

TransIT®-Lenti Transfection Reagent

Protocol for MIR 6600, 6603, 6604, 6605, 6606, 6610

mirus bio®

Quick Reference Protocol, SDS and Certificate of Analysis available at mirusbio.com/literature

INTRODUCTION

Lentivirus is an enveloped, single-stranded RNA virus from the *Retroviridae* family capable of infecting both dividing and non-dividing cells. Combined with an efficient host-genome integration mechanism, this capability has led to recombinant lentivirus becoming a central gene delivery tool for robust and stable transgene expression in target cells.

Though relevant across cell biology applications, the lentivirus platform is often limited by insufficient viral titers requiring concentration before use in target cells. To address this limitation, Mirus Bio developed TransIT®-Lenti Transfection Reagent for enhanced delivery of the essential vectors (including *gag*, *pol*, *rev*, and VSV-G genes) required for higher-titer lentivirus production in both suspension and adherent HEK 293 cell types. With TransIT®-Lenti, greater than 2-fold higher functional titers are achieved over competing transfection reagents.

SPECIFICATIONS

Storage	Store TransIT®-Lenti Transfection Reagent tightly capped at -20°C. Before each use , warm to room temperature and vortex gently.
Product Guarantee	1 year from the date of purchase, when properly stored and handled.



Warm TransIT®-Lenti Reagent to room temperature and vortex gently before each use.

MATERIALS

TransIT®-Lenti Transfection Reagent is supplied in the following formats.

Product No.	Quantity
MIR 6603	1 × 0.3 mL
MIR 6604	1 × 0.75 mL
MIR 6600	1 × 1.5 mL
MIR 6605	5 × 1.5 mL
MIR 6606	10 × 1.5 mL

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For Research Use Only

BEFORE YOU START:

Important Tips for Optimal Lentivirus Production

Mirus recommends using HEK 293T/17 cells or FreeStyle™ 293-F Cells for high titer lentivirus production in adherent or suspension HEK 293 cultures, respectively. The suggestions below yield high efficiency plasmid DNA transfection using the *TransIT®-Lenti Transfection Reagent*.

- **Cell density (% confluence) at transfection.** The recommended cell density for:
 - Adherent HEK 293T/17 cells is 80 - 95% confluence. DO NOT transfect cells at < 80% confluency as this may result in high cytotoxicity and low virus titers.
 - Suspension 293-F cells is 2×10^6 cells/mL. Passage cells 18–24 hours before transfection to ensure that cells are actively dividing (i.e. doubling every 24 hours) at time of transfection. DO NOT transfect if cells are < 95% viable at time of transfection.
- **DNA purity.** Use highly pure, sterile, and endotoxin-free DNA for transfection with a $A_{260/280}$ absorbance ratio of 1.8–2.0. DNA prepared using miniprep kits is not recommended as it might contain high levels of endotoxin. We recommend using MiraCLEAN® Endotoxin Removal Kit (MIR 5900) to remove endotoxin from your DNA preparation.
- **Packaging and transfer plasmids.** The *TransIT®-Lenti* reagent was optimized using a pre-mix of lentivirus packaging vectors. If using individual packaging plasmids, we recommend a starting ratio of 4 µg *gag-pol* vector, 1 µg *rev* vector and 1 µg *VSV-G* vector. Premix the packaging plasmids with an equal amount of the transfer vector (e.g. 6 µg) to maintain a 1:1 (wt:wt) ratio of packaging to transfer plasmids.
- **Ratio of TransIT®-Lenti to DNA.** Determine the best *TransIT®-Lenti* Reagent:DNA ratio for each cell type. Start with 3 µL of *TransIT®-Lenti* per 1 µg of total DNA. Vary the amount of *TransIT®-Lenti* Reagent from 2–4 µL per 1 µg DNA to find the optimal ratio. Refer to **Tables 1-2** in the adherent and suspension lentivirus sections for recommended starting conditions based on cell culture vessel size.
- **Complex formation conditions.** Prepare *TransIT®-Lenti* Reagent:DNA complexes in serum-free growth medium (e.g. Opti-MEM® I Reduced-Serum Medium).
- **Cell culture conditions.** Culture cells in the appropriate medium, with or without serum (e.g. DMEM + 10% FBS + 10mM HEPEs pH 7.4 for adherent HEK 293T cultures; FreeStyle™ F17 + 4mM L-Glutamine + 0.2% Poloxamer 188 for suspension HEK 293 cultures). After transfection, there is no need to perform a medium change to remove the transfection complexes.
- **Presence of antibiotics.** Antibiotics should not be in the serum-free media used to mix DNA and transfection reagent. Antibiotics can be present in the complete media to grow cells.
- **Media change post-transfection.** A media change is not required and could be detrimental to lentivirus titers.
- **Post-transfection incubation time.** The optimal incubation time for harvesting high titer lentivirus is 48 hours.



