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PROTOCOL

Efficient Transition of Human Pluripotent Stem Cell Cultures from StemFlex™ Medium into NutriStem® hPSC XF Medium on Matrigel®

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Introduction

Establishing ideal culture methods has been a known challenge in human pluripotent stem cell (hPSC) research since the creation of the first embryonic stem cell line in the late 90s and the discovery of induced pluripotent stem cells in 2006. Traditional protocols often call for highly variable components such as cell feeder layers, due to their ability to aid cell maintenance through secretion of essential growth factors, ECM components, and cytokines including bFGF, TGF-β, laminin, and others.[1] However, as the need for more defined cultures becomes increasingly prevalent, carefully formulated microenvironments have since evolved for more efficient maintenance of cellular pluripotency and purity, in turn reducing the use of feeder layers. Ultimately, as standards for clinical-quality cell use in therapeutic applications are determined, media formulations and culture conditions must be refined and optimized while fully supporting proper phenotype and genetic stability.

Today, there are multiple commercially available serum-free formulations for hPSC maintenance, including Essential 8™, mTeSR™, and StemFlex™ culture media. When compared to Biological Industries' NutriStem® hPSC Medium, these media contain extensive amounts of growth factors with the intention of maintaining pluripotency and preventing differentiation.[2] However, it has been shown that high amounts of growth factors also play a critical, and sometimes detrimental, role in regulating the downstream differentiation of hPSCs into mature cell types. For example, researchers have shown that high concentrations of bFGF can inhibit early neural differentiation of hPSCs into PAX6+ neuroectodermal cells yet are beneficial in promoting more mature neuronal differentiation of lineage committed early neural precursors.[3]

Considering both the positive and negative downstream effects related to daily exposure of hPSCs to high concentrations of growth factors, an ideal cell culture medium should contain low amounts of growth factors that can be controlled and supplemented to higher levels as needed, rather than subjecting cells to high amounts of growth factors that cannot be reduced.

NutriStem hPSC Medium has been optimized with minimal amounts of bFGF while still maintaining pluripotency, allowing hPSCs to expand efficiently on a variety of substrates (Matrigel®, vitronectin, and laminin) with minimal differentiation. However, when transitioning from a high bFGF-containing medium, such as StemFlex™ Medium, to a low bFGF medium like NutriStem hPSC Medium, users should be aware that they may notice initial differences in hPSC colony appearance and morphology (such as less compact colonies with less defined borders).

This protocol is the suggested method for adapting hPSCs originally cultured in StemFlex to NutriStem hPSC Medium. For this transition, a simple and direct adaptation can be followed with cultures exhibiting similar morphology as well as higher levels of pluripotency when compared to StemFlex.

Adaptation Protocol

Generally, there are two options for transitioning cells from one medium to another: direct or gradual adaptation. With direct adaptation active cultures are switched from the first medium directly into the next all at once, in a single medium exchange. Alternatively, with gradual adaptation, active cultures are switched from the first medium into the next in several steps. Gradual adaptation tends to be gentler on cells than direct adaptation, but its necessity should be determined on a case-by-case basis.

To transition cultures from StemFlex Medium to NutriStem hPSC Medium, direct adaptation can be performed.

Protocol

Transition (7 Days)	**DAY 0**	Begin with active hPSC cultures
	DAYS 1-4	100% StemFlex
	DAY 5	100% NutriStem hPSC Medium (completely replace StemFlex)
	DAY 6	100% NutriStem hPSC Medium (change media)
	DAY 7	Passage hPSC cultures onto fresh Matrigel in 100% NutriStem hPSC Medium
Stabilized (15-20 Days)	**DAYS 7-28**	Passage hPSC cultures every 4-5 days during the stablization process and feed daily with 100% NutriStem hPSC Medium.
	DAY 28+	Downstream experiments (scale-up, gene editing, differentiation)

