5|N U G A G |T F C G A1U A  |C U C A A |C G G C A C C |G C C A
                                                       |  ========|               |========  |**************|


         C Y S T E I N E

0410   C U A                                         G |U C C G G |T F C G A C U  |C C G G A |A C G C G C C |U C C A
                                                       |==========|               |==========|**************|
0440   U G G7D                                       C5|C U U A G |T F C G A1U C  |C U G A G |U G C G A G C |U C C A
                                                       |====  ====|               |====  ====|**  **********|
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0315/54 PARTIALLY F
0330/65 30% PSEUDOURIDINE
0330/55 20% URIDINE
0340/58 MODIFIED ADENOSINE
0340/26 MODIFIED GUANOSINE
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0340/38 MODIFIED CYTIDINE
0340/48 MODIFIED CYTIDINE
0340/49 MODIFIED CYTIDINE
0360/0  MAMMALIAN MITO TRNA CANNOT BE FITTED TO THE GENERALISED CLOVERLEAF
        ARRANGEMENT
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                               AMINOACYL STEM|    | D STEM |        D LOOP        |D STEM  |  | ANTIC.STEM| ANTIC.LOOP   ANTIC.STEM

                               1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37  |39  41  43
                                             |    |  11  13|  15  17  18  20  B   |22  24  |26|  28  30  |32  34  36  38|  40  42
                               ------------------------------------------------------------------------------------------------------

                     G L U T A M I N E

0510  1   E.COLI               U G G G G U A |U4C |G C C A |A G C     G3G D     A |A G G C |A |C C G G U |U3U N*U G A2F |A C C G G
          K12                  **************|    |......  |                      |  ......|  |----------|              |----------
0520  2   E.COLI               U G G G G U A |U4C |G C C A |A G C     G3G D     A |A G G C |A |C C G G A |U3U C U G A2F |F Ç C G G
          K12                  **************|    |......  |                      |  ......|  |----------|              |----------
0525      H.VOLCANII           A G U C C C A |U G |G4G G F |A G U     G G C C A A |U C C U |G |U U G C C |U U N*U G G1G |G G C A A
                               **************|    |  ......|                      |  ......|  |----------|              |----------
0530      PHAGE T4             U G G G A A U |U4A |G C C A |A G D D   G G D     A |A G G C |A |U A G C A |C U N*U G A2C |F G C U A
                               **************|    |......  |                      |  ......|  |----------|              |----------
0531      PHAGE T4             U G G G A A U |U4A |G C C A |A G D D   G G D     A |A G G C |A |U A G C A |C U N*U A A2C |F G C U A
          PSU+2 OC             **************|    |......  |                      |  ......|  |----------|              |----------
0532      PHAGE T4             U G G G A A U |U4A |G C C A |A G D D   G G D     A |A G G C |A |U A G C A |C U C U A A2C |F G C U A
          C34 PSU+2 AM         **************|    |......  |                      |  ......|  |----------|              |----------
0533      PHAGE T5             U G G G G A U |U A |G C U U |A G C U U G G C U C A |A A G C |U |U C G G C |C U U U G A A |G F C G A
                                 ************|    |........|                      |........|  |------  --|              |--  ------
0540      PHAGE T4             U G G G A A U |U4A |G C C C |A A G D D G G D A   A |G G G C |A |U A G C A |C U N*U G A2C |F G C U A
          (FROM PRECURSOR)     **************|    |........|                      |........|  |----------|              |----------

                     G L U T A M I C   A C I D

0610  1   E.COLI               G U C C C C U |U C |G U C F |A G A     G G C C C A |G G A C |A |C C G C C |C U U8U C A2C |G G C G G
          B                    ************* |    |......  |                      |  ......|  |----------|              |----------
0620  2   E.COLI               G U C C C C U |U C |G U C F |A G A     G G C C C A |G G A C |A |C C G C C |C U U8U C A2C |G G C G G
                               **************|    |......  |                      |  ......|  |----------|              |----------
0625      H.VOLCANII           G C U C U G U |U G |G4U G F |A G U C C G G C C A A |U C A U |A |U C A C C |C U N*U C A C |G G U G A
          HALOBACTERIUM SP.    ********  ****|    |  ....  |                      |  ....  |  |----------|              |----------
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```
                     EXTRA ARM                    | TF STEM  | TF LOOP      |TF STEM   |AMINOACYL STEM|
          45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        ------------------------------------------|----------|--------------|----------|--------------|--------

            G L U T A M I N E

0510    C A U U                                 C |C C U G G |T F C G A A U |C C A G G |U A C C C C A |G C C A
                                                  |==========|              |==========|**************|
0520    C A U U                                 C |C G A G G |T F C G A A U |C C U C G |U A C C C C A |G C C A
                                                  |==========|              |==========|**************|
0525    C G A                                   C |C C A G G |F F C3G A A U |C C U G G |U G G G A C U |A C C A
                                                  |==========|              |==========|**************|
0530    G A U G                                 C |A A A G G |T F C G A G U |C C U U U |A U U C C C A |G C C A
                                                  |==========|              |==========|**************|
0531    G A U G                                 C |A A A G G |T F C G A G U |C C U U U |A U U C C C A |G C C A
                                                  |==========|              |==========|**************|
0532    G A U G                                 C |A A A G G |T F C G A G U |C C U U U |A U U C C C A |G C C A
                                                  |==========|              |==========|**************|
                                                              * *
0533    G A U                                   C |A U U G G |T F C A A A U |C C A A U |A U C C C C U |G C C A
                                                  |==========|              |==========|************  |
0540    G A U G                                 C |A A A G G |T F C G A G U |C C U U U |A U U C C C A |G C C A
                                                  |==========|              |==========|**************|

