REFERENCES

Agrawal, R. K., Spahn, C. M. T., Penczek, P., Grassucci, R. A., Nierhaus, K. H., and Frank, J. (2000). Visualization of tRNA movements on the *Escherichia coli* 70S ribosome during the elongation cycle. J Cell Biol *150*, 447-459.

Allen, D. W., and Zamecnik, P. C. (1962). The effect of puromycin on rabbit reticulocyte ribosomes. Biochim Biophys Acta *55*, 865-874.

Andersen, G. R., Nissen, P., and Nyborg, J. (2003). Elongation factors in protein biosynthesis. Trends Biochem Sci *28*, 434-441.

Aoki, H., Adams, S. L., Turner, M. A., and Ganoza, M. C. (1997). Molecular characterization of the prokaryotic efp gene product involved in a peptidyltransferase reaction. Biochimie *79*, 7-11.

Bartetzko, A., and Nierhaus, K. H. (1988). A simple Mg^{2+}/NH_4^+/polyamine system for poly(U) dependent poly(Phe) synthesis with near *in vivo* characteristics. Methods Enzymol *164*, 650-658.

Berg, P., Bergmann, F. H., Ofengand, E. J., and Dieckmann, M. (1961). The enzymatic synthesis of amino acyl derivatives of ribonucleic acid: I. The mechanism of leucyl-, valyl-, isoleucyl-, and methionyl ribonucleic acid formation. J Biol Chem *236*, 1726-1734.

Bergemann, K., and Nierhaus, K. H. (1983). Spontaneous, elongation factor G independent translocation of *Escherichia coli* ribosomes. J Biol Chem *258*, 15105-15113.

Blaha, G., Burkhardt, N., and Nierhaus, K. H. (2002). Formation of 70S ribosomes: Large activation energy is required for the adaptation of exclusively the small ribosomal subunit. Biophys Chem *96*, 153-161.

Blaha, G., and Nierhaus, K. H. (2001). Features and functions of the ribosomal E site. Cold Spring Harbor Symposia on Quantitative Biology *65*, 135-145.

Blaha, G., Stelzl, U., Spahn, C. M. T., Agrawal, R. K., Frank, J., and Nierhaus, K. H. (2000). Preparation of functional ribosomal complexes and the effect of buffer conditions on tRNA positions observed by cryoelectron microscopy. Methods Enzymol *317*, 292-309.

Blumberg, B. M., Nakamoto, T., and Kezdy, F. J. (1979). Kinetics of Initiation of Bacterial Protein Synthesis. PNAS USA *68*, 3122-3126.

Bocharov, E. V., Sobol, A. G., Pavlov, K. V., Korzhnev, D. M., Jaravine, V. A., Gudkov, A. T., and Arseniev, A. S. (2004). From structure and dynamics of protein L7/L12 to molecular switching in ribosome. J Biol Chem *279*, 17697-17706.

Burkhardt, N., Jünemann, R., Spahn, C. M. T., and Nierhaus, K. H. (1998). Ribosomal tRNA binding sites: Three-sites models of translation. Crit Rev Biochem Mol Biol *33*, 95-149.

Henry R. Bourne, David A. Sanders, Frank McCormick. (1991). The GTPase superfamily: conserverd structure and molecular mechanism. Nature 349, 117-127

Butland, G., Peregrin-Alvarez, J. M., Li, J., Yang, W., Yang, X., Canadien, V., Starostine, A., Richards, D., Beattie, B., Krogan, N.*, et al.* (2005). Interaction network containing conserved and essential protein complexes in *Escherichia coli*. Nature *433*, 531-537.

Carter, A. P., Clemons, W. M., Jr., Brodersen, D. E., Morgan-Warren, R. J., Hartsch, T., Wimberly, B. T., and Ramakrishnan, V. (2001). Crystal structure of an initiation factor bound to the 30S ribosomal subunit. Science *291*, 498-501.

Caskey, C. T., Forrester, W. C., and Tate, W. (1984). Peptide chain termination. Gene Expression

proceeding of The Alfred Benzon Symposium, Copenhagen Munkgard *19*, 457-466.

Chaconas, G., and Sande, J. H. v. d. (1980). 5' ^{32}P labelling of RNA and DNA restriction fragments. Methods Enzymol *65*, 75-88.

Cobianchi, F., and Wilson, S. (1987). Enzymes for modifying and labeling DNA and RNA. Meth Enzymol *152*, 94-110.

