

TECHNICAL MANUAL

Integrated Workflow for the Isolation, Expansion, and Reprogramming of CD34+ Progenitor Cells

Table of Contents

1.0	Introduction	1
2.0	Materials, Reagents, and Equipment	2
2.1	CD34+ Progenitor Reprogramming Kit (Catalog #05925).....	2
2.2	Additional Materials and Reagents	3
2.3	Equipment Required	4
3.0	Procedure Diagram	5
4.0	Preparation of Reagents and Materials	6
4.1	CD34+ Expansion Medium	6
4.2	ReproTeSR™	6
4.3	Coating Cultureware with Corning® Matrigel®.....	6
5.0	CD34+ Cell Pre-Enrichment, Isolation, and Expansion.....	7
5.1	Pre-Enrichment of Hematopoietic Progenitor Cells from Whole Blood	7
5.2	EasySep™ CD34 Positive Selection	8
5.3	Expansion of CD34+ Progenitor Cells	9
6.0	Transfection/Transduction of CD34+ Progenitor Cells	10
7.0	Reprogramming of CD34+ Progenitor Cells.....	10
7.1	Identification and Isolation of iPS Cell Colonies	11
7.1.1	Identification of iPS Cell Colonies	11
7.1.2	Isolation of iPS Cell Colonies	12
8.0	Troubleshooting.....	13
9.0	References.....	14

1.0 Introduction

Peripheral Blood Cells for Reprogramming

Human induced pluripotent stem (iPS) cells are generated by reprogramming somatic cells to a pluripotent state, through the transient overexpression of key reprogramming factors.

Dermal fibroblasts were the first human cell type to be converted to iPS cells and are still one of the most common sources used for reprogramming experiments.^{1,2} Since then, numerous primary cell sources such as keratinocytes, mesenchymal stem cells, T cells, B cells, hematopoietic progenitor cells, and urine epithelial cells have also been reprogrammed to iPS cells.¹⁻⁸ The choice of starting cell type is influenced by factors such as availability of donor tissue from normal and diseased patients, invasiveness of sample collection procedures, genomic integrity, epigenetic memory, and reprogramming efficiency.

Peripheral blood (PB) is a popular tissue source for generating iPS cells.⁹ Blood collection is a well-established and minimally invasive procedure, and collected cells are naturally replaced as the tissue is self-renewing. Banked blood samples are also available for a wide variety of disease, age, gender, and geographical subtypes. Since the cells are continually replenished from stem cells in the bone marrow, it is expected that they will contain fewer environment-associated point mutations than skin, which is exposed to long-term ultraviolet radiation.

However, PB contains a heterogeneous mixture of cell types, the most prevalent of which are enucleated (e.g. mature red blood cells [RBCs] and platelets) and therefore not suitable for reprogramming. The first step in preparing whole PB samples for reprogramming is therefore to separate the PB mononuclear cell (PBMC) fraction from the RBCs and platelets. This is generally done by density gradient centrifugation.

The PBMC fraction consists of T and B lymphocytes, macrophages, monocytes, erythroid progenitor cells, and rare circulating stem cells. Many of these cell types have been successfully reprogrammed with varying efficiencies.⁹ While T cells and B cells are the most abundant cell types in the PBMC fraction and have been successfully reprogrammed, they contain V(D)J genomic rearrangements of the T cell receptor or immunoglobulin loci, respectively. The ability to generate iPS cells from specific T cells has been utilized for proof-of-principle experiments in T cell therapy,¹⁰ but little is known about how these rearrangements may affect the function of other downstream cell lineages.

Less abundant cell types, including CD34+ hematopoietic stem and progenitor cells and erythroid progenitor cells, are attractive for reprogramming due to their lack of genomic rearrangements and demonstrated reprogramming ability.^{7,11} However, owing to their low frequency in whole blood, these cells need to be isolated from PB and/or expanded in vitro to obtain sufficient cell numbers for reprogramming.

A Complete Workflow

We have developed an integrated set of tools to facilitate the reprogramming of PB to human iPS cells. First, RBCs, platelets, and lineage-committed cells are depleted from blood using a RosetteSep™ cocktail and SepMate™ density gradient centrifugation tubes. CD34+ cells are then isolated from the RosetteSep™-enriched fraction by positive selection using the immunomagnetic, column-free EasySep™ platform. Enriched cells can then be directly cultured in StemSpan™ media and supplements for CD34+ cell expansion.

Once sufficient cell numbers have been generated, reprogramming can begin through transfection/transduction of reprogramming factors. ReproTeSR™ is a xeno-free medium that supports rapid and efficient feeder-free reprogramming of blood-derived cells. iPS cells generated from this workflow can transition seamlessly to our TeSR™ family of iPS cell maintenance media and the STEMdiff™ suite of products (e.g. STEMdiff™ Neural Induction Medium, Catalog #05835) for directed differentiation.

