HOW DO STEM CELLS HELP MEDICINE?

Scientists use stem cells to study the backgrounds of certain diseases and develop new treatments. In the future, we may be able to improve the treatment of a number of severe diseases or even cure them.

1. Understanding how organisms develop
2. Enhancing research on disease and abnormal development
3. Reducing animal experiments
4. Replacing damaged cells caused by disease instead of transplanting organs

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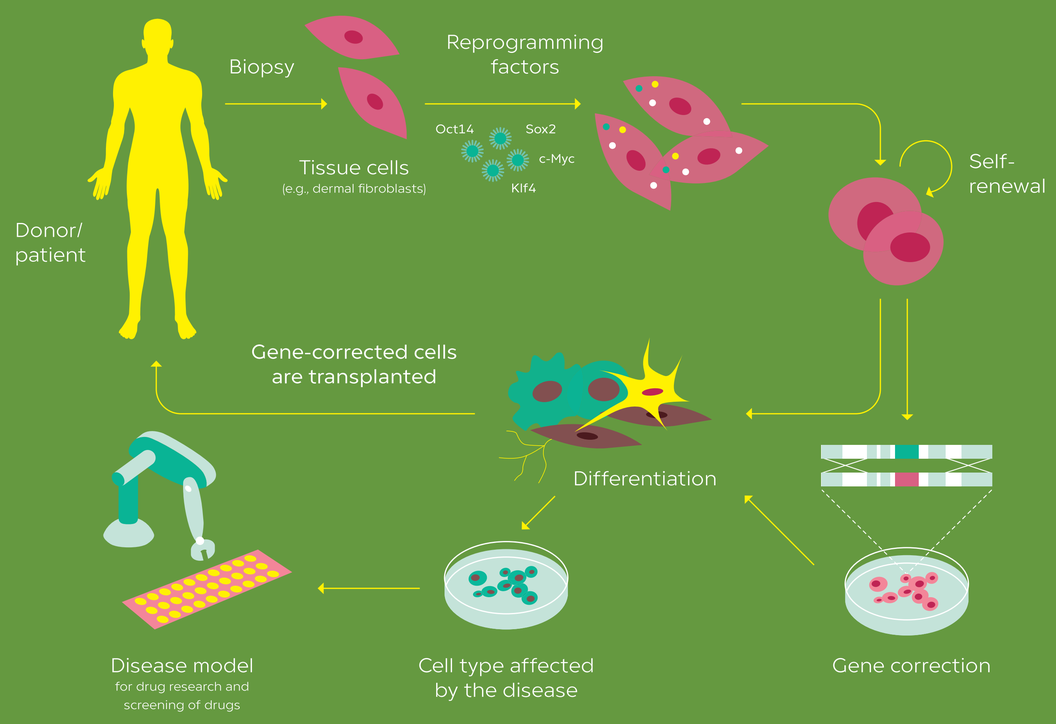
WHAT STEM CELLS CAN DO FOR MEDICINE

Stem cells for life

We all have stem cells in our bodies. Without these cells, our body would be unable to regenerate. Stem cells have unique properties that make them interesting for research and medicine. They can help us understand and treat diseases.

What can develop from different types of stem cells



WHAT ARE STEM CELLS?

What role do stem cells play?

In order for the body to function, it must continuously produce new cells, for instance, when muscles are damaged after physical exertion. Some specialized cells, such as muscle cells or blood cells, are unable to regenerate themselves. To do this, the body uses stem cells, which are responsible for regeneration and repair.

What makes stem cells unique?

Stem cells are experts at cloning. In contrast to specialized cells, stem cells can keep dividing and producing copies of themselves. They can also generate specialized cell types during division. One egg cell – which is also a stem cell – can even give rise to an entire human being.

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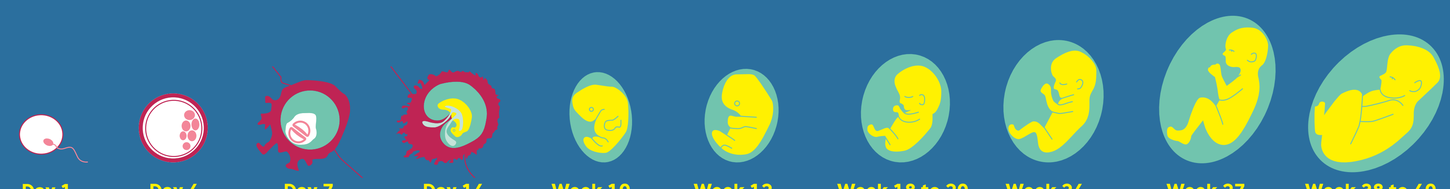
WHAT'S SO CONTRO-VERSIAL?

Key stages of embryonic and fetal development



Day 1
Fertilization

Day 4
Blastocyst forms

Day 7
Blastocyst implants itself in the uterus

Day 14
First cells of the nervous system are formed

Week 10
All organs and extremities are present

Week 12
Fetus makes controlled movements

Week 18 to 20
Fetal movements can be felt

Week 24
Fetus reacts to light and sounds

Week 27
Eyes open

Week 38 to 40
Baby is fully developed

Why is embryonic stem cell research so controversial?

In order to harvest human embryonic stem cells, a blastocyst is needed. A blastocyst represents a very early developmental stage of human life. The status of this cell cluster is viewed in a wide range of ways. Some people consider it to be an unborn child. Others say that unneeded fertilized egg cells from fertility treatments should be used for research rather than being destroyed.

What does the debate mean for stem cell research?

Ethical discussions on embryonic stem cell research help put in place key guidelines and laws for dealing with embryonic cells.
Debates serve to allow scientists to perform research legally. And they are the basis of social discourse that weighs research for potential treatment against the protection of life.

ETHICAL CONCERNS ASSOCIATED WITH EMBRYONIC STEM CELL RESEARCH

What is research allowed to do?

Embryonic stem cell research can contribute to developing new treatment methods for severe diseases. The dependence on the use of human embryos in this type of research makes it the subject of heated debate. There are also other ethical questions that arise in the context of stem cell research that are not directly related to the status of the human embryo.

WHAT COMPROMISES ARE POSSIBLE?

The positions on embryonic stem cell research are highly diverse. In addition to categorical rejection or advocacy, there are a number of standpoints that approve of embryonic stem cell research with restrictions.

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1
Doing research on animal embryos

2
Using unneeded embryos that are created during in vitro fertilization

3
Reducing the number of actually needed embryos

4
Continuing the social debate

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WHERE DO WE STAND?

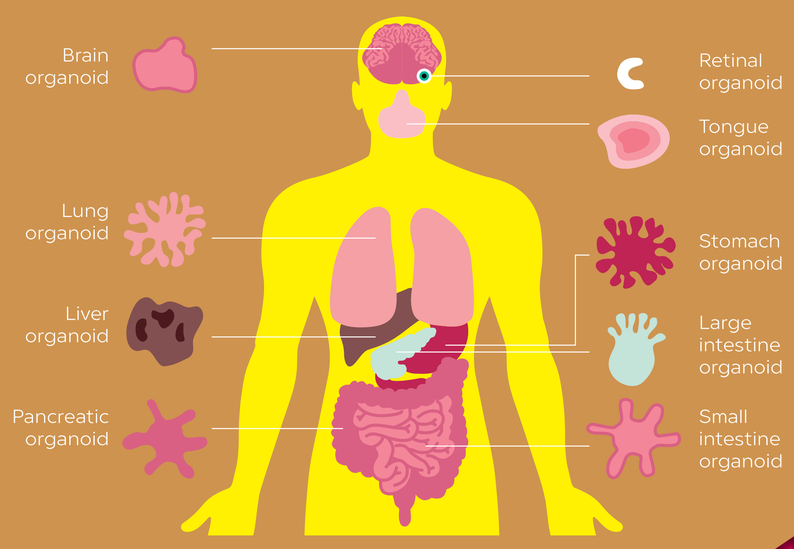
What do we know?

Organoids offer scientists alternatives to animal experiments or research methods that reach their limits owing to ethical questions or limited availability. They allow complex arrangements and interactions of cells to be viewed in a three-dimensional space. Today, organoids are already used to study diseases and to develop drugs.

What are we investigating?

Currently, we are studying how all different types of human tissue can be grown in the form of organoids. This allows us to study the development of diseases in an organ. Scientists test organoids for their applicability in regenerative medicine. In the future, new pharmaceutical agents can first be tested on organoids instead of directly on animals or humans.

Organoids grown in the laboratory



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MINI-ORGANS FROM THE LABORATORY

Organoids

Scientists have succeeded in creating so-called organoids in the laboratory. Organoids are cell clusters that already consist of several types of cells typical for the respective organ and develop rudimentary 3D structures. While their structure resembles that of the bowel or the brain, they grow to a size no larger than a pea.
In the future, they could be used in research and in regenerative medicine.

WHAT DO WE WANT TO ACHIEVE?

Using organoids, scientists study the development and disease of organs. In the future, the cell structures that have been grown can contribute to the development of new treatments and drugs.

1 Growing all types of human tissue

2 Understanding how organs are formed

3 Using organoids to study diseases of organs

4 Testing new drugs on organoids

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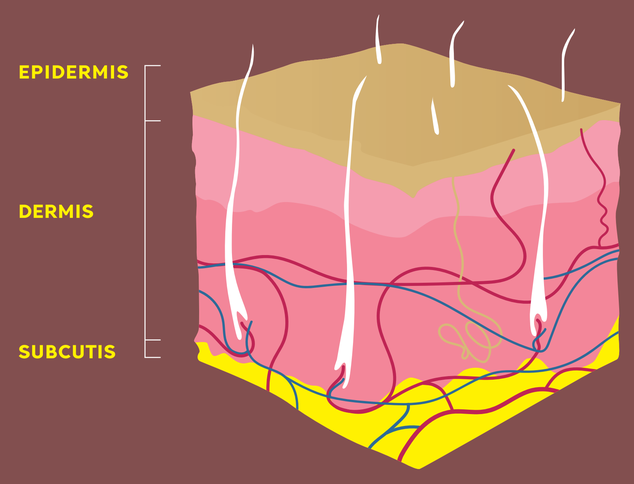
Structure of our skin



WHERE DO WE STAND?

What do we know?

The human skin consists of three layers. Different types of stem cell types are responsible for its regeneration. Skin transplants grown from stem cells do not match the natural skin, however, because so far they have only been generated from stem cells of the epidermis, the outermost layer of the skin. They lack skin appendages such as the sweat and sebaceous glands and hair roots.

What are we investigating?

To ensure that artificial skin transplants function as well as possible, scientists are investigating methods that enable transplants to be produced that have sweat and sebaceous glands and hair follicles. They are also attempting to treat congenital skin conditions using genetically modified skin stem cells. This method has already been used to treat the first cases of epidermolysis bullosa successfully.

STEM CELLS AND OUR LARGEST ORGAN

The skin and skin diseases

Our skin protects us from external influences.
To do this job, it renews itself every four weeks – using stem cells. The study of these cells is the basis for growing tissue in the laboratory that can be used for skin transplants for burn patients and for skin conditions.

WHAT DO WE WANT TO ACHIEVE?

1. Growing the different elements of the skin
2. Eliminating the need for animal cells for growing skin cells
3. Making transplant methods available to more patients
4. Treating congenital skin conditions

In the future, scientists hope to develop methods for producing different types of skin and quickly make the tissue obtained this way available for patients such as burn victims.

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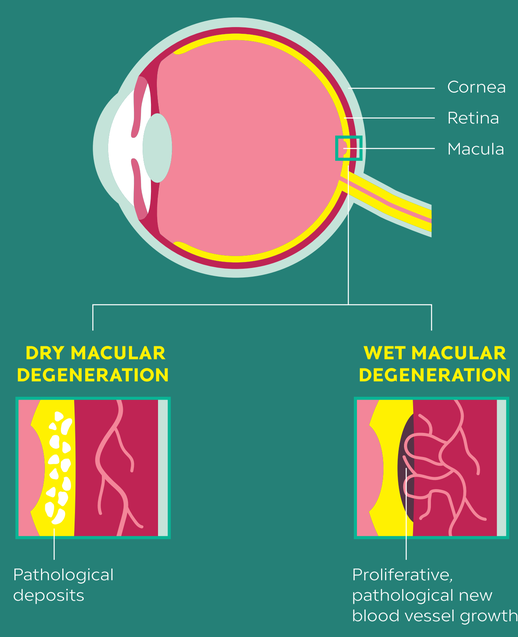
STEM CELL THERAPY OFFERS THE HOPE FOR A CURE

Blindness and visual impairment

Blindness deprives a person of one of their main senses. The vision loss may be caused by damage to the cornea or by age-related macular degeneration (AMD). In patients with AMD, damage to the retina impairs visual acuity. Up to now, most of the reasons for blindness have barely been treatable, or not at all. But in some cases, stem cell therapy has already been successful.

WHERE DO WE STAND?

Macular degeneration



What do we know?

In patients with macular degeneration, damaged retinal pigment epithelial cells lose the ability to support the retina, which is responsible for image processing in the eye, leading to vision loss. For damage to the cornea, however, stem cell therapy (Holoclar®) has now been used to replace the damaged corneal cells and, in so doing, retain vision. To do this, limbal stem cells must still be present in the patient's eye.

What are we investigating?

For patients with cornea damage, researchers are searching for treatment methods that are not dependent on the presence of the patient's own stem cells, but that restore vision through a stem cell transplant. For the treatment of macular degeneration, clinical studies are being carried out that study how cell layer obtained from stem cells can repair the damaged retina.

WHAT DO WE WANT TO ACHIEVE?

Scientists are investigating which pluripotent or adult stem cell types can be used to treat blindness. One focus of stem cell research is how stem cells can contribute to repairing or restoring the retina and the cornea.

1. Investigating types of stem cells in the eye
2. Preventing the causes of blindness
3. Restoring tissue in the eye
4. Developing transplant methods

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WHERE DO WE STAND?

