

Alt-R™ CRISPR-Cas12a (Cpf1) System

Delivery of ribonucleoprotein complexes into HEK-293 cells using the Amaxa™ Nucleofector™ System

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REVISION HISTORY

Version	Release date	Description of changes
3	January 2023	Updated Lonza protocol link and remediated content to the internal MAPSS standard.
2.1	May 2018	Added note about use of updated Cas12a enzyme (V3).
2	May 2017	Updated Cpf1 PAM sequence from TTTN to TTTV, based on new IDT research data (see www.idtdna.com/CRISPR-Cpf1/#tab4). Updated instructions for crRNA preparation. Updated control PCR primer ordering information.
1	January 2017	Original protocol.

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INTRODUCTION

This protocol describes the delivery of a CRISPR-Cas12a (Cpf1) ribonucleoprotein (RNP) complex, containing Alt-R CRISPR-Cas12a (Cpf1) crRNA and any of the available Cas12a variants (A.s. Cas12a (Cpf1), A.s. Cas12a (Cpf1) *Ultra*, L.b. Cas12a *Ultra*), into HEK-293 cells using electroporation with the Amaxa Nucleofector system (Lonza). To detect on-target mutations and estimate editing efficiency, we recommend using the **Alt-R Genome Editing Detection Kit**.

The CRISPR-Cas12a (Cpf1) system is distinct from the more commonly used CRISPR-Cas9 system. For example, Cas12a nuclease does not require a tracrRNA; recognizes a T-rich, protospacer-adjacent motif (PAM: TTTV, where V is an A, C, or G base); and creates a staggered double-stranded DNA cut with a 5' overhang. For additional information, visit www.idtdna.com/CRISPR-Cpf1.

GUIDELINES

1. **Use low-passage, healthy cells.** A critical factor affecting the success of electroporation is the health of the cells. It is important to:
 - Use the lowest passage number cells available
 - Subculture cells for at least 2–3 days before the electroporation procedure
 - Replace the media the day before electroporation
 - Determine the optimal confluency for your cell type

Optimal confluency for HEK-293 cells is 80–90% at the time of Nucleofection. Higher cell densities are likely to reduce viability and electroporation efficiency.

2. **Wash cells after trypsinization.** Trypsin and FBS may contain RNase activity that can quickly degrade critical CRISPR RNA components. Therefore, **it is crucial to wash the cells with PBS** to remove any trypsin or FBS-containing media. Alternatively, use “enzyme-free” dissociation media instead of trypsin.
3. **Alt-R Cas12a (Cpf1) Electroporation Enhancer, a non-targeting, single-stranded carrier DNA, is required for successful electroporation.** See the Product data drop-down section at www.idtdna.com/CRISPR-Cpf1 for supporting data.
4. **Always include appropriate controls in your experiment.** We recommend using an *HPRT*-specific, positive control crRNA and a non-targeting negative control. For suggested sequences for studies in human and mouse cells, see the [Recommended control crRNAs](#) on the next page.

To detect on-target editing of the suggested *HPRT* control crRNA, use Alt-R *HPRT* PCR Primer Mix (available for human and mouse) with the [Alt-R Genome Editing Detection Kit](#) (T7 endonuclease I assay).

CONSUMABLES AND EQUIPMENT

Item	Ordering information
4D-Nucleofector System	Lonza (Cat # AAF-1002B with AAF-1002X)
96-well Shuttle™ System	Lonza (Cat # AAM-1001S)
SF Cell Line 96-well Nucleofector Kit	Lonza (Cat # V4SC-2096)
Dulbecco's Modified Eagle's Medium (DMEM)	ATCC (Cat # 30-2002)
Fetal bovine serum (FBS)	General laboratory supplier
Trypsin	General laboratory supplier
Penicillin-streptomycin (Pen-Strep)	General laboratory supplier
1X Phosphate buffered saline (PBS)	General laboratory supplier
Alt-R CRISPR-Cas12a crRNA	IDT custom crRNA (www.idtdna.com/CRISPR-Cpf1)
Alt-R A.s. Cas12a (Cpf1)	
Cas12a variants:	
A.s. Cas12a (Cpf1)	1081068, 1081069
A.s. Cas12a (Cpf1) <i>Ultra</i>	10001272, 10001273, 10007804
L.b. Cas12a <i>Ultra</i>	10007922, 10007923, 10007924
	IDT (Cat # 1076300, 1076301)
Alt-R Cas12a (Cpf1) Electroporation Enhancer	Note: The Electroporation Enhancer does not have significant homology to the human or mouse genomes, and has been tested as carrier DNA in multiple cell lines, including HEK-293, Jurkat, and HeLa.
Nuclease-Free IDTE, pH 7.5 (1X TE solution)	IDT (Cat # 11-01-02-02)