            G L U T A M I C   A C I D

0610    U A A                                   C |A G G G G |T F C G A A U |C C C C U |G G G G A C |G C C A
                                                  |==========|              |==========|  ************|
0620    U A A                                   C |A G G G G |T F C G A A U |C C C C U |A G G G G A C |G C C A
                                                  |==========|              |==========|**************|
0625    U G A                                   C |C5A G G G |F1F C3G A A U |C C C U G |A C G G A G C |A C C A
                                                  |==========|              |==========|****  ********|
```

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
0531/34 N IS AN UNKNOWN DERIVATIVE OF URIDINE

0533/54 30% URIDINE
0533/55 30% URIDINE
0540/34 N IS AN UNKNOWN DERIVATIVE OF URIDINE
0625/34 PARTIALLY MODIFIED

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                                    AMINOACYL STEM |    | D STEM  |       D LOOP           |D STEM  | ANTIC.STEM | ANTIC.LOOP   ANTIC.STEM

                                    1 2 3 4 5 6 7 |8 9 |10  12   |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37 |39  41  43
                                                  |    |   11  13|  15  17  18  20  B    |22  24  |26|  28  30  |32  34  36  38|  40  42
                                    ------------------------------------------------------------------------------------------------------

              GLUTAMIC ACID  cont.

0630    3    YEAST                  U C C G A U A |U A |G U G F  |A A C   G G C D    A    |U C A C |A |F C A C G |C U U9U C A C |C G U G G
                                    **************      ......                              .......     ---------                 --------
0635    1    S.POMBE                U C C G U U G |U G1|G U C C  |A A C   G G C D    A    |G G A U |U |C G U C G |C U U9U C A C |C G A C G
                                    **************        ......                          ......      ----------                ----------
                                                                                                                   *
0670         D.MELANOGASTER         U C C C A U A |U G |G U C F  |A G D   G G C D    A    |G G A U |A |U C U G G |C3U U2U C A C |C C A G A
                                    **************        ....                              ....      ----------                ----------


              G L Y C I N E

0710    1    E.COLI                 G C G G G C G |U4A |G U U C  |A A U   G G D      A    |G A A C |G |A G A G C |U U C C C A A |G C U C U
                                    **************      ........                          ........    ----------                ----------
0711         E.COLI                 G C G G G C G |U4A |G U U C  |A A U   G G D      A    |G A A C |G |A G A G C |U U C U C A A |G C U C U
             SUP T                  **************      ........                          ........    ----------                ----------
                                                                  *
0712         S.TYPHIMURIUM          G C G G G C G |U A |G U U C  |A A U   G3G D      A    |G A A C |G |A G A G C |U U C·C C A A |G C U C U
                                    **************      ........                          ........    ----------                ----------
                                                                  *                                                    *
0713         S.TYPHIMURIUM          G C G G G C G |U A |G U U C  |A A U   G3G D      A    |G A A C |G |A G A G C |U U CCC C A A |G C U C U
             SUF D                  **************      ........                          ........    ----------                ----------
                                                                                                                        *
0720    2    E.COLI                 G C G G G C A |U C |G U A U  |A A U   G G C U    A    |U U A C |C |U C A G C |C U N C C A A |G C U G A
                                    **************      ......                              ......    ----------                ----------
                                                                                                                        *       *
0721    2    E.COLI                 G C G G G C A |U C |G U A U  |A A U   G G C U    A    |U U A C |C |U C A G C |C U N C U N A |G C U G A
             TSU A36                **************      ......                              ......    ----------                ----------
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          45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        ------------------------------------------------------------------------------------------------------

             GLUTAMIC ACID  cont.

0630    A G A                                   C |C5G G G G |T F C G A C U |C C C C G |U A U C G G A |G C C A
                                                  |==========|              |==========|**************|
0635    G G A                                   G |C5G G G G |T F C G A C U |C C C C G |C A A C G G A |G C C A
                                                  |  ========|              |==========|**************|
                                                  | * *
0670    A G G                                   C |C C G G G |T F C G A U U |C C C G G |U A U G G G A |A C C A
                                                  |==========|              |==========|**************|

             G L Y C I N E

0710    A U A                                   C |G A G G G |T F C G A U U |C C C U U |C G C C C G C |U C C A
                                                  |  ========|              |========  |**************|
0711    A U A                                   C |G A G G G |T F C G A U U |C C C U U |C G C C C G C |U C C A
                                                  |  ========|              |========  |**************|
0712    A U A                                   C |G A G G G |T F C G A U U |C C C U U |C G C C C G C |U C C A
                                                  |  ========|              |========  |**************|
0713    A U A                                   C |G A G G G |T F C G A U U |C C C U U |C G C C C G C |U C C A
                                                  |  ========|              |========  |**************|
0720    U G A                                   U |G C G G G |T F C G A U U |C C C G C |U G C C C G C |U C C A
                                                  |==========|              |==========|**************|
0721    U G A                                   U |G C G G G |T F C G A U U |C C C G C |U G C C C G C |U C C A
                                                  |==========|              |==========|**************|
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0670/32 PARTIALLY MODIFIED
0670/49 AND OR 50; IN POSITION 49 AND OR 50 M5C IS PRESENT
0712/18 PARTIALLY MODIFIED
0713/18 PARTIALLY MODIFIED

0713/34 ADDITIONAL C AT POS. 34:1
0720/34 N IS AN UNIDENTIFIED DERIVATIVE OF URIDINE, AND PARTIAL MODIFICATION
0721/34 PARTIALLY N; N IS AN UNIDENTIFIED DERIVATIVE OF URIDINE
0721/37 N IS PROBABLY A 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
		GLYCINE cont.									
0730	3	E.COLI	G C G G G A A	U A	G C U C	A G D D G G D A	G A G C	A	C G A C C	U U G* C C A A	G G U C G
			**************		....		....		----------		----------
0731		E.COLI SU+ A78	G C G G G A A	U A	G C U C	A G D D G G D A	G A G C	A	C G A C C	U U G C A A5A	G G U C G
			**************		....		....		----------		----------
0740	1A	S.EPIDERMIDIS TEXAS 26	G C G G G A G	U4A	U U U C	A A C U U U D A	G A A U	A	C G U U C	C U U C C C G	G A A C G
			******** ****		......		......		----------		----------
0750	1B	S.EPIDERMIDIS TEXAS 26	G C G G G A G	U4A	G U U C	A A U U U D A	G A A C	A	C A U U C	C U U C C C G	G A A U G
			******** ****		....		....		----------		----------
0755	1	B.SUBTILIS	G C G G G U G	U A	G U U U	A G U G G D A	A A A C	C	U C A G C	C U V4C C A A	G C U G A
			**************		....		....		----------		----------
0757		M.MYCOIDES SUBSP.CAPRI	G C A G G U G	U4A	G U U U	A A U G G C A	G A A C	U	U C A G C	C U U C C A6A	G C U G A
			**************		......		......		----------		----------
0760		PHAGE T4	G C G G A U A	U C	G U A U	A A U G3G D A	U U A C	C	U C A G A	C U N* C C A A	F C U G A
			**************		......		......		----------		----------
0770		YEAST	G C G C3A A G	U G1	G U U F	A G D G G D A	A A A U	C	C A A C G	F U G C C A F	C G U U G
			**************		......		......		----------		----------
0775		YEAST MITO	A U A G A U A	U A	A G U U	A A U D G G D A	A A C U	G4	G A U G F	C U U C C N* A	A C A U U
			**************		....		....		--------		--------
0780	1	WHEAT GERM	G C A C3C A G	U G1	G U C F	A G D G G U A	G A A U	A	G U A C C	C U G C C A C5	G G U A C
			**************		..		..		----------		----------

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                              EXTRA ARM                              | TF STEM  | TF LOOP      | TF STEM  |AMINOACYL STEM|
          45    47    B     D     F     H     J     L     N     P    |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
       44    46    A     C     E     G     I     K     M     O     48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
       --------------------------------------------------------------|----------|--------------|----------|--------------|--------

          GLYCINE  cont.

0730   G  G  G7U                                                   C |G C G A G |T F C G A G U |C U C G U |U U C C C G C |U C C A
                                                                     |  ========|              |========  |**************|
0731   G  G  G7U                                                   C |G C G A G |T F C G A G U |C U C G U |U U C C C G C |U C C A
                                                                     |  ========|              |========  |**************|
0740   A  G  A                                                     U |A U A G G |U G C A A A U |C C U A U |C U U C C G C |U C C A
                                                                     |==========|              |==========|****  ********|
0750   A  G  G                                                     U |A U A G G |U G C A A G U |C C U A U |C U U C C G C |U C C A
                                                                     |==========|              |==========|****  ********|
0755   U  G  U                                                     C |G U G A G |T F C G A U U |C U C A U |C A C C C G C |U C C A
                                                                     |  ========|              |========  |**************|
0757   U  U  G                                                     U |G A G G G |U F C G A U U |C C C U U |C A C C U G C |U C C A
                                                                     |  ========|              |========  |**************|
0760   U  G  A                                                     U |G U G A G |T F C G A U U |C U C A U |U A U C C G C |U C C A
                                                                     |  ========|              |========  |**************|
0770   G  G                                                        C |C5C C G G |T F C G A U U |C C G G G |C U U G C G C |A C C A
                                                                     |==========|              |==========|**************|
0775   G  A  A                                                     U |G C G A G |T F C G A U U |C U C G C |U A U C U A U |A C C A
                                                                     |==========|              |==========|**************|
0780   A  G  A                                                     C5|C5C5G G G |U F C G A1U U |C C C G G |C U G G U G C |A C C A
                                                                     |==========|              |==========|**************|
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0730/34 MUTATION E.COLI INS HAS G-34 = U-34
0760/34 PROBABLY RELATED TO MAM5S2U
0775/37 IS I6A OR MS2I6A

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                               AMINOACYL STEM      D STEM        D LOOP         D STEM   ANTIC.STEM  ANTIC.LOOP  ANTIC.STEM

                                1 2 3 4 5 6 7 8 9 10  12  14  16  A   19  A   21  23  25  27  29  31  33  35  37  39  41  43
                                                    11  13  15  17  18  20  B   22  24  26  28  30  32  34  36  38  40  42
                                --------------------------------------------------------------------------------------------

            GLYCINE  cont.

0790    1   BOMBYX MORI         G C A U3C G G U G1G U U C A G U     G G D     A G A A U G C U C G C C U G C C A C5G C G G G
                                ***************     ......                      ......    --  ------              ------  --
0791    2   BOMBYX MORI         G C G U3U G G U G1G U G F A A D     G G D C   A G C A U A G F U G C C U N*C C A A G C A G U
                                ***************     ....                          ....        ------              ------
                                      *   *
0792    GCC HUMAN PLACENTA      G C A U3U G2G U G G U U C A G U     G G D     A G A A U U C U C G C C U G C C A C5G C G G G
                                ***************     ......                      ......    --  ------              ------  --
                                      *   *
0793    CCC HUMAN PLACENTA      G C G C3C G2C U G G U G F A G U     G G D     A U C A U G C A A G A U3U C C C A U F3C U U G
                                ***************     ....                          ....    ----------              ----------

            H I S T I D I N E

0810*   1   E.COLI            G G U G G C U A U4A G C U C A G D D   G G D     A G A G C C C U G G A U U Q U G A2F*F*C C A G
                                ***************   .........                     ......... ----------              ----------
0820        PHAGE T5          U G U G G C U A U A U C A U A A U U   G G U U   A A U G G U C C U G A U U G U G A A F*C A G G
                                ***************     ......                      ......    ----------              ----------
0840        YEAST             G G U G A A U A U A U U U C A A D     G G D     A G A A A A F A C G C F U G U G G1F G C G U U
            MITO                ***************   .........                     .........   --------              --------
0870        D.MELANOGASTER    G G C C G U G A U C G U C F A G D     G G D D   A G G A C C C C A C G F U G U G G1C C G U G G
                                ***************   ......                        ......    ----------              ----------
0871        SHEEP LIVER       G G C C G U G2A U C G U A F A G U     G G D D   A G U A C U C U G C G F U Q U G G1C C G C A G
                                ***************   ......                          ......  ----------              ----------
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                        EXTRA ARM                 |TF STEM   |   TF LOOP    |TF STEM   |AMINOACYL STEM|

          45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        ------------------------------------------------------------------------------------------------------

            GLYCINE  cont.

0790    C G G                                   C5|C5C5G G G |T F C G A1U U |C C C G G |C C G A U G C |A C C A
                                                  |==========|              |==========|**************|
0791    U G A                                   U |C5C5G G G |T F C G A1U U |C C C G G |C C A A C G C |A C C A
                                                  |==========|              |==========|**************|
0792    A G G                                   C5|C5C5G G G |T F C G A1U U |C C C G G |C C A A U G C |A C C A
                                                  |==========|              |==========|**************|
                                                  |          |        *     |          |              |
0793    C G A                                   C |C5C5G G G |T F C G A1U U |C C C G G |G C G G C G C |A C C A
                                                  |==========|              |==========|**************|

            H I S T I D I N E

0810    U U G7U                                 C |G U G G G |T F C G A A U |C C C A U |U A G C C A C |C C C A
                                                  |  ========|              |========  |**************|**
0820    C C U A                                 U |G U G G A |T F C G A A U |U C U A C |U A G C C A C |A C C A
                                                  |====  ====|              |====  ====|**************|**
0840    A A A                                   U |C U G A G |T F C G A U U |C U C A G |U A U U C A C |C C C A
                                                  |==========|              |==========|**************|**
0870    U A A                                   C |C C5A G G |U F C G A1A U |C C U G G |U C A C G G C5|A C C A
                                                  |==========|              |==========|**************|
0871    C A A                                   C |C5U C G G |U F C G A1A U |C C G A G |U C A C G G C5|A C C A
                                                  |==========|              |==========|**************|
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         (1980) J.BIOCHEM. 88, 1151-1157
0792/4 PARTIALLY MODIFIED
0792/6 PARTIALLY MODIFIED
0793/4 PARTIALLY MODIFIED

0793/6 PARTIALLY MODIFIED
0793/58 PARTIALLY MODIFIED
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

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                              AMINOACYL STEM|    | D STEM |        D LOOP        |D STEM  | ANTIC.STEM |ANTIC.LOOP    ANTIC.STEM
                              1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25| |27  29  31|  33  35  37  |39  41  43
                                            |    |  11  13|  15  17  18  20  B   |22  24  |26  28  30  |32  34  36  38|  40  42
                              --------------|----|--------|----------------------|--------|-|----------|--------------|----------

            ISOLEUCINE

0910    1   E.COLI            A G G C U U G |U A |G C U C |A G G D*  G G D D   A |G A G C |G|C A C C C |C U G A U A7A |G G G U G
                              ********  ****|    |........|                      |........| |----------|              |----------
0911*   2   E.COLI            G G C C C C U |U4A |G C U C |A G U     G3G D D   A |G A G C |A|A G C G A |C U N A U A7A |F C G C U
                              **************|    |........|                      |........| |----------|              |----------
0913        H. VOLCANII       G G G C C A A |U A |G C U C |A G U C A G G U     U |G A G C |G4C F C G G |C U G A U N A |C C5G G G
                              **************|    |........|                      |........| |--  ------|              |------  --
0915*       PHAGE T4          G G C C C U G |U A |G C U C |A A U     G3G D D A G |C A G C |A|G U C C C |C U N A U N*A |G G G A A