2.0 Materials, Reagents, and Equipment

2.1 CD34+ Progenitor Reprogramming Kit (Catalog #05925)

The following table lists the components of the CD34+ Reprogramming Kit. The materials provided in the kit are sufficient to process 80 mL of fresh peripheral blood.

COMPONENT/PRODUCT NAME	QUANTITY/SIZE	COMPONENT #
SepMate™-50 (sample size)	6 x 50 mL tubes	15440
Lymphoprep™	250 mL	07801
Complete Kit for Human Whole Blood CD34+ Cells	1 Kit	15086
RosetteSep™ Human Hematopoietic Progenitor Cell Enrichment Cocktail	3 x 2 mL	15186C
EasySep™ Human CD34 Positive Selection Cocktail	0.4 mL	18066C.1
EasySep™ Dextran RapidSpheres™ 50100	1 mL	50100
StemSpan™ SFEM II	100 mL	09605
StemSpan™ CD34+ Expansion Supplement (10X)	10 mL	02691
ReproTeSR™	500 mL Kit	05926
TeSR™-E7™/ReproTeSR™ Basal Medium	480 mL	05919
ReproTeSR™ 25X Supplement	20 mL	05928

PRODUCTS ARE FOR RESEARCH USE ONLY AND NOT INTENDED FOR HUMAN OR ANIMAL DIAGNOSTIC OR THERAPEUTIC USES UNLESS OTHERWISE STATED. FOR ADDITIONAL QUALITY INFORMATION, REFER TO WWW.STEMCELL.COM/COMPLIANCE.

2.2 Additional Materials and Reagents

PRODUCT	CATALOG #
Tissue culture-treated cultureware	e.g. 38016 (6-well plates)
Falcon® Conical Tubes	38009 (15 mL) AND 38010 (50 mL)
D-PBS (Without Ca ⁺⁺ and Mg ⁺⁺)	37350
Dulbecco's Phosphate Buffered Saline with 2% Fetal Bovine Serum (PBS + 2% FBS)	07905
OR	OR
EasySep™ Buffer	20144
OR	OR
RoboSep™ Buffer	20104
DMEM/F-12 with 15 mM HEPES	36254
Corning® Matrigel® hESC-Qualified Matrix	Corning 354277
3% Acetic Acid with Methylene Blue	07060
Magnet for cell separation	
• EasySep™ Magnet	18000
OR	OR
• "The Big Easy" EasySep™ Magnet	18001
OR	OR
• EasyEights™ EasySep™ Magnet	18103
OR	OR
RoboSep™/RoboSep™-S	20000 or 21000
Epi5™ Episomal iPSC Reprogramming Kit	Thermo Fisher A15960
P3 Primary Cell 4D-Nucleofector™ X Kit L	Lonza V4XP-3024
• P3 Primary Cell Nucleofector™ Solution	
iPS cell maintenance medium	
• mTeSR™ 1	85850
OR	OR
• mTeSR™ Plus	05825
OR	OR
• TeSR™-E8™	05990
OR	OR
• TeSR™2	05860
Y-27632	72302
Passaging reagent	
• Gentle Cell Dissociation Reagent	07174
OR	OR
• ReLeSR™	05872

For a complete list of products available from STEMCELL Technologies Inc., visit www.stemcell.com.

