# Project Report in Experts in Teamwork

# TBT4850 - Stem Cells Studies: Research and Ethical Aspects

*Institute of Biotechnology (spring 2011)*
*NTNU*

## Abstract

This project report aims to describe how we made a PowerPoint animation, why we made the animation and how our product can be used to raise awareness concerning stem cells and their applications in diseases; more concrete leukemia, diabetes type two and alopecia (baldness). We address bigger ethical issues concerning these treatments to make the viewer aware of, and reflect on, the issues connected to stem cells. The molecular basis and applications are described in a way that it is suited to be distributed to an audience from the age of 16 and up. The product is distributed through our own webpage (http://folk.ntnu.no/birgitmc/eit/), Facebook, YouTube and hopefully through The Norwegian Biotechnology Advisory Board.

We feel this product give an alternative approach to explaining stem cell applications to the adult public. In the animation, we have included the essence of the science behind the different applications and simplified it in order to increase awareness and curiosity regarding this topic. We believe that our product is of important social relevance because it is based on scientific reports, has been simplified and distributed through popular media in order to reach a broad audience.

# Content



# Appendix:

# 1. Introduction

This report starts by describing our project questions and moves on to our motivation for making a movie. The report continues by explaining how we decided on which computer program to use and why we settled on using PowerPoint. The storyline is described and the different characters in the movie are introduced. We raise certain issues regarding each scene and discuss why they were made the way they are.

The report is summarized with a discussion of how to distribute our final product through our own website, YouTube, Facebook and The Norwegian Biotechnology Advisory Board.

## 1.1 Project questions

Our project aims to increase public awareness on stem cells; *what are they? How can we use stem cells to cure diseases like diabetes type 2, blood-cancer and improve treatments for hair loss? What is the molecular basis, the psychological and ethical issues connected to these diseases and situations? How can we distribute and explain it to the adult public?*

The group has a broad basis in medicinal, molecular and cell biology as well as biological psychology and process engineering. The challenge lies in distributing and including our disciplines in an actual product that will answer the questions above and help enlighten the public around 16 years of age and above about stem cells. The goal was to make a movie that:

1. **Describes the basics of stem cells**
2. **Explains how stem cells can be used to treat blood-cancer, diabetes type 2 and baldness**
3. **Address ethical and psychological issues and most importantly**
4. **Is aimed to increase knowledge on stem cell applications to the adult public**

### 1.2 Motivation

We had several sources of motivations for choosing an animation as the final product. First, a movie is easily distributed through the internet and it is easier to catch public's attention with a virtual product than for example a written text. Second, by animating we can simplify the explanations for the molecular basis of the different treatments. Third, by having the public watch a movie instead of reading a text they will hopefully remember the cases, and therefore also our message, longer.

Having one group member who is not very familiar and confident with the English language, making a movie helped us circumvent possible language problems. If we chose to write a report instead of animating, the contribution from that person might have been smaller compared to the other group members, and we wanted to avoid this possible problem. Making the animation was also a motivation in itself because it enables us as a group to be creative as well as scientific. The project was a valuable opportunity to use our imagination and to do something completely different than writing reports, which is the usual and scientific way of addressing topics within our disciplines.

## 2. Making the animation

When we decided to make an animation as our product, we were basically moving into an unknown territory concerning that none of the group members had made an animation before. In order to make the animation we needed a free and easy to use program installed on our computers. We also needed the program to have recording opportunities. We quickly discovered that PowerPoint filled all our criteria, and that all group members, except one, had the program already installed on their computer. When we started animating it was obvious that making an animation would be challenging and very time consuming. To meet the set deadline, it was decided that each group member had to work between each Wednesdays in addition to the village days. During this process we have had major computer problems; files crashing, recordings that had to be done twice and then redone and problems with putting all the files together. This made the process of making a movie a lot more challenging than anybody could have expected. We spent late hours at school and countless hours of our spare time to make the final product which we are proud of.

## 2.1 Making the animation in PowerPoint

We wanted to include several characters and longer dialogues in our animation. This had the consequence that we had to make the characters simple and easy to manipulate. When making the movie we have only used drawing and animation functions in PowerPoint. The voices and sound has been added with PowerPoint's own recording and sound options using a web camera microphone as voice recording device. In order to record the voices we choose "Slide Show" in the PowerPoint menu line. The slide that is to be recorded is marked and we press "Record Slide Show" and choose "Start Recording from current slide". Then, a pop-up box occurs and both boxes should be ticked before pressing "Enter". Then the recording starts. When we did the recordings each dialogue was printed out and marked. The marks indicated when to press "Space" when recording. A star indicated that the slide had animations, while a line indicated the end of the slide. It was important to indicate because we then knew if two people were talking on the same slide, which required more practice and practical issues when recording. This part of the project was challenging to overcome because we needed a quiet room to avoid background noise. It was also challenging to read the different voices because a lot our characters are males and we have only one male in the group. The female group members had to modify their voices in order to make them sound masculine.

Figure 2-1 shows the main character the doctor and his dog. As can be seen in the figure, the characters have freely moving hands in order to make the movement clear for the viewers and easy for us as animators. The facial expressions are also easily manipulated. The characters are made with figures and drawing functions in PowerPoint. The figures in themselves are somewhat simple, but it still took a while to finish them and give them a personality.

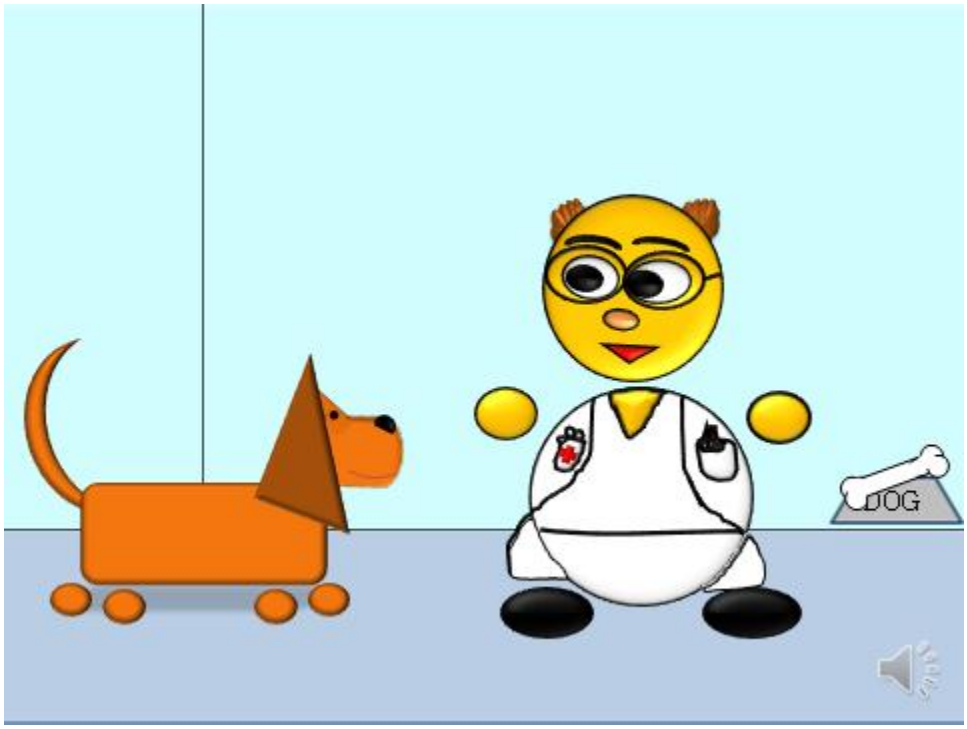


**Figure 2-1: The doctor and his dog.**

PowerPoint was good tool for this kind of animation because we could have movement on each slide and did not have to make several slides in order to make the characters move, like in old fashioned cartoons. It makes the movie resemble an actual animation as the slides actually are animated. Figure 2-2 a) and b) shows an example of the beginning and end of one single slide.