                              **  ******  **|    |......  |                      |  ......| |  --------|              |--------
0920        T.UTILIS          G G U C C C U |U G |G2C C C |A G D D   G G D D   A |A G G C |G4F G G U G |C U I A U A7A |C G C C A
                              **************|    |......  |                      |  ......| |------  --|              |--  ------
0950        YEAST             G A A A C U A |U A |A U U C |A A D D   G G D U   A |G A A U |A|G U A U F |U U G A U A7A |G G U A C
            MITO              **************|    |........|                      |........| |------    |              |    ------

            LEUCINE

1010**  1   E.COLI            G C G A A G G |U G |G C G G |A A D D   G3G D A   G |A C G C |G|C U A G C |U U C A G N*F*|G F*U A G
            B/K12             ********  ****|    |......  |                      |  ......| |------  --|              |--  ------
1011*   2   E.COLI            G C C G A G G |U G |G U G G |A A D D   G3G D A   G |A C A C |G|C U A C C |U U G A G N*F |G G U A G
            K12               ************  |    |......  |                      |  ......| |----------|              |----------
1012    5   E.COLI            G C C C G G A |U4G |G U G G |A A D C   G3G D A   G |A C A C |A|A G G G A |F U N*A A A5A |F C C C U
                                ************|    |......  |                      |  ......| |----------|              |----------
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                       EXTRA ARM                  |TF STEM   |TF LOOP       |TF STEM   |AMINOACYL STEM|

          45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        ------------------------------------------|----------|--------------|----------|--------------|--------

                ISOLEUCINE

0910    A G G7X*                                C |G G U G G |T F C A A G U |C C A C F |C A G G C C U |A C C A
                                                  |  ========|              |========  |****  ********|
0911    U G G7X                                 C |G C U G G |T F C A A G U |C C A G C |A G G G G C C |A C C A
                                                  |==========|              |==========|**************|
0913    A G G C                                 C |C5G C G G |  F C3G2A A U |C C G C G |U U G G C C C |A C C A
                                                  |==========|              |==========|**************|
0915    A G G7U                                 U |A C C A G |T F C A A A U |C U G G U |C U G G G U C |A C C A
                                                  |==========|              |==========|**  ******  **|
0920    A G A D                                 C5|A G C A G |T F C G A1U C |C U G C U |A G G G A C C |A C C A
                                                  |==========|              |==========|**************|
0950    A A A                                   U |A U A G G |T F C A A U C |C C U G U |U A G U U U C |A C C A
                                                  |==  ======|              |======  ==|**************|


                LEUCINE

1010    U G U C C U U A C G G A C G             U |G G G G G |T F C A A G U |C C C C C |C C C U C G C |A C C A
          ::::::::        ::::::::                |==========|              |==========|****  ********|
1011    U G C C C A A U A G G G C U             U |A C G G G |T F C A A G U |C C C G U |C C U C G G U |A C C A
          ::::::::        ::::::::                |==========|              |==========|************  |
1012    C G G C G U U C G C G C U G             U |G C G G G |T F C A A G U |C C C G C |U C C G G G U |A C C A
        ::  ::::::        ::::::  ::              |==========|              |==========|************  |
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0910/17 PARTIALLY MODIFIED
0910/47 PROBABLY X
0911/0 DESIGNED AS TRNA-ISOLEUCINE-MINOR
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
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.LETT. 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

			AMINOACYL STEM		D STEM	D LOOP	D STEM	ANTIC.STEM		ANTIC.LOOP	ANTIC.STEM
			1 2 3 4 5 6 7	8 9	10 12 11 13	14 16 A 19 A 21 15 17 18 20 B	23 25 22 24	26	27 29 31 28 30	33 35 37 32 34 36 38	39 41 43 40 42
		LEUCINE cont.									
1015		H.VOLCANII HALOBACTERIUM SP.	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 G1G	C5G C U G ----------
1030		PHAGE T4	G C G A G A A **************	U G	G U C A	A A D D G3G D A A	A G G C	A	C A G C A ----------	C U N* A A A5A	F G C U G ----------
1031		PHAGE T5	G G G G C U A **************	U G	C U G G	A A C U G3G D A G	A C A A	U	A C G G C --------	C U U A G A6U	F C C G U --------
1040	3	YEAST	G G U U G U U ********** **	U G	G2C C4G	A G C G3G D C D A	A G G C	G4	C C U G A ----------	F U C5A A G1C	F C A G G ----------
1050		YEAST	G G G A G U U ** ****** **	U G	G2C C4G	A G D G3G D D D A	A G G C	G4	F C A G A ----------	F U U A G G1C	F C U G A ----------
1055	1	N.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	2	N.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 G1C	C G G A A ----------
1057	CAA	ANACYSTIS NIDULANS	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 NIDULANS	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 G1F	F C U A G ----------

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                        EXTRA ARM                  TF STEM    TF LOOP     TF STEM   AMINOACYL STEM

          45  47  B   D   F   H   J   L   N   P   49  51  53  55  57  59  61  63  65  67  69  71  73  75
        44  46  A   C   E   G   I   K   M   O   48  50  52  54  56  58  60  62  64  66  68  70  72  74  76
        --------------------------------------------------------------------------------------------------

            LEUCINE  cont.

1015    U C C U G U A G A G G U C               C5G C C G G   F C3G2A A U C C G G U C C C A C G C A C C A
          ::::::        ::::::                      ========              ========  **************
1030    C G G A A U G A U U U C C U             U G U G G G T F C G A G U C C C A C U U C U C G C A C C A
          ::::::::        ::::::::                ==========              ==========**************
1031    A G C U U A A A U G C G                 U G G G A G T F C G A G U C U C C C U A G C C C C A C C A
          ::::            ::::                    ==========              ==========**************
1040    U A U C G U A A G A U G                 C5A A G A G T F C G A A U C U C U U A G C A A C C A C C A
          ::::::        ::::::                    ==========              ==========**  **********
1050    U A U C U U C G G A U G                 C5A A G G G T F C G A1A U C C C U U A G C U C U C A C C A
          ::::::        ::::::                    ==========              ==========**  ******  **
1055    G G G C U U C A A G C U G               U G A A G G T F C A A G U C C U U C U U C G G A U A C C A
            ::::::      ::::::                    ==========              ==========  ************
1056    U G G U U U A A A A A C U G             U A C A A G T F C A A G U C U U G U C A U C U A U A C C A
            ::::::        ::::::                  ==========              ==========****  ********
1057    C G C U A G C G A U A G U G             U G U G G G T F C G A G U C C C A C C U U G C C C A C C A
        ::  ::::::        ::::::  ::              ==========              ==========**************
1058    U G G U U U C A C G A C U G             U C C G G G T F C A A G U C C C G G G U U C C G C A C C A
            ::::        ::::                      ==========              ==========**************
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1030/34 N IS A DERIVATIVE OF URIDINE
1055/34 N IS A MODIFIBD URIDINE
1057/37 IS A MODIFIED 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 12 11 13	14 16 A 19 A 21 15 17 18 20 B	23 25 22 24	26	27 29 31 28 30	33 35 37 32 34 36 38	39 41 43 40 42
		LEUCINE cont.									
1060		T.UTILIS	G G A U C U U ********** **	U G	G2C C4A	A G C G3G D D U A	A G G C	G4	C U C G A ----------	C3U C3A A G1A	F C G A G ----------
1070		S.POMBE SUP 8-E	G C G G C U A ********** **	U G	C C C4G	A G D G G D G D A	A G G G	G4	G C A G A --------	F U N* C A G1C	C C U G C --------
1074		YEAST MITO	G C U A U U U **************	U G	G U G G	A A D D* G G D A G	A C A C	G4	A U A C F --------	C U N* A A G1A	F G U A U --------
1075	1	BEAN CHLORO	G G G G A U A **************	U G	G C G A	A A U U G3G D A G	A C G C	F	A C G G A ----------	C U N* A A A*4A	F C C G U ----------
1076	2	BEAN CHLORO	G G C U U G A ** **********	U G	G U G A	A A U U G3G D A G	A C A C	G	C G A G A ----------	C U C3A A N* A	U C U C G ----------
1077	3	BEAN CHLORO	G C C G C U A **************	U G	G U G A	A A U U G3G D A G	A C A C	G	C U G C U ----------	C U U A G7G1A	A G C A G ----------
1078	3	SPINACH CHLORO	G C C G C U A **************	U G	G U G A	A A U U G3G D A G	A C A C	G	C U G C U ----------	C U U A G7G1A	A G C A G ----------
1080		BOVINE LIVER	G G U A G C G **** ********	U G	G2C C4G	A G C G G D C F A	A G G C	G4	C U G G A ----------	F3U I A G G1C	F C C A G ----------
1081		MORRIS HEPATOMA	G U C A G G2A ********** **	U G	G*2C C*4G	A G U G G D C F A	A G G C	G4	C C A G A ----------	C U N* A A N* F	F C U G G ----------

1060 A.MURASUGI,S.TAKEMURA(1978) J.BIOCHEM. 83, 1029-1038
1070 R.WETZEL,J.KOHLI,F.ALTRUDA,D.SOELL (1979) MOL.GEN.GEN. 172 , 221-228
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
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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

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                         EXTRA ARM                      | TF STEM  | TF LOOP      | TF STEM  |AMINOACYL STEM|
          45  47  B   D   F   H   J   L   N   P        |49  51  53| 55  57  59   |61  63  65| 67  69  71   |73  75
        44  46  A   C   E   G   I   K   M   O   48     | 50  52   |54  56  58  60|  62  64  |66  68  70  72| 74  76
        ---------------------------------------------------------------------------------------------------------

               LEUCINE  cont.

1060    U A U C G U A A G A U G                      C5|A U G A G|T F C G A1A U|C U C A U|A G G A U C C|A C C A
          ::::::      ::::::                           |=========|             |=========|**  *********|
1070    U G U U G U A A A A C G                      C5|G A G A G|T F C G A1A C|C U C U C|U G G C C G C|A C C A
          ::::::      ::::::                           |=========|             |=========|**  *********|
1074    U A C U U U A C A G U A                      U |G A A G G|T F C A A G U|C C U U U|A A A U A G C|A C C A
        ::::::::      ::::::::                         |  =======|             |=======  |*************|
1075    C G A C U U A A U A A A U C A                U |G A G G G|T F C A A G U|C C C U C|U A U C C C C|A C C A
          ::::  ::::        ::::  ::::                 |=========|             |=========|*************|
1076    U G C U A A A G A G C G                      U |G G A G G|T F C G A G U|C C U C U|U C A A G U C|A C C A
          ::::::      ::::::                           |  =======|             |=========|**********  **|
1077    U G C U A G A G C A                          U |C U C G G|T F C G A G U|C C G A G|U A G C G G C|A C C A
        ::::::      ::::::                             |=========|             |=========|*************|
1078    U G C G A G A G C A                          U |C U C G G|T F C G A G U|C C G A G|U A G Ç G G C|A C C A
        ::::::      ::::::                             |=========|             |=========|*************|
1080    U C F C F U C G G G G G                      C5|G U G G G|T F C G A1A U|C C C A C|C G C U G C C|A C C A
          ::  ::      ::  ::                           |  =======|             |=========|********  ****|
1081    N*F C C G U*A U G G A G                      C5|G U G G G|T F C G A1A U|C C C A C|U U C U G A C|A C C A
          ::::::      ::::::                           |=========|             |=========|**  *********|
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1070/34 N IS A DERIVATIVE OF URIDINE
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
1081/47:2 (B) ISOACCEPTOR : A

			AMINOACYL STEM 1 2 3 4 5 6 7	8 9	D STEM 10 12 11 13	D LOOP 14 16 A 19 A 21 15 17 18 20 B	D STEM 23 25 22 24	26	ANTIC.STEM 27 29 31 28 30	ANTIC.LOOP 33 35 37 32 34 36 38	ANTIC.STEM 39 41 43 40 42
		LEUCINE cont.									
1082		COW MAMMARY GLAND	G U C A G G2A	U G	G2C C4G	A G C G G D D C A	A G G C	G4	C U G C G	U3U C A G G1N	C G C A G
			********** **		......		......		----------		----------
1083		MORRIS HEPATOMA MITO	A C U U U* U A	U A1	G2G A U	A G A A G D A	A U C C	A	F U G G U	C U U A G G1A	A C C A A
			**************		....		....		----------		----------
		L Y S I N E									
1110		E.COLI B	G G G U C G U	U A	G C U C	A G D D G G D A	G A G C	A	G U U G A	C U U8U U A7A	F C A A U
			**************		....		....		--------		--------
1115		H.VOLCANII HALOBACTERIUM SP.	G G G C C G G	U A	G C U C	A N U U A G G C A	G A G C	G4	U C U G A	C3U N* U U N A	U C A G A
			**************		....		....		----------		----------
1120		B.SUBTILIS	G A G C C A U	U A	G C U C	A G U D G G D A	G A G C	A	U C U G A	C U V*5U U A*9A	F C A G A
			**************		....		....		----------		----------
1130	1	YEAST (HAPLOID)	G C C U U G U	U G*2	G2C G C	A A D C G G D A	G C G C	G4	F A U G A	C U C U U A7A	F C A U A
			****** ******		....		....		----------		----------
1140*	2	YEAST	F C C U U G U	U A	G2C U C	A G D D G G D A	G A G C	G4	F F C G G	C U U9U U A7A	C C G A A
			******** **		....		....		----------		----------
1170	2	D.MELANOGASTER	G C C C G G C	U A	G2C U C	A G D C G G D A	G A G C	A	F G A G A	C U C U U A7A	F C U C A
			******** **		....		....		----------		----------
1181	1	RABBIT LIVER	G C C C G G C	U A	G2C U C	A G D C G G D A	G A G C	A	F G G G A	C U C U U A7A	F C C C A
			******** **		....		....		----------		----------

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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
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                          EXTRA ARM                     | TF STEM  | TF LOOP       |TF STEM  |AMINOACYL STEM|
         45 47 B  D  F  H  J  L  N  P                   |49 51 53  | 55 57 59      |61 63 65 | 67 69 71     |73 75
       44 46 A  C  E  G  I  K  M  O                   48| 50 52    |54 56 58 60    | 62 64   |66 68 70 72   | 74 76
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          LEUCINE  cont.

1082   U3C F C C C U G G A G G                        C5|G U G G G |T F C G A1A U  |C C C A C|U U C U G A C |A C C A
            ::::::      ::::::                          |==========|               |=========|**  **********|
1083   A A A                                          C |C5U U G G |U G C A A C U  |C C A A A|U A A A A G U |A C C A
                                                        |  ========|               |======== |**************|


          L Y S I N E

1110   U G G7X                                        C |G C A G G |T F C G A A U  |C C U G C|A C G A C C C |A C C A
                                                        |==========|               |=========|**************|
                                                        |      *   |*
1115   C G G U                                        C5|G C G F G |N F C3G2A A U  |C G C G U|C C G G C C C |A C C A
                                                        |  ====  ==|               |==  ==== |**************|
1120   G G G7U                                        C |G A A G G |T F C G A G U  |C C U U C|A U G G C U C |A C C A
                                                        |==========|               |=========|**************|
                                                        |          |        *      |         |              |
1130   A G G7U                                        U |A G G G G |T F C G A1G C  |C C C C U|A C A G G G C |U C C A
             *                                          |==========|               |=========|******  ******|
1140   A U G7D                                        C5|A G G G G |T F C G A1G C  |C C C C U|A F G A G G A |G C C A
                                                        |==========|               |=========|**    ********|
                                                        |          | * *           |         |              |
1170   G G G7D                                        C |G U G G G |N U C G A1G C  |C C C A C|G U U G G G C |G C C A
                                                        |==========|               |=========|**    ********|
1181   G G G7D                                        C5|G U G G G |T3F C G A1G C  |C C C A C|G U U G G G C |G C C A
                                                        |==========|               |=========|**    ********|
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1083/5 PARTIALLY GUANOSINE
1115/34 PARTIALLY MODIFIED TO UNIDENTIFIED DERIVATIVE OF CYTIDINE
1115/52 PARTIALLY MODIFIED
1115/54 N IS AN UNIDENTIFIED DERIVATIVE OF URIDINE
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

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
1170/54 N IS VERY LIKELY TM
1170/55 U IS PROBABLY PARTLY MODIFIED TO F

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                               AMINOACYL STEM|    |D STEM  |       D LOOP         |D STEM  |   |ANTIC.STEM|ANTIC.LOOP    |ANTIC.STEM
                               1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25|   |27  29  31|  33  35  37  |39  41  43
                                             |    |  11  13|  15  17  18  20  B   |22  24  |26 |  28  30  |32  34  36  38|  40  42
                               --------------|----|--------|----------------------|--------|---|----------|--------------|----------

           LYSINE  cont.

1182   2   RABBIT LIVER        G C C C G G C |U A |G2C U C |A G D C   G G D     A |G A G C |A  |F G A G A |C U C U U A7A |F C U C A
                               ********    **|    |........|                      |........|   |--------- |              |---------
1183   3   RABBIT LIVER        G C C C G G A |U A |G2C U C |A G D C   G G D     A |G A G C |A  |F C A G A |C U U9U U A9A |F C U G A
                               *********** **|    |........|                      |........|   |--------- |              |---------
                                                                                                *                    *
1184       MOUSE FIBROBLAST    G C C C G G C |U A |G2C U C |A G D C   G G U     A |G A G C |A  |F G A G A |C U C U U N A |F C U C A
           (SV 40 TRANSFORMED) ********    **|    |........|                      |........|   |--------- |              |---------

           M E T H I O N I N E
                                                                *     *
1210   1   E.COLI              G G C U A C G |U4A |G C U C |A G D D   G3G D D   A |G A G C |A  |C A U C A |C U C4A U A7A |F G A U G
           CA 265              **************|    |........|                      |........|   |--------- |              |---------
1230       B. SUBTILIS         G G C G G U G |U A |G C U C |A G C     G G C D   A |G A G C |G  |U A C G G |U U C A U A6C |C C G U G
                                 ********  **|    |........|                      |........|   |  ------- |              |-------
                                                                                                *