Premix packaging and transfer plasmids together prior to adding to the complex formation medium.



Do not use serum or antibiotics in the medium during transfection complex formation.

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SECTION I: Lentivirus Generation in Adherent HEK 293T Cell Cultures

The following procedure describes plasmid DNA transfections for lentivirus generation in adherent HEK 293T cell types in a 6-well plate format. If using an alternative culture vessel, increase or decrease the amounts of serum-free medium, *TransIT®-Lenti* Reagent, total plasmid DNA and complete culture medium based on the size of the cell culture vessel (refer to **Table 1** below).

Table 1. Recommended *TransIT®-Lenti* starting conditions for DNA Transfections

Culture vessel	48-well plate	24-well plate	12-well plate	6-well plate	10-cm dish	T75 flask
Surface area	1.0 cm ²	1.9 cm ²	3.8 cm ²	9.6 cm ²	59 cm ²	75 cm ²
Complete growth medium	263 µL	0.5 mL	1.0 mL	2.0 mL	10 mL	15 mL
Serum-free medium	26 µL	50 µL	100 µL	200 µL	1.0 mL	1.5 mL
Transfer DNA (1 µg/µL stock)	0.13 µL	0.25 µL	0.5 µL	1.0 µL	5 µL	7.5 µL
Packaging DNA Premix (1 µg/µL stock)	0.13 µL	0.25 µL	0.5 µL	1.0 µL	5 µL	7.5 µL
<i>TransIT®-Lenti</i> Reagent	0.78 µL	1.5 µL	3 µL	6 µL	30 µL	45 µL



Surface areas are based on Greiner tissue culture plates, Falcon 10-cm dishes and T75 flasks. Volumes are per well (or dish) for a given culture vessel.

If small volumes of *TransIT®-Lenti* need to be pipetted, dilute the reagent in serum-free medium before each use to avoid pipetting errors. **Do not** store diluted *TransIT®-Lenti* Reagent.

Materials Required but Not Supplied

- HEK 293T cells (e.g. HEK 293T/17 cells, ATCC Cat. No. CRL-11268)
- Complete culture medium (e.g. DMEM + 10% FBS + 10mM HEPES pH 7.4)
- Nucleic acid (2nd or 3rd generation packaging plasmids and transfer vector with GOI)
- Serum-free medium (e.g. Opti-MEM® I Reduced-Serum Medium)
- 0.45 µm PVDF filter (e.g. Millipore Cat. No. SE1M003M00 or SLHV033RS)

Transient Plasmid Transfection Protocol per Well of a 6-Well Plate

A. Plate cells

1. Approximately 18–24 hours before transfection, plate cells in 2.0 mL complete growth medium per well in a 6-well plate. A starting cell density of 4.0 – 5.0 × 10⁵ cells/mL is recommended. Cultures should be 80 - 95% confluent at the time of transfection.
DO NOT transfect cells at a lower confluence as this may lead to high toxicity and lower lentivirus titers.
2. Incubate cell cultures at 37°C in 5% CO₂ overnight.