Craigen, W. J., Cook, R. G., Tate, W. P., and Caskey, C. T. (1985). Bacterial peptide chain release factors: conserved primary structure and possible frameshift regulation of release factor 2. Proc Natl Acad Sci USA *82*, 3616-3620.

Czworkowski, J., Wang, J., Seitz, T. A., and Moore, P. B. (1994). The crystal structure of elongation factor G complexed with GDP, at 2.7 Å resolution. EMBO J *13*, 3661-3668.

Dabrowski, M., Spahn, C. M. T., and Nierhaus, K. H. (1995). Interaction of tRNAs with the ribosome at the A and P sites. EMBO J *14*, 4872-4882.

Dabrowski, M., Spahn, C. M. T., Schäfer, M. A., Patzke, S., and Nierhaus, K. H. (1998). Contact patterns of tRNAs do not change during ribosomal translocation. J Biol Chem *273*, 32793-32800.

Dahlquist, K. D., and Puglisi, J. D. (2000). Interaction of translation initiation factor IF1 with the *E. coli* ribosomal A site. J Mol Biol *299*, 1-15.

Dallas, A., and Noller, H. F. (2001). Interaction of translation initiation factor 3 with the 30S ribosomal subunit. Mol Cell *8*, 855-864.

Dibb, N. J., and Wolfe, P. B. (1986). lep operon proximal gene is not required for growth or secretion by *Escherichia coli*. J Bacteriol *166*, 83-87.

Dinos, G., Wilson, D. N., Teraoka, Y., Szaflarski, W., Fucini, P., Kalpaxis, D., and Nierhaus, K. H. (2004). Dissecting the ribosomal inhibition mechanisms of edeine and pactamycin: the universally conserved residues G693 and C795 regulate P-site RNA binding. Mol Cell *13*, 113-124.

Dube, P., Wieske, M., Stark, H., Schatz, M., Stahl, J., Zemlin, F., Lutsch, G., and van Heel, M. (1998). The 80S rat liver ribosome at 25 A resolution by electron cryomicroscopy and angular reconstitution. Structure *6*, 389-399.

Erlacher, M. D., Lang, K., Shankaran, N., Wotzel, B., Huttenhofer, A., Micura, R., Mankin, A. S., and Polacek, N. (2005). Chemical engineering of the peptidyl transferase center reveals an important role of the 2'-hydroxyl group of A2451. Nucleic Acids Res *33*, 1618-1627.

Freistroffer, D. V., Pavlov, M. Y., MacDougall, J., Buckingham, R. H., and Ehrenberg, M. (1997). Release factor RF3 in *E. coli* accelerates the dissociation of release factors RF1 and RF2 from the ribosome in a GTP-dependent manner. EMBO J *16*, 4126-4133.

Ganoza, M. C. (1977). Novel factors in protein biosynthesis. (review). Can J Biochem *55*, 267-281.

Ganoza, M. C., and Barraclough, N. (1975). Isolation of a factor that stimulates cleavage of ribosomal bound N-acetyl or N-formyl methionyl tRNAfMet. FEBS Lett *53*, 159-163.

Gavrilova, L. P., Kostiashkina, O. E., Koteliansky, V. E., Rutkevitch, N. M., and Spirin, A. S. (1976). Factor-free(non-enzymic and factor-dependent systems of translation of polyU by E coli ribosomes. J Mol Biol *101*, 537-552.

Geigenmüller, U., and Nierhaus, K. H. (1990). Significance of the third tRNA binding site, the E Site, on *E. coli* ribosomes for the accuracy of translation : an occupied E site prevents the binding of non-cognate aminoacyl-transfer RNA to the A site. EMBO J *9*, 4527-4533.

Gillam, I., Milward, S., Blew, D., von Tigerstrom, M., Wimmer, E., and Tener, G. M. (1967). The separation of soluble ribonucleic acids on benzoylated diethylaminoethylcellulose. Biochemistry *6*, 3043-3056.

Gnirke, A., Geigenmüller, U., Rheinberger, H.-J., and Nierhaus, K. H. (1989). The allosteric three-site model for the ribosomal elongation cycle. J Biol Chem *264*, 7291-7301.

Gnirke, A., and Nierhaus, K. H. (1989). Large-scale synthesis of the mRNA analogue $C_{17}AUGA_4C_{17}$. Biochem Int *18*, 551-559.

Grajevskaja, R. A., Ivanov, Y. V., and Saminsky, E. M. (1982). 70-S ribosomes of *Escherichia coli* have an additional site for deacylated tRNA binding. Eur J Biochem *128*, 47-52.