1235       SCENEDESMUS OBLIQUUSG C C U G C U |F A |G C U C |A G U D   G3G C C   A |G A G C |A  |N C C G F |F U C A U A2C |G C G G A
           CHLORO              **************|    |........|                      |........|   |  -----   |              |  -----
                                                                                               **
1240   3   YEAST               G C U U C A G |U A |G2C U C |A G D A   G G A     A |G A G C |G4 |F C A G F |C U C A U A7A |F C U G A
                               ******  ******|    |........|                      |........|   |-------   |              |  -------
1245       SPINACH             A C C U A C U |U A |A C U C |A G C     G3G D D   A |G A G F |A  |F F G C F |U U C A U A C |G G C G G
           CHLORO              **************|    |........|                      |........|   |    ---   |              |  ---
                                                                                                               *
1250*      MAMMALIAN           G C C U C G2U |U A |G2C G C |A G D A   G G D     A |G C G C |G4 |F C A G F |C U C3A U A7A |F C U G A
                               ******  ******|    |........|                      |........|   |-------   |              |  -------
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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,
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                             EXTRA ARM                | TF STEM | TF LOOP      |TF STEM  |AMINOACYL STEM|
           45  47  B   D   F   H   J   L   N   P      |49 51  53| 55  57  59   |61 63  65| 67  69  71   |73  75
         44  46  A   C   E   G   I   K   M   O      48| 50  52  |54  56  58  60| 62  64  |66  68  70  72| 74  76
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              LYSINE  cont.
1182     G G G7D                                    C5|G U G G G|T3F C G A1G C|C C C A C|G U U G G G C|G C C A
                                                      |=========|             |=========|**   ********|
1183     G G G7D                                    C5|C5A G G G|T3F C A A1G U|C C C U G|U U C G G G C|G C C A
                                                      |=========|             |=========|** **********|
1184     G G G7D                                    C5|G U G G G|U*F C G A1G C|C C C A C|G U U G G G C|G C C A
                                                      |=========|             |=========|**   ********|

             M E T H I O N I N E

1210     G G G7X                                    C |A C A G G|T F C G A A U|C C C G U|C G U A G C C|A C C A
                                                      |====  ===|             |====  ===|*************|
1230     A G G7D                                    C |G G G G G|T F C G A U C|C C C U C|C G C C G C U|A C C A
                                                      |==  =====|             |=====  ==|**  ******** |
1235     A A G7D                                    C |A C U A G|T F C G A A U|C U A G U|A G C A G G C|N C C A
                                                      |=========|             |=========|*************|
1240     A G G7D*                                   C5|G A G A G|T F C G A1A C|C U C U C|C U G G A G C|A C C A
                                                      |=========|             |---------|******  *****|
1245     G A G7X                                    C |A U U G G|T F C A A A U|C C A A U|A G U A G G U|A C C A
                                                      |=========|             |=========|*************|
1250     A G G7D                                    C5|G U G A G|T F C G A1U C|C U C A C|A C G G G G C|A C C A
                                                      |=========|             |=========|*****  ******|
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1184/27 PARTIALLY MODIFIED
1184/37 N IS PROBABLY A·PRECURSOR OF T6A
1184/54 CONTAINS U, T, TM AND F
1210/16 PARTIALLY MODIFIED
1210/18 PARTIALLY MODIFIED
1235/27 N IS A MODIFIED URIDINE

1240/26 PARTIALLY MODIFIED
1240/27 PARTIALLY MODIFIED
1240/47 PARTIALLY MODIFIED
1250/0 MOUSE MYELOMA AND RABBIT LIVER
1250/34 PARTIALLY MODIFIED

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                              AMINOACYL STEM       D STEM        D LOOP         D STEM   ANTIC.STEM  ANTIC.LOOP  ANTIC.STEM

                                1 2 3 4 5 6 7 8 9 10  12  14  16  A   19  A   21  23  25  27  29  31  33  35  37  39  41  43
                                                    11  13  15  17  18  20  B   22  24  26  28  30  32  34  36  38  40  42
                                --------------------------------------------------------------------------------------------

             METHIONINE  cont.
                                                                                        *
1255        T.ACIDOPHILUM       G C C G G G G U4G G C U C A N C U   G G A     G G A G C G4C C G G A C3U C A U A7A U C C G G
                                *************     .........                     ........  ----------              ----------
1260        TETRAHYMENA THERMOPHA G C A G G G U G1G C G A A A D     G3G A     A U C G C G U F G G G C U C A U A7A C F C A A
            CYTO                **********  **    .........                     ........  ------  --              --  ------
1265        RAT                 G C U U G U A U A G U U U A A D D   G G D U   A A A A C A U U U G F C U C A U A7A A U A A A
            MITO                  *************   .........                     ........  ------  --              --  ------

             M E T H I O N I N E - I N I T I A T O R

1310        E.COLI              C G C G G G G U4G G A G C A G C C U G G D     A G C U C G U C G G G C3U C A U A A C C C G A
            CA 265                *************   .........                     ........  ----------              ----------
1315        H.VOLCANII          A G C G G G A U G G G A F A N C C A G G A G   A U U C C G C C G   G G G C U C A U A A C C C
            HALOBACTERIUM SP.   ***************   ......                          ......  ----==  ------              ------
1320    1   T.THERMOPHILUS      C G C G G G G U4G G A G C A G C C U G3G D     A G C U C G U C G G G C3U C A U A A C C C G A
                                  *************   .........                     ........  ----------              ----------
1321    2   T.THERMOPHILUS      C G C G G G G U4G G A G C A G C C U G3G D     A G C U C G U C G G G C3U C A U A A C C C G A
                                  *************   .........                     ........  ----------              ----------
1330        B.SUBTILIS          C G C G G G G U G G A G C A G U U C G G D     A G C U C G U C G G G C U C A U A A C C C G A
                                  *************   .........                     ........  ----------              ----------
1340        ANACYSTIS NIDULANS  C G C G G G G U A G A G C A G C C U G G D     A G C U C G U C G G G C3U C A U A A C C C G A
                                  *************   .........                     ........  ----------              ----------
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                      EXTRA ARM                 |TF STEM  |  TF LOOP    |TF STEM  |AMINOACYL STEM
            45  47  B   D   F   H   J   L   N   P |49 51 53 | 55 57 59    |61 63 65 | 67 69 71    |73 75
          44  46  A   C   E   G   I   K   M   O 48|  50 52  |54 56 58 60  |  62 64  |66 68 70 72  | 74 76
          -----------------------------------------------------------------------------------------------

              METHIONINE  cont.

1255      A G G U                               C |U C G G G|F F C3G A U C|C C C G A|U C C C G G C|A C C A
                                                  |=========|             |=========|  ***********|
1260      A A G7U                               C5|A G A G G|A F C G A1A A|C C U C U|C U C U G C U|A C C A
                                                  |=========|             |=========|**  *********|
1265      U A A                                 U |GUA A G G|T F C A A U U|C C U U C|U A C A A G U|A C C A
                                                  |  =======|             |=========|***********  |

              METHIONINE-INITIATOR
              *
1310      A G G7U                               C |G U C G G|T F C A A A U|C C G G C|C C C C G C A|A C C A
                                                  |==  =====|             |=====  ==|***********  |
1315      G G A G A U                             |  C G G U|A F C3G2A A U|C U A C C|U C C C G C U|A C C A
          ----                                    |    =====|             |=========|*************|
1320      A G G7U                               C |G C C G G|T2F C A A1A U|C C G G C|C C C C G C A|A C C A
                                                  |=========|             |=========|***********  |
1321      A G G7U                               C |G C G G G|T2F C A A1A U|C C C G C|C C C C G C A|A C C A
                                                  |=========|             |=========|***********  |
1330      A G G U                               C |G C A G G|T F C A A A U|C C U G C|C C C C G C A|A C C A
                                                  |=========|             |=========|***********  |
1340      A G G7U                               C |A G A G G|T F C A A A U|C C U C U|C C C C G C C|A C C A
                                                  |=========|             |=========|***********  |
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1255/26 GUANOSINE DERIVATIVE

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

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                                AMINOACYL STEM |    | D STEM  |        D LOOP            |D STEM   | ANTIC.STEM   | ANTIC.LOOP    ANTIC.STEM

                                1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A     21|  23  25 |  27  29  31| 33  35  37  |39  41  43
                                              |    |  11  13| 15  17  18  20  B      |22  24   |26  28  30  |32  34  36  38| 40  42
                                -----------------------------------------------------------------------------------------------------

             METHIONINE-INITIATOR  cont.

1350   MYCOPLASMA SP.           C G C G G G G |U4A |G A G C |A G U D*    G G D     A |G C U C |G |C C G G G |C U C A U A A |C C C G G
                                **************     ........                          .........   ----------                -----------
1354   SCENEDESMUS OBLIQUUSC    G C A G G A   |U A |G A G C |A G U C U G3G D        A |G C U C |G4F G G G G |C U C A U A A |F C C C A
       CHLORO                     ************     ........                          .........   --------                    ---------
1355   SCENEDESMUS OBLIQUUSA    G C U G A G   |U G1G2C G C |A G D       G G A      A |G C G F |G2A F G G G |C U C A U A7A |C C C A U
                                **************       ......                          ......      ----------                -----------
1360   N.CRASSA                 U G C G G A U |U A |U U G U |A A D       A G D      A |A C A U |A |U U U G G |C U C A U G1N*|C C G A A
       MITO                     **************       ......                          ......      ----  ----                ----  ----
1370   N.CRASSA                 A G C U G C A |U G1G C G C |A G C       G G A      A |G C G C |G4C N*G G G |C U C A U A7A |C C C G G
       CYTO                     **************     ........                          .........   ----------                -----------
1375   WHEAT GERM               A U C A G A G |U G1G2C G C |A G C       G G A      A |G C G U |G2G F G G G |C C C A U A7A |C C C A C
                                **************       ......                          ......      ----------                -----------
1376   BEAN                     A U C A G A G |U G1G2C G C |A G C       G G A      A |G C G U |G2G U G G G |C C C A U A7A |C C C A C
       CYTO                     **************       ......                          ......      ----------                -----------
1377   BEAN                     C G C G G A G |U A |G A G C |A A C U U G3G D        A |G C U C |G |C A A G G |C U C A U A A |C C U U G
       CHLORO                     ************     ........                          .........   ----------                -----------
1378   SPINACH                  C G C G G G G |U A |G A G C |A G U U U G3G ·D       A |G C U C |G |C A A G G |C U C A U A A |C C U U G
       CHLORO                     ********   **    ........                          .........   ----------                -----------
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                      EXTRA ARM                   | TF STEM  | TF LOOP      |TF STEM   |AMINOACYL STEM|

         45  47  B   D   F   H   J   L   N   P    |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
       44  46  A   C   E   G   I   K   M   O    48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
--------------------------------------------------|----------|--------------|----------|--------------|--------

             METHIONINE-INITIATOR  cont.

1350   A G G C                                   C|G C A G G |U F C G A G U |C C U G C |C C C C G C A |A C C A
                                                  |==========|              |==========|************* |
1354   A U G7D                                   C|G C A G G |T F C A A A U |C C U G C |U C C U G C A |A C C A
                                                  |==========|              |==========|************* |
1355   A G G7D                                  C5|A C A G G |A U C G A1A A |C C U N*U |C U C A G C U |A C C A
                                                  |==========|              |======  ==|**************|
1360   U G A                                     C|A U A G G |U G C A A A U |C C U G U |A U C C G C A |U C C A
                                                  |==  ======|              |======  ==|**************|
1370   A G G7U                                   C|A C U C G |A U C G A1A A |C G A N*U |U G C A G C U |A C C A
                                                  |==========|              |==========|**************|
1375   A G G7D                                  C5|C5C A G G |A F C G A1A A |C C U G N*|C U C U G A U |A C C A
                                                  |==========|              |========  |**************|
1376   A G G7D                                  C5|C C A G G |A F C G A1A A |C C U G3G |C U C U G A U |A C C A
                                                  |==========|              |==========|**************|
1377   A A G7X                                   U|A C G G G |T F C A A A U |C C C G U |C U C C G C A |A C C A
                                                  |==========|              |==========|************* |
1378   A G G7U                                   C|A C G G G |T F C A A A U |C C U G U |C U C C G C A |A C C A
                                                  |====  ====|              |====  ====|**   ******** |
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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
1375/65 IS PROBABLY A DERIVATIVE OF GUANOSINE

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                                  AMINOACYL STEM |     | D STEM    |      D LOOP                |D STEM    | ANTIC.STEM   | ANTIC.LOOP   ANTIC.STEM

                                  1 2 3 4 5 6 7  |8 9  |10   12    |14  16  A   19  A    21     | 23  25   |  27  29  31  | 33  35  37   |39  41  43
                                                 |     |   11   13 |  15  17  18  20  B        |22  24    |26  28  30    |32  34  36  38| 40  42
                                  -------------------------------------------------------------------------------------------------------------------

                  METHIONINE-INITIATOR  cont.

1380    YEAST                     A G C C G C G  |U G1 |G2C G C    |A G D     G G A       A     |G C G C   |G4|C A G G G   |C U C A U A7A |C C C U G
                                  ********==**** |     |........   |                            |........  |  |----------  |              |---------
1381    YEAST                     U G C A A U A  |U G  |A U G U    |A A D U   G G D U     A     |A C A U   |U |U U A G G   |G U C A U G1A |C C U A A
        MITO                        ************ |     |........   |                            |........  |  |----------  |              |---------
1382    T. UTILIS                 A G C G U C U  |U G1 |G2C G C    |A G D     G G A       A     |G C G C   |G4|C A G G G   |C U C A U A7A |C C C U G
                                  ************** |     |........   |                            |........  |  |----------  |              |---------
1385    D. MELANOGASTER           A G C A G A G  |U G1 |G2C G C    |A G U     G G A       A     |G C G U   |G2|C U G G G   |C C C A U A7A |C C C A G
                                  ************** |     |  ......   |                            |......    |  |----------  |              |---------
1386    STARFISH                  A G C A G A G  |U G1 |G2C G C    |A G U     G G A       A     |G C G U   |G |C U G G G   |C C C A U A7A |C C C A G
                                  ************** |     |  ......   |                            |......    |  |----------  |              |---------
1390*   MAMMALIAN                 A G C A G A G  |U G1 |G2C G C    |A G C     G G A       A     |G C G U   |G2|C U G G G   |C C C A U A7A |C C C A G
                                  ************** |     |  ......   |                            |......    |  |----------  |              |---------

                  P H E N Y L A L A N I N E

1410    E.COLI                    G C C C G G A  |U4A  |G C U C    |A G D C   G G D       A     |G A G C   |A |G G G G A   |F U G A A A5A |F C C C C
                                  ************** |     |........   |                            |........  |  |----------  |              |---------
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                        EXTRA ARM                  | TF STEM  | TF LOOP       |TF STEM   |AMINOACYL STEM|

              45  47  B   D   F   H   J   L   N   P |49 51 53 | 55 57 59      |61 63 65  |67 69 71      |73 75
            44  46  A   C   E   G   I   K   M   O 48| 50 52   |54 56 58 60   | 62 64    |66 68 70 72   | 74 76
            ---------------------------------------------------------------------------------------------------------

                METHIONINE-INITIATOR  cont.
                                                                                    *  *
1380        A U G7D                              C5|C5U C G G |A U C G A1A A  |C C G N N |C G C G G C U |A C C A
                                                   |========= |               |========= |******==******|
                                                                                                      *
1381        U U A                                U |A U A C G |T F C A A A U  |C G U A U |U A U U G C F |A C C A
                                                   |========= |               |========= |************  |