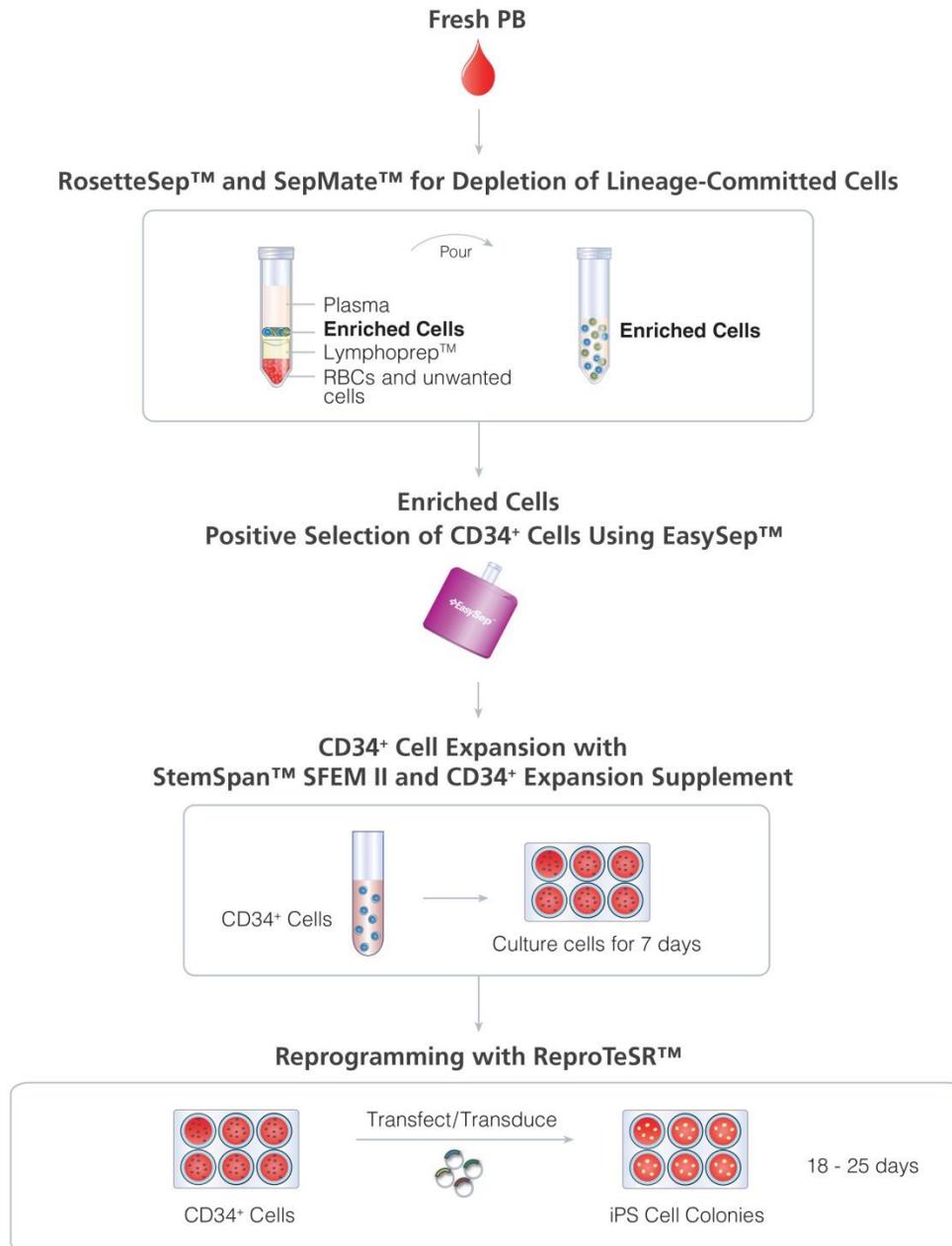
PRODUCTS ARE FOR RESEARCH USE ONLY AND NOT INTENDED FOR HUMAN OR ANIMAL DIAGNOSTIC OR THERAPEUTIC USES UNLESS OTHERWISE STATED. FOR ADDITIONAL QUALITY INFORMATION, REFER TO WWW.STEMCELL.COM/COMPLIANCE.

2.3 Equipment Required

- Biohazard safety cabinet certified for Level II handling of biological materials
- Incubator with humidity and gas control to maintain 37°C and 95% humidity in an atmosphere of 5% CO₂ in air
- Low-speed centrifuge with a swinging bucket rotor
- Pipette-aid with appropriate serological pipettes
- Pipettor with appropriate tips
- 22 gauge needle or pulled glass pipette
- Inverted microscope with a total magnification of 20X to 100X
- -20°C freezer
- Refrigerator (2 - 8°C)
- 4D-Nucleofector™ System (e.g. Lonza AAF-1001B)

3.0 Procedure Diagram

CD34⁺ Progenitor Cell Reprogramming



PRODUCTS ARE FOR RESEARCH USE ONLY AND NOT INTENDED FOR HUMAN OR ANIMAL DIAGNOSTIC OR THERAPEUTIC USES UNLESS OTHERWISE STATED. FOR ADDITIONAL QUALITY INFORMATION, REFER TO WWW.STEMCELL.COM/COMPLIANCE.

4.0 Preparation of Reagents and Materials

The following reagents and materials are required in the protocols in sections 5.0 - 7.0. Prepare as needed. For storage and stability information, refer to the Product Information Sheets (PIS's) supplied with each product.

4.1 CD34+ Expansion Medium

Use sterile technique when preparing CD34+ Expansion Medium (StemSpan™ SFEM II + StemSpan™ CD34+ Expansion Supplement). The following example is for preparing 100 mL of CD34+ Expansion Medium. If preparing other volumes, adjust accordingly.

1. Thaw StemSpan™ CD34+ Expansion Supplement (10X) at room temperature (15 - 25°C) until just thawed. Mix thoroughly.
2. Add 10 mL of StemSpan™ CD34+ Expansion Supplement (10X) to 90 mL of StemSpan™ SFEM II. Mix thoroughly.

4.2 ReproTeSR™

Use sterile technique when preparing complete ReproTeSR™ medium (TeSR™-E7™/ReproTeSR™ Basal Medium + 25X Supplement). The following example is for preparing 500 mL of ReproTeSR™ medium. If preparing other volumes, adjust accordingly.

1. Thaw ReproTeSR™ 25X Supplement at room temperature (15 - 25°C) or at 2 - 8°C. Mix thoroughly.
2. Add 20 mL of ReproTeSR™ 25X Supplement to 480 mL of TeSR™-E7™/ReproTeSR™ Basal Medium. Mix thoroughly.