Gualerzi, C., Brandi, L., Caserta, E., La teana, A., Spurio, R., Tomsic, J., and Pon, C. (2000). Translation initiation in bacteria. In The ribosome. structure, function, antibiotics, and cellular interactions, R. A. Garrett, S. R. Douthwaite, A. Liljas, A. T. Matheson, P. B. Moore, and H. F. Noller, eds. (Washington D.C., ASM Press), pp. 477-494.

Gualerzi, C. O., and Pon, C. L. (1990). Initiation of messenger-RNA translation in prokaryotes. Biochemistry *29*, 5881-5889.

Haenni, A., and Chapeville, F. (1966). The behaviour of acetylphenylalanyl soluble ribonucleic acid in polyphenylalanine synthesis. Biochim Biophys Acta *114*, 135-148.

Hagiya, A., Naganuma, T., Maki, Y., Ohta, J., Tohkairin, Y., Shimizu, T., Nomura, T., Hachimori, A., and Uchiumi, T. (2005). A mode of assembly of P0, P1, and P2 proteins at the GTPase-associated center in animal ribosome: in vitro analyses with P0 truncation mutants. J Biol Chem *280*, 39193-39199.

Hanawa-Suetsugu, K., Sekine, S., Sakai, H., Hori-Takemoto, C., Terada, T., Unzai, S., Tame, J. R., Kuramitsu, S., Shirouzu, M., and Yokoyama, S. (2004). Crystal structure of elongation factor P from *Thermus thermophilus* HB8. Proc Natl Acad Sci U S A *101*, 9595-9600.

Hapke, B., and Noll, H. (1976). Structural dynamics of bacterial ribosomes: IV.Classification of ribosomes by subunit interaction. J Mol Biol *105*, 97-109.

Hartwick, R. A., Assenza, S. P., and Brown, P. R. (1979). Identification and quatitation of nucleotides, bases and other UV-absorbing compounds in serum, using reversed-phase High-Performance Liquid Chromatography. J Chromatogr *186*, 647-658.

Hartz, D., Mc Pheeters, D. S., and Gold, L. (1990). From polynucleotide to natural mRNA translation initiation: Function of *Escherichia coli* initiation factors. In The Ribosome: Structure, Function and Evolution, W. E. Hill, A. Dahlberg, R. A. Garrett, P. B.

Moore, D. Schlessinger, and J. R. Warner, eds. (Washington, USA, American Society of Microbiology), pp. 275-280.

Hartz, D., McPheeters, D. S., Green, L., and Gold, L. (1991). Detection of *Escherichia coli* ribosome binding at translation initiation sites in the absence of transfer-RNA. J Mol Biol *218*, 99-105.

Hartz, D., McPheeters, D. S., Traut, R., and Gold, L. (1988). Extension inhibition analysis of translation initiation complexes. Methods Enzymol *164*, 419-425.

Hentzen, D., Mandel, P., and Garel, J. P. (1972). Relation between aminoacyl tRNA stability and the fixed amino acid. Biochim Biophys Acta *281*, 228-232.

Jinks, R. S., Baughman, G., and Nomura, M. (1984). Regulation of ribosome biosynthesis in E. coli. Alfred Benzon Symp.

Jinks, R. S., and Nomura, M. (1987). Ribosomes and tRNA. In Escherichia coli and Salmonella typhimurium, pp. 1358-1381.

Jorgensen, F., and Kurland, C. G. (1990). Processivity errors of gene expression in *Escherichia coli*. J Mol Biol *215*, 511-521.

Kang, H. A., and Hershey, J. W. (1994). Effect of initiation factor eIF-5A depletion on protein synthesis and proliferation of Saccharomyces cerevisiae. J Biol Chem *269*, 3934-3940.

Karimi, R., Pavlov, M., Buckingham, R., and Ehrenberg, M. (1999). Novel roles for classical factors at the interface between translation termination and initiation. Mol Cell *3*, 601-609.

Kelmers, A. D., Weeren, H. O., Weiss, J. F., Pearson, R. L., Stulberg, M. P., and Novelli, D. (1971). Reversed-phase chromatography system for transfer ribonucleic acids-preparatory-scale methods. Meth Enzymol *20*, 9-34.

Kiser, G. L., and Weinert, T. A. (1995). GUF1, a gene encoding a novel evolutionarily conserved GTPase in budding yeast. Yeast *11*, 1311-1316.