To order control crRNAs, enter the appropriate sequence into the Cas12a (Cpf1) crRNA ordering tool (accessible at www.idtdna.com/CRISPR-Cpf1). These sequences are available online for copying and pasting into the ordering tool.


Recommended control crRNAs	Sequence
Positive control Cas12a (Cpf1) crRNA, Human <i>HPRT1</i>	GGTTAAAGATGGTTAAATGAT
Positive control Cas12a (Cpf1) crRNA, Mouse <i>HPRT</i>	GGATGTTAAGAGTCCCTATCT
Positive control Cas12a (Cpf1) crRNA, Rat <i>HPRT1</i>	ATGCTTAAGAGGTATTTGTTA
Negative control Cas12a (Cpf1) crRNA #1	CGTTAATCGCGTATAATACGG
Negative control Cas12a (Cpf1) crRNA #2	CATATTGCGCGTATAGTCGCG
Negative control Cas12a (Cpf1) crRNA #3	GGCGCGTATAGTCGCGCGTAT

PROTOCOL

A. Culture cells

 **Note:** This procedure is based on the **Amaxa™ 96-well Shuttle™ Basic Protocol from Primary Mammalian Epithelial Cells** (Lonza).

1. Do not use freshly thawed cells for electroporation: passage your cells 1X after thawing, and verify that they grow well and look healthy.
2. Use cells with the lowest passage number possible. Lonza recommends not using HEK-293 cells after passage 20.
3. Replace cell culture media every 2–3 days. For stable cell lines, make sure to include appropriate selection antibiotic.
4. Split cells to maintain confluency $\leq 90\%$.

 **Note:** The target confluency for electroporation of HEK-293 cells with the Nucleofector system is 80–90%; higher cell densities may reduce electroporation efficiency.

5. Subculture cells for a minimum of 2–3 days before electroporation, and visually inspect the cells with a microscope to ensure healthy appearance.

B. Form the RNP complex

1. Resuspend Alt-R CRISPR-Cas12a crRNA to 100 μM in IDTE Buffer. For assistance, use the IDT Resuspension Calculator at www.idtdna.com/SciTools.

 **Note:** Store resuspended RNA at -20°C .


2. For each well undergoing electroporation, dilute the crRNA (from **Step B1**) and Cas12a (Cpf1) protein in PBS, gently swirling the pipette tip while pipetting:

Component	Amount
PBS	1.4 μL
Alt-R CRISPR-Cas12a crRNA (from Step B1)	1.6 μL
Alt-R Cas12a (Cpf1) Nuclease*	2 μL
Total volume	5 μL†

* Alt-R A.s. Cas12a (Cpf1) and A.s. Cas12a (Cpf1) *Ultra* are provided at a stock concentration of 63 μM . Alt-R L.b. Cas12a *Ultra* is provided at a stock concentration of 67 μM .

† The 5 μL total volume is for a single Nucleofection reaction; scale up as necessary for your experiment.

3. Incubate at room temperature for 10–20 min.

 **Note:** To save time, the RNP can be prepared during the 2 x 10 min centrifugation in the following **Steps D8** and **D11**.


C. Prepare Nucleofector system

1. Turn on Nucleofector system and Shuttle device. Open software and log in. Make sure the software connects to the device.
2. Open new parameter file.
3. Select wells on the 96-well plate; then select the appropriate Nucleofector program for your cell line (for example, 96-DS-150 program for HEK-293 cells).


