
**Thermo Scientific**
**Human *In Vitro* Translation Products**




# 1 step
## to functional proteins

1-Step Human Coupled *In Vitro* Translation System • 1-Step Human High-Yield *In Vitro* Translation System • 1-Step Heavy Protein *In Vitro* Translation System

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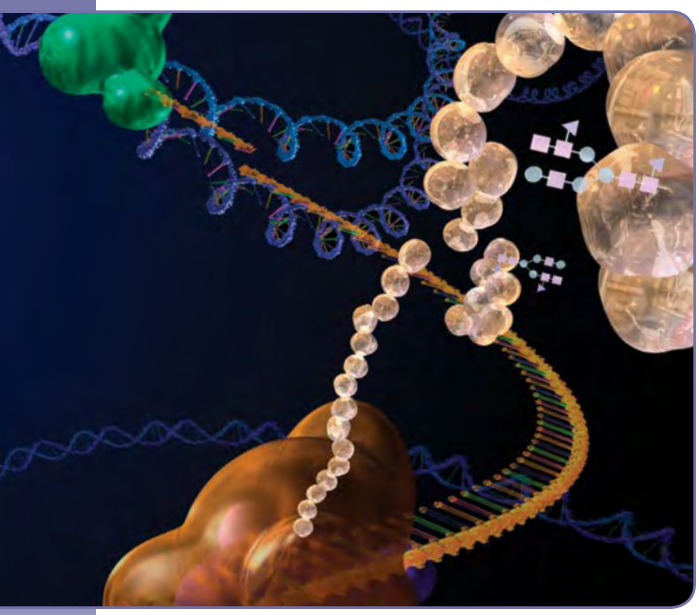
# Why is a human IVT system better?



## Easy protocol

The Thermo Scientific 1-Step Human *In Vitro* Translation (IVT) System synthesizes functional proteins using the human translation machine. The 1-Step Human IVT System couples DNA transcription and translation, delivering protein in as little as 90 minutes. Optimal protein expression is achieved using our pT7CFE1 family of vectors, which contain the proper transcription and translation elements. This system uses a T7 RNA Polymerase to drive efficient transcription, coupled with HeLa cell-free extracts to drive translation.

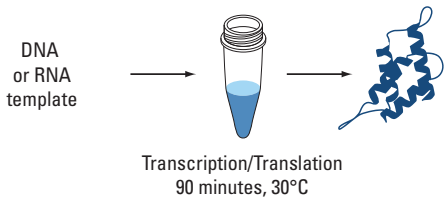



**Figure 1. *In vitro* translation with Thermo Scientific 1-Step Human IVT System.**

Compared to traditional methods for protein expression, human *in vitro* translation enables researchers to:

- Express protein in minutes without the need to grow and transfect cells
- Generate protein with post-translational modifications
- Easily express a large number of clones
- Label proteins efficiently with unnatural amino acids
- Generate proteins which are cytotoxic or difficult to express in a cell-based system

**The 1-Step Human *In Vitro* Translation System Selection Guide.**

| | 1-Step Human Coupled *In Vitro* Translation System | 1-Step Human High Yield *In Vitro* Translation System | 1-Step Heavy Protein *In Vitro* Translation System |
|---|---|---|---|
| **1-Step reaction volume** | 25µL | 0.1, 0.25 or 1mL | 25µL |
| **Protein yield (concentration)** | 40-100µg/mL | 250-750µg/mL | 40-100µg/mL |
| **Reaction time** | 90 min - 6 hrs | 6-24 hrs | 90 min - 6 hrs |
| **Applications** | • Mutational analysis<br>• Electrophoretic Mobility Shift Assays (EMSA)<br>• Co-Immunoprecipitation (Co-IP)<br>• High-throughput protein expression<br>• Express cytotoxic proteins<br>• Unnatural amino acid incorporation<br>• Screening for translation inhibitors<br>• Identifying optimal peptide fragments for analysis by mass spec[3] | • Overnight expression of milligram quantity of protein<br>• Express proteins difficult to generate in traditional systems due to cytotoxicity or protein denaturation<br>• Incorporate unnatural amino acids<br>• Structural analysis | • Incorporation of isotopic amino acids<br>• Controls in mass spectrometry analysis for sample prep loss or protein digestion<br>• Generating quantification standards |

For more information, or to download product instructions, visit www.thermoscientific.com/pierce

## Higher protein activity

Functional activity is based on protein structure and post-translational modifications. Comparison of the expression of the green *Renilla* luciferase enzyme in *E. coli* cultures and in the 1-Step Human High Yield *In Vitro* Translation System demonstrates 25 times greater luciferase activity in the human *in vitro* translation system, due to improved protein folding (Figure 2).