Klenow, H., and Henningsen, I. (1970). Selective elimination of the exonuclease activity of the deoxiribonucleic acid polymerase from Escherichia coli B by limited proteolysis. Proc Natl Acad Sci USA *65*, 168-175.

Kutay, U. R., Spahn, C. M. T., and Nierhaus, K. H. (1990). Similarities and differences in the inhibition patterns of thiostrepton and viomycin - evidence for 2 functionally different populations of P-sites when occupied with acphe-transfer RNA. Biochim Biophys Acta *1050*, 193-196.

Laemmli, U. K., and Favre, M. (1973). Maturation of the head of bacteriophage T4. I. DNA packaging events. J Mol Biol *80*, 575-599.

Lake, J. A. (1976). Ribosome structure determined by electron microscopy of E coli small subunits, large subunits and monomeric ribosomes. J Mol Biol *105*, 131-159.

LaRiviere, F. J., Wolfson, A. D., and Uhlenbeck, O. C. (2001). Uniform binding of aminoacyl-tRNAs to elongation factor Tu by thermodynamic compensation. Science *294*, 165-168.

La Teana, A., Pon, C.L., Gualerzi, C.O. (1996) Late events in translation initiation. Adjustment of fMet-tRNA in the ribosomal P-site. J. Mol. Biol. 256, 667-675.

Lill, R., Robertson, J. M., and Wintermeyer, W. (1984). tRNA binding sites of ribosomes from *Escherichia coli*. Biochemistry *23*, 6710-6717.

Lipmann, F. (1963). Messenger ribonucleic acid. Prog Natl Acid Res *1*, 135-161.

Lockwood, A. H., Chakraborty, P. R., and Maitra, U. (1971). A complex between initiation factor IF2, guanosine triphosphate, and fMet-tRNA: an intermediate in initiation complex formation. PNAS USA *68*, 3122-3126.

Luchin, S., Putzer, H., Hershey, J. W. B., Cenatiempo, Y., Grunberg-Manago, M., and Laalami, S. (1999). In vitro study of two dominant inhibitory GTPase mutants of *Escherichia coli* translation initiation factor IF2 - Direct evidence that GTP hydrolysis is necessary for factor recycling. Journal of Biological Chemistry *274*, 6074-6079.

Maniatis, R. B., Fritsch, E. F., and Sambrook, J. (1982). Molecular Cloning: A Laboratory Manual., Cold Spring Harbour Laboratory).

March, P. E., and Inouye, M. (1985a). Characterization of the lep operon of *Escherichia coli*. Identification of the promoter and the gene upstream of the signal peptidase I gene. J Biol Chem *260*, 7206-7213.

March, P. E., and Inouye, M. (1985b). GTP-binding membrane protein of *Escherichia coli* with sequence homology to initiation factor 2 and elongation factors Tu and G. Proc Natl Acad Sci U S A *82*, 7500-7504.

Márquez, V. (2002) Switching off the mechanism for maintaining the ribosomal reading frame: Translational regulation of release factor 2, Free University Berlin, Berlin.

Marquez, V., Wilson, D. N., and Nierhaus, K. H. (2002). Functions and interplay of the tRNA-binding sites of the ribosome. Biochem Soc Trans *30*, 133-140.

Marquez, V., Wilson, D. N., Tate, W. P., Triana-Alonso, F., and Nierhaus, K. H. (2004). Maintaining the ribosomal reading frame: The influence of the E site during translational regulation of release factor 2. Cell *118*, 45-55.

Martemyanov, K. A., and Gudkov, A. T. (1999). Domain IV of elongation factor G from Thermus thermophilus is strictly required for translocation. FEBS Lett *452*, 155-159.

Maxam, A. M., and Gilbert, W. (1977). A new method for sequencing DNA. Proc Natl Acad Sci USA *74*, 560-564.

Meinnel, T., Sacerdot, C., Graffe, M., Blanquet, S., Springer, M. (1999). Discrimination by *Escherichia coli* initiation factor IF3 against initiation on non-canonical codons relies on complementarity rules. J Mol Biol *290* 825-837

Mesters, J. R., Potapov, A. P., de Graaf, J. M., and Kraal, B. (1994). Synergism between the GTPase activities of EF-Tu.GTP and EF-G.GTP on empty ribosomes. Elongation factors as stimulators of the ribosomal oscillation between two conformations. J Mol Biol *242*, 644-654.

Milligan, F., and Uhlenbeck, O. C. (1989). Synthesis of small RNAs using T7 RNA polymerase. Meth Enzymol *180*, 51-62.