D. Perform electroporation of cells with the Nucleofector system

 **Note:** This procedure is based on the **Amaxa™ 96-well Shuttle™ Basic protocol from Primary Mammalian Epithelial Cells** (Lonza).


1. Prepare the Alt-R Cas12a (Cpf1) Electroporation Enhancer. For assistance, use the Resuspension Calculator at www.idtdna.com/SciTools.
 - a. At first use, resuspend the Alt-R Cas12a (Cpf1) Electroporation Enhancer to 100 µM in IDTE to create a stock solution.
 - b. For each set of experiments, dilute stock to 78 µM (working solution); you will need 1 µL of working solution for each electroporation.
2. Add the entire Supplement to the Nucleofection Solution SF before first use, as directed by the manufacturer.
3. Prepare 96-well culture plate to receive cells following nucleofection.

 **Note:** We recommend dividing each nucleofection into 3 replicate wells.


- a. Fill necessary wells with 175 µL of culture media (DMEM, 10% FBS).
 - b. Store in a tissue culture incubator (37°C, 5% CO₂).
4. Prepare an additional aliquot of 75 µL/well of culture media (DMEM, 10% FBS) and pre-warm to 37°C.
 5. Harvest cells in a 150 cm² flask by trypsinization.
 - a. Aspirate media from cultured cells and wash with 10 mL of 1X PBS.
 - b. Add 4 mL of 1X trypsin solution to the cells and incubate at 37°C until the cells just release from flask.
 6. Count the trypsinized cells.
 7. Transfer the total number of cells you need for your experiment to a sterile, 15 mL tube.


 **Important:** Avoid over trypsinizing the cells! Make sure a single-cell suspension is achieved at this step.

- c. Neutralize trypsin by adding 16 mL of culture media (DMEM, 10% FBS).

 **Note:** Typically, (2 to 5) × 10⁵ cells per well is the optimal range of HEK-293 cells for nucleofection. We used 3.5 × 10⁵ HEK-293 cells per nucleofection to develop this protocol. Scale up for the appropriate number of wells.

8. Centrifuge the cells at 200 rpm (Beckman GH-3.8 rotor: 6 × g) for 10 min at room temperature.
9. Remove as much supernatant as possible without disturbing the pellet.
10. Wash cells in 5 mL of 1X PBS.

 **Important:** Trypsin and FBS commonly contain RNase activity. Therefore, after neutralizing trypsin with FBS-containing media, it is crucial to wash the cells with PBS. A good alternative is to use 'enzyme-free' dissociation media.

11. Centrifuge at 200 rpm (Beckman GH-3.8 rotor: 6 x g) for 10 min at room temperature.
12. Remove as much supernatant as possible without disturbing the pellet.
13. Resuspend cells by adding 20 μ L of Nucleofector Solution SF (from **Step D2**) per 3.5×10^5 cells.
14. Pipette 20 μ L of cell suspension into each well of a V-bottom plate.
15. To each well, add 5 μ L of the Cas12a (Cpf1) RNP (from **Step B3**) and 1 μ L of 78 μ M Alt-R Cpf1 Electroporation Enhancer (from **Step D1b**).
16. Pipette up and down 2 times, and transfer 25 μ L of the cell/RNP complex mixture to the wells of the 96-well Nucleocuvette module.
17. Gently tap the Nucleocuvette module to make sure no air bubbles are present.
18. Place Nucleocuvette module in Shuttle device, and select **Upload and start**.
 **Note:** Save the file before nucleofection takes place.
19. After electroporation, remove the Nucleocuvette module from the instrument.
20. Add 75 μ L of pre-warmed culture media per well (from **Step D4**) and resuspend cells by gently pipetting up and down.
21. Transfer 25 μ L of resuspended cells to the 175 μ L of culture media (DMEM, 10% FBS) from **Step D3**, in triplicate.
22. Incubate cells in a tissue culture incubator (37°C, 5% CO₂) for 48 hr.
23. To find on-target mutations with the Alt-R Genome Editing Detection Kit (T7EI mismatch assay), follow the [Alt-R Genome Editing Detection Kit protocol](#).

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