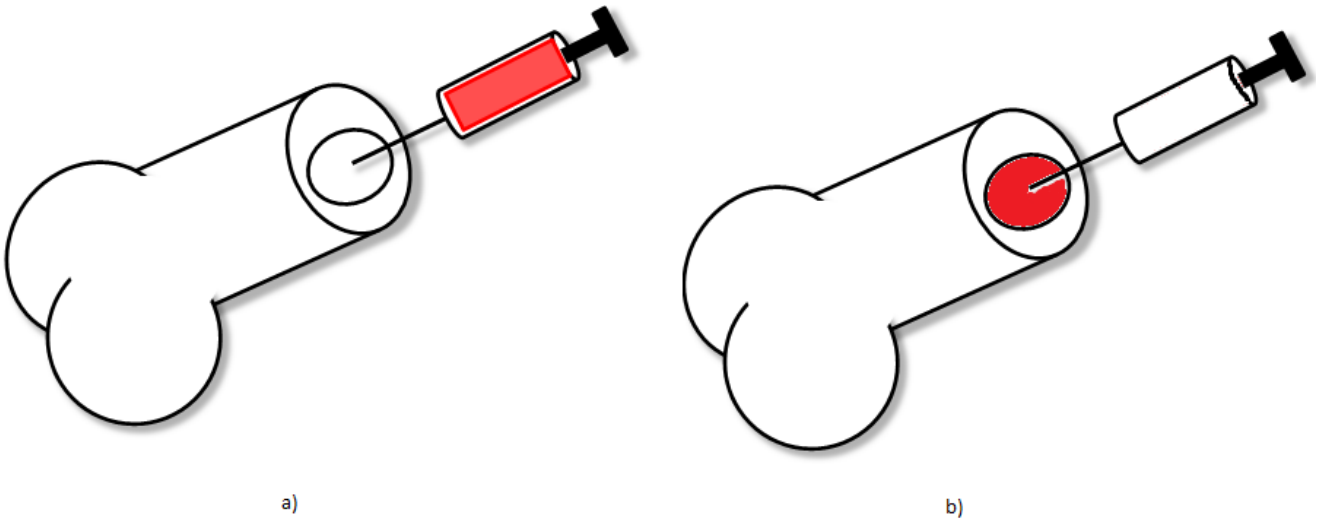


**Figure 2-2: Animations done on the same slide in PowerPoint.**

Part a) shows and empty bone and needle with bone marrow stem cells, and part b) shows the injection of stem cells.

Figure 2-2 does not show the actual animation for obvious reasons. This slide in the actual movie shows stem cells (red colour) being injected from the syringe and into the bone. Throughout the animation we switch between scenes were the characters are talking face to face and scenes were the entire screen shows the treatment or molecular basis of the diseases (illustrated in figure 2-3).

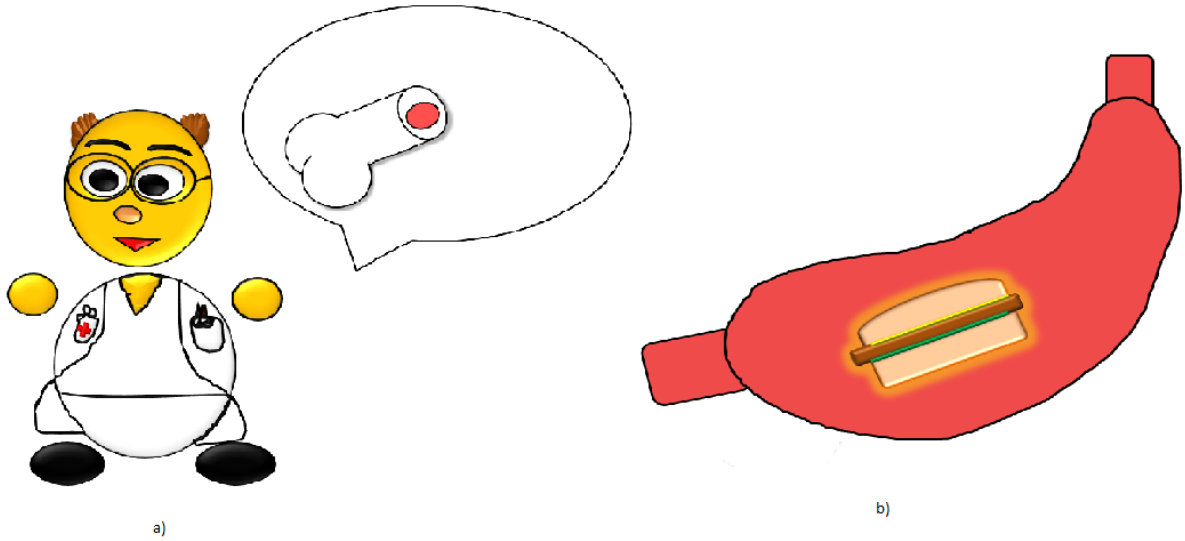


**Figure 2-3: Illustration of different scenes in the animation**. a) Shows the doctor talking and b) shows the stomach digesting a hamburger in order to explain how insulin helps the intestines to absorb nutrients.

## 2.3 The storyline

Our story happens sometime in the future and is seen from the viewpoint of a doctor who uses stem cells to cure his patients. The main character, Doctor Peters, has a dog the viewers meet in the beginning and in the end of the movie. We chose the dog to be the character that should ask simple questions about stem cells like; *what is a stem cell? How can it be used in disease treatments?* The reason for this was partially humoristic and partially because it was one of our initial ideas. We also use the dog in the final discussion on ethical issues asking critical questions.

Sadly, we had to exclude a scene from the movie. This scene described how skin renewal could be possible by using a stem cell cream with dermal growth factors. We had to skip this scene because we did not have time to do the voice recordings for it. The initial plan was to have the scene between the baldness scene and the scene addressing ethical issues. The scenes dialogue is included in Appendix A together with all the other dialogues, and the deleted scenes storyline is included in Appendix B.

### 2.3.1 Introduction

*The aim of the introducing scene is to give some basic knowledge concerning stem cells in order to give the viewer some knowledge in stem cell biology and thus make it easier to follow the animation.*

The movie starts with the doctor leaving home to go to work. Based on the short conversation before he leaves the dog decides to do some research on stem cells because he is curious about his owner's job. During this scene the basics of cells is described and the animation shows how an egg cell is fertilized to give a zygote. Then the different types of stem cells; the mono-, multi- and pluripotent stem cells are introduced and described.