4.3 Coating Cultureware with Corning® Matrigel®

Corning® Matrigel® hESC-Qualified Matrix is recommended for reprogramming. It should be previously aliquoted and frozen. Consult the Certificate of Analysis supplied with Corning® Matrigel® for the recommended aliquot size ("Dilution Factor") to prepare 25 mL of diluted matrix. Ensure to keep Matrigel® on ice when thawing and handling to prevent it from gelling.

Note: Use tissue culture-treated cultureware.

1. Thaw one aliquot of Corning® Matrigel® on ice.
2. Dispense 25 mL of cold DMEM/F-12 into a 50 mL conical tube and keep on ice.
3. Add thawed Matrigel® to the cold DMEM/F-12 and mix well. The vial may be washed with cold medium if desired.
4. Immediately use the diluted Matrigel® solution to coat tissue culture-treated cultureware. See Table 1 below for recommended coating volumes.

Table 1. Recommended Volumes for Coating Cultureware

CULTUREWARE	VOLUME OF DILUTED MATRIGEL®
6-well plate	1 mL/well
100 mm dish	6 mL
T-25 cm ² flask	3 mL
T-75 cm ² flask	8 mL

5. Swirl the cultureware to spread the Matrigel® solution evenly across the surface.
Note: If the cultureware surface is not fully coated by the Matrigel® solution, it should not be used for human ES or iPS cell culture.
6. Incubate at room temperature (15 - 25°C) for at least 1 hour before use. Do not let the Matrigel® solution evaporate.
Note: If not used immediately, the cultureware must be sealed to prevent evaporation of the Matrigel® solution (e.g. with Parafilm®) and can be stored at 2 - 8°C for up to 1 week after coating. Allow stored coated cultureware to warm to room temperature (15 - 25°C) for 30 minutes before proceeding to the next step.
7. Gently tilt the cultureware onto one side and allow the excess Matrigel® solution to collect at the edge. Remove the excess solution using a serological pipette or by aspiration. Ensure that the coated surface is not scratched.
8. Immediately add the appropriate medium (e.g. 2 mL/well if using a 6-well plate).

5.0 CD34+ Cell Pre-Enrichment, Isolation, and Expansion

5.1 Pre-Enrichment of Hematopoietic Progenitor Cells from Whole Blood

RosetteSep™ + SepMate™ Pre-Enrichment

Recommended medium is EasySep™ Buffer or RoboSep™ Buffer or PBS + 2% FBS with 1 mM EDTA. Medium should be free of Ca⁺⁺ and Mg⁺⁺.

Ensure that the blood sample, recommended medium, CD34+ Expansion Medium, Lymphoprep™, and centrifuge are all at room temperature (15 - 25°C).

1. Add RosetteSep™ Human Hematopoietic Progenitor Cell Enrichment Cocktail to the blood sample at **50 µL/mL** of blood (e.g. for 30 mL of blood, add 1.5 mL of cocktail).
2. Incubate at room temperature (15 - 25°C) for **20 minutes**.
3. Dilute sample with an equal volume of recommended medium. Mix gently.
For example, dilute 30 mL of sample with 30 mL of recommended medium.
4. Add Lymphoprep™ to the SepMate™-50 tube by carefully pipetting it through the central hole of the SepMate™ insert.
Note: For 30 mL of sample, add 15 mL of Lymphoprep™ to each of two SepMate™-50 tubes. For other sample volumes, refer to the PIS for SepMate™.
5. Keeping the SepMate™-50 tube vertical, add the diluted sample by pipetting it down the side of the tube. The sample will mix with the density gradient medium above the insert.
Note: For 30 mL of initial sample, add 30 mL of diluted sample to each of two SepMate™-50 tubes.
Note: The sample can be poured down the side of the tube. Take care not to pour the diluted sample directly through the central hole.
6. Centrifuge at **1200 x g** for **10 minutes** at room temperature (15 - 25°C), with the **brake on**.
Note: For samples older than 24 hours, a centrifugation time of 20 minutes is recommended.

- Pour off the top layer, which contains the pre-enriched cells, into a new standard 50 mL tube. Do not hold the SepMate™ tube in the inverted position for longer than 2 seconds. Pool samples from the same donor into one tube.

Note: Some RBCs may be present on the surface of the SepMate™ insert after centrifugation. This will not affect performance.

- Wash pre-enriched cells by topping up the tube with recommended medium and centrifuge at **300 x g** for **10 minutes** with the **brake on low**.
- Remove and discard supernatant.
- Resuspend cell pellet in recommended medium as indicated in Table 2.

Table 2. Resuspension Volumes for EasySep™ Human CD34 Positive Selection

STARTING SAMPLE (mL)	VOLUME OF RECOMMENDED MEDIUM (mL)
< 50	0.5
≥ 50 - 100	0.75
> 100 - 150	1.0

5.2 EasySep™ CD34 Positive Selection

This procedure is for processing 0.5 mL of pre-enriched cells prepared using RosetteSep™ Human Hematopoietic Progenitor Cell Enrichment Cocktail (section 5.1).