B. Prepare *TransIT®-Lenti*:DNA complexes (Immediately before transfection)

1. Warm *TransIT®-Lenti* Reagent to room temperature and vortex gently before using.
2. Place 200 µL of Opti-MEM® I Reduced-Serum Medium in a sterile tube.
3. In a separate sterile tube, combine the packaging plasmid premix (or individual plasmids) and transfer plasmid encoding the gene of interest (GOI). Mix thoroughly.
4. Transfer 2.0 µg (1 µg packaging plasmid mix + 1 µg transfer plasmid) of the DNA prepared in Step B.3 to the tube containing Opti-MEM® I Reduced-Serum Medium.
5. Pipet gently to mix completely.
6. Add 6.0 µL *TransIT®-Lenti* Reagent to the diluted DNA mixture.
7. Pipet gently to mix completely.
8. Incubate at room temperature for 10 minutes to allow transfection complexes to form.

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C. Distribute the complexes to cells in complete growth medium

1. Add the TransIT®-Lenti Reagent:DNA complexes (prepared in Step B) drop-wise to different areas of the wells.
2. Gently rock the culture vessel back-and-forth and from side-to-side to evenly distribute the TransIT®-Lenti Reagent:DNA complexes.
3. Incubate at 37°C in 5% CO₂ for 48 hours. NOTE: It is not necessary to replace the complete growth medium with fresh medium post-transfection.



There is no need to change culture medium after transfection.

D. Harvest and storage of lentivirus

1. Harvest cell supernatant containing recombinant lentivirus particles.
NOTE: If cells detach during harvest, centrifuge cells at 300 x g for 5 minutes and retain the virus-containing supernatant.
2. Filter virus-containing supernatant through a 0.45 µm PVDF filter to remove any cells.
3. Immediately flash freeze aliquots of lentivirus in cryogenic tubes and store at -80°C.

Transfection complexes, visualized as small particles, are sometimes observed following transfection. The complexes are not toxic to cells and do not affect transfection efficiency or transgene expression.

SECTION II: Lentivirus Generation in Suspension HEK 293-F Cell Cultures

The following procedure describes plasmid DNA transfections for lentivirus generation in 125 mL Erlenmeyer shake flasks using 25 mL of complete growth medium. If using an alternate cell culture vessel, increase or decrease the amounts of serum-free complex medium, TransIT®-Lenti Reagent, and total DNA based on the **volume of complete growth medium** to be used. To calculate the required reagent quantities based on the recommended starting conditions and total culture volume, refer to the calculation worksheet in **Table 2** (below).

Table 2. Calculation worksheet for scaling TransIT®-Lenti Reagent transfections

Starting conditions per milliliter of complete growth medium			
	Per 1 mL	Total culture volume	Reagent quantities
Complex formation solution (e.g. OptiMEM®)	96 µL	x	= _____ mL
Transfer plasmid DNA (1 µg/µL stock)	0.5 µL	x	_____ mL = _____ µL
Packaging DNA premix (1 µg/µL stock)	0.5 µL	x	= _____ µL
TransIT®-Lenti Transfection Reagent	3 µL	x	= _____ µL
Total Complex Volume	100 µL		



The TransIT®-Lenti Reagent was optimized using a pre-mix of lentivirus packaging vectors. If using individual packaging plasmids, we recommend a starting ratio of 4 µg gag-pol vector, 1 µg rev vector and 1 µg VSV-G vector. Premix the packaging plasmids with an equal amount of the transfer vector (e.g. 6 µg) to maintain a 1:1 (wt/wt) ratio of packaging to transfer plasmids.

Materials Required but Not Supplied

- FreeStyle™ 293-F cells (Life Technologies® Cat. No. R790-07)
- Complete Culture Medium (e.g. FreeStyle™ F17 + 4mM L-Glutamine + 0.2% Poloxamer 188)
- Nucleic acid (2nd or 3rd generation packaging plasmids and transfer vector with GOI)
- Serum-free medium (e.g. Opti-MEM® I Reduced-Serum Medium, Cat. No. 31985070)
NOTE: OptiPRO™ SFM (Life Technologies, Cat. No. 12309050) is animal-origin free and can be used for complex formation but may cause some cell clumping in suspension cultures.
- Erlenmeyer shake flasks (e.g. Corning® Cat. No. 431143 or Thomson Cat. No. 931110)
- 50 mL conical tube(s) for virus collection
- 0.45 µm PVDF filter (e.g. Millipore Cat. No. SE1M003M00 or SLHV033RS)

Transient Plasmid Transfection Protocol per 25 mL 293-F Culture

A. Maintenance of Cells

- Passage suspension HEK 293 cells 18–24 hours prior to transfection to ensure that cells are actively dividing at the time of transfection and to obtain a density of $2\text{-}3 \times 10^6$ cells/mL the next day.