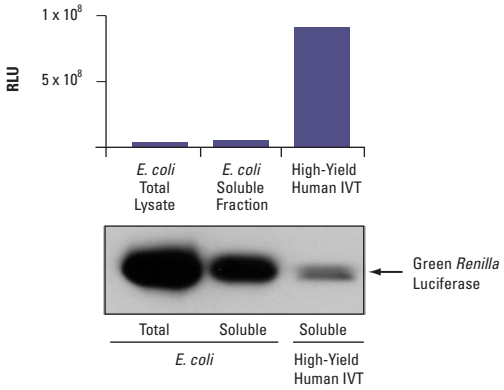



**Figure 2. Higher levels of green *Renilla* luciferase activity when expressed in the Thermo Scientific 1-Step Human IVT System.** Green *Renilla* luciferase expressed in *E. coli* cells-lysate samples was then either used directly (Total) or clarified at 10,000 X *g* for 5 minutes (Soluble). *In vitro* translation of green *Renilla* luciferase was done using the 1-Step Human High Yield IVT Kit (Product # 88886). Activity was measured using the Thermo Scientific Pierce Green *Renilla* Luciferase Flash Assay Kit (Product # 16164) and Western blots were carried out using 2µL of each of indicated samples. RLU = relative luciferase units.

## Higher protein yield

Compared to rabbit reticulocyte-based systems, any of our HeLa-based *in vitro* translation systems delivers higher protein yields with sustained expression for longer periods of time. Additionally, rabbit reticulocyte-based systems can produce background signals in Western blots because of cross reactivity with common Western blot antibodies, such as the globulin signal (Figure 3).

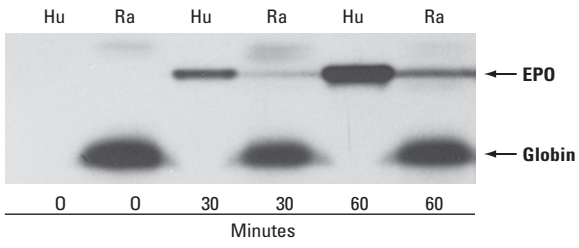



**Figure 3. Increased Erythropoietin (EPO) expression using the Thermo Scientific 1-Step Human IVT Kit compared to rabbit reticulocyte-based systems.** HA-tagged EPO expression was carried out using 1-Step Human Coupled IVT Kit (Hu) and the rabbit reticulocyte (Ra)-based system according to the manufacturers' instructions. 2µL of samples were removed from each reaction at indicated times and analyzed for EPO expression in a western blot using anti-HA antibodies.

## Easier assay development

The absence of heme protein in our human translation reaction eliminates interference with assays using fluorescent or colorimetric signal. Translation reactions containing green fluorescent protein (GFP) mRNA were performed with the 1-Step Human IVT System (Human) and a leading rabbit reticulocyte lysate system (Rabbit), followed by fluorescent detection. (Figure 4).

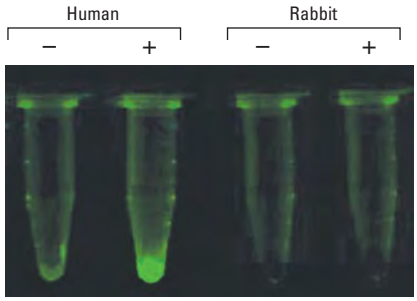



**Figure 4. *In vitro* protein expression in a human system enables easy detection of fluorescent proteins.** Translation reactions containing green fluorescent protein (GFP) mRNA were performed with the Thermo Scientific 1-Step Human *In Vitro* System (Human) and a leading rabbit reticulocyte lysate system (Rabbit). Expression of tGFP was easily monitored directly in reaction tubes using a FITC filter. The 1-Step Human IVT System is compatible with fluorescence and colorimetric protein detection. The rabbit reticulocyte lysate system interferes with fluorometric as well as colorimetric detection.

## Faster protein expression

The time required to express a protein in tissue culture cells is longer than *in vitro* methods. Additionally, cytotoxic proteins fail in tissue culture methods compared to *in vitro* translation (Figure 5).

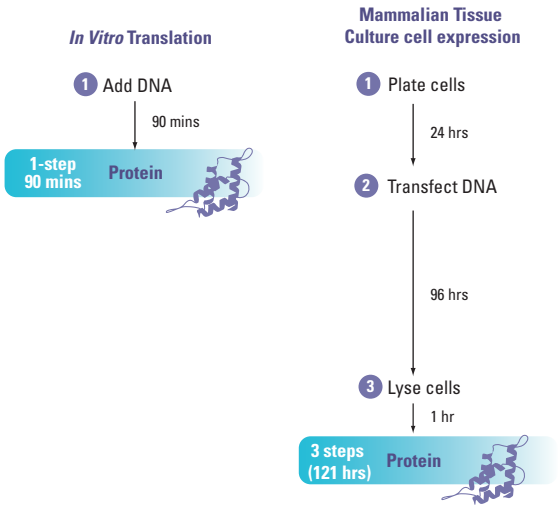



**Figure 5. Faster protein expression with human *in vitro* translation system versus expression in mammalian cell culture.**

# 1 step
# to functional protein


## Thermo Scientific 1-Step Human Coupled *In Vitro* Translation System

The 1-Step Human Coupled IVT Kit is a HeLa cell lysate-based protein expression system ideal for generating microgram quantities of protein. Protein expression is performed in a single 90-minute reaction that can be extended for up to six hours, with continued protein production up to 100µg/mL when combined with the optimized pT7CFE1 Expression Vector (included with each kit). Expression can be driven directly from our pT7CFE expression vector (DNA kits) or from mRNA transcripts (RNA kits).