### 2.3.2 Leukemia

*In this scene we describe how a cancerous pluripotent stem cell can cause leukemia and how it can be treated with stem cell therapy.*

In the next scene we meet the doctor at his office with the first patient of the day. The first patient is a woman with leukemia; more specified Acute Myelogenous Leukemia (AML). Figure 2-4 shows Mrs. Jones, the patient.

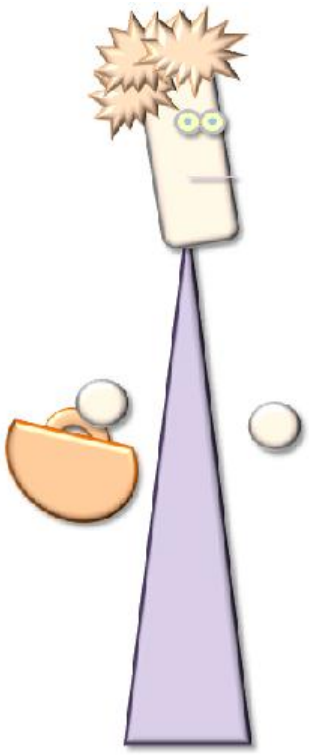

**Figure 2-4: Leukaemia patient, Mrs. Jones**

The dialogue starts with the doctor explaining the three main components in the blood, the white and the red blood cells and blood platelets. He continues with describing how these cells are made in the bone marrow from pluripotent stem cells called hematopoiethic stem cells. Figure 2-5 shows how this is presented in the animation.

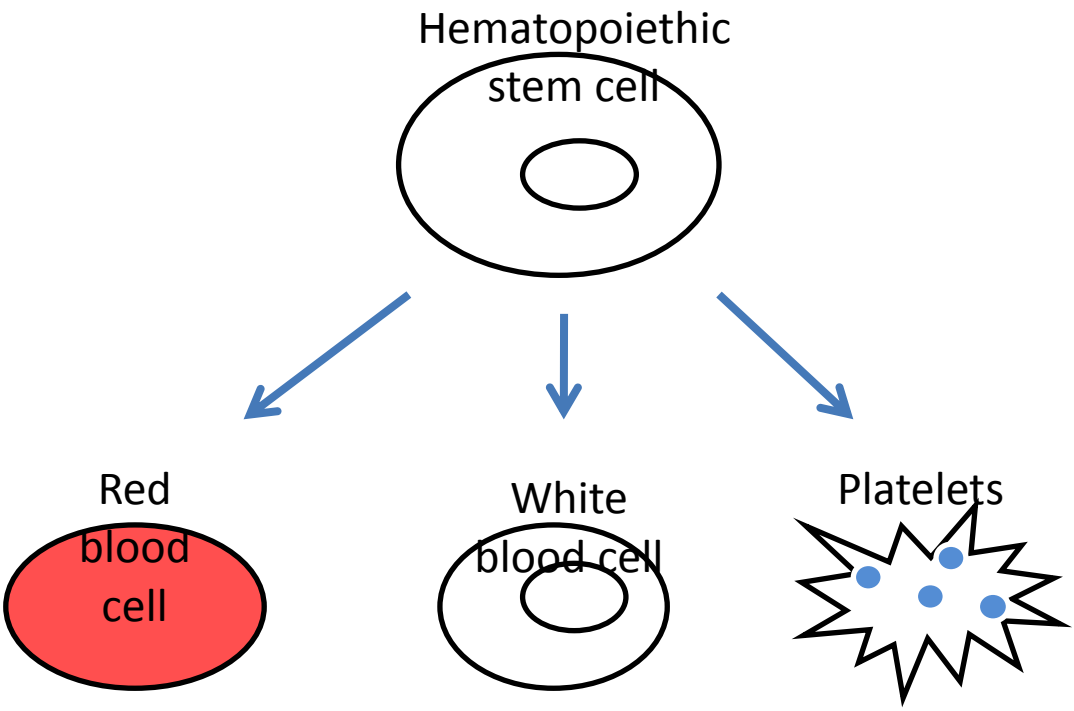


**Figure 2-5: Hematopoiethic stem cell.** The figure shows how a pluripotent stem cell, the hematopoiethic stem cell, can give rise to red blood cells, white blood cells and blood platelets.

The doctor explains how a cancerous hematopoiethic stem cell gives rise to leukemia. He continues by explaining how it used to be treated in the "old days", and how the stem cells from a stem cell bank can be used in order to treat AML. The treatment being described is actually being used to cure people with AML today.

In this first patient scene we also included some psychological issues by mentioning depression as a possible side effect resulting from the treatment.

The reason why we chose leukemia as one of the diseases was because the treatment described actually is being performed in some countries like USA today. It was important to us that the movie did not end up being a too futuristic, and thus unrealistic, movie about stem cell treatment.

### 2.3.3 Diabetes type 2

*This scene aims to describe what diabetes type 2 is, how it effects affected individual and how injecting stem cells into the pancreas can treat diabetes type 2.*

The next patient is a girl who is diagnosed with type 2 diabetes. She is a young adult named Susan (See figure 2-6).

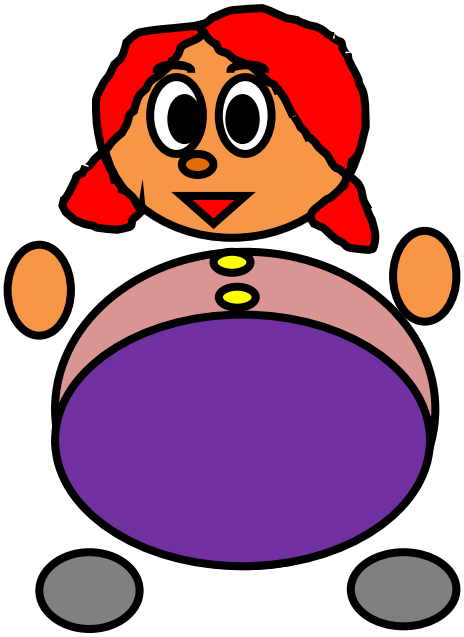

**Figure 2-6: Diabetes type 2 patient, Susan**

During the scene, Doctor Peters explains how food is broken down in the stomach and how glucose is taken up in the blood in a healthy individual. He continues by explaining how β-cells in the pancreas make insulin and that these cells are damaged in patients with type 2 diabetes. These cells are also the basis for the stem cell treatment. Purified bone marrow stem cells are injected into an artery near the pancreas and Susan is placed under pressure in an oxygen chamber. This induces the growth of β-cells and normalizes the insulin production. A person going through with this treatment does not have to monitor the blood glucose levels anymore and therefore does not have which requires carrying around a blood glucose monitor and insulin. The treatment that is described is being tested on humans and is, based on the references, promising. As already mentioned in the leukemia scene, it was important to give examples treatment that is being executed or tested on humans in order to make the movie more realistic.

### 2.3.4 Alopecia (Baldness)

*In this scene we aim to describe different types of baldness, the psychological issues connected to baldness and how being bald can be treated by using stem cell therapy.*

The scene starts with a phone call from psychologist Stevens to Doctor Peters. The psychologist wants to transfer one of his patients to Doctor Peters. Psychologist Stevens is concerned about his patient, Tom Baldwin, because he used to be outgoing and successful, but after his hair loss his self–esteem has decreased dramatically. Next, Tom Baldwin shows up at the doctor's office and Dr. Peters gives him a thorough examination explaining the different types of hair loss and how hair loss can be. The treatment then carried out by taking a scalp sample, extract stem cells in the hair follicles and cultivating them in the lab. Figure 2-7 shows Tom Baldwin before and after the treatment.

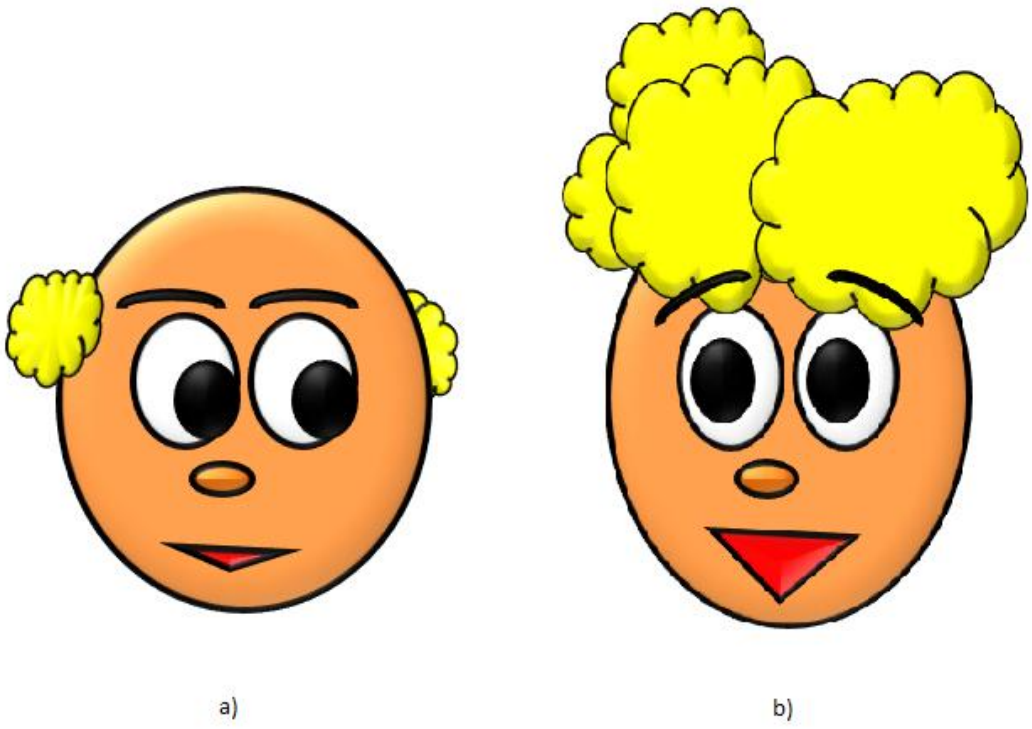


**Figure 2-7: Tom Baldwin** a) before and b) after hair treatment with stem cells.

Also in this scene we have included some psychological aspects as well as chemical engineering aspects when describing stem cell therapy.

### 2.3.5 Ethical issues regarding the different treatments

The next scene takes place in Dr. Peters home. The scene is once again a dialogue between him and the dog. They discuss ethical issues concerning Dr. Peters' use of stem cells. In this part of the movie we had to shorten the discussion to shorten the movie. Some of the main ethical issues as we see it are the use of embryonic stem cells; the difficult discussion on when a human mind develops and is to be recognized as a human being. But in order to stay in touch with the storyline we decided not to include these topics in the dialogue. One argument is that in the treatments described, Dr. Peters use stem cells from the umbilical cord collected in the stem cell bank, and not embryonic stem cells from discarded embryos. Including that in the scene might have confused the viewer, and did not really have any relevance for the movie. Instead we decided to raise some of the big questions to invite the viewers to reflect and think on their own on the use of stem cells and how it can change society in a good or a bad way.

### 2.3.6 Last scene: Phone call from Tom Baldwin

The final scene in our animation is a phone call from the former bald guy, Tom Baldwin. He calls Doctor Peters from a party and to tell him that his hair has grown back and that he is very happy. One of the slides is shown in figure 2-8.

**Figure 2-8: The finale scene.** Tom Baldwin calls Doctor Peters to tell him that his hair has grown back.

We wanted to have a happy and funny ending to our movie. Placing the funny scene after the ethics scene seemed like a good idea. By making this our final scene we have closure to our final patient and we hopefully leave the viewers with a positive impression of stem cell treatment. Since hair loss is not as severe as the other diseases we have described, it is easier for us to joke about this topic and make conclusions on how it will work in the future. Despite this, we want to underline that alopecia also can have serious consequences and is not just a joke.

## 3. Distributing the animation to increase public awareness

By making this movie we aimed to explain the science and rationale behind stem cell application to a non-scientific audience in order to increase their knowledge on this topic. Since stem cells is a highly controversial issue on the political level, increasing the overall knowledge of stem cells and their applications can increase the voters knowledge and helping them form their own opinions. This can again help them in the future debate concerning stem cell banks and applications. If the voters do not have any knowledge about the issue at hand, how are they and the society going to cope with the ongoing research on stem cells, and how is society going to react when it is confronted with stem cell therapy in the future?

Increasing knowledge and curiosity concerning stem cell studies and important applications is indeed of democratic and ethical importance. If a person with diabetes type 2 is against stem cell research for no certain reason, but is not aware of the benefits for treating his/her own disease, the person will probably vote against stem cell research if given the chance. If a patient is faced with a treatment that includes stem cell therapy, an educated patient will be more qualified in deciding for or against the treatment. On the other hand, increasing the knowledge on stem cell therapy can make patients demand stem cell therapy. In our opinion increasing stem cell awareness needs to address a larger audience, as we have demonstrated with this animation, to be successful.

Using a common disease as an example for stem cell treatment is, in our minds, a better option than bombarding the public with difficult scientific terms. By illustrating the treatment with some simplified animations, we make it easier and thus more interesting for a younger audience. That is one of the main

reasons why we decided to make a movie instead of writing a scientific report. Also, by applying stem cell therapy on humanlike characters, like in our project, can open the eyes of non-scientist and scientists of other disciplines on therapeutic benefits of stem cells.

Biotechnology research in Norway is restricted by the laws implemented and recommended by amongst others The Norwegian Biotechnology Advisory Board (in Norwegian: Bioteknologinemda). We sent them an e-mail briefly describing our project. We also asked if they were interested in distributing the movie on their website or if they would like to link it in some way or another. They replied that they will consider it when the finished product is published on YouTube. Getting help to distribute our product through The Norwegian Biotechnology Advisory Board would be beneficial, but in the meantime the movie is being distributed on our website:

- http://folk.ntnu.no/birgitmc/eit

Our movie has also been distributed in three parts on YouTube:

- Part 1: http://www.youtube.com/watch?v=z3KHwUyVgiQ
- Part 2: http://www.youtube.com/watch?v=7re_HSKs7Wc
- Part 3: http://www.youtube.com/watch?v=8zvM89fJOjQ

In addition to this, we have created a group on Facebook called "*Ethical Issues on Stem Cell Research"*.

We want to emphasize that knowledge of the ethical issues are just as important as being aware of the therapeutic possibilities and complications of stem cells. As we argued in chapter 2.3.6 it was important to us to make the viewer more aware of these issues and hopefully make the viewers come up with their own opinion.

We are aware that the product is somewhat biased since none of the individuals in the group are against stem cell therapy. Since this product is only a prototype, an improvement of the product would include feedback from an audience and further debates on the ethical issues amongst other scenes. If this product is to be improved in some way the group thinks that it would be a better product if the deleted scene on skin treatment was included. Improving the animations, voices and adding music would also capture a broader audience. In a later stage of this project, the psychological aspects concerning the therapies could also be included *e.g* the uncertain future, pain caused by the therapy and concerned family member.

# 4. Summary

In this project we have raised and answered the question of how having a stem cell bank can lower the risks of stem cell therapy and how stem cells can be used to treat leukemia, diabetes type 2, baldness and skin aging problems. We have explained the molecular basis of leukemia, diabetes type 2, skin impairment as well as the cellular basis for baldness. The descriptions are of such a character that the movie is suited for distribution to an audience aged 16 and above. We are distributing our product, minus the skin treatment scene, through our own webpage (http://folk.ntnu.no/birgitmc/eit/), Facebook, YouTube and hopefully through The Norwegian Biotechnology Advisory Board.

We believe that our product is of important social relevance because we have used our expertise within science and technology to extract the essences of stem cell applications from scientific reports and explained it in a way that makes it easy to comprehend. We believe that the majority of the population does not read scientific reports on this topic for several reasons; it is relatively new and difficult, it requires previous knowledge of the topic and higher education to understand the main points in the reports. We think it is important to increase the knowledge on this topic, but it needs to be done in a "non-scientific" way and thinking outside the box in order to capture the audience.

# Appendix A: The Dialogues

The following dialogues represent the main drafts of the dialogues recorded in the movie. The dialogues actually recorded might differ slightly from the dialogues written here. The excluded scene with treatment with stem cell cream is also included here.

## Scene 1: Introduction

***The scene is set at Doctor Peters appartment***

***Dr. Peters:*** I have to leave for work now, Dog. I have an interesting day ahead of me; I'm meeting many of my patients to discuss their treatment plan using stem cells.
***Dog:*** Sounds interesting Doc! Hey, remember to bring me back a bone please.
***Dr. Peters:*** Sure thing Dog, have a nice day and be a good boy.
*Doc leaves the house*
***Dog (Thinking):*** Stem cells? Hmm, what is a stem cell actually??! I have to look it up.
*Dog retrieves his IPAD*
Hmm, I don't even know what a cell is! I'll start with that!
*Dog Types "Cell" in google*
*WIKIPEDIA ARTICLE; THE CELL*
The cell is the basic biological unit that carries out the necessary functions for life [1].
All organisms are composed of cells. Some organisms, for example bacteria, consist only of a single cell which makes them unicellular organisms. Other organisms have more than one cell and are called multicellular, like humans who have around 100 trillion cells in their body [2].
The human body consists of many different cell types, like blood cells, muscle cells, nerve cells, and many others. Each cell type has its own special function; blood cells carry oxygen around the body and muscle cells are responsible for muscle contractions when your body performs work. The different specialized cells in our bodies constitute our tissue and organs like muscles, skin, brain and heart.
Cells also contain DNA, the hereditary information which is the genetic code used to develop and keep living organisms functioning [3]. It is like a cells recipe for how to maintain their work and growth.
Cells are either prokaryotic or eukaryotic. The bacteria are prokaryotic and have no cell nucleus, while

eukaryotic cells have a nucleus. The eukaryotic cells are more complex and are found in animals, plants and fungi.

*Change Slide to picture of cell*

This an eukaryotic cell, the typical size of these cells varies from 10-100 um [2].

The outer layer of the cell is the plasma membrane and it defines the cells boundary. It provides protection and regulates the transport of solutes in and out of the cell via proteins located in cell membrane.

The DNA contains the hereditary information and is located in the nucleus of the cell.

Cells contain many different organelles that are like the cell organs.

**Stem cell**

A stem cell is a cell which is the origin to all specialized cells in the body [4]. Nerve, muscle and skin cells all come from a stem cell and are formed from stem cells through differentiation.

A stem cell has 2 important functions that distinguish it from a normal cell.

- The first function is proliferation. This means that stem cells have the ability to renew themselves for a long period through cell division in an undifferentiated state.
- The second function is differentiation; it can differentiate into a specialized cell like a muscle or nerve cell.

Stem cells divide either by symmetric division, where they duplicate the number of stem cells or by asymmetric division where one normal stem cell and one differentiated stem cell is produced [5]. Stem cells keep amplifying themselves by self-renewal to expand their number during development or to maintain the number in the body after cell injury.

A stem cell can be either totipotent, pluripotent, multipotent or unipotent.

A totipotent stem cell is a cell that on all stages of development can differentiate into all kinds of cells; even into cells that form the placenta and umbilical cord [4]. In mammals the cells right after fertilization are totipotent, and later on they differentiate into pluripotent stem cells, also called embryonic stem cells. Pluripotent stem cells can differentiate into almost all types of cells that exists in the body, like muscle, nerve or skin cells. The only exceptions are cells that form the umbilical cord and the placenta [4].

Multipotent cells are a bit like pluripotent cells, but they are more restricted concerning the category of cells they can differentiate into [4]. For example one type of multipotent stem cell can divide into all the different types of blood cells, but not into muscle cells. Another type of multipotent stem cells is

responsible for the different muscle cells.

Unipotent stem cells can only differentiate into their own type of cells; this means that they can only produce one type of cells [6].

**Where do stem cells come from?**

There are 3 main categories of stem cells according to where they come from [7]. First there are embryonic stem cells. These are the cells that, with time, develop into a human being. The second group consists of adult stem cells which replenish worn out specialized cells. The third group of stem cells is induced pluripotent stem cells. They are genetically reproduced pluripotent cells from multipotent or unipotent adult stem cells.

Embryonic stem cells are pluripotent and can differentiate into any kind of cell in the adult body. During fertilization, a sperm cell enters the egg cell and a zygote consisting of totipotent stem cells is formed [8]. The zygote starts to divide and produce many cells. Around the fifth day after fertilization, the zygote has developed into a blastocyst. The inner cell mass in this blastocyst contains embryonic stem cells which can be extracted and used for research or therapy [7, 4].

The challenges with embryonic stem cells are that they are known to form tumors [9] and also cause immune rejection when transplanted for use in therapy [10]. The source of embryonic stem cells has given rise to many ethical issues and discussions. Using fertilized eggs are much discussed because of their potential to develop into a complete human being.

The adult stem cells resides in their corresponding tissue and are either multipotent or unipotent cells which can differentiate into the specialized tissue cells when needed[4]. Adult stem cells function as a reservoir to replenish dead or injured tissue cells that lack the ability to renew themselves. The problem with adult stem cells when using them in therapy is to produce enough cells. The amount of adult stem cells in tissue is very low and they have a limited capacity to divide [11].

Induced pluripotent stem cells are produced by introducing genetic elements encoding proteins into different types of specialized cells, e.g. skin cells [7]. This is called reprogramming of adult cells into pluripotent stem cells. Induced pluripotent stem cells eliminate the ethical issues connected to using embryonic stem cells. Using induced pluripotent stem cells means that you are using the patient's own cells and the problems of immune rejection are therefore also avoided. The biggest challenge when using induced pluripotent stem cells is the lack of precise methods to make them differentiate into desired specialized cells efficiently.

**How can stem cells differentiate into a lot of other stem cells?**

The differentiation can be controlled and regulated by certain factors:

- The composition of the culture medium [12]
- The surface of which the cells are growing concerning the dimension of the network and and the biomaterial used [7]
- Insertion of specific genes in cells that controls their fate [7]
- External signals, like growth factors secreted by adjacent cells [13]

**+ a short ending that gives a neat transition to next slide (which is?) or maybe the dog starts to think about ethical issues? Suggestion:**

***Dog exclaims:*** Wow, what a mouthful! But what about the ethical issues of using stem cells? I have to discuss this with Doc when he gets home.

## Scene 2: Leukemia

***The scene is set at Doctor Peters Office:***

***Dr. Peters:*** Hi, Mrs. Jones. How are you feeling today?

***Mrs. Jones:*** Hi, Dr. Peters. I'm feeling tired as usual, but ok. How are you?

***Dr. Peters:*** I'm good. As I said on the phone I have some news for you today. Would you please take a seat? After examining your blood in the microscope I am sorry to tell you that you have acute myelogenous leukemia. [14, 15]

***Mrs. Jones:*** oh, what is that?

***Dr. Peters:*** Leukemia is also known as blood cancer. [15]

***Mrs. Jones:*** wow, cancer...

***Dr. Peters:*** Do not worry, these days it is fully treatable. I will tell you some more about leukemia. Your blood consists of three different types of cells; the red cells that transport the oxygen, the white cells that keep you safe from infections and the platelets that make your blood clot when you get injured. All these cells develop from a common source: the pluripotent stem cells, also known as blood stem cells. These cells live in your bone marrow, which is inside the bones. [16] In your case, some of the stem cells that differentiate into white blood cells are cancerous and this causes leukemia. [17]

***Mrs. Jones:*** So I have cancer tumors in my blood?

***Dr. Peters:*** No, that is not completely right. The cells with cancer are located in your bone marrow. A

cancer cell is very hyperactive when it divides and it produces an unusually high number of white blood cells, and many of them look unnormal and does not function well. [18] These cells will eventually outnumber the other blood cells. [19] This will lead to headaches caused by insufficient oxygen transportation to your brain you will also feel fatigue and be more exposed to infections. Since your blood clotting is not functioning well you will bruise more than before. [18] One experimental treatment for leukemia is to destroy your bone marrow with chemotherapy and radiation [20] and then inject some of your stem cells in its place. [16, 18]

***Mrs. Jones:*** wow, so I can basically treat myself with my own cells?

***Dr. Peters:*** Yes, today you can. In earlier days, the doctors had to give full anesthetics, turn the patient on his stomach, and two doctors each had a needle the size of a pen that they penetrated the skin and bone with, extracting the bone marrow. They had to repeat the penetrations 50-100 times in order to get enough cells, being 1 to 1.5 liters of bone marrow [18].

***Mrs. Jones:*** Damn! That sounds painful...

***Dr. Peters:*** yes, but since the revolution of stem cells you can treat this disease with your own cells from your stem cell bank.

***Mrs. Jones:*** wow, is it dangerous?

***Dr. Peters:*** well, your embryonic stem cells are in the stem cell bank and since we are using your own stem cells as donor cells it is less dangerous than it used to [15].Your own cells have the same immune system as the rest of your body, meaning that your immune system will back to normal faster than if we used donated cells. It is also safer to use your own cells as the body is more likely to reject donated cells [3]. You will also lose your hair from the chemotherapy [18].

***Mrs. Jones:*** My hair? Why? And why would I have more infections?

***Dr. Peters:*** Hair cells are fragile cells and do not survive chemotherapy, but it will grow back, I promise [18].For the infection; your white blood cells play an important role in your immune system and when we destroy the bone marrow we also destroy the production of white blood cells, making you more available for infection. This is the most dangerous part and you will also need to retake childhood vaccines [19].

***Mrs. Jones:*** Are there complications?

***Dr. Peters:*** If the chemotherapy does not kill every single one of the bad stem cells just one cell can divide and cause leukemia again...Luckily, there is an unlimited supply of stem cells in your bank account. With this in mind you should be hopeful towards the future.

***Mrs. Jones:*** Thank you doctor!

***Dr. Peters:*** And remember, if you feel depressed or delirious, you should call this psychologist (gives patient the psychologist card).

## Scene 3: Diabetes type 2

***The scene is set at Doctor Peters office:***

***Susan:*** Hi Dr. Peters! I'm here for my diabetes treatment.

***Dr. Peters:*** Hi Susan, I have been expecting you. Before we start the treatment I want you to understand what diabetes mellitus is all about. Have you read or heard anything about diabetes?

***Susan:*** I have read some, there is so much information. Could you please explain it to me?

***Dr. Peters:*** Ok. To understand diabetes you first need to know some basics about how food is broken down in the body and used for energy. When food is digested; a sugar called glucose enters the bloodstream. Glucose is the main energy source for your body. High levels of glucose in the blood are unhealthy. The body controls the blood glucose level with the help of the pancreas. The pancreas contains beta cells whish secrete insulin. Insulin is a hormone that enters the bloodstream and binds to insulin receptors on the cell surface of different cells. This makes the cells able to take up glucose from the blood. When a healthy person eats a high energy meal the pancreas will produce more insulin to lower the blood glucose levels, also known as blood sugar levels. The secretion of insulin is strictly regulated to keep the blood glucose within a healthy level [21,22, 23].

High blood glucose levels over a longer period of time can cause problems with the kidneys, nerves, eyes and feet. It also causes a higher risk for heart disease, bone and joint disorders. Other long-term effects can be digestive and skin problems, sexual dysfunction and problems with the teeth and gums [21].

Very high or very low blood glucose levels can lead to very serious conditions and even death if left untreated [21].

***Susan:*** So, what do all this have to do with diabetes?

***Dr. Peters:*** Well, there are two main types of diabetes; type 1 and 2.

People who have type 1 diabetes, which is usually diagnosed in childhood, produce little or no insulin. This is caused by an autoimmune destruction of the insulin secreting β-cells. Why this happens to some individuals this is still unknown. Without insulin production the body will not be able to control the blood glucose levels [21, 22].

You have type 2 diabetes, which is the most common form of diabetes. In type 2 diabetes patients the pancreas does not produce enough insulin to keep the blood glucose levels within the normal range. People that have type 2 diabetes may produce enough insulin, but the cells do not respond well to insulin, and therefore need more insulin to keep the blood glucose level within the normal range. As I said, Type 2 diabetes the most common form of diabetes. In 2011 more than 220 million people had type 2 diabetes [21, 22,24].

***Susan:*** Wow! That's a lot of people! I think I have heard that the number of diabetics has increased even the last years… Thank you for explaining all this. Can we start the treatment now?

***Dr. Peters:*** Sure! I picked up some purified bone marrow stem cells from your stem cell bank account and now I will inject them to an artery near your pancreas. Then you will be placed under pressure in an oxygen chamber with high oxygen concentrations. After a while in the chamber some of the injected bone marrow stem cells will develop to pancreatic stem cells and form more pancreatic tissue. In the end this will increase your insulin production and lower your blood glucose levels [25,26].

After treatment:

***Susan:*** Thank you Dr. Peter. I'm so glad I don't have to monitor my glucose levels anymore!

***Dr. Peters:*** You are not finished yet young lady! You have to measure your glucose levels for a while to make sure the treatment works as expected. But in the end you will hopefully be cured for diabetes forever.

## Scene 4: Alopecia/ Baldness

***The scene is set at Doctor Peters Office:***

(Telephone is ringing)

***Nurse:*** Doctor Peters, there is a phone call for you.

***Dr. Peters:*** Thank you Nurse.

***Psychologist Stevens:*** Hi Doc, it is psychologist Stevens again.

***Dr. Peters:*** Oh, hi. What do you have for me this time?

***Psychologist Stevens:*** I have a patient I hope you can cure. It is a young male and he is suffering from serious hair loss. The hair loss has caused him several problems. He used to be an outgoing and very successful business man and now he is barely leaving the house.

***Dr. Peters:*** Hmmm… why?

***Psychologist Stevens:*** The hair loss has had a dramatic effect on his self-esteem, he is constantly stressed and depressed..

***Dr. Peters:*** Well, that is not good.

***Psychologist Stevens:*** No, I know. And I'm not sure how much I will be able to help him anymore. It's too much for him to handle.

***Dr. Peters:*** Did you try therapy, you are normally so good at that?

***Psychologist Stevens:*** I did, but I think the only thing that could help him would be to give him his hair back.

***Dr. Peters:*** You better send him to me then!

***Psychologist Stevens:*** So you can help him?

***Dr. Peters:*** Yes, stem cells can help cure practically anything these days!

***Psychologist Stevens:*** That is great Doc, I'll send him right over!

(Some hours later)

***Nurse:*** Doctor Peter, your next patient is waiting; he wants to see you concerning his hair loss. You talked to his psychologist earlier today.

***Dr. Peters:*** Ok, please let him in.

Tom Baldwin: Hello Doctor, my name is Tom Baldwin. I was hoping you could help me, I'm losing my hair.

***Dr. Peters:*** Well, tell me your symptoms and medical history. Have you noticed any scars on your scalp? Is your hair shedding or just thinning?

***Tom Baldwin:*** I have not seen any scars or other skin problems; only that my hair got thin and bald spots started to show up. I have not noticed more shedding than normal. Apart from the hair loss, I'm healthy, but I am depressed over losing my hair considering I am only 25 years old.

***Dr. Peters:*** Let's see, the medical term for hair loss is alopecia. It's either age-related or caused by disease [27]. First we have to determine if the hair loss is focal or diffuse. In focal alopecia the hair loss is concentrated to one or several spots. Diffuse alopecia gives a more widespread hair loss and often turns the remaining gray.

Focal hair loss it is generally caused by an underlying disease, and can be either scarring or non-scarring. Non-scarring is usually caused by fungal infections. If it leaves scars it can be caused by many different skin conditions. I recommend visiting a dermatologist if that is the case.

Diffuse hair loss results from hair shedding or hair thinning. Hair shedding is massive hair loss caused by stressful events. The most usual cause of diffuse hair loss is hair thinning; also called androgenic

alopecia which is female or male pattern hair loss.

Let's take a look at your scalp. There are no signs of skin disorders and your hair loss is diffuse and widespread. It looks like you have androgenic alopecia. Just to be sure that you are not shedding I would like to do a hair pull test. You are not shedding like you said.

***Mr. Baldwin:*** What causes my hair loss?

***Dr. Peters:*** Androgenic alopecia is caused by disturbances in the hair growth cycle [28]. Hair is rooted in a skin organ, the hair follicle, which originates deep in the skin [29]. The hair follicle contains stem cells that give the hair massive regenerative capacity [30]. The stem cells are responsible for hair growth and repair of the follicle if it is injured.

The hair growth cycle consist of 3 phases [31]. The first phase is the anagen phase when the hair is actively growing. The next phase is the catagen phase where the hairs root is moving towards the surface. The last phase is the telogen phase where the hair falls out and the circle starts all over again. In androgenic alopecia the growth phase is reduced [32], which results in shorter hair and hair falling off more rapidly.

Several hormones, in particular dihydrotestosteron, are believed to cause the cycle disturbances [31]. Dihydrotestosteron is an active metabolite of the male sex hormone testosterone which stimulates and controls the development of male features [33]. High levels of dihydrotestosterone are shown to inhibit hair regrowth in mice [34]. The role of DHT is to increase the size of the hair follicle during puberty, but at later stages of life it causes hair follicles to decrease in size that in turn results in male pattern hair loss [31].

Hereditary genetic factors might increase the sensitivity to the hormone making you more receptive to hair loss [35]. It seems that defects in several genes can influence the hair cycle most of them located on the X-chromosome explaining why the disease is prominent in men since we only have one X-chromosome. When you have two X-chromosomes like women you can make up for the defect gene if one of the chromosomes is healthy.

***Mr. Baldwin:*** Ok, I know it is normal for men to lose their hair, but also in your twenties?

Doctor: It is normal among men, even at your age. The condition affects up to 30% of men under the age of 30 and more than 50% of men over the age of 50 [36].

***Mr. Baldwin:*** Can it be treated?

***Dr. Peters:*** Yes, earlier this was treated with a drug that inhibited the enzyme that converts testosterone to dihydrotestosterone [28]. Unfortunately it was unsuccessful in advanced alopecia. These days I take a scalp sample from you and extract the stem cells in hair follicles that are in the growth phase [37]. These

cells will be cultivated and expanded in the lab. The cells will be introduced in a bioreactor together with a scaffold that provides the appropriate biomaterial and 3 dimensional structures that allows them to grow into hair follicles [38]. These hair follicles will be transplanted into your scalp and hair will start to grow back. The stem cells of the hair follicle contain information on how to grow into a fully developed hair follicle and to correctly perform the hair cycle. The technique of growing hair follicles in lab was actually discovered in 2010 by researchers at the University of Berlin [37].

***Mr. Baldwin:*** That sounds great Doctor. Are there complications?

***Dr. Peters:*** You will see some white round scars after the implantation, but they will not be visible when the hair grows back. Right after the transplantation your scalp can be itchy and some minor bleeding may occur. There is a moderate risk of immune rejection, but since we are using stem cells from your body the risk is minor. The nurse will set up an appointment where we will take a scalp sample and start growing hair in the lab.

***Tom Baldwin:*** Thank you Doctor, I look forward to see the result.

The following scene was not included in the movie:

## Treating Damaged Skin with Stem Cell Cream

***The scene is set at Doctor Peters Office:***

***Nurse:*** Doc. Mrs. Lawson is here. Com on in Mrs. Lawson..

***Dr. Peters:*** Hello, Mrs. Lawson. It's been a while, how are you?

***Mrs. Lawson:*** Hello Doctor Peters, please call me Flora. I'm fine, I just have one question for you.

***Dr. Peters:*** Oh, well. Ask away Flora!

***Mrs. Lawson:*** Could you help me with my skin problems, or it's not really a problem; people have bigger problems than I have but still. I'm getting old and it shows. Is there anything you can do to help me get rid of my wrinkles?

***Dr. Peters:*** I see, you are not the first to ask that question. Have you been exposed to a lot of sun?

***Mrs. Lawson:*** In my younger days I was always at the beach, for hours and hours.

***Dr. Peters:*** The UV radiation from the sun causes photoaging of the skin and results in deep wrinkles and dark spots [38]. An important substance to keep the skin strong and youthful is collagen [39]. UV increases collagenese levels which degrades collagen [40]. Dark spots are caused by an overproduction

of the skins natural pigmentation called melanin [41].

***Mrs. Lawson:*** I don't think I have any dark spots…

***Dr. Peters:*** No, that's right. I can still help you with the wrinkles. I can inject multipotent stem cells in your skin [42]. The stem cells will then transform into new tissue cells and produce collagen. To help speed up the process you should apply this stem cell cream that contains growth factors that activate your skin cells [43] twice a day.

***Mrs. Lawson:*** Sounds painful, is it?

***Dr. Peters:*** The injections might cause some itching and minor scars. To stop you from touching the injected area you need to wear a bandage for a week. But the wounds will heal nicely as long as you follow my instructions.

***Mrs. Lawson:*** Ok, let us get started.

***Doctor just does his job (no talk needed) Animation***

***Mrs. Lawson:*** (all bandaged up) Thank you doctor! I cannot wait to see the result!

***Dr. Peters:*** It will take some time for the cells to produce collagen, so be patient. Please come back in a month for a checkup.

***Power-point-slide: 1 month later…***

***Mrs. Lawson:*** Hello again doctor. Thank you so much for helping me, look, the wrinkles are gone! When the wrinkles started disappearing I was so happy! You really are a magician!

***Dr. Peters:*** Good to hear, it is my pleasure to help you!

## Scene 5: Ethical Issues

***The scene is set at Doctor Peters appartment:***

***Dr. Peters:*** Hello Dog, I'm home. And I didn't forget your bone.

***Dog Oscar:*** Hi Doc. How was your day?

***Dr. Peters:*** Fine, I helped a lot of patients today.

***Dog Oscar:*** What did you do? Did you use the stem cells you were talking about before you left?

***Dr. Peters:*** Yes, I did. I treated one with leukemia, diabetes, a person going bald and an old lady who wanted to get rid of her wrinkles and look young again.

***Dog Oscar:*** Wow! That was a lot… Where did you get the stem cells from?

***Dr. Peters:*** I get them in the stem cell bank. It's just like the bank that keeps the money except your

account holds your own stem cells.

***Dog Oscar:*** OK, sound smart. But can you call getting rid of wrinkles curing a disease?

***Dr. Peters:*** I'm not sure, but that was what she wanted and I was able to help her so why shouldn't I do it. It improves her wellbeing, confidence and life quality because it makes her feel better, how can I then say no?

***Dog Oscar:*** Mm.. Good point. Even if I think it's more important to like who you are no matter what you look like. Just take a look at dogs, we come in all different sizes and shapes and we are all happy.. Can you cure everything with stem cells? Like any kind of disease?

***Dr. Peters:*** Not at the moment, but I bet they can cure some of the major diseases in a few years. There is still an enormous job to do before we get that far.

***Dog Oscar:*** So since you can cure everything and everyone, you are sort of playing god at work every day?

***Dr. Peters:*** No, at the moment we cannot cure everything, but I guess doctors in the future will have a big responsibility on their shoulders when they have to choose who to cure...

***Dog Oscar:*** So in the future those who have enough money to pay for the treatment can live forever?

***Dr. Peters:*** Hmm… Maybe that is how it's going to be someday… If scientist figure out why cells get old we are one step closer to controlling the aging process…

***Dog Oscar:*** But then, if no one gets old and every sick person is cured, isn't the world going to get crowded?

***Dr. Peters:*** Oh, I never thought about it that way before but I guess you are right.. Or at least the part of the world that can afford that kind of treatment.. And we wouldn't want that to happen, would we…?

## Scene 6: Last scene; Phone call from Tom Baldwin

***The scene is set at Doctor Peters appartment***

***Some Months later***

Telephone ringing. Forever young plays in the background of the party where Mr. Baldwin is.

***Dr. Peters:*** Hello?

***Mr. Baldwin:*** Hello Doc, it's Mr. Baldwin. I just wanted to thank you for helping me out! I have gotten my hair back and I couldn't be happier!

***Dr. Peters:*** Oh, I'm happy to help.

***Mr. Baldwin:*** I feel like the old me again! Thank you!

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# Appendix B: Skin treatment with Stem Cell cream

This appendix describes the scene that had to be excluded from the animation due to lack of time.

### Skin treatment with Stem Cell cream

The next patient, Mrs. Lawson, has damaged skin due to her age and excessive exposure to the sun. She is shown in figure 2-6.

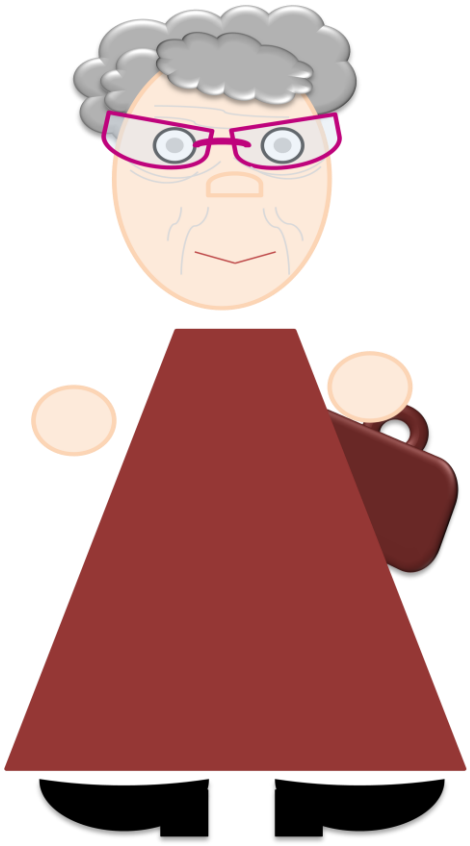

**Figure 2-6: Mrs. Lawson**

The Doctor explains how the collagen in the skin is damaged by the sun. The treatment includes injection of multipotent stem cells to the skin, and then the patient has to put on a cream that has growth factors that will induce growth of the injected cells.

The treatment described here was largely based on a medical hypothesis that stem cells can be used to

treat skin problems. A cream with growth factors does exist and is meant to be used as described above. The reason for including this scene in the animation was because the Village Leader encouraged us to include it and because we wanted to give a commercial aspect into stem cell treatments.