NOTE: Perform cell counts and evaluate viability daily to ensure that cells are doubling every 24 hours and $\geq 95\%$ viable by trypan blue exclusion. DO NOT proceed with transfection if cells are not doubling normally or $< 95\%$ viable.

- Incubate cells overnight at appropriate temperature and CO₂ levels (e.g. 37°C, 5-8% CO₂, shaking).

B. Prepare TransIT®-Lenti:DNA complexes (Immediately before transfection)

- Immediately prior to transfection, seed cells at a density of 2×10^6 cells/mL into a transfection culture vessel (e.g. 25 mL per 125 mL Erlenmeyer shake flask).
- Warm TransIT®-Lenti Reagent to room temperature and vortex gently.
- Place 2.5 mL of serum-free medium (e.g. OptiMEM®) in a sterile tube.
- Add 25 µg total plasmid DNA (i.e. 12.5 µg Transfer vector encoding GOI + 8.3 µg Gag-pol vector + 2.1 µg Rev vector + 2.1 µg VSV-G vector). Pipet gently to mix completely.
- Add 75 µL TransIT®-Lenti Reagent to the diluted DNA. Pipet gently to mix completely.
- Incubate at room temperature for 10-15 minutes to allow transfection complexes to form.



Warm TransIT®-Lenti Reagent to room temperature and vortex gently before each use.

C. Distribute the complexes to cells in complete growth medium

- Add the TransIT®-Lenti Reagent:DNA complexes (prepared in Step B) to the flask containing cells.
- Shake flasks on an orbital shaker (125 rpm when using a shaker with a 1.9 cm orbital throw) at appropriate temperature and CO₂ levels (e.g. 37°C, 5-8% CO₂).
- Incubate cultures for 48 hours prior to virus harvest.



There is no need to change culture medium after transfection, unless required by your cell type or culture conditions.

D. Virus Harvest

- Following the 48-hour incubation, centrifuge the culture in sterile conical tube at 300 x g for 5 minutes. DO NOT dispose of supernatant following centrifugation.
- Collect the virus-containing supernatant using a serological pipet into a sterile conical tube. NOTE: If producing a large batch of the same virus, supernatants can be combined.
- Filter the virus-containing supernatant through a 0.45 µm PVDF filter (e.g. Millipore Steriflip-HV, Cat. No. SE1M003M00) to remove any cells.
- Immediately flash-freeze aliquots of lentivirus in cryogenic tubes and store at -80°C.

SECTION III: Lentivirus Transduction and Titering Protocol Using GFP Reporter Virus

The following procedure describes transduction of HEK 293T/17 cells grown in a 24-well format with a GFP reporter lentivirus to determine functional lentivirus titers. The number of wells needed for this assay will depend on the number of lentivirus stocks titered and the number of dilutions required for testing per stock (see step B.4). Testing several dilutions is recommended to accurately determine the functional lentivirus titer.

Materials Required, but not Supplied

- HEK 293T/17 cells (ATCC Cat. No. CRL-11268)
- Appropriate cell culture medium (e.g. DMEM + 10% FBS + 10mM HEPES pH 7.4)
- Lentivirus stock(s) expressing GFP reporter
- *TransduceIT™* Reagent (10 mg/mL, Mirus Cat. No. MIR 6620) or hexadimethrine bromide (Sigma, Cat. No. H9268)
- 24-well tissue culture plate(s)
- 1X PBS and trypsin
- Flow cytometer equipped with a GFP compatible laser

A. Plate cells

1. Approximately 18–24 hours before transduction, plate HEK 293T/17 cells in 0.5 mL complete growth medium per well in a 24-well plate. A starting cell density of 2.0×10^5 cells/mL is recommended. Cultures should be $\geq 40\%$ confluent at the time of transduction.
NOTE: Plate at least two extra wells to trypsinize and count on the day of transduction. An accurate cell count at the time of transduction is critical to determine an accurate functional titer (see B.1).
2. Incubate cell cultures at 37°C in 5% CO₂ overnight.