The EasySep™ Magnet (Catalog #18000) is used in this procedure; for other volumes and magnets, or for RoboSep™, refer to the PIS for EasySep™ Complete Kit for Human Whole Blood CD34+ Cells.

Recommended medium is EasySep™ Buffer or RoboSep™ Buffer or PBS + 2% FBS with 1 mM EDTA. Medium should be free of Ca⁺⁺ and Mg⁺⁺.

- Add pre-enriched cells (prepared in section 5.1) to a 5 mL (12 x 75 mm) polystyrene round-bottom tube (e.g. Catalog #38007).
- Add EasySep™ Human CD34 Positive Selection Cocktail at **50 µL/mL** of sample. Mix well and incubate at room temperature (15 - 25°C) for **10 minutes**.
- Vortex EasySep™ Dextran RapidSpheres™ 50100 for 30 seconds to ensure they are in a uniform suspension.
- Add EasySep™ Dextran RapidSpheres™ 50100 at **50 µL/mL** of sample. Mix well and incubate at room temperature (15 - 25°C) for **3 minutes**.
- Add recommended medium to top up the sample to a volume of 2.5 mL. Mix by gently pipetting up and down 2 - 3 times. Place the tube (without cap) into the EasySep™ Magnet and incubate at room temperature (15 - 25°C) for **3 minutes**.
- Pick up the magnet, and in one continuous motion invert the magnet and tube, pouring off the supernatant. Remove the tube from the magnet; this tube contains the isolated cells.
- Repeat steps 5 and 6 three more times, for a total of 4 x 3-minute separations.
- Remove and discard supernatant.
- Resuspend cells in CD34+ Expansion Medium (see section 4.1). Be sure to collect cells from the sides of the tube. Isolated cells are now ready for use.

5.3 Expansion of CD34+ Progenitor Cells

1. **Day 0:** Count CD34+ progenitor cells (obtained in section 5.2 step 9) using 3% Acetic Acid with Methylene Blue, and resuspend to a cell density of $< 5 \times 10^4$ cells/mL in CD34+ Expansion Medium.
Note: For instructions on cell counting, refer to the PIS for 3% Acetic Acid with Methylene Blue, available at www.stemcell.com or contact us to request a copy.
2. Plate $< 1 \times 10^5$ CD34+ progenitor cells (2 mL) per well of a 6-well plate.
Note: The CD34+ Progenitor Reprogramming Kit contains enough CD34+ Expansion Medium to expand 10 wells (in 6-well plates) for 7 days.
3. Incubate at 37°C and 5% CO₂.
4. **Day 2:** Change the medium as described below.
The following example is for changing medium in 1 well. If changing medium from a different number of wells, adjust accordingly.
 - a. Transfer cells to a 15 mL conical tube.
 - b. Centrifuge cells at 300 x g for 5 minutes.
 - c. Remove supernatant and resuspend cells in 2 mL of fresh CD34+ Expansion Medium.
 - d. Plate 2 mL per well of a 6-well plate. Incubate at 37°C and 5% CO₂.
5. **Day 4:** Count CD34+ progenitor cells as described in step 1. The cultured-expanded cells may require splitting; this is usually done when they reach a cell density of 4 - 6 x 10⁵ cells. A 1:6 split is typical, as described below.
 - a. Transfer cells from 1 well to a 15 mL conical tube.
 - b. Centrifuge cells at 300 x g for 5 minutes.
 - c. Remove supernatant and resuspend cells in 12 mL of fresh CD34+ Expansion Medium.
 - d. Plate 2 mL per well of a 6-well plate. Incubate at 37°C and 5% CO₂.
6. **Day 6:** Change the medium as described below.
The following example is for changing medium in 6 wells. If changing medium from a different number of wells, adjust accordingly.
 - a. Transfer cells to a 15 mL conical tube.
 - b. Centrifuge cells at 300 x g for 5 minutes.
 - c. Remove supernatant and resuspend cells in 12 mL of fresh CD34+ Expansion Medium.
 - d. Plate 2 mL per well of a 6-well plate. Incubate at 37°C and 5% CO₂.
7. **Day 7:** Centrifuge cells at 300 x g for 5 minutes. Remove supernatant and resuspend cells in 2 mL of fresh CD34+ Expansion Medium. Perform a cell count using 3% Acetic Acid with Methylene Blue. Cells are now ready for transfection/transduction (section 6.0).
Note: For further information on expansion of CD34+ progenitor cells, refer to the Brochure: An Integrated Workflow for Reprogramming Blood Cells (Document #28722), available at www.stemcell.com or contact us to request a copy.