                                                                                    *
1382        A U G7D                              C5|C5C U G G |A U C G A1A A  |C C A N G |A G A C G C U |A C C A
                                                   |========= |               |========= |**************|
1385        A G G7D                              C5|C G A G G |A U C G A1A A  |C C U U G |C U C U G C U |A C C A
                                                   |==  ===== |               |======  ==|**************|
1386        A G G7D                              C5|C G A G G |A F C G A1A A  |C C U C G |C U C U G C U |A C C A
                                                   |========= |               |========= |**************|
1390        A G G7D                              C5|G A U G G |A U C G A1A A  |C C A U C |C U C U G C U |A C C A
                                                   |========= |               |========= |**************|

                P H E N Y L A L A N I N E

1410        G U G7X                              C |C U U G G |T F C G A U U  |C C G A G |U C C G G G C |A C C A
                                                   |====  === |               |====  ====|**************|


1380/64 N IS A DERIVATIVE OF ADENOSINE                       1390/0  RABBIT LIVER,SHEEP MAMMARY GLANDS,SALMON TESTES,SALMON LIVER,HUMAN
1380/65 N IS A DERIVATIVE OF GUANOSINE                               PLACENTA,MOUSE MYELOMA CELLS,OOCYTES AND SOMATIC CELLS OF XENOPUS
1381/72 PARTIALLY MODIFIED                                           LAEVIS
1382/64 N IS A DERIVATIVE OF GUANOSINE
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                                AMINOACYL STEM|   | D STEM |       D LOOP         |D STEM  | ANTIC.STEM  | ANTIC.LOOP  ANTIC.STEM
                                1 2 3 4 5 6 7 |8 9|10  12  |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37  |39  41  43
                                              |   |  11  13|  15  17  18  20  B   |22  24  |26|  28  30  |32  34  36  38|  40  42
                                --------------|---|--------|----------------------|--------|--|----------|--------------|----------

             PHENYLALANINE  cont.

1420        B.STEAROTHERMOPHILUSG G C U C G G |U4A|G C U C |A G U C   G G D     A |G A G C |A |A A G G A |C U G3A A A5A |F C C U U
                                **************|   |........|                      |........|  |----------|              |----------
1430        B.SUBTILIS          G G C U C G G |U A|G C U C |A G U D   G G D     A |G A G C |A |A C G G A |C U G3A A A5A |F C C G U
                                **************|   |........|                      |........|  |----------|              |----------
1440        MYCOPLASMA SP.      G G U C G U G |U A|G C U C |A G U C   G G D     A |G A G C |A |G C A G A |C U G A A G1C |F C U G C
                                **************|   |........|                      |........|  |----------|              |----------
1445        YEAST               G C U U U U A |U A|G C U U |A G D     G G D     A |A A G C |G4|A U A A A |F U G A A G1A |F U U A U
            MITO                ****    ******|   |........|                      |........|  |----------|              |----------
1450        BEAN                G U C G G G G |U A|G C U C |A G U D   G3G D     A |G A G C |A |G A G G A |C U G A A A5A |F C C U C
            CHLORO              **  **  ****  |   |........|                      |........|  |----------|              |----------
1451        SPINACH             G U C G G G A |U A|G C U C |A G C U   G3G D     A |G A G C |A |G A G G A |C U G A A A5A |U C C U C
            CHLORO              **  **  ******|   |........|                      |........|  |----------|              |----------
1460        EUGLENA GRACILIS    G C U G G G A |U A|G C U C |A G D U   G G3U     A |G A G C |G |G A G G A |C U G A A A5A |F C C U U
            CHLORO              ******  ******|   |........|                      |........|  |  --------|              |--------
1461        EUGLENA GRACILIS    G C C G A C U |U A|G2C U C3|A G D D   G G G     A |G A G C |G4|F F A G A |C3U G3A A Y1A |F C U A A
            CYTO                **************|   |........|                      |........|  |----------|              |*---------
1462        BLUE GREEN ALGAE    G C C A G G A |U A|G C U C |A G U U   G3G D     A |G A G C |A |G A G G A |C U G A A N A |N C C U C
            CYANOBACTERIUM SP.  ******  ******|   |........|                      |........|  |----------|              |----------
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                    EXTRA ARM                      | TF STEM   | TF LOOP      |TF STEM   |AMINOACYL STEM|
         45  47  B   D   F   H   J   L   N   P     |49  51  53 | 55  57  59   |61  63  65| 67  69  71   |73  75
       44  46  A   C   E   G   I   K   M   O   48  | 50  52    |54  56  58  60| 62  64   |66  68  70  72| 74  76
       ----------------------------------------------------------------------------------------------------------

          PHENYLALANINE  cont.

1420   G U G7U                                   C |G G C G G  |T F C G A U U |C C G U C |C C G A G C C |A C C A
                                                   |==  ====== |              |======  ==|**************|
1430   G U G7U                                   C |G G C G G  |T F C G A U U |C C G U C |C C G A G C C |A C C A
                                                   |==  ====== |              |======  ==|**************|
1440   G U G7U                                   C |G G C G G  |U F C A A U U |C C G U C |C A C G A C C |A C C A
                                                   |== .====== |              |======  ==|**************|
1445   U U A                                     C*|A U GUA G  |U F C G A U U |C U C A U |U A A G G G C |A C C A
                                                   |========== |              |==========|******    ****|
1450   G U G7X                                   C |A C C A G  |T F C A A A U |C U G G U |U C C U G G C |A C C A
                                                   |========== |              |==========|  ****  **  **|
1451   G U G7X                                   C |A C C A G  |T F C A A A U |C U G G U |U C C U G G C |A C C A
                                                   |========== |              |==========|******  **  **|
1460   G U G7X                                   C |A C C A G  |T F C A A A U |C U G G -U|U C C U A G C |A C C A
                                                   |========== |              |==========|******  ******|
1461   A G G7U                                   C |C*C U G G  |T F C G A1U C |C C G G G |A G F C G G C |A C C A
                                                   |====  ==== |              |====  ====|**************|
1462   G U G7U                                   C5|G G C G G  |T F C A A U U |C C G C C |U C C C G G C |A C C A
                                                   |========== |              |==========|******  ******|
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1445/48 FOR ALTERNATIVE ALIGNMENT SEE NUCLEIC ACIDS RES. 5, P.4587
1460/20 PARTIALLY MODIFIED TO D

1461/49 PROBABLY A DERIVATIVE OF CYTIDINE
1462/39 N IS PROBABLY A DERIVATIVE OF URIDINE

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                             AMINOACYL STEM|   | D STEM|      D LOOP         |D STEM | ANTIC.STEM | ANTIC.LOOP ANTIC.STEM
                              1 2 3 4 5 6 7|8 9|10  12 |14  16  A   19  A  21|  23 25|  |27  29 31|  33  35  37 |39  41  43
                                           |   |  11 13|  15  17  18  20  B  |22  24 |26|  28  30 |32  34  36 38|  40  42
                              -------------|---|-------|---------------------|-------|--|---------|-------------|----------

             PHENYLALANINE  cont.
                                                         *                                                    *
1465         N.CRASSA         G C G G G U U|U A|G2C U C|N G D D   G G G     A|G A G C|G4|F C A G A|C3U G3A A N A|F C5U G A
                              ******** ****|   |.......|                     |.......|  |---------|             |---------
1470         YEAST            G C G G A U U|U A|G2C U C|A G D D   G G G     A|G A G C|G4|C C A G A|C3U G3A A Y1A|F C5U G G
                              ****** ******|   |.......|                     |.......|  |---------|             |---------
                                               * *                                   *
1471         S.POMBE          G U C G C A A|U N|G2U G F|A G D D   G G G     A|G C A F|G2|A C A G A|C3U G3A A Y1A|F C5U G U
                              ****** ******|   |  .... |                     |  .... |  |---------|             |  -------
1479         LUPIN            G C G G G G A|U A|G2C U C|A G D D   G G G     A|G A G C|G4|F C A G A|C3U G3A A Y2A|F C U G A
                              ******** ****|   |.......|                     |.......|  |---------|             |---------
1480         WHEAT,PEA,BARL.  G C G G G G A|U A|G2C U C|A G D D   G G G     A|G A G C|G4|F C A G A|C3U G3A A Y2A|F C U G A
                              ******** ****|   |.......|                     |.......|  |---------|             |---------
                                                                                                   *
1484         BOMBYX MORI      G C C G A A A|U A|G2C U C|A G D D   G G G     A|G A G C|G4|F F A G A|C3U G3A A G1A|F C U A A
                              *************|   |.......|                     |.......|  |---------|             |---------
                                                                                                   *
1485         D.MELANOGASTER   G C C G A A A|U A|G2C U C|A G D D   G G G     A|G A G C|G4|F F A G A|C3U G3A A G1A|F C U A A
                              *************|   |.......|                     |.......|  |---------|             |---------
1490*        MAMMALIAN        G C C G A A A|U A|G2C U C|A1G D D   G G G     A|G A G C|G4|F F A G A|C3U G3A A Y2A|F C U A A
                              *************|   |.......|                     |.......|  |---------|             |---------
1491    1    BOVINE LENS      G C C G A A A|U A|G2C U C|A1G D D   G G G     A|G A G C|G4|F F A G A|C3U G3A A Y2A|F C U A A
                              *************|   |.......|                     |.......|  |---------|             |---------
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                        EXTRA ARM                  | TF STEM | TF LOOP     |TF STEM   |AMINOACYL STEM|
 45  47  B   D   F   H   J   L   N   P  |49  51  53| 55  57  59 |61  63  65| 67  69  71 |73  75
44  46  A   C   E   G   I   K   M   O  48| 50  52 |54  56  58  60| 62  64 |66  68  70  72| 74  76
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      PHENYLALANINE  cont.

1465  A G G7D                          C5|G U G U G|T F C G A1U C|C A C A C|A A A C C G C|A C C A
                                         |=========|             |=========|****  *******|
1470  A G G7U                          C |C5U G U G|T F C G A1U C|C A C A G|A A U U C G C|A C C A
                                         |=========|             |=========|******  *****|
1471  U G G7N*                         C |A U C G G|T F C G A U C|C C G G U|U U G U G A C|A C C A
                                         |==  =====|             |=====  ==|******  *****|
1479  A G G7D                          C |A C G U G|T F C G A1U C|C A C G U|U C A C C G C|A C C A
                                         |=========|             |=========|****  *******|
1480  A G G7D                          C |G C G U G|T F C G A1U C|C A C G C|U C A C C G C|A C C A
                                         |=========|             |=========|****  *******|
1484  A G G7D*                        *C5|C C U G G|T F C G*A1U C|C C G G G|U U U C G G C|A C C A
                                         |====  ===|             |====  ===|*************|
1485  A G G7D*                         C |C C C G G|T F C A A1U C|C C G G G|U U U C G G C|A C C A
                                         |=========|             |=========|*************|
1490  A G G7D*                         C |C5C U G G|T*F C G A1U C|C C G G G|U U U C G G C|A C C A
                                         |====  ===|             |====  ===|*************|
1491  A G G7D                          C |C5C U G G|T F C A*A1U C|C C G G G|U U U C G G C|A C C A
                                         |====  ===|             |====  ===|*************|
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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
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1484/48 MODIFICATION EITHER IN POSITION 48 OR 49
1484/57 MINOR SPECIES HAS A57
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
1491/57 PHE 1 HAS G, PHE 2 HAS A
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                                  AMINOACYL STEM|    |D STEM  |       D LOOP         |D STEM  |  |ANTIC.STEM|ANTIC.LOOP    |ANTIC.STEM
                                  1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37  |39  41  43
                                                |    |  11  13|  15  17  18  20  B   |22  24  |26|  28  30  |32  34  36  38|  40  42
                                  ----------------------------------------------------------------------------------------------------

              P R O L I N E
                                                  *                                                               *
1510          PHAGE T4            C U C C G U G |U4A |G C U C |A G U U U G G D     A |G A G C |G |C C U G A |U3U N G G G1A |F C A G G
                                  ********  **  |    |........|                      |........|  |----------|              |----------
1511          PHAGE T5            C U C C G A U |U A |G C U C |A A U U   G G C D   A |G A G U |A |C A C C G |U U U G G G1G |C G G U G
                                  ********  ****|    |  ......|                      |......  |  |----------|              |----------
                                                                                                                  *       *
1515          H.VOLCANII          G G G C C G G |U G |G4G G F |A N C U U G G U     A |U C C U |U |C G G C C |U U N G G G1F |G G C C G
              HALOBACTERIUM SP.   **************|    |  ....  |                      |  ....  |  |----------|              |----------
1560          SPINACH             A G G G A U G |U A |G C G C |A G C U U G3G D     A |G C G C |F |F U U G U |F U N G G N F |A C A A A
              CHLORO              **************|    |........|                      |........|  |----------|              |----------
                                                                                                              *
1580    1     MOUSE/CHICKEN/M-MULVG G C U3C G2U |U G1|G U C F |A G       G G G D   A |U G A U |U |C U C G C |N U I G G G1F |G C G A G
                                  **************|    |  ....  |                      |  ....  |  |----------|              |----------
                                                                                                                  *
1581    2     MOUSE/CHICKEN/M-MULVG G C U3C G2U |U G1|G U C F |A G       G G G D   A |U G A U |U |C U C G C |F U N G G G1F |G C G A G
                                  **************|    |  ....  |                      |  ....  |  |----------|              |----------

              S E R I N E

1610    1     E.COLI              G G A A G U G |U4G |G C C G |A G C     G3G D D G A |A G G C |A |C C G G U |C3U V1G A A5A |A C C G G
                                  **********  **|    |......  |                      |  ......|  |----------|              |----------
                                                                                                              *
1620    3     E.COLI.             G G U G A G G |U4G |G C C G |A G A     G G C D G A |A G G C |G |C U C C C |C2U G C U A7A |G G G A G
                                  **************|    |......  |                      |  ......|  |----------|              |----------
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                           EXTRA ARM                          |   TF STEM     |      TF LOOP        |   TF STEM     |   AMINOACYL STEM    |
           45    47    B     D     F     H     J     L     N     P     |49    51    53 |   55    57    59    |61    63    65 |   67    69    71    |73    75
        44    46    A     C     E     G     I     K     M     O     48 |   50    52    |54    56    58    60 |   62    64    |66    68    70    72 |   74    76
        -------------------------------------------------------------------------------------------------------------------------------------------------------------

             P R O L I N E

1510    A  G  G7U                                                C  |C  A  A  G  G  |T  F  C  A  A  A  U  |C  C  U  U  G  |U  A  U  G  G  A  G  |A  C  C  A
                                                                    |===============|                     |===============|   **   ************|
1511    G  G  G7U                                                U  |G  A  A  G  G  |T  F  C  G  A  G  U  |C  C  U  U  C  |A  U  U  G  G  A  G  |A  C  C  A
                                                                 *  |===============|   *                 |===============|******  ************|
1515    U  A  A                                                  C5 |C5U C  A  G    |F1F  C3G A  A  U     |C  U  G  A  G  |C  C  G  G  C  C  C  |A  C  C  A
                                                                    |===============|                     |===============|*********************|
1560    A  U  G7U                                                C  |A  C  G  G  G  |T  F  C  A  A  A  U  |C  C  U  G  U  |C  A  U  C  C  C  U  |A  C  C  A
                                                                    |=====    ======|                     |=====    ======|*********************|
1580    A  G  G7D                                                C5 |C5C G  G  G    |F  F  C  A  A1A U    |C  C  C  G  G  |A  C  G  A  G  C  C  |C  C  C  A
                                                                    |===============|                     |===============|*********************|
1581    A  G  G7D                                                C5 |C5C G  G  G    |F  F  C  A  A1A U    |C  C  C  G  G  |A  C  G  A  G  C  C  |C  C  C  A
                                                                    |===============|                     |===============|*********************|

             S E R I N E

1610    C  G  A  C  C  C  G  A  A  A  G  G  G  U  U              C  |C  A  G  A  G  |T  F  C  G  A  A  U  |C  U  C  U  G  |C  G  C  U  U  C  C  |G  C  C  A
              : : : : : : : :           : : : : : : : :             |===============|                     |===============|**   ***************|
1620    U  A  U  G  C  G  G  U  C  A  A  A  A  G  C  U  G  C  A  U  C  |C  G  G  G  G  |T  F  C  G  A  A  U  |C  C  C  C  G  |C  C  U  C  A  C  C  |G  C  C  A
         : : : : : : : :   : :                        : :   : : : : : : : :   |===============|                     |===============|*********************|
```