The 1-Step Human IVT System is ideal for expressing functional enzymes, phosphoproteins and glycoproteins; studying protein interactions; and performing rapid mutational analysis. Certain membrane proteins with 1-3 transmembrane domains have also been produced. This format is amendable to high throughput protein expression and has been used to express protein libraries for the identification of peptide fragments optimized for mass spectrometry detection[3].

### Highlights:

- **Functional** – uses the human translational machinery to express active proteins
- **Convenient** – perform transcription and translation in a single step
- **High performance** – greater yields compared to rabbit reticulocyte *in vitro* translation
- **Reliable** – express proteins that fail in rabbit reticulocyte systems

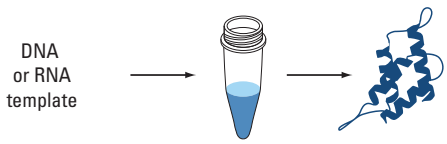



**Figure 6. *In vitro* translation with Thermo Scientific 1-Step Human IVT System.**

## Protein yield

Luciferase was expressed using the 1-Step Human Coupled *In Vitro* Translation System and compared to yields in rabbit reticulocyte-based systems. Protein yields from the 1-Step Human IVT Kit were much higher as measured by luciferase assay and Western blotting (Figure 7).

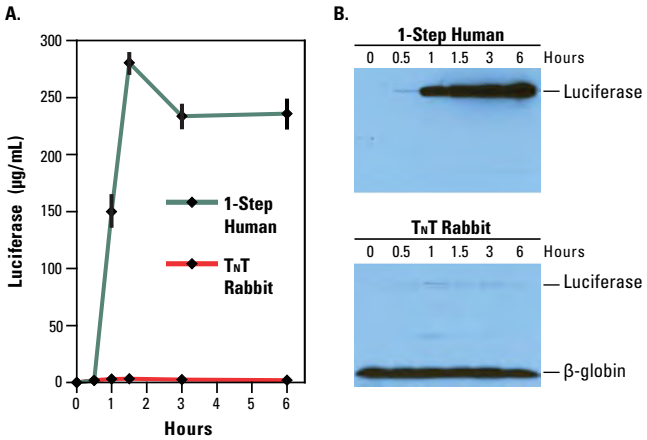



**Figure 7. The Thermo Scientific 1-Step Human Coupled IVT Kit produces more active protein without interfering substances.** *In vitro* luciferase expression reactions were performed with the 1-Step Human Coupled IVT Kit and the rabbit reticulocyte-based TNT T7 Quick Coupled Transcription/Translation System according to supplied instructions. Samples were removed from each reaction at the indicated intervals and analyzed for (**A.**) luciferase activity (correlated to µg/mL of active protein) or (**B.**) Western blot (1µL). The 1-Step Coupled Human *In Vitro* Expression Kit produced luciferase protein without contaminating beta-globin.


For more information, or to download product instructions, visit www.thermoscientific.com/pierce

## Protein labeling

Luciferase was expressed using the 1-Step Human Coupled *In Vitro* Translation System, and either fluorescent (Figure 8A and B) or radioactive (Figure 8C) amino acids were incorporated. Compared to proteins expressed in a rabbit reticulocyte system, detection of either fluorescent or radioactive signal was enhanced in protein expressed in the human IVT system resulting from higher protein yields.