6.0 Transfection/Transduction of CD34+ Progenitor Cells

1. Transfer 1×10^6 culture-expanded CD34+ progenitor cells (from section 5.3 step 7) into a 15 mL conical tube.
2. Centrifuge at $300 \times g$ for 5 minutes. Remove supernatant and resuspend cells in 100 μ L of P3 Primary Cell Nucleofector™ Solution.
3. Add 1 μ g of each episomal vector to the cell suspension and mix well.
Note: It is recommended to use the set of 5 episomal vectors provided in the Epi5™ Episomal iPSC Reprogramming Kit. The amount of episomal vectors used may require optimization depending on the transfection efficiency and cell source.
4. Electroporate cells with reprogramming vectors according to the manufacturer's instructions.
Note: For transfection of episomal vectors using the Lonza Nucleofector™, use the electroporation setting indicated for human CD34+ cells.
5. Transfer cells to a 15 mL conical tube containing 6 mL of CD34+ Expansion Medium (section 4.1).

7.0 Reprogramming of CD34+ Progenitor Cells

Note: Warm ReproTeSR™ medium (section 4.2) to room temperature (15 - 25°C) before use.

1. **Day 0:** Plate 3.3×10^5 cells (i.e. 2 mL of cell suspension from section 6.0) in each well of a 6-well plate coated with Corning® Matrigel® (section 4.3). Incubate at 37°C.
Note: The suggested plating density is optimized for the transfection of CD34+ cells with an episomal system. Plating density may need further optimization depending on the vector system used and growth kinetics of the cells being reprogrammed.
2. **Day 2:** Add 1 mL of CD34+ Expansion Medium (section 4.1) to the transfected/transduced cells (without removing any medium from the well). Incubate at 37°C.
3. **Day 3:** Add 1 mL of ReproTeSR™ medium (without removing medium from the well). Incubate at 37°C.
4. **Day 5:** Add 1 mL of ReproTeSR™ medium (without removing medium from the well). Incubate at 37°C.
5. **Day 7:** Aspirate medium from each well and replace with 2 mL of fresh ReproTeSR™ medium. Incubate at 37°C.
6. **Day 8 - 25:** Perform daily medium changes (2 mL/well) using ReproTeSR™ medium. Monitor the cells until iPS cell colonies appear.

Note: iPS cell colonies typically arise between days 18 - 25, but may vary depending on cell type and vector system used. To achieve optimal reprogramming efficiency, use blood-derived cells at low passage. For a representative example of an iPS cell colony, see section 7.1.

7.1 Identification and Isolation of iPS Cell Colonies

7.1.1 Identification of iPS Cell Colonies

iPS cells have characteristic cellular and colony morphology that can be used to distinguish them from non-reprogrammed cells in the same culture. Putative iPS cell colonies are recognizable by their relatively large size, tight cell packing, and well-defined borders. Identification is facilitated by the low degree of colony overgrowth from differentiated cells in feeder-free reprogramming media such as ReproTeSR™. Within iPS cell colonies, the cells are small, with high nuclear to cytoplasmic ratio. These characteristics can be used to manually select putative iPS cell colonies. Confirmation of pluripotency is recommended for all newly generated iPS cell clones, once a cell line is established.

