

HIGH MOLECULAR MASS AMINO ACYL-tRNA SYNTHETASE COMPLEXES IN EUKARYOTES

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1. Introduction

Aminoacyl-tRNA synthetases (AARS) are enzymes which play an indispensable role in protein biosynthesis by catalyzing the formation of aminoacyl-tRNA from amino acid, the cognate tRNA, and ATP by highly selective intermolecular interactions [57]. Joachimiak and Barciszewski [41] have provided an extensive compilation of the properties of the aminoacyl-tRNA synthetases; however, information on the eukaryotic high M_r (HM_r) complexes of aminoacyl-tRNA synthetases was lacking. Here, we intend to fill this void by providing a summary of the properties of the eukaryotic aminoacyl-tRNA synthetase complexes.

Eukaryotic aminoacyl-tRNA synthetases may occur as complexes with M_r -values of $>10^6$ in contrast to the prokaryotic counterparts which have M_r -values of $\leq 250\,000$. These eukaryotic HM_r -AARS complexes appear ubiquitous in a wide spectrum of cell types from yeast to human placenta as shown in table 1. Although not all 20 aminoacyl-tRNA synthetases were examined in each case shown in table 1, it appears that the AARS commonly associated with M_r complexes are those specific for Arg, Gln, Glu, Ile, Leu, Lys and Met. The properties of these HM_r -AARS complexes are most consistent with multienzyme complexes of aminoacyl-tRNA synthetases [19,20,43,46]. The physicochemical properties, composition, and stoichiometry of the more rigorously characterized complexes are shown in table 2.

The mechanism(s) of intermolecular interaction between the aminoacyl-tRNA synthetases is not known, but the putative interactions of aminoacyl-tRNA synthetases with a variety of biomolecules have been suggested to play a role in complex formation as shown in table 3. Our present knowledge of the func-

tional significance of HM_r -AARS is profoundly lacking; however, interactions of the aminoacyl-tRNA synthetases with other components of the protein biosynthetic machinery and other enzymes suggest the intriguing possibility of higher organization of eukaryotic protein biosynthesis. Table 4 is a summary of the possible interactions of the aminoacyl-tRNA synthetases with subcellular components and other enzymes.

This presentation is a brief summary of the properties of the high molecular weight eukaryotic aminoacyl-tRNA synthetase complexes. We hope that this compilation will complement that presented in [41] and will provide useful information for workers in this and other related fields.

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Table 1
Occurrence of high M_r aminoacyl-tRNA synthetases in eukaryotes

Source	Ala	Arg	Asp	Asn	Cys	Gln	Glu	Gly	His	Ile	Leu	Lys	Met	Phe	Pro	Ser	Thr	Tyr	Val	References
Mouse liver	+	+	+	+	ND	+	ND	+	+	+	+	+	+	+	+	+	+	+	+	[7-11]
Mouse liver		+	+	+	+	+	+			+	+	+	+							[64]
Mouse embryo		+	+	+	+	+	+			+	+	+	+							[64]
Rat liver	+	+	+	ND	ND	+	+	+	+	+	+	+	+	+	+	+	+	+	+	[5,6,22,24]
Rat liver		+	+	+	+	ND	+	+		+	+	+	+							[12,28]
Rat liver		+	+	+	+	+	+	+		+	+	+	+							[18-20,42]
Rat liver		+	+	+	+	+	+	+		+	+	+	+							[43]
Rat liver		+	+	+	+	+	+	+		+	+	+	+							[56]
Rat liver		+	+	+	+	+	+	+		+	+	+	+							[68-71]
Rat liver		+	+	+	+	+	+	+		+	+	+	+							[16,17,29,30]
Rat mammary gland		+	+	+	+	+	+	+		+	+	+	+							[35]
Rat skeletal muscle		+	+	+	+	+	+	+		+	+	+	+							[4]
Rabbit reticulo-cytes		+	+	+	+	+	+	+		+	+	+	+							[61]
Porcine thyroid gland		+	+	+	+	ND	+	+	+	+	+	+	+				+	+	+	[67]
Sheep liver		+	+	+	+	+	+	+		+	+	+	+				+	+	+	[13,44-46]
Bovine brain		+	+	+	+	+	+	+		+	+	+	+							[65,66]
Calf brain	+	+	+	+	ND	+	+	+	+	+	+	+	+				+	+	+	[15]
Human placenta		+	+	+	+	+	+	+		+	+	+	+							[21]
Chick embryo		+	+	+	+	+	+	+		+	+	+	+							[64]
Friend leukemia cells		+	+	+	+	+	+	+		+	+	+	+							[64]
Chinese hamster ovary cells		+	+	+	+	+	+	+		+	+	+	+							[27,33,52,53]
Ehrlich ascites cells ^a									+	+	+	+	+							[54,55]
<i>Drosophila</i> ^a	+								+	+	+	+	+							[58]
Wheat germ ^a		+							+	+	+	+	+							[50]
Yeast ^a									+	+	+	+	+							[25,26]