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
1580/32 N IS PROBABLY A UM DERIVATIVE
1581/34 N IS MOST LIKELY A U DERIVATIVE
1620/32 IN THE POSITION 32 IS MOST PROBABLY 2-THIOCYTIDINE

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                                AMINOACYL STEM    D STEM        D LOOP          D STEM   ANTIC.STEM  ANTIC.LOOP    ANTIC.STEM

                                1 2 3 4 5 6 7 8 9 10  12  14  16  A   19  A   21  23  25   27  29  31  33  35  37  39  41  43
                                                    11  13  15  17  18  20  B   22  24  26   28  30  32  34  36  38  40  42
                                -----------------------------------------------------------------------------------------------

                    SERINE  cont.

1625    1   H.VOLCANII          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
            HALOBACTERIUM SP.   **************    ......                        ......     ------  --     *        --  ------
1626    2   H.VOLCANII          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
            HALOBACTERIUM SP.   **************    ........                      ........   ----------              ----------
1630        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
                                **************    ......                        ......     ----------              ----------
1631        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 C U A A5A|A C C G G
            PSU+ 1 AM           **************    ......                        ......     ----------              ----------
1637*       BOVINE              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
            MITO                **************                                               --------              --------
1638*       HUMAN               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
            MITO                **************                                             --  ----                  ----  --
1640    1   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    2   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    UCG 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 G A G A|N U C G A A4A|F C U C U
                                **  ******  **    ......                        ......     ----------              ----------
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                      EXTRA ARM                    TF STEM   TF LOOP       TF STEM   AMINOACYL STEM

          45  47  B   D   F   H   J   L   N   P   49  51  53  55  57  59  61  63  65  67  69  71  73  75
        44  46  A   C   E   G   I   K   M   O   48  50  52  54  56  58  60  62  64  66  68  70  72  74  76
        --------------------------------------------------------------------------------------------------

            SERINE  cont.

1625    U G G C G U C A A G C C                 C5C5G G G G   F C3G A A U C C C C G C C G C A A C G C C A
          ::::::          ::::::                  ==========              ==========**************
1626    U G U C C A U U C G G A C A             C5G U G A G   F C3G2A A U C U C A C C C U C G G C G C C A
        ::::::::::        ::::::::::              ==========              ==========**************
1630    C A G U C G C U C C G G C G A C U       C A U A G G T F C A A A U C C U A U C G C C U C C G C C A
          ::::::::::::        ::::::::::::        ==========              ==========**************
1631    C A G U C G C U C C G G C G A C U       C A U A G G T F C A A A U C C U A U C G C C U C C G C C A
          ::::::::::::        ::::::::::::        ==========              ==========**************
1637    U G C U                                 C C C A U A U C U A A U AGU A U*G*G C U U U U U C G C C A
                                                  ==========              ==========**************
1638    G C C                                   C C C A U G U C U A A C AAC A U G G C U U U C U C A C C A
                                                  ==========              ==========**************
1640    U3G G G C U C U G C C C G               C5G C A G G T F C A A A U C C U G C A G U U G U C G C C A
          ::::::::      ::::::                    ==========              ==========**********  **
1650    U3G G G C U U U G C C C G               C5G C A G G T F C G A G U C C U G C A G U U G U C G C C A
          ::::::::      ::::::::                  ==========              ==========**********  **
1651    U3G G G C U C U G C C C G               C5G C U G G T F C A A A U C C U G C U G G U G U C G C C A
          ::::::::      ::::::::                  ====  ====              ====  ====**  ******  **
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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

1638/0 COMPARE R.J.BAER, T.R.DUBIN (1980) NUCLEIC ACIDS RES. 8, 3603-3610
1651/32 N IS PROBABLY 3-METHYLCYTOSINE

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                                  AMINOACYL STEM |    | D STEM  |        D LOOP            |D STEM    | ANTIC.STEM |ANTIC.LOOP    ANTIC.STEM

                                  1 2 3 4 5 6 7 |8 9 |10   12  |14  16  A   19  A    21|  23  25 |27  29  31 | 33  35  37 |39  41  43
                                                |    |   11  13| 15  17  18  20   B    |22  24   |26 28  30  |32  34  36  38| 40  42
                                  --------------------------------------------------------------------------------------------------------

                 SERINE  cont.
                                                                                                         *   *
1652    UCA YEAST                 G G C A C U A |U G |G C C4G  |A G D      G3G D D    A|A G G C  |G4A C A G A|N U N G A A4A |F C U G U
                                  **  ******  **|    |......   |                       |  ......  |  ---------|              |---------
                                                                                                              *
1658        S.POMBE               G U C A C U A |U G |U C C4G  |A G D      G G D D    A|A G G A  |G4F U A G A|C6U U7C A A4A |F C U A A
            SUP3-E                **********  **|    |......   |           *           |  ......  |  ---------|              |---------
1660    1   RAT LIVER,HEPATOMA    G U A G U C G |U G |G C C4G  |A G D      G3G D D    A|A G G C  |G4A F G G A|C6U I G A A4A |F3C C A U
                                  **************|    |......   |                       |  ......  |  ---------|              |---------
1670    3   RAT LIVER             G A C G A G G |U G |G C C4G  |A G D      G3G D D    A|A G G C  |G4A F G G A|C6U G C U A8A |F C C A U
                                  **************|    |......   |                       |  ......  |  ---------|              |---------
1675    1   YEAST                 G G A A A A U |U A |A C U A  |D A        G G D      A|A A G U  |GGA U U A F|F U G C U A A |G U A A U
            MITO                  **************|    |......   |                       |  ......  |  -------  |              |  -------
                                                                                                    *
1676    2   YEAST                 G G A U G G U |U G |A C U G  |A G D      G G D U U  A|A A G U  |G4F G A U A|F U U G A G1C |F A U C A
            MITO                  **********  **|    |......   |                       |  ......  |  ---------|              |---------

                 T H R E O N I N E

1710        E.COLI                G C U G A U A |U A |G C U C  |A G D D    G G D      A|G A G C  |G C A C C C|U U G G U A8A |G G G U G
                                  **************|    |........ |                       |........  |  ---------|              |---------
                                                                              *
1720        B.SUBTILIS            G C C G G U G |U A |G C U C  |A A U D    G G D      A|G A G C  |A A C U G A|C U V2G U A7A |F C A G U
                                  **********    |    |........ |                       |........  |  ---------|              |---------
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1676 G.DIRHEIMER (1981) PERSONAL COMMUNICATION
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                        EXTRA ARM                 |TF STEM  |  TF LOOP    |TF STEM  |AMINOACYL STEM|

          45  47  B   D   F   H   J   L   N   P   |49  51  53  55  57  59 |61  63  65  67  69  71 |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52 |54  56  58  60  62  64 |66  68  70  72  74  76
        ---------------------------------------------------------------------------------------------------

             SERINE  cont.