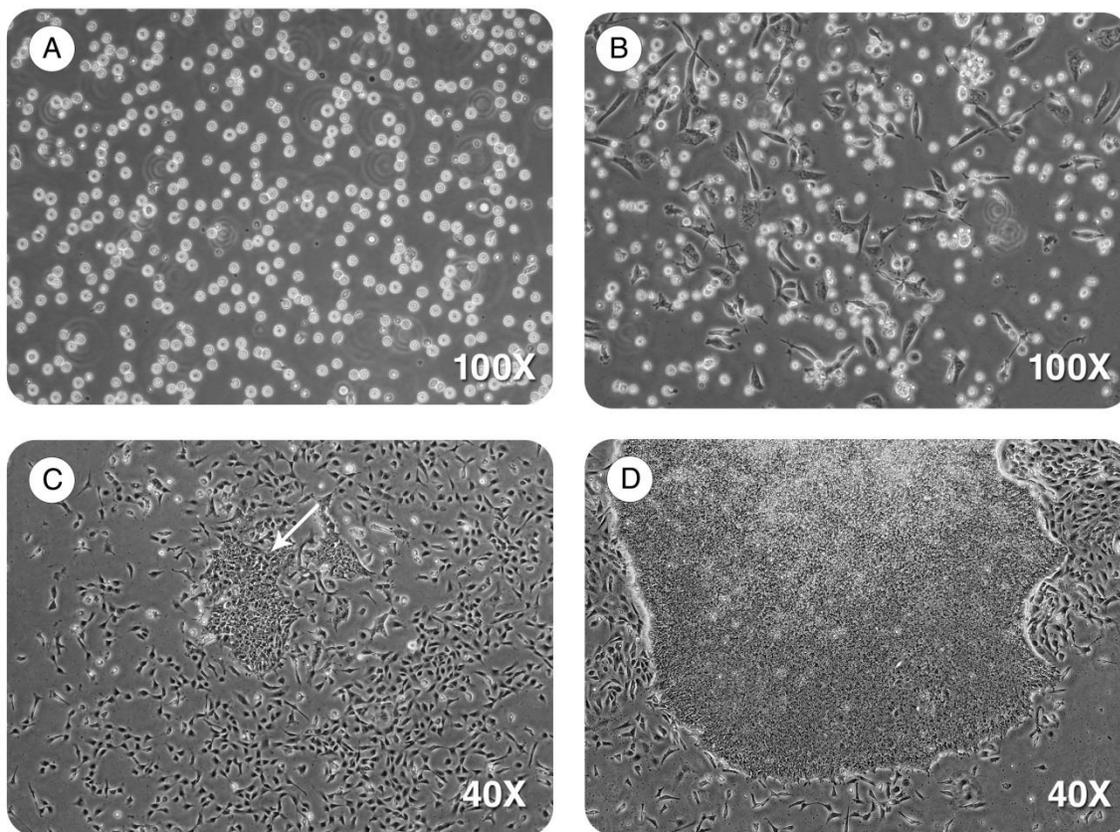


Figure 1. Morphological Changes Observed During the Induction Phase of Reprogramming Blood-Derived Cells

- (A) Prior to transfection (or transduction) of reprogramming factors, blood-derived cells expand as suspension cultures.
(B) On day 7 (post-transfection of reprogramming factors), blood-derived cells are shown attached to the plate.
(C) After 2 weeks, pre-iPS cell colonies form, exhibiting epithelial-like morphology.
(D) By 3 weeks, putative iPS cell colonies arise.

7.1.2 Isolation of iPS Cell Colonies

The procedures below should be performed under a stereomicroscope using sterile conditions. Warm media and coated plates to room temperature (15 - 25°C) before use.

1. Cut the putative iPS cell colony into small fragments using either a 22 gauge needle or a pulled glass pipette (Figure 2).

Note: If there are many untransfected, partially reprogrammed, and/or differentiated cells surrounding the putative iPS cell colony, these may need to be scraped away prior to isolating the iPS cell colony.

2. Scrape and aspirate colony fragments using a 200 μ L pipettor with a filtered tip.
3. Immediately plate iPS cell colony fragments on cultureware coated with desired matrix (e.g. Corning® Matrigel®, section 4.3) and containing iPS cell maintenance medium (e.g. mTeSR™ 1, mTeSR™ Plus, or TeSR™-E8™).

Note: To facilitate the initial attachment of iPS cell colony fragments, add Y-27632 to the maintenance medium at a final concentration of 10 μ M. After 24 hours, replace the maintenance medium (without Y-27632).

4. Incubate at 37°C and perform iPS cell maintenance medium changes accordingly.

Note: For the first few passages, perform manual (i.e. chemical- and enzyme-free) passaging of newly isolated iPS cell lines. This can help to reduce the presence of contaminating cells such as fibroblasts, partially reprogrammed cells, or differentiated cells. Once iPS cell lines are established, chemical or enzymatic passaging methods may be used (e.g. Gentle Cell Dissociation Reagent or ReLeSR™). For complete instructions on how to maintain iPS cells using mTeSR™ 1, mTeSR™ Plus, TeSR™-E8™, or TeSR™ 2, refer to the Technical Manuals available at www.stemcell.com or contact us to request a copy.

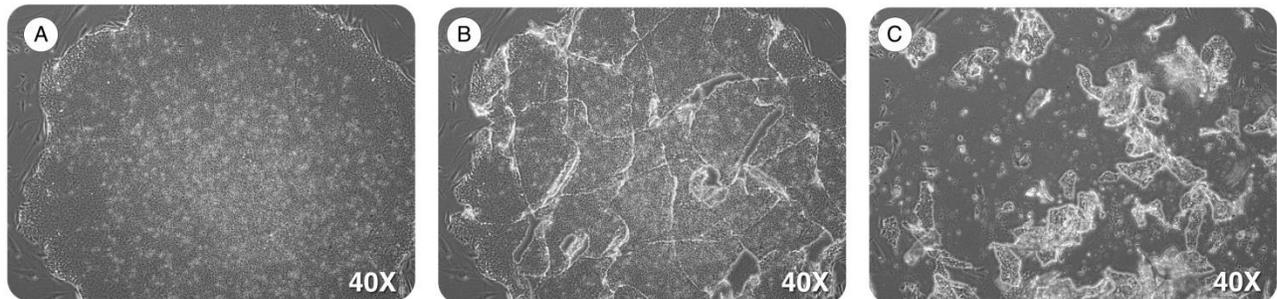


Figure 2. Manual Isolation of Putative iPS Cell Colonies

(A) Putative human iPS cell colonies exhibiting morphological characteristics similar to human ES cells with compact morphology, high nuclear-to-cytoplasmic ratio, and defined borders. **(B)** Using a 22 gauge needle or pulled glass pipette, the putative iPS colony is cut into smaller fragments. **(C)** These smaller fragments are then scraped off the plate with a filtered 200 μ L pipette tip.