B. Transduce with GFP-encoding recombinant lentivirus

1. Trypsinize and count 2 wells of untransduced cells (plated in A.1) to obtain an accurate cell concentration at the time of transduction.
2. Dilute *TransduceIT™* Reagent or hexadimethrine bromide to a working concentration of 16 µg/mL in pre-warmed complete growth medium (e.g. add 16 µL of a 10 mg/mL solution into 10 mL of growth medium).
3. Gently remove half of the medium from each well using a P1000 micropipettor.
4. Immediately add 250 µL of the *TransduceIT™* or hexadimethrine bromide working solution to each well. The final concentration should be 8 µg/mL per well.
NOTE: If transducing cell types other than HEK 293T/17, the optimal concentration of *TransduceIT™* or hexadimethrine bromide should be empirically determined.
5. Add dilutions of the lentivirus stock to separate wells. Testing several dilutions is recommended to accurately determine functional titer. Guidelines are as follows:
 - For titers expected to be $\leq 5.0 \times 10^7$ TU/mL: Add 1µL, 3µL and 5µL of the lentiviral stock to separate wells.
 - For titers expected to be $\geq 5.0 \times 10^7$ TU/mL: Dilute the virus stock 10-fold in complete growth media. Add 1µL, 3µL and 5µL of the diluted lentivirus stock to separate wells.
6. Incubate the remaining assay wells at 37°C in 5% CO₂ for 72 hours post-transduction.

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C. Cell Harvest and Analysis

1. Gently wash cells with 1X PBS and immediately add 100 μ L of trypsin to each well.
2. Incubate the plate at 37°C and closely monitor cell rounding and detachment.
3. After cells have rounded, add 400 μ L of complete growth media to each well to inactivate the trypsin and resuspend the cells.
4. Transfer 100 μ L of cell suspension from each well to separate wells in a non-treated 96-well plate (or similar culture vessel) that is compatible with your flow cytometer.
5. Add 150 μ L of complete growth medium to each well to dilute the cells. This is required to obtain accurate flow cytometry results. NOTE: The optimal volume added for dilution may vary depending on the flow cytometer.
6. Analyze for GFP expression by flow cytometry.
7. Calculate the functional titer of the lentivirus stock using the following equation:

$$\text{Titer (Transducing units/mL)} = \left[\frac{\text{Number of target cells (Count at day 2, transduction) x [% GFP positive cells/100]}}{\text{Volume of lentivirus stock in mL}} \right]$$