1652    U3G G G C U C U G C C C G                C5|G C U G G|T F C A A A U|C C U G C|U G G U G U C|G C C A
          ::::::::      ::::::::                   |===   ===|             |===   ===|**  *****  **|
1658    U G G G C U U U G C C C G               C5|G C A G G|T F C A A1A U|C C U G C|U G G U G A C|G C C A
            ::::::      ::::::::                   |=========|             |=========|**  *********|
1660    U3G G G G U C6U C C C C G               C5|G C A G G|T F C G A1A U|C C U G C|C G A C U A C|G C C A
          ::::::::      ::::::::                   |=========|             |=========|*************|
1670    U3G F G C U C6U G C A C G               C5|G U G G G|T F C G A1A U|C C C A U|C C U C G U C|G C C A
          ::::::::      ::::::::                   |=========|             |=========|*************|
1675    U G A A U U G U A A A U U C U            U|A U G A G|T F C G A A U|C U C A U|A U U U U C C|G C C A
          ::::::::::      ::::::::::               |=========|             |=========|*************|
1676    U U A G U C U U U A U U G G C U A        C|G U A G G|T F C A A A U|C C U A C|A U C A U C C|G C C A
          ::::::  ::            ::  ::::::         |=========|             |=========|**  *********|


            T H R E O N I N E

1710    A G G7U                                  C|G G C A G|T F C G A A U|C U G C C|U A U C A G C|A C C A
                                                   |=========|             |=========|*************|
1720    A G G7U                                  U|G G G G G|T F C A A G U|C C U C U|U G C C G G C|A C C A
                                                   | ==   ===|             |====  == |    *********|
```

1652/32 N IS PROBABLY 3-METHYLCYTOSINE
1652/34 N IS A   MODIFIED URIDINE
1658/34 PARTLY MCM5U,PARTLY S2U

1660/18 HEPATOMA LACKS MODIFICATION
1676/27 PARTIALLY MODIFIED
1720/20 PARTIALLY MODIFIED

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                            AMINOACYL STEM     D STEM       D LOOP       D STEM   ANTIC.STEM  ANTIC.LOOP  ANTIC.STEM

                             1 2 3 4 5 6 7 8 9 10  12  14  16  A   19  A   21  23  25  27  29  31  33  35  37  39  41  43
                                               11  13  15  17  18  20  B   22  24  26  28  30  32  34  36  38  40  42
                            ------------------------------------------------------------------------------------------

           THREONINE  cont.
                                                                                                   *     *
1730       PHAGE T4          G C U G A U U U A G C U C A G D A  G G D   A G A G C A C C U C A C U N G U N A F G A G G
                             ***************    ........              ........  -----------             ----------
1740       N.CRASSA          G C C U G G U U A G C A U A A A    A G D   A A U G C A A U U G F U U U G U A7A F C A A U
           MITO              ******    ****     .........             .........  ---------                 ---------
1760   1A1BYEAST             G C U U C U A U G G2C C A A G D D  G G D   A A G G C G4C C A C A C6U I G U A7A F G U G G
                             **********  **     ......                  ......  -----------             ----------
1765   1   YEAST             G U A A A U A U A A U U U A A D    G G D   A A A A U G2F A U G F UUU U A G G1F G C A U A
           MITO              ***************    ........              ........  ---------                 ---------
1770       SPINACH           G C C C C U U U A A C U C A G U    G3G D   A G A G U A A C G C C A U G G U A8A G G C G U
           CHLORO            ***************    ........              ........  -----------             ----------

           T R Y P T O P H A N

1810       E.COLI            A G G G G C G U4A G U U C A A D D  G G D   A G A G C A C C G G U C3U C C A A5A A C C G G
           CA 244            ***************    ..  ....              ....  ..  -----------             ----------
1811       E.COLI            A G G G G C G U4A G U U C A A D D  G G D   A G A A C A C C G G U C3U C C A A5A A C C G G
           PSU+ UGA          ***************    ........              ........  -----------             ----------
1812       E.COLI            A G G G G C G U4A G U U C A A D D  G G D   A G A G C A C C G G U C3U C U A A5A A C C G G
           PSU+ 7 AM         ***************    ..  ....              ....  ..  -----------             ----------
1813       E.COLI            A G G G G C G U4A G U U C A A D D  G G D   A G A G C A C C G G U C3U U U A A5A A C C G G
           PSU+ 7 OC         ***************    ........              ........  -----------             ----------
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                    EXTRA ARM                    | TF STEM |   TF LOOP   |TF STEM  |AMINOACYL STEM

          45  47  B   D   F   H   J   L   N   P  |49  51  53  55  57  59 |61  63  65  67  69  71 |73  75
        44  46  A   C   E   G   I   K   M   O   48  50  52 |54  56  58  60  62  64 |66  68  70  72  74  76
        -------------------------------------------------------------------------------------------------

            THREONINE  cont.

1730    A U G7U                                 C|G G C G G|T F C G A U U|C C G U C|A A U C A G C|A C C A
                                                  ==  ======              ======  ==**************
1740    A G A                                   A|G C A A G|T G C G A U A|C U U G C|A C U G G G C|U C C A
                                                  ==========              ==========****    ******
1760    A G A D                                C5|A*U C G G|T F C A A1A U|C C G A U*U G G A A G C|A C C A
                                                  ==========              ==========**  **********
1765    U U A                                   U|C U A A G|T F C A A A U|C U U A G|U A U U U A C|A C C A
                                                  ==========              ==========**************
1770    A A G7D                                 C|A U C G G|T F C A A A U|C C G A U|A A G G G G C|U C C A
                                                  ==========              ==========**************

            T R Y P T O P H A N

1810    G U G7U                                 U|G G G A G|T F C G A G U|C U C U C|C G C C C C U|G C C A
                                                  ==  ======              ======  ==**************
1811    G U G7U                                 U|G G G A G|T F C G A G U|C U C U C|C G C C C C U|G C C A
                                                  ==  ======              ======  ==**************
1812    G U G7U                                 U|G G G A G|T F C G A G U|C U C U C|C G C C C C U|G C C A
                                                  ==  ======              ======  ==**************
1813    G U G7U                                 U|G G G A G|T F C G A G U|C U C U C|C G C C C C U|G C C A
                                                  ==  ======              ======  ==**************
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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

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                                AMINOACYL STEM|    | D STEM |       D LOOP         |D STEM  | ANTIC.STEM  | ANTIC.LOOP    ANTIC.STEM

                                1 2 3 4 5 6 7 |8 9 |10  12  |14  16  A   19  A   21|  23  25|  |27  29  31|  33  35  37  |39  41  43
                                              |    |  11  13|  15  17  18  20  B   |22  24  |26|  28  30  |32  34  36  38|  40  42
                                ----------------------------------------------------------------------------------------------------

          TRYPTOPHAN  cont.

1814      E.COLI                A G G G G C A |U4A |G U U C |A A D D   G G D     A |G A G C |A |C C G G U |C3U C C A A5A |A C C G G
          TEM.-SENS.            *************                                   
                                              |    |..  ....|                      |....  ..|  |----------|              |----------
1840      YEAST                 G A A G C G G |U G1|G2C U C |A A D     G3G D     A |G A G C |F |F F C G A |C3U C3C A A A |F C G A A
                                ******  ******|    |........|                      |........|  |----------|              |----------
1841      YEAST                 A A G G A U A |U A |G U U U |A A D     G G D     A |A A A C |A |G U U G A |F U N*C A N*A |F C A A U
          MITO                  **************|    |........|                      |........|  |  --------|              |--------
1845      N.CRASSA              A A G A G U A |U A |G U U U |A A U     G G D     A |A A A C |A |G A A A G |C U U*C A A*C |C U U U A
          MITO                  **************|    |........|                      |......  |  |  --------|              |--------
1846      SPINACH CHLORO        G C G C U C U |U A |G U U C |A G U U C G3G D     A |G A A C |G2|F G G G F |C U C C A A4A*|A C C C G
                                  ************|    |........|                      |........|  |  --------|              |--------
1850*     CHICKEN CELLS         G A C C U C G |U G1|G2C G C |A A C     G3G D     A |G C G C |G4|F C U G A |C3U C3C A G1A |F3C A G A
                                ********  ****|    |........|                      |........|  |----------|              |----------
1860      BOVINE LIVER          G A C C U C G2*|U G1|G2C G C |A A D*    G3G D     A |G C G C |G4|F C U G A |C3U C*3C A G1A|F3C A G A
                                ********  ****|    |........|                      |........|  |----------|              |----------

          T Y R O S I N E

1910      E.COLI                G G U G G G G |U4U*4|C C C G |A G C     G3G C C A A |A G G G |A |G C A G A |C U Q U A A5A |F C U G C
                                **************|    |......  |                      |  ......|  |----------|              |----------
1911      E.COLI                G G U G G G G |U4U4|C C C G |A G C     G3G C C A A |A G G G |A |G C A G A |C U C U A A5A |F C U G C
          PSU+ 3 AM             **************|    |......  |                      |  ......|  |----------|              |----------
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                      EXTRA ARM                   | TF STEM  | TF LOOP      |TF STEM   |AMINOACYL STEM|
          45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
        44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
        -------------------------------------------------------------------------------------------------------

            TRYPTOPHAN  cont.

1814    G U G7U                                 U |G G G A G |T F C G A G U |C U C U C |C G C C C C U |G C C A
                                                  |==  ======|              |======  ==|  ************|
1840    G G G7D                                 U |G C A G G |T F C A A1U U |C C U G F |C C G U U U C |A C C A
                                                  |  ========|              |========  |******  ******|
1841    C A U                                   U |A G G A G |T F C G A A U |C U C U U |U A U C C U U |G C C A
                                                  |==  ======|              |======  ==|**************|
1845    A A U                                   U |C U U A G |T F C G A G U |C U A A G |U A C U C U U |G C C A
                                                  |==========|              |==========|**************|
1846    A U G N                                 C |G U A G G |T F C A A G U |C C U A C |A G A G C G U |G C C A
                                                  |==========|              |==========|************  |
1850    A G G7C                                 U |G C G U G |F F C G A1A U |C A C G U |C G G G G U C |A C C A
                                                  |  ========|              |========  |****  ********|
            *  *                                                    *
1860    A G G7D                                 U |G C G U G |F F C G A1A U |C A C G U |C G G G G U C |A C C A
                                                  |  ========|              |========  |****  ********|


            T Y R O S I N E
                  * *
1910    C G U C A U C G A C U U                 C |G A A G G |T F C G A A U |C C U U C |C C C C A C C |A C C A
          ::::::      ::::::                      |==========|              |==========|**************|
1911    C G U C A U C G A C U U                 C |G A A G G |T F C G A A U |C C U U C |C C C C A C C |A C C A
          ::::::      ::::::                      |==========|              |==========|**************|
```

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
1850/0	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
1910/9	U IS PROBABLY MODIFIED TO S4U
1910/47	2 (B) PARTIALLY C
1910/47	3 (C) PARTIALLY A