8.0 Troubleshooting

PROBLEM	SOLUTION
Poor expansion of CD34+ progenitor cells	<ul style="list-style-type: none"> • Ensure that complete CD34+ Expansion Medium is used within 2 weeks of preparation. • Whole peripheral blood less than 24 hours old is recommended as the primary cell source for isolation of CD34+ progenitor cells.
Low reprogramming efficiency	<ul style="list-style-type: none"> • Depending on the vector system being used, ensure that the transfection or transduction efficiency has been optimized with CD34+ progenitor cells. • Ensure that the vector being used has not been compromised by checking whether the reprogramming factors are being expressed.
Differentiation of CD34+ progenitor cells	<ul style="list-style-type: none"> • The optimal culture time is 7 - 8 days; extended culture of CD34+ progenitor cells can lead to increased spontaneous differentiation of CD34+ progenitor cells.
Low cell viability after transfection or transduction	<ul style="list-style-type: none"> • Ensure transfection or transduction is optimized for CD34+ progenitor cells.

PRODUCTS ARE FOR RESEARCH USE ONLY AND NOT INTENDED FOR HUMAN OR ANIMAL DIAGNOSTIC OR THERAPEUTIC USES UNLESS OTHERWISE STATED. FOR ADDITIONAL QUALITY INFORMATION, REFER TO WWW.STEMCELL.COM/COMPLIANCE.

9.0 References

1. Takahashi K et al. (2007) Induction of pluripotent stem cells from adult human fibroblasts by defined factors. *Cell* 131(5): 861–72.
2. Yu J et al. (2007) Induced pluripotent stem cell lines derived from human somatic cells. *Science* 318(5858): 1917–20.
3. Aasen T et al. (2008) Efficient and rapid generation of induced pluripotent stem cells from human keratinocytes. *Nat Biotechnol* 26(11): 1276–84.
4. Niibe K et al. (2011) Purified mesenchymal stem cells are an efficient source for iPS cell induction. *PLoS One* 6(3): e17610.
5. Loh Y-H et al. (2010) Reprogramming of T cells from human peripheral blood. *Cell Stem Cell* 7(1): 15–9.
6. Choi SM et al. (2011) Reprogramming of EBV-immortalized B-lymphocyte cell lines into induced pluripotent stem cells. *Blood* 118(7): 1801–5.
7. Mack AA et al. (2011). Generation of induced pluripotent stem cells from CD34+ cells across blood drawn from multiple donors with non-integrating episomal vectors. *PLoS One* 6(11): e27956.
8. Zhou T et al. (2011) Generation of induced pluripotent stem cells from urine. *J Am Soc Nephrol* 22(7): 1221–8.
9. Zhang X-B. (2013) Cellular reprogramming of human peripheral blood cells. *Genomics Proteomics Bioinformatics* 11(5): 264–74.
10. Nishimura T et al. (2013) Generation of rejuvenated antigen-specific T cells by reprogramming to pluripotency and redifferentiation. *Cell Stem Cell* 12(1): 114–26.
11. Chou B-K et al. (2011). Efficient human iPS cell derivation by a non-integrating plasmid from blood cells with unique epigenetic and gene expression signatures. *Cell Res* 21(3), 518–29.

Copyright © 2020 by STEMCELL Technologies Inc. All rights reserved including graphics and images. STEMCELL Technologies & Design, STEMCELL Shield Design, Scientists Helping Scientists, ReproTeSR, RosetteSep, StemSpan, STEMdiff, ReLeSR, EasySep, RoboSep, and SepMate are trademarks of STEMCELL Technologies Inc. Lymphoprep is a trademark of Alere Technologies. Corning, Matrigel, and Falcon are trademarks of Corning Incorporated. E8, mTeSR, and TeSR are trademarks of WARF. Nucleofector is a registered trademark of Lonza Cologne GmbH. Epi5 is a trademark of Thermo Fisher Scientific. Parafilm is a registered trademark of Bemis Company Inc. All other trademarks are the property of their respective holders. While STEMCELL has made all reasonable efforts to ensure that the information provided by STEMCELL and its suppliers is correct, it makes no warranties or representations as to the accuracy or completeness of such information.

PRODUCTS ARE FOR RESEARCH USE ONLY AND NOT INTENDED FOR HUMAN OR ANIMAL DIAGNOSTIC OR THERAPEUTIC USES UNLESS OTHERWISE STATED. FOR ADDITIONAL QUALITY INFORMATION, REFER TO WWW.STEMCELL.COM/COMPLIANCE.

TECHNICAL MANUAL

Integrated Workflow for the Isolation, Expansion, and Reprogramming of CD34+ Progenitor Cells



TOLL-FREE PHONE 1 800 667 0322

PHONE +1 604 877 0713

INFO@STEMCELL.COM

TECHSUPPORT@STEMCELL.COM

FOR GLOBAL CONTACT DETAILS VISIT WWW.STEMCELL.COM

DOCUMENT #1000005581 VERSION 01 JUN 2020 | FOR INTERNAL USE: MATERIAL #29801