TROUBLESHOOTING GUIDE

POOR DNA TRANSFECTION EFFICIENCY

Problem	Solution
Incorrect vector sequence	If you do not observe expression of your target insert, verify the sequence of the transfer vector plasmid DNA.
Suboptimal TransIT®-Lenti:DNA ratio	Determine the best TransIT®-Lenti Reagent:DNA ratio for each cell type. Titrate the volume of TransIT®-Lenti Reagent from 2–4 μ L per 1 μ g DNA. Refer to “Before You Start” on Page 2.
Suboptimal DNA concentration	Determine the DNA concentration accurately. Use plasmid DNA preps that have an $A_{260/280}$ absorbance ratio of 1.8–2.0.
Low-quality plasmid DNA	The optimal DNA concentration generally ranges between 1–3 μ g/well of a 6-well plate. Start with 2.0 μ g/well of a 6-well plate. Consider testing more or less DNA while scaling the amount of TransIT®-Lenti Reagent accordingly.
Cells not actively dividing at the time of transfection	Use highly purified, sterile, endotoxin- and contaminant-free DNA for transfection. We recommend using Mirus MiraCLEAN Endotoxin Removal Kit (MIR 5900) for removal of endotoxin from your DNA preparation. Alternatively, use cesium chloride gradient or anion exchange purified DNA which contains levels of endotoxin that do not harm most cells.
Transfection incubation time	Do not use DNA prepared using miniprep kits as it might contain high levels of endotoxin.
TransIT®-Lenti was not mixed properly	Divide the culture at least 18–24 hours before transfection to ensure that the cells are actively dividing and reach optimal cell density at time of transfection.
Precipitate formation during transfection complex formation	Determine the optimal transfection incubation time for each cell type and experiment. Test a range of incubation times (e.g. 24–72 hours). The best incubation time for lentivirus production is 48 hours.
	Warm TransIT®-Lenti Reagent to room temperature and vortex gently before each use.
	During complex formation, scale all reagents according to Table 1-2 including: serum-free media, TransIT®-Lenti Reagent, packaging vectors and transfer plasmid DNA.
	Precipitation may be observed when excess DNA is used during complex formation. This may negatively impact transfection efficiency. To avoid precipitation when using high concentrations of DNA, increase the volume of serum-free medium during complex formation by two-fold.

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Proper experimental controls were not included

To assess delivery efficiency of plasmid DNA, use Mirus Label IT® Nucleic Acid Labeling Kits to label the target plasmid or use Mirus prelabeled Label IT® Plasmid Delivery Controls.

To verify efficient transfection, use TransIT®-Lenti Reagent to deliver a positive control such as a luciferase, beta-galactosidase or green fluorescent protein (GFP) encoding plasmid.

HIGH CELLULAR TOXICITY

Problem	Solution
Cell density not optimal at time of transfection	Determine optimal cell density for each HEK 293 subtype to maximize transfection efficiency. Use this density to ensure reproducibility. For high lentivirus titers using TransIT®-Lenti, ensure that cells are between 80 and 95% confluent at the time of transfection. High toxicity and cell death may be observed if cells are less than 80% confluent at the time of transfection. DO NOT transfect at lower or higher cell densities. The recommended cell density for suspension HEK 293-F cells is 2×10^6 cells/mL. Passage cells 18–24 hours before transfection to ensure that cells are actively dividing and reach the appropriate density at time of transfection.
Cell morphology has changed	Overexpression of the vesicular stomatitis virus (VSV) G protein causes changes in cell morphology and can even result in cell-cell fusion. This is normal and does not adversely affect the yielded virus.
Transfection complexes and cells not mixed thoroughly after complex addition	Mycoplasma contamination can alter cell morphology and affect transfection efficiency. Check your cells for mycoplasma contamination. Use a fresh frozen stock of cells or use appropriate antibiotics to eliminate mycoplasma.
Transfection complexes added to cells cultured in serum-free medium	A high or low cell passage number can make cells more sensitive and refractory to transfection. Maintain 293T/17 cells below passage 30 for optimal recombinant lentivirus production
	Add transfection complexes drop-wise to the cells. Gently rock the dish back-and-forth and from side-to-side to distribute the complexes evenly. Do not swirl or rotate the dish, as this may cause uneven distribution.
	TransIT®-Lenti Transfection Reagent efficiently transfects cells cultured in serum-free medium; however, toxicity may be higher if serum is not present at transfection for cells typically cultured in serum-containing medium. HEK 293 cells adapted to serum-free suspension conditions readily transfect with TransIT®-Lenti and no cytotoxicity is observed.

RELATED PRODUCTS

- TransIT® Lentivirus System
- TransIT-VirusGEN® Transfection Reagent
- Lentivirus Packaging Mix Powered by MISSION® Genomics
- TransducetIT™ Reagent
- TransIT-X2® Dynamic Delivery System
- TransIT®-2020 Transfection Reagent
- TransIT®-LTI Transfection Reagent
- Ingenio® Electroporation Solution and Kits
- Label IT® Nucleic Acid Labeling Kits
- MiraCLEAN® Endotoxin Removal Kits

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