			AMINOACYL STEM		D STEM	D LOOP	D STEM		ANTIC.STEM	ANTIC.LOOP	ANTIC.STEM
			1 2 3 4 5 6 7	8 9	10 12 11 13	14 16 A 19 A 21 15 17 18 20 B	23 25 22 24	26	27 29 31 28 30	33 35 37 32 34 36 38	39 41 43 40 42
		TYROSINE cont.									
1912		E.COLI	G G U G G G G	U4U4	C C C G	A G C G3G C C A A	A G G G	A	G C A G A	C U *U U A A5A	F C U G C
		A2 PSU+ 3 OC	**************		......		......		----------		----------
1915		H.VOLCANII	C C G C U C U	U A	G C U C	A N C C U G G C A	G A G C	A	G C C G A	*C3U G U A G1A	F C G G C
			**************		....		....		----------		----------
1918	*1,2	B.SUBTILIS	G G A G G G G	U4A	G C G A	A G U G3G C U A A	A1C G C	G	G C G G A	C U Q U A *A4A	F C C G C
			**************		......		......		----------		----------
1920		B.STEAROTHERMOPHILUS	G G A G G G G	U4A	G C G A	A G U G3G C U A A	A1C G C	G	G C G G A	C U Q U A A5A	F C C G C
			**************		......		......		----------		----------
1925		N.CRASSA	A G G A G G G	U U	C C G U	U U G U U G G D A U G	A C G G	G4	F U A A G	C U G U A *N A	C U U A A
		MITO	********** **		....		....		----------		----------
1930		YEAST	C U C U C G G	U A	G2C C A	A G D D G3G D D D A	A G G C	G4	C A A G A	C U G F A A4A	F C U U G
			****** ******		......		......		----------		----------
1931		YEAST	C U C U C G G	U A	G2C C A	A G D D G3G D D D A	A G G C	G4	C A A G A	C U C F A A4A	F C U U G
		SUP-5AM	****** ******		......		......		----------		----------
1940		T.UTILIS	C U C U C G G	U G1	G2C C A	A G D D G3G D D D A	A G G C	G4	F C A G A	C U G F A A4A	F C U G A
			**************		......		......		----------		----------
1941		S.POMBE	C U C C U G A	U G1	G U G F	A G D D G G D D A	U C A C	A	*C C C G G	C U G F A A4A	C C G G U
			**************		......		......		--------		--------

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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
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1930 J.T.MADISON,H.-K.KUNG(1967) J.BIOL.CHEM. 242, 1324-1330
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                        EXTRA ARM                TF STEM     TF LOOP     TF STEM   AMINOACYL STEM

         45  47  B   D   F   H   J   L   N   P   49  51  53  55  57  59  61  63  65  67  69  71  73  75
       44  46  A   C   E   G   I   K   M   O   48  50  52  54  56  58  60  62  64  66  68  70  72  74  76
       -------------------------------------------------------------------------------------------------

             TYROSINE  cont.

1912   C G U C A U C G A C U U                 C G A A G G T F C G A A U C C U U C C C C C A C C A C C A
         ::::::      ::::::                      ==========              ====================**************
1915   U U G U                                 C5C C C C G F4F C3G2A A U C G G G G A G A G C G G A C C A
                                                 ==========              ====================**************
1918   U C C C U C A G G G U U                 C G G C A G T F C G A A U C U G C C C C C C U C C A C C A
         ::::::      ::::::                      ==========              ====================**************
1920   U C C C U U U G G G U U                 C G G C G G T F C G A A U C C G U C C C C C U C C A C C A
         ::::::      ::::::     *               *==  ======              ======  ==**************
1925   U G A C U A A U U A G U C G U           C G A A G G T F C A A U U C C U U U C U C U C C U A C C A
         ::::::::        ::::::::                  ========              ========  **  **********
1930   A G A D                                 C5G G G C G T F C G A1C U C G C C C C C G G G A G A C C A
                                                 ==========              ====================******  ******
1931   A G A D                                 C5G G G C G T F C G A1C U C G C C C C C G G G A G A C C A
                                                 ==========              ====================******  ******
1940   A C A D                                 C5G G G C G T F C G A1A U C G C C C C C G A G A G A C C A
                                                 ==========              ====================**************
1941   U G G7U                                 C5G C U A G T F C G A1U U C U G G C U C A G G A G A C C A
                                                 ====  ====              ====  ====**************
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1912/34 URIDINE MAY BE MODIFIED; S.ALTMAN(1976) NUCLEIC ACIDS RES. 3, 441-448
1915/32 PARTIALLY MODIFIED
1918/0 SEE FOOTNOTE 37
1918/37 IN THE SPECIES 2 MS2I6 AT THIS POSITION
1925/37 N IS PROBABLY ISOPENTENYL ADENOSINE
1925/47 9 (I) OR 48: ONE OF CYTIDINES IS MODIFIED TO M5C
1941/27 F IN 20% OF THE TRNA

			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
		TYROSINE cont.									
1950		YEAST MITO	G G A G G G A	U U	U U C A	A U G U D G G D A G U	U G G A	G4	F U G A G	C U G U A A* A	C U C A A
			**************		.. ....		.... ..				
		VALINE									
2010	1	E.COLI K12/B	G G G U G A U	U4A	G C U C	A G C D G G G A	G A G C	A	C C U C C	C U V1A C A6A	G G A G G
			**************		....		....				
2020	2A	E.COLI	G C G U C C G	U4A	G C U C	A G D D G G D D A	G A G C	A	C C A C C	U U G A C A U	G G U G G
			**************		....		....				
2021	2B	E.COLI	G C G U U C A	U4A	G C U C	A G D D G G D D A	G A G C	A	C C A C C	U U G A C A U	G G U G G
			**************		....		....				
2023		H.VOLCANII HALOBACTERIUM SP.	G G G U U G G	U G	G U C F	A G U C U G G U U A	U G A C	A	C C U C C	U U G A C A U	G G A G G
			**************		......		......				
2025	1	B.SUBTILIS	G G A G G A U	U A	G C U C	A G C D G G G A	G A G C	A	U C U G C	C U V2A C A6A	G C A G A
			**************		....		....				
2028		SPINACH CHLORO	A G G G C U A	U A	G C U C	A G U U A G3G D A	G A G C	A	C C U C G	U U N* A C A C	C G A G A
			**************		....		....				
2030		B.STEAROTHERMOPHILUS	G A U U C C G	U A	G C U C	A G C D G G G A	G A G C	G	C C A C C	U U G A C A6G	G G U G G
			**************		....		....				
2040	1	YEAST	G G U U U C G	U G1	G U C F	A G D C G G D D A	U G G C	A	F C U G C	F U I A C A C	G C A G A
			** **********		.. ..		.. ..				

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2010 M.YANIV,B.G.BARRELL(1969) NATURE 222, 278-279
F.KIMURA,F.HARADA,S.NISHIMURA(1971) BIOCHEMISTRY 10, 3277-3283
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2028 H.M.SPROUSE, M.KASHDAN, L.OTIS, B.DUDOCK (1981) NUCLEIC ACIDS RES. 9, 2543-2547
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                    EXTRA ARM                   |TF STEM   |TF LOOP       |TF STEM   |AMINOACYL STEM|
        45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
      44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
      ------------------------------------------------------------------------------------------------------

            TYROSINE  cont.

1950  U G A C U U A G G U C U U               C |A U A G G |T F C A A U U |C C U A U |U C C C U U C |A C C A
        ::::::        ::::::                    |==========|              |==========|**********  **|

            V A L I N E

2010  G G G7U                                 C |G G C G G |T F C G A U C |C C G U C |A U C A C C C |A C C A
                                                |==  ======|              |======  ==|**************|
2020  G G G7X                                 C |G G U G G |T F C G A G U |C C A C U |C G G A C G C |A C C A
                                                |  ========|              |========  |**************|
2021  G G G7X                                 C |G U U G G |T F C G A G U |C C A A U |U G A A C G C |A C C A
                                                |  ========|              |========  |**************|
2023  A G G C                                 C5|G G C A G |F1F*C3G2A A U |C U G C C |C C A A C C C |A C C A
                                                |==========|              |==========|**************|
2025  G G G7U                                 C |G G C G G |T F C G A G C |C C G U C |A U C C U C C |A C C A
                                                |==  ======|              |======  ==|**************|
2028  A A G7N                                 C |U A C G G |T F C G A G U |C C G U A |U A G C C C U |A C C A
                                                |==========|              |==========|**************|
2030  A G G7U                                 C |G C U G G |T F C G A G C |C C A G U |C G G A A U C |A C C A
                                                |  ========|              |========  |**************|
2040  A C G7D                                 C |C5C C A G |T F C G A1U C |C U G G G |C G A A A U C |A C C A
                                                |==========|              |==========|**********  **|
```

1950/37 A=I6A OR MS2I6A
2023/55 PARTIALLY MODIFIED
2028/34 N IS A DERIVATIVE OF URIDINE

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                              AMINOACYL STEM    D STEM          D LOOP        D STEM  ANTIC.STEM  ANTIC.LOOP    ANTIC.STEM

                              1 2 3 4 5 6 7 8 9 10  12  14  16  A   19  A   21  23  25  27  29  31  33  35  37  39  41  43
                                                  11  13  15  17  18  20  B   22  24  26  28  30  32  34  36  38  40  42
                              --------------------------------------------------------------------------------------------

          VALINE  cont.
                                                                                                      *
2050  2A  YEAST               G G U C C A A U G G2U C C A G D     G G D D C'A A G A C G4F C G C C F U N A C A C G G C G A
                              **  **********    *.....                        ......    ----------              ----------
2051  2B  YEAST               G U U C C A A U A G2U G F A G C     G G C D   A U C A C G2F F G C C F U C A C A C G G C A A
                              **************    ......                        ......    ----------              ----------
2055      N.CRASSA            G A G A G A U U A G C U C A G U U   G G D     A G A G C A A C C G U U U U A C A C A C G G A
          MITO                ********  ****    .........                     ........    --------              --------
2060  1   T.UTILIS            G G U U U C G U G1G U C F A G D D   G G D C   A U G G C A F C U G C F U I A C A C G C A G A
                              **  **********    ..  ..                        ..  ..    ----------              ----------
2070*     MAMMALIAN           G U U U C C G U A G U G F A G D     G G D D   A U C A C G2F U C G C C3U I A C A C5G C G A A
                              **************    ......                        ......    ----------              ----------
2071  1B  HUMAN PLACENTA      G U U U C C G U A G U G F A G D     G G D D   A U C A C G2F U C G C C U C A C A C G C G A A
                              **************    ......                        ......    ----------              ----------
2075      RAT LIVER           G U U U C C G U A G U G F A G D     G3G D D   A U C A C G2F U C G C C U N A C A C5G C G A A
                              **************    ......                        ......    ----------              ----------
2076      RAT HEPATOMA        G U U U C C G U A G U G F A G D     G G D D   A U C A C G2F U C G C C3U I A C A C5G C G A A
                              **************    ......                        ......    ----------              ----------
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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

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                    EXTRA ARM                   |TF STEM   |TF LOOP       |TF STEM   |AMINOACYL STEM|
        45  47  B   D   F   H   J   L   N   P   |49  51  53|  55  57  59  |61  63  65|  67  69  71  |73  75
      44  46  A   C   E   G   I   K   M   O   48|  50  52  |54  56  58  60|  62  64  |66  68  70  72|  74  76
      ------------------------------------------------------------------------------------------------------

          VALINE  cont.

2050  A G A D                                  C|C5C G A G |T F C G A1A C |C U C G G |U U G G A U C |A C C A
                                                 ==========                ========== **********  **
2051  A G G7D                                  C|C5C G A G |T F C G A1U C |C U C G G |U U G G A A C |A C C A
                                                 ==========                ========== **************
2055  A G G U                                  U|G G G U G |T F C G A A U |C A C C C |A U U U C U C |A C C A
                                                 ==========                ========== ****  ********
2060  A C                                     C5|C C C A G |T F C G A1U C |C U G G G |C G A A A U C |A C C A
                                                 ==========                ========== **********  **
                                                            *           *
2070  A G G7D                                 C5|C5C C G G |U F C G A1A A |C C G G G |C G G A A A C |A C C A
                                                 =============          ============= **************
2071  A G G7D                                 C5|C5C C G G |U F C G A1A A |C C G G G |C G G A A A C |A C C A
                                                 =============          ============= **************
2075  A G G7D                                 C5|C5C C G G |U F C G A1A A |C C G G G |C G G A A A C |A C C A
                                                 ==========                ========== **************
2076  A G G7D                                 C5|C5C C G G |U F C G A1A A |C C G G G |C G G A A A C |A C C A
                                                 ==========                ========== **************
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2050/34 N IS A DERIVATIVE OF URIDINE
2051/10 PARTIALLY MODIFIED
2070/0 MOUSE MYELOMA,RABBIT LIVER AND HUMAN PLACENTA 1A, IN THE LATTER
CASE C-32 AND C-38 ARE UNMODIFIED
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