Morphology Comparison

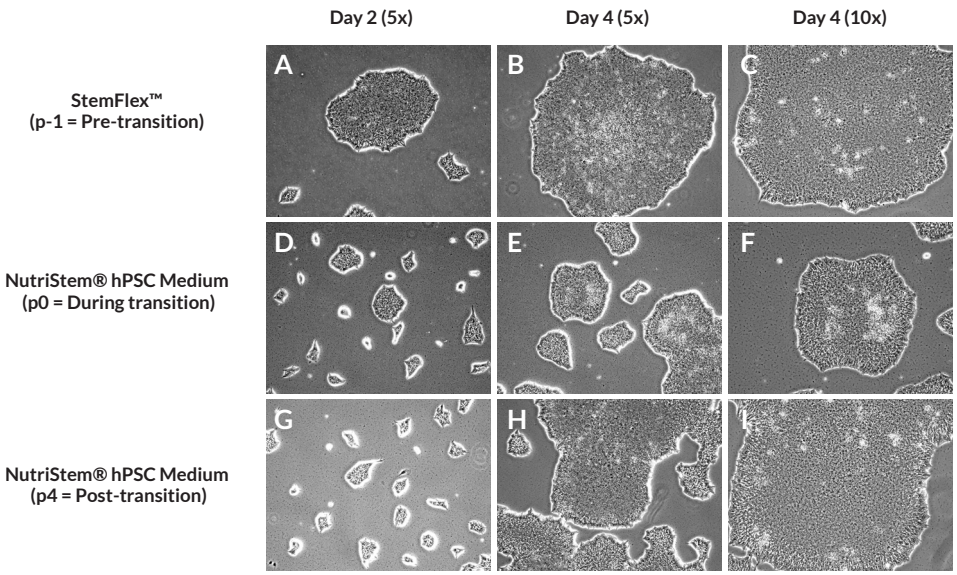

Figure 1. hPSC cultures transitioned from StemFlex to NutriStem hPSC Medium exhibit equivalent morphologies. A morphological comparison of hPSC cultures before, during, and after transition from StemFlex to NutriStem hPSC demonstrates tight colony borders with consistent outward colony expansion in StemFlex (Fig. 1, A-C), slightly smaller colonies with less compact borders upon initial transition to NutriStem hPSC Medium (Fig. 1, D-F), and a return to faster expanding, compact colonies with tighter colony borders upon continued culture in NutriStem hPSC Medium for 4 passages (Fig. 1, G-I). NutriStem hPSC cultures were the result of a direct culture medium transition (as outlined in the Protocol).

Pluripotency Comparison

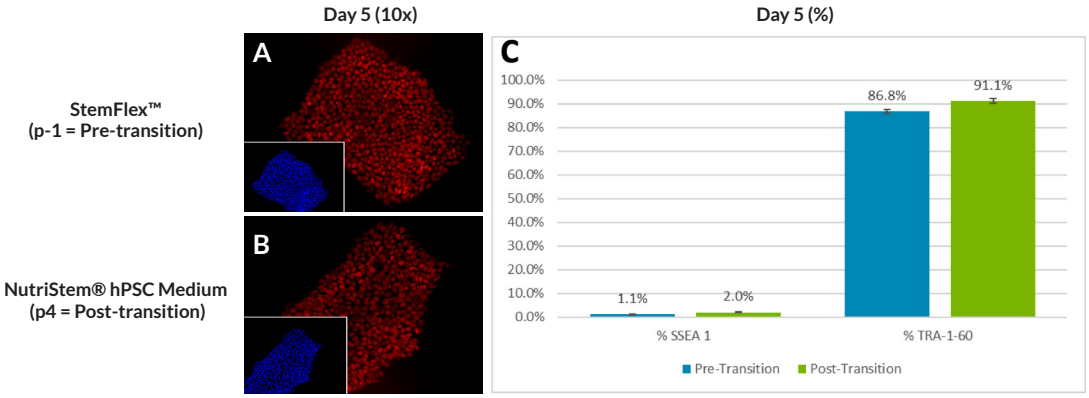

Figure 2. hPSC cultures transitioned from StemFlex to NutriStem hPSC Medium exhibit higher levels of pluripotency marker expression. Pluripotency was measured both pre- and post-transition from StemFlex to NutriStem hPSC Medium. Prior to the transition, active hPSC cultures in StemFlex were assessed via immunocytochemistry for the nuclear pluripotency marker Nanog (Fig. 2, A) as well as by flow cytometry for SSEA1 and TRA-1-60 (Fig. 2, C). Following transition of hPSCs to NutriStem hPSC Medium, cultures were also assessed via immunocytochemistry for the nuclear pluripotency marker Nanog (Fig. 2, B) as well as by flow cytometry for SSEA1 and TRA-1-60 (Fig. 2, C) demonstrating that hPSC cultures transitioned into NutriStem hPSC Medium result in higher levels of pluripotency (Fig. 2, C) when compared to hPSC cultures maintained in StemFlex.

Key Notes and Take-aways:

To adapt cells to a different medium it is important that the cultures typically are:

- High quality with a high density of cells (≥ 60% confluent).
- Free of differentiating areas. If the cultures contain more than 10% differentiating colonies, the cells should be "cleaned up" by manually removing the differentiated cells.

Culture in NutriStem hPSC Medium is amenable to weekend-free feeding schedules by simply passaging before the weekend and performing a double feed.

General recommendations:

- Make a frozen stock of the cells in original media prior to adaptation.
- Maintain a set of cell cultures in each of their original media when starting the next level of adaptation as a fallback if the cells do not survive in the next passage.

References:

1. Dakhore, S., et al. 2018. Human Pluripotent Stem Cell Culture: Current Status, Challenges, and Advancement. Stem Cells Int. 2018:7396905.
2. Lanner, F., et al. 2010. The role of FGF/Erk signaling in pluripotent cells. Development. 137: 3351-3360.
3. Greber, B., et al. 2011. FGF signalling inhibits neural induction in human embryonic stem cells. EMBO J. 30: 4874-4884.

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