Moazed, D., and Noller, H. F. (1989a). Interaction of tRNA with 23S rRNA in the ribosomal A, P, and E sites. Cell *57*, 585-597.

Moazed, D., and Noller, H. F. (1989b). Intermediate states in the movement of transfer RNA in the ribosome. Nature *342*, 142-148.

Moazed, D., and Noller, H. F. (1990). Binding of tRNA to the ribosomal A and P sites protects two distinct sets of nucleotides in the 16S rRNA. J Mol Biol *211*, 135-145.

Nierhaus, K. H. (1990). The allosteric three-site model for the ribosomal elongation cycle: features and future. Biochemistry *29*, 4997-5008.

Nierhaus, K. H. (1993). Solution of the ribosomal riddle: How the ribosome selects the correct aminoacyl-tRNA out of 41 similar contestants. Mol Microbiol *9*, 661-669.

Nierhaus, K. H. (1996a). Protein synthesis - An elongation factor turn-on. Nature *379*, 491-492.

Nierhaus, K. H. (1996b). The tricks of ribosomal elongation factors. Angew Chem Int Ed *35*, 2198-2201.

Nierhaus, K. H., Wadzack, J., Burkhardt, N., Jünemann, R., Meerwinck, W., Willumeit, R., and Stuhrmann, H. B. (1998). Structure of the elongating ribosome: Arrangement of the two tRNAs before and after translocation. Proc Natl Acad Sci USA *95*, 945-950.

Nirenberg, M., and Leder, P. (1964). RNA codewords and protein synthesis. The effect of trinucleotides upon the binding of sRNA to ribosomes. Science *145*, 1399-1407.

Nissen, P., Kjeldgaard, M., and Nyborg, J. (2000). Macromolecular mimicry. EMBO J *19*, 489-495.

Noller, H. F., Yusupov, M. M., Yusupova, G. Z., Baucom, A., and Cate, J. H. D. (2002). Translocation of tRNA during protein synthesis. FEBS Letter *514*, 11-16.

Odom, O. W., Deng, H. Y., and Hardesty, B. (1988). Separation of ribosomal proteins and tRNA. Methods in Enzymology, 174-187.

Ogle, J. M., Brodersen, D. E., Clemons Jr, W. M., Tarry, M. J., Carter, A. P., and Ramakrishnan, V. (2001). Recognition of cognate transfer RNA by the 30S ribosomal subunit. Science *292*, 897-902.

Polacek, N., and Barta, A. (1998). Metal ion probing of rRNAs: evidence for evolutionarily conserved divalent cation binding pockets. Rna *4*, 1282-1294.

Polacek, N., Patzke, S., Nierhaus, K. H., and Barta, A. (2000). Periodic Conformational Changes in rRNA: Monitoring the Dynamics of Translating Ribosomes. Mol Cell *6*, 159-171.

Ramakrishnan, V., and Moore, P. B. (2001). Atomic structures at last: the ribosome in 2000. Curr Opin Struct Biol *11*, 144-154.

Rappoport, S., and Lapidot, Y. (1974). The chemical preparation of acetoaminoacyl-tRNA. Meth Enzymol *29*, 685-688.

Remme, J., Margus, T., Villems, R., and Nierhaus, K. H. (1989). The third ribosomal tRNA-binding site, the E site, is occupied in native polysomes. Eur J Biochem *183*, 281-284.

Rheinberger, H.-J., Geigenmüller, U., Wedde, M., and Nierhaus, K. H. (1988). Parameters for the preparation of *Escherichia coli* ribosomes and ribosomal subunits active in tRNA binding. Methods Enzymol *164*, 658-670.

Rheinberger, H.-J., and Nierhaus, K. H. (1980). Simultaneous binding of the 3 tRNA molecules by the ribosome of *E coli*. Biochem Internatl *1*, 297-303.

Rheinberger, H.-J., Sternbach, H., and Nierhaus, K. H. (1981). Three tRNA binding sites on *Escherichia coli* ribosomes. Proc Natl Acad Sci USA *78*, 5310-5314.

Richardson, C. C. (1981). Bacteriophage T4 polynucleotide kinase. In The Enzymes, P. D. B. ed., ed. (New York, Acad. Press.), pp. 299-314.

Schilling-Bartetzko, S., Bartetzko, A., and Nierhaus, K. H. (1992). Kinetic and thermodynamic parameters for transfer RNA binding to the ribosome and for the translocation reaction. J Biol Chem *267*, 4703-4712.