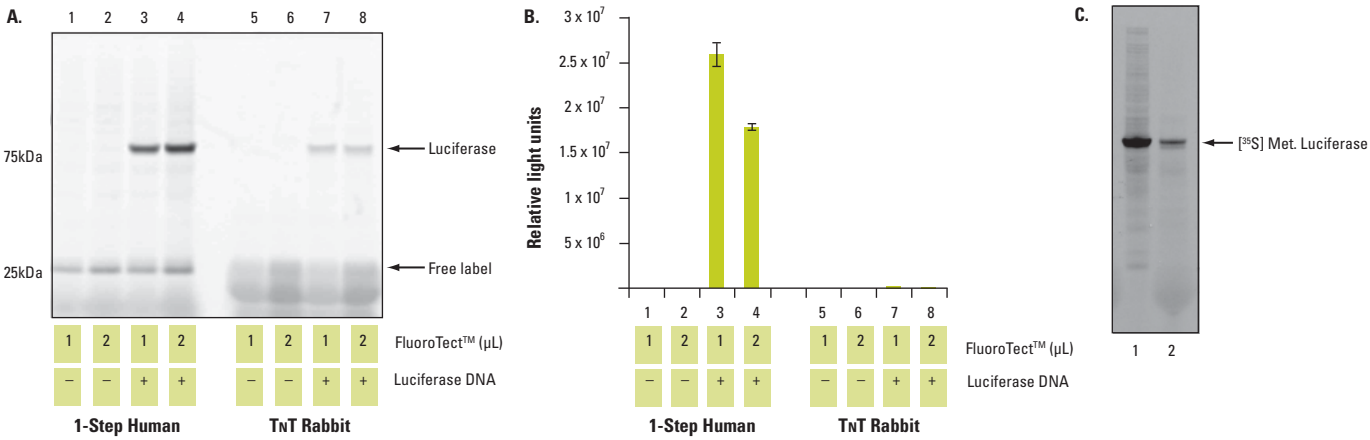



**Figure 8. Improved labeling and activity of luciferase expressed in the Thermo Scientific 1-Step Human Coupled IVT Kit compared to rabbit reticulocyte-based TnT system.** Luciferase was expressed in the 1-Step Human Coupled IVT Kit (Product # 88882) with the following modifications: 25µL reaction containing 50% human cell lysate, 2.5µL accessory proteins, 5µL reaction mix, 1µg firefly luciferase in pCFE1-CHis Vector, 1 or 2µL of Fluorotect™ BODIPY®-conjugated lysine for 3 hours. Reactions containing rabbit reticulocyte lysates were exactly carried out according to the manufacturing instructions except that incubations were carried out for 3 hours. **A:** 2µL of samples were run on a 4-12 % SDS-PAGE gel and analyzed for BODIPY labeled luciferase using a Typhoon® instrument with a 532 excitation. **B:** 2µL of each translation reaction was analyzed for luciferase activity using the Thermo Scientific Firefly Luciferase Assay Kit (Product # 16174). **C:** Comparison of incorporation of [$^{35}$S]-methionine into luciferase. Radioactive labeling of luciferase was performed with the 1-Step Human Coupled IVT Kit (Lane 1) and the rabbit reticulocyte-based TnT T7 Quick Coupled Transcription/Translation System (Lane 2) according to manufacturers instructions and control plasmids using 1µL of [$^{35}$S]-L-methionine. Samples were removed from each reaction at the 90 min. separated by SDS-PAGE gels, dried and exposed to X-ray film.

## Ordering Information

All kits below contain:
- HeLa Lysate
- Accessory Proteins
- Reaction Mix
- Positive Control DNA: pCFE-GFP
- pT7CFE1-CHis
- Nuclease-free Water

| Product # | Description | Pkg. Size |
|---|---|---|
| **88881** | **1-Step Human Coupled IVT Kit - DNA**<br>*Sufficient for 8 reactions of 25µL each.* | 8-rxn kit |
| **88882** | **1-Step Human Coupled IVT Kit - DNA**<br>*Sufficient for 40 reactions of 25µL each.* | 40-rxn kit |
| **88883** | **1-Step Human IVT Kit - mRNA**<br>*Sufficient for 8 reactions of 25µL each.* | 8-rxn kit |
| **88884** | **1-Step Human IVT Kit - mRNA**<br>*Sufficient for 40 reactions of 25µL each.* | 40-rxn kit |

# 1 step
# to higher yields

## Thermo Scientific 1-Step Human High-Yield *In Vitro* Translation System

The 1-Step High-Yield IVT System uses modified HeLa cell extracts to take advantage of the robust human transcription and translation machinery and generate functional full-length proteins. In this system, protein expression is performed in a unique dialysis device that allows a continuous supply of nucleotides, amino acids and energy-generating substrates into the reaction while removing inhibitors of proteins synthesis. This continuous-exchange system enables protein expression for up to 24 hours and produces protein yields ranging from 250 to 750µg/mL. The complete kits come with all components required for proper transcription and translation of recombinant protein, including a pT7CFE1 Expression Vector. Proteins made in the 1-Step High-Yield System can be purified using tag-specific resins and the tag can be cleaved by using HRV3C.

**Highlights:**

- **High expression** – up to 750µg/mL of expressed protein
- **Reproducibility** – low variability between experiments
- **Fast** – express high levels of protein with an overnight incubation
- **Functional** – obtain more active protein than with bacterial, rabbit or wheat germ protein expression

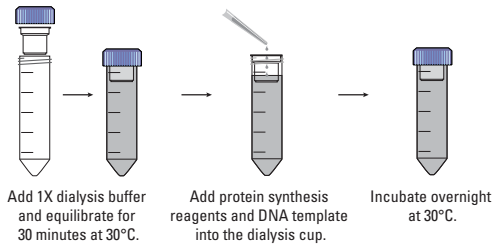



**Figure 9. Procedure for Thermo Scientific 1-Step Human High-Yield *In Vitro* Translation.**

## Protein yield

The 1-Step Human High-Yield IVT System is capable of expressing much higher levels of protein than traditional mammalian *in vitro* expression systems (Figure 10).

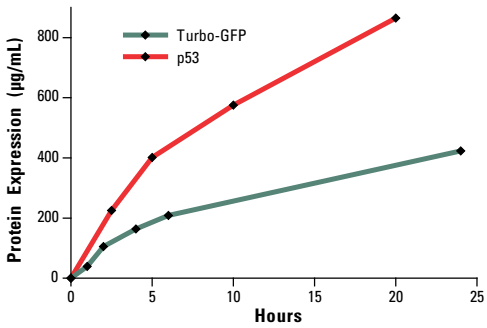



**Figure 10. *In vitro* expression of TurboGFP™ and p53 using the Thermo Scientific 1-Step Human High-Yield IVT Kit.** Recombinant p53 and GFP proteins were expressed using the 1-Step Human High-Yield Mini-IVT Kit. At each time point, 5µL aliquots were withdrawn from the reactions and stored at -20°C until assayed. The amount of p53 was quantified by ELISA and TurboGFP was quantified using a fluorescent plate-based assay.