^a Only a few synthetase activities were examined; ND = not determined

Table 2
 Physicochemical properties and composition of eukaryotic aminoacyl-tRNA synthetase complexes a,b

Source	M_r ($\times 10^{-3}$)	$s_{20,w}$	Ala	Arg	Asp	Asn	Cys	Gln	Glu	Gly	His	Ile	Leu	Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Val	References
Chinese hamster ovary	-	30	-	+	+	-	-	+	+	-	+	+	+	+	+	-	+	-	+	-	-	-	[52]
Rat liver	-	18	-	-	-	-	+	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	[69,71]
Rat liver ^c	1000	18	-	+	-	-	(+)	-	-	-	(1)	(1)	2	1	-	-	-	-	-	-	-	-	[43]
Rat liver	900	24	-	+	-	-	+	+	-	-	+	+	+	+	+	-	+	-	-	-	-	-	[20]
Rat liver ^d	285	12	-	(2)	-	-	-	-	-	-	-	-	(2)	-	-	-	-	-	-	-	-	-	[17]
Rat mammary gland	-	20-28	-	+	-	-	+	+	-	-	+	+	+	+	+	-	-	-	-	-	-	+	[35]
Rabbit reticulocytes	550	16	-	+	-	-	-	-	-	-	+	+	+	+	+	-	-	-	-	-	-	-	[61]
Sheep liver	1000	-	-	+	-	-	+	+	+	-	+	+	+	+	+	-	-	-	-	-	-	-	[46]
Human placenta	-	17-20	-	+	-	-	-	+	+	-	-	+	+	+	+	-	-	-	-	-	-	-	[21]

a Only complexes characterized with published activity profiles are included in table 2

b A plus signifies that the synthetase activity for the indicated amino acid is present in the complexes

c The numbers indicate the stoichiometry determined by active site titration; parentheses signify tentative assignments (details in [43])

d The numbers indicate tentative values of the stoichiometry

Table 3
Biomolecules with putative role in HM_T aminoacyl-tRNA synthetase complex formation^a

Biomolecule	Method of analysis	Enzyme source	References
Carbohydrate	SDS-polyacrylamide gel staining (periodic acid Schiff reagent)	Thr-RS; rat liver	[24]
	Gas chromatography of enzyme hydrolysate	Lys-, Arg-RS; rat liver	[16,29]
Lipid			
Cholesteryl ester, cholesterol	Extraction of enzyme preparation, paper chromatography	Complex; rat liver	[6]
		Complex; rat mammary gland	[35]
Cholesteryl 14-methylhexadecanoate	Extraction of enzyme preparation	Rat liver	[36,37]
Ergosterol	Extraction of enzyme preparation	Lys-RS; yeast	[25]
Glycolipid	Paper chromatography of enzyme preparation extract	Complex; rat liver	[56]
Ribonucleic acid			
tRNA, 4 S RNA	Extraction of enzyme preparation amino acid acceptor activity	Complex; mouse liver	[9]
		Complex; rat liver	[5]
		Complex; rat liver	[56]
High M_T RNA	Analysis of binding by gel filtration and sucrose gradient ultracentrifugation Affinity chromatography	Ehrlich ascites cells Rabbit reticulocytes	[55] [3]

^a Studies included in table 3 vary in levels of exactness and enzyme purity

Table 4
The interaction of aminoacyl-tRNA synthetases with subcellular components and other enzyme activities^{a,b}

Organelle or enzyme	Method of analysis	Source	References
Microsome	Cell fractionation	Chinese hamster ovary	[32]
		Rat skeletal muscle	[4]
		Rat liver	[63]
		Chicken embryo	[49]
		Yeast	[26]
		Wheat germ	[50]
Ribosome	Copurification, reconstitution	Rat liver	[63]
	Copurification	Chinese hamster ovary	[48]
	Copurification or reconstitution	Rabbit reticulocyte	[39,59,62,64]
	Enzyme activity stimulation	Rabbit reticulocyte	[31]
	Protection of enzyme activity	Wheat germ	[14]
	Copurification	Yellow lupin seed	[40]
Elongation Factors	Copurification	Friend leukemic cells, chicken embryo, mouse liver, mouse embryo	[64]
	Copurification	Ehrlich ascites cell	[55]
Peptidyl acetyltransferase	Copurification	Rat liver	[60]
	Copurification	Rabbit reticulocyte	[38]
Initiation Factors	Copurification	Rat liver	[56]
	Copurification	Rabbit reticulocyte	[38]
tRNA Methyltransferase	Copurification	Human and mouse leukocytes	[1,2]
	Copurification	Rat liver	[34]
tRNA Sulfurtransferase	Copurification	Porcine thyroid gland	[67]
	Copurification	Hela cell	[51]
Ribonuclease	Copurification		
DNA Polymerase α	Copurification		

^a Mitochondrial enzymes are different from the cytosolic enzymes [23] and are not considered; nucleolar aminoacyl-tRNA synthetase activities have been detected in purified nucleoli [47]

^b Studies included in table 4 vary in levels of enzyme purity