Schmeing, T. M., Huang, K. S., Strobel, S. A., and Steitz, T. A. (2005). An induced-fit mechanism to promote peptide bond formation and exclude hydrolysis of peptidyl-tRNA. Nature *438*, 520-524.

Spahn, C. M., Beckmann, R., Eswar, N., Penczek, P. A., Sali, A., Blobel, G., and Frank, J. (2001). Structure of the 80S ribosome from *Saccharomyces cerevisiae*-tRNA-ribosome and subunit-subunit interactions. Cell *107*, 373-386.

Stöffler, G., and Stöffler-Meilicke, M. (1984). Transcription of an artificial ribosomal RNA gene in yeast. Annu Rev Biophys Bioeng.

Traub, P., and Nomura, M. (1969). Structure and function of the *Escherichia coli* ribosome. Mechanism of assembly of 30S ribosomes studied *in vitro*. J Mol Biol *40*, 391-413.

Traut, R. R., and Monro, R. E. (1964). The puromiycin reaction and its relation to protein synthesis. J Mol Biol *10*, 63-72.

Trobro, S., and Aqvist, J. (2005). Mechanism of peptide bond synthesis on the ribosome. Proc Natl Acad Sci U S A *102*, 12395-12400.

Wadzack, J., Burkhardt, N., Jünemann, R., Diedrich, G., Nierhaus, K. H., Frank, J., Penczek, P., Meerwinck, W., Schmitt, M., Willumeit, R., and Stuhrmann, H. B. (1997). Direct localization of the tRNAs within the elongating ribosome by means of neutron scattering (Proton-spin contrast-variation). J Mol Biol *266*, 343-356.

Wallace, R. B., and Miyada, C. G. (1987). Oligonucleotide probes for the screening of recombinant DNA libraries. Meth Enzymol *152*, 432-442.

Walters, L. C., and Novelli, G. D. (1971). Analytical reversed-phase chromatography of Escherichia coli aminoacyl-tRNAs. Meth Enzymol *20*, 39-44.

Watanabe, S. (1972). Interaction of siomycin with the acceptor site of Escherichia coli ribosomes. J Mol Biol *67*, 443-457.

Watson, J. D. (1963). Involvement of tRNA in the synthesis of proteins. Science *140*, 17-26.

Watson, J. D. (1964). The synthesis of proteins upon ribosomes. Bull Soc Chim Biol *46*, 1399-1425.

Weiss, R. B., Murphy, J. P., and Gallant, J. A. (1984). Genetic screen for cloned release factor genes. J Bacteriol *158*, 362-364.

Wilson, D. N., Blaha, G., Connell, S. R., Ivanov, P. V., Jenke, H., Stelzl, U., Teraoka, Y., and Nierhaus, K. H. (2002). Protein synthesis at atomic resolution: mechanistics of translation in the light of highly resolved structures for the ribosome. Curr Protein Pept Sci *3*, 1-53.

Wilson, D. N., and Nierhaus, K. H. (2003). The ribosome through the looking glass. Angew Chem Int Ed Engl *42*, 3464-3486.

Wilson, K. S., and Noller, H. F. (1998). Molecular movement inside the translational engine. Cell *92*, 337-349.

Wimmer, E., Maxwell, J. H., and Tener, G. M. (1968). A simple method for isolating highly purified yeast phenylalanine transfer ribonucleic acid. Biochemistry *7*, 2623-2628.

Youngman, E. M., Brunelle, J. L., Kochaniak, A. B., and Green, R. (2004). The active site of the ribosome is composed of two layers of conserved nucleotides with distinct roles in peptide bond formation and peptide release. Cell *117*, 589-599.

Yusupov, M. M., Yusupova, G. Z., Baucom, A., Lieberman, K., Earnest, T. N., Cate, J. H., and Noller, H. F. (2001). Crystal structure of the ribosome at 5.5 A resolution. Science *292*, 883-896.

Zaniewski, R., Petkaites, E., and Deutscher, M. P. (1984). A multiple mutant of *Escherichia coli* lacking the exoribonucleases RNase II, RNase D, and RNase BN. J Biol Chem *259*, 11651-11653.

Zavialov, A. V., Buckingham, R. H., and Ehrenberg, M. (2001). A posttermination ribosomal complex is the guanine nucleotide exchange factor for peptide release factor RF3. Cell *107*, 115-124.

Zwizinski, C., and Wickner, W. (1980). Purification and characterization of leader (signal) peptidase from *Escherichia coli*. J Biol Chem *255*, 7973-7977.