## Enzyme activity

*Cypridina* luciferase was expressed in the 1-Step Human High-Yield IVT System, and compared to *E. coli* expression (Figure 11). Luciferase activity was 1,000 times higher in the human-expressed *Cypridina* because of the ability of the human system to fold the enzyme properly and form the 17 disulfide bridges.

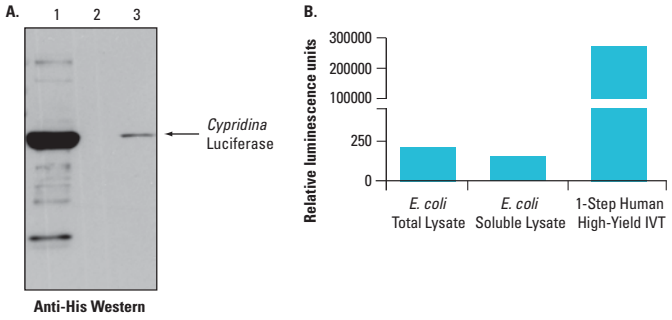



**Figure 11. *Cypridina* luciferase is produced with higher functional activity in the Human 1-Step High-Yield IVT Kit compared to *E. coli* expression cultures. A:** His-tagged *Cypridina* luciferase was expressed in *E. coli* cultures and in the 1-Step Human High-Yield IVT system. Equal volumes of either *E. coli* cell lysate or human IVT reaction expressing *Cypridina* luciferase were immunoblotted for luciferase. **Lane 1**, *E. coli* total lysate; **Lane 2**, *E. coli* soluble fraction (clarified a 10,000 x *g* for 5 min); **Lane 3**, 1-Step Human High-Yield IVT. **B:** Activity of *Cypridina* luciferase was assessed in equal volumes of either *E. coli* total lysate, *E. coli* soluble fraction or the 1-Step Human High-Yield IVT reactions using the Thermo Scientific Pierce *Cypridina* Luciferase Assay Kit (Product #16168). These results indicate that *Cypridina* luciferase expressed in the 1-Step Human High-Yield IVT System has significantly greater activity than that expressed in *E. coli* cultures.

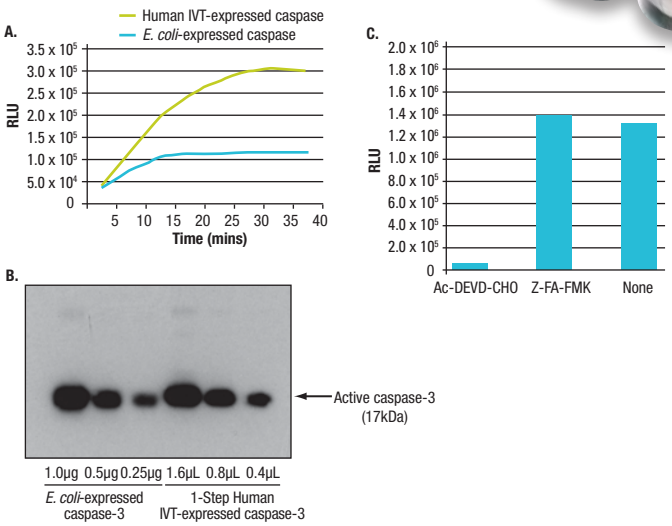



**Figure 12. Higher activity of human caspase-3 expressed in Thermo Scientific 1-Step Human High-Yield IVT System versus *E. coli*. Panel A.** Equal amounts of human caspase-3 either expressed in *E. coli* or using 1-Step Human High-Yield IVT Kits were assayed for active caspase-3 activity using caspase-3 glo® assay reagent mix containing cleavable DEVD-aminoluciferin and luciferase substrate. *E. coli*-expressed caspase-3 is supplied at 5.88 units/mg of protein. **Panel B.** Caspase-3 expressed in either *E. coli* or human IVT system tends to undergo self-proteolysis resulting in 17kDa and 12kDa proteins. Indicated amounts of recombinant caspase-3 proteins or volumes from the total reaction expressing caspase-3 from 1-Step Human High-Yield IVT Kits were separated on SDS-PAGE and Western blotting carried out using active-caspase-3 antibodies and Thermo Scientific SuperSignal Chemiluminescent Pico Substrate. **Panel C.** 0.1µL of 1-Step Human High-Yield IVT-expressed caspase-3 was incubated with 1µM of either a caspase-3 specific inhibitor Ac-DEVD-CHO or a negative control A-FA-FMK inhibitor for 10 minutes and measured for caspase-3 activity using caspase-3 glo assay reagent. None indicates no chemical added before measuring for luciferase activity.

## Ordering Information

All kits below contain:

- HeLa Lysate
- Accessory Proteins
- Reaction Mix
- 5X Dialysis Buffer
- Positive Control DNA: pCFE-GFP
- pT7CFE1-CGST-HA-His
- Slide-A-Lyzer® MINI Dialysis Device
- Cap Lock
- Pierce® Microcentrifuge Tube
- Nuclease-free Water

| Product # | Description | Pkg. Size |
|---|---|---|
| **88885** | **1-Step Human High-Yield Mini IVT Kit** *Sufficient for 2 high-yield reactions of 100µL each (approx. 50µg of GFP protein total.)* | 2-rxn kit |
| **88886** | **1-Step Human High-Yield Mini IVT Kit** *Sufficient for 10 high-yield reactions of 100µL each (approx. 250µg of GFP protein total.)* | 10-rxn kit |
| **88887** | **1-Step Human High-Yield Midi IVT Kit** *Sufficient for 8 high-yield reactions of 250µL each (approx. 500µg of GFP protein total.)* | 8-rxn kit |
| **88889** | **1-Step Human High-Yield Maxi IVT Kit** *Sufficient for 4 high-yield reactions of 1mL each (approx. 1mg of GFP protein total.)* | 4-rxn kit |

### Related Products

| Product # | Description | Pkg. Size |
|---|---|---|
| **88221** | **HisPur Ni-NTA Resin** *Sufficient for binding up to 60mg of His-tagged protein per mL of resin.* | 10mL |
| **89964** | **HisPur Cobalt Resin** *Sufficient for binding >10mg of His-tagged protein per mL of resin.* | 10mL |
| **16100** | **Pierce Glutathione Agarose** *Sufficient for binding >10mg of GST-tagged protein per mL of resin.* | 10mL |
| **26182** | **Pierce Anti-HA Agarose** *Sufficient for binding >60nmol HA-tagged protein per mL of resin.* | 10mL |

*Please visit thermoscientific.com/pierce to discover more package sizes and formats of these resins.*

# 1 step
# to heavy proteins


## Thermo Scientific 1-Step Heavy Protein *In Vitro* Translation System

Thermo Scientific 1-Step Heavy Protein *In Vitro* Protein Expression Kits enable rapid cell-free expression of recombinant proteins containing stable isotope-labeled (i.e., heavy) amino acids. The 1-Step Heavy Protein IVT Kit uses a unique HeLa cell lysate supplemented with heavy amino acids for *in vitro* translation of proteins with 90 to 95% isotope incorporation efficiency in less than eight hours. Heavy proteins expressed using this system can be used as mass spectrometry controls for sample prep loss, digestion efficiency determination or as quantification standards.

**Highlights:**

- **Efficient** – express heavy proteins with 90-95% isotope incorporation
- **Functional** – uses the human translational machinery to express more biologically active proteins than other IVT systems
- **Flexible** – express light proteins or heavy proteins containing $^{13}C_6{}^{15}N_2$ L-lysine and/or $^{13}C_6{}^{15}N_4$ L-arginine
- **Convenient** – perform transcription and translation in a single step
- **High performance** – greater yields compared to rabbit reticulocyte *in vitro* translation

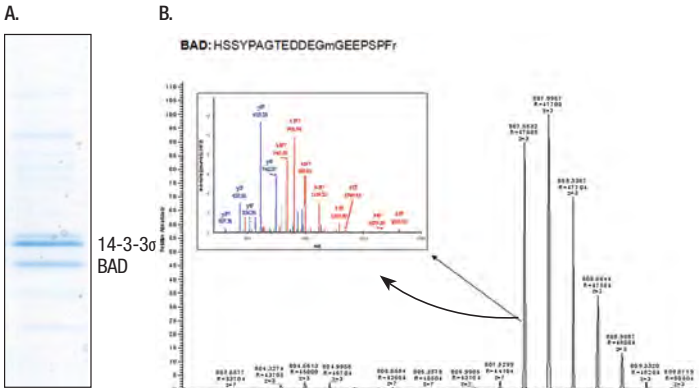



**Figure 13. Expression and analysis of stable-isotope labeled BAD protein with the Thermo Scientific 1-Step Heavy Protein IVT Kit. A:** HA-tagged BAD was expressed using the 1-Step Heavy Protein IVT Kit and affinity purified using the Thermo Scientific Pierce HA Tag IP/Co-IP Kit and analyzed by SDS-PAGE. **B**: The protein bands were excised, digested and analyzed using a Thermo Scientific LTQ Orbitrap XL mass spectrometer and identified as heavy BAD and light 14-3-3σ which co-purified during immunoprecipitation. MS spectrum of a light and heavy BAD peptide showing >95% heavy isotope incorporation. MS/MS spectrum used for peptide identification is shown in the figure insert.

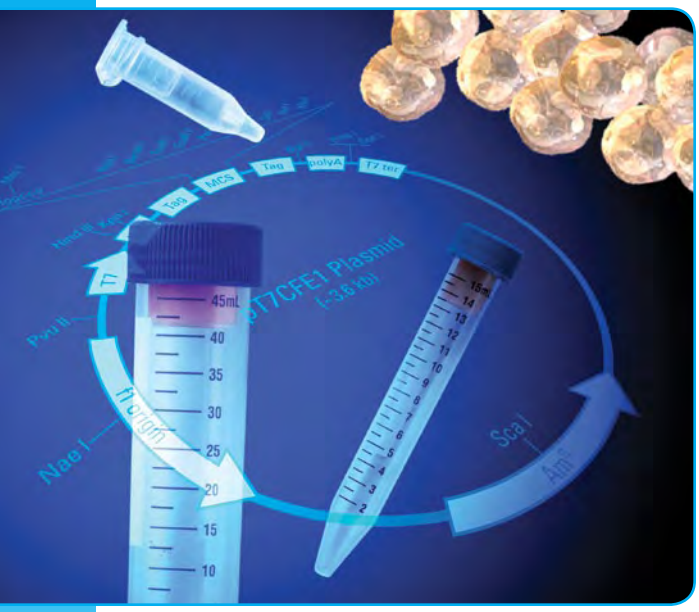
Average total heavy amino acid incorporation into recombinant proteins expressed using the Thermo Scientific 1-Step Heavy Protein IVT Kit.

| Expressed Protein | Heavy Amino Acid Incorporation |
|---|---|
| BAD | 92% |
| CCND1 | 97% |
| TP53 | 91% |
| RB | 96% |
| GAPDH | 94% |
| GFP | 95% |

## Ordering Information

| Product # | Description | Pkg. Size |
|---|---|---|
| **88330** | **1-Step Heavy Protein IVT Kit**<br>*Sufficient for 8 reactions of 25µL each.*<br>Kit Contents:<br>HeLa Lysate, 110µL<br>Accessory Proteins, 25µL<br>Reaction Mix, 40µL<br>$^{13}C_6{}^{15}N_4$ L-Arginine, 25µL<br>$^{13}C_6{}^{15}N_2$ L-Lysine, 25µL<br>Positive Control DNA: pCFE-GFP, 10µg<br>pT7CFE1-CGST-HA-His, 10µg<br>Nuclease-free Water 1.5mL | 8-rxn kit |
| **88331** | **1-Step Heavy Protein IVT Kit**<br>*Sufficient for 40 reactions of 25µL each.*<br>Kit Contents:<br>HeLa Lysate, 550µL<br>Accessory Proteins, 125µL<br>Reaction Mix, 200µL<br>$^{13}C_6{}^{15}N_4$ L-Arginine, 25µL<br>$^{13}C_6{}^{15}N_2$ L-Lysine, 25µL<br>Positive Control DNA: pCFE-GFP, 10µg<br>pT7CFE1-CGST-HA-His, 10µg<br>Nuclease-free Water 1.5mL | 40-rxn kit |

# convenient vectors
## complete the family




### Human *In Vitro* Translation Expression Vectors

Thermo Scientific T7 Cell-Free Expression Vectors (pT7CFE1) are expression plasmids optimized to use with the Thermo Scientific 1-Step Human *In Vitro* Protein Expression System. The pT7CFE1 Expression Vectors contain the Encephalomyocarditis virus (EMCV) internal ribosome entry site (IRES) element that is critical for high levels protein expression in the Human *In Vitro* Translation System. Each vector features an identical multiple cloning site (MCS) to facilitate easy insertion of protein coding sequences into and between vectors. The pT7CFE1 Vector is available with single or tandem affinity tags at the N- and/or C-terminus to facilitate protein purification and detection. The pT7CFE Vectors are suitable for insertion of cloned genes, cDNAs, ORFs or PCR products. Custom cloning services are also available.

**Highlights:**

- **Optimized performance** – designed to provide the highest yield in the human *in vitro* translation system
- **Many options** – multiple tag and tag-location options available
- **Modular MCS** – multiple cloning site is maintained across vector family to facilitate subcloning
- **Cleavable tags** – HRV 3C cleavage site available on select vectors

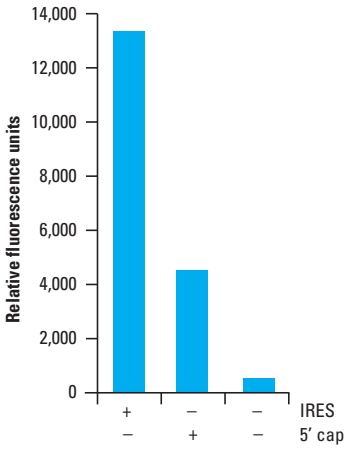
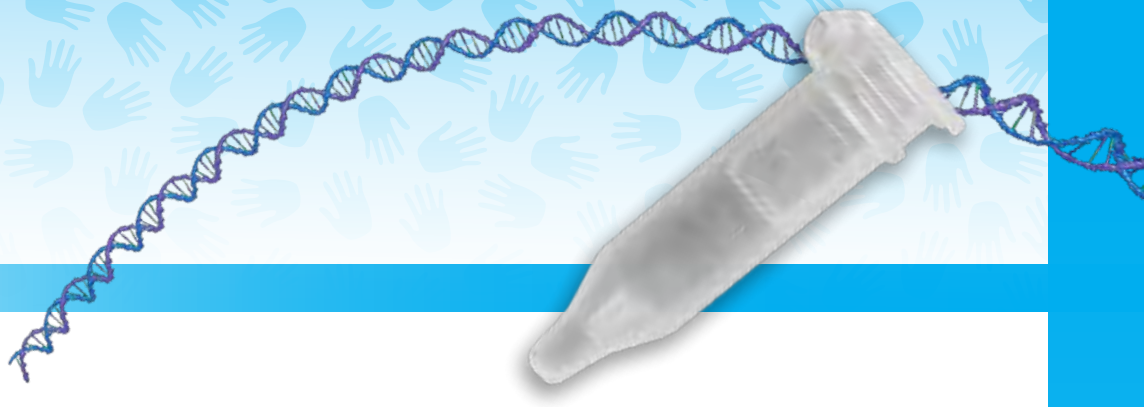



**Figure 16. IRES-mediated protein expression is significantly greater than 5' capped mRNA.** tGFP mRNA was transcribed from the pCFE expression plasmids containing an upstream IRES element (+ IRES) or another plasmid without an IRES element. The mRNA generated without an IRES element was either used directly (- IRES, - 5' cap) or chemically modified to have an N-terminal Anti-Reverse Cap Analog (ARCA, + 5' cap). Equal amounts of all the three mRNA's were used in human *in vitro* translation reactions for 2 hours at 30°C and the relative amount of GFP was determined by fluorescence.

**Thermo Scientific T7 Cell-Free Expression Vectors Selection Guide.**
For each order, 10 micrograms of vector is supplied at 0.5µg/µL in 10mM Tris-HCl, pH 8.5. Custom cloning services are also available.

| Product # | Vector name | N-terminus Tag | C-Terminus tag | Cleavage site | |
|---|---|---|---|---|---|
| **88859** | pT7CFE1-NHis | 6xHis | - | | |
| **88860** | pT7CFE1-CHis | - | 6xHis | | |
| **88861** | pT7CFE1-NHA | | - | | |
| **88862** | pT7CFE1-CHA | - | | | |
| **88863** | pT7CFE1-NMyc | c-Myc | - | | |
| **88864** | pT7CFE1-CMyc | - | c-Myc | | |
| **88865** | pT7CFE1-NFtag | Flag™-tag | - | | |
| **88866** | pT7CFE1-CFtag | - | Flag-tag | | |
| **88867** | pT7CFE1-NHA-CHis | HA | 6xHis | | |
| **88868** | pT7CFE1-CGST-HA-His | - | GST, HA, 6xHis | HRV 3C | |
| **88869** | pT7CFF1-CGFP-HA-His | - | GFP, HA, 6xHis | HRV 3C | |

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# References

## Publications Using Human IVT System


1. Boohaker R. J., *et al.* (2011). BAX supports the mitochondrial network, promoting bioenergetics in nonapoptotic cells. *Am J Physiol Cell Physiol.* **300**, C1466-78.
2. Loughran G., *et al.* (2011). Ribosomal frameshifting into an overlapping gene in the 2B-encoding region of the cardiovirus genome. *Proc Natl Acad Sci U S A.* **108**, E1111-9.
3. Stergachis, A. (2011). Rapid empirical discovery of optimal peptides for targeted proteomics. *Nature Methods* **8**, 1041-1043.
4. Wang Q. Y., *et al.* (2011). A translation inhibitor that suppresses dengue virus *in vitro* and *in vivo*. *Antimicrob Agents Chemother.* **55**, 4072-80.
5. Boyne, J. (2010). Kaposi's sarcoma-associated herpesvirus ORF57 protein interacts with PYM to enhance translation of viral intronless mRNAs. *EMBO Journal* **29**, 1851-1864.
6. Kasinathan, R. (2010). Schistosoma mansoni express higher levels of multidrug resistance-associated protein 1 (SmMRP1) in juvenile worms and in response to praziquantel. *Molecular and Biochemical Parasitology* **173**, 25-31.
7. Khatua, A. (2010). Inhibition of LINE-1 and Alu retrotransposition by exosomes encapsidating APOBEC3G and APOBEC3F. *Virology* **400**, 68-75.


## General references


1. Imataka, H. and Mikami, S. (2009). Advantages of human cell-derived cell-free protein synthesis systems (Japanese). *Seikagaku* **81(4)**, 303-7.
2. Kobayashi, T., *et al.* (2007). An improved cell-free system for picornavirus synthesis. *J. Virol. Methods* **142(1-2)**, 182-8.
3. Kozak, M. (2005). Regulation of translation via mRNA structure in prokaryotes and eukaryotes. *Gene* **361**, 13-37.
4. Kozak, M. (1983). Comparison of initiation of protein synthesis in prokaryotes, eukaryotes, and organelles. *Microbiol. Rev.* **47(1)**, 1-45.
5. Mikami, S., *et al.* (2006). An efficient mammalian cell-free translation system supplemented with translation factors. *Protein Expr. Purif.* **46(2)**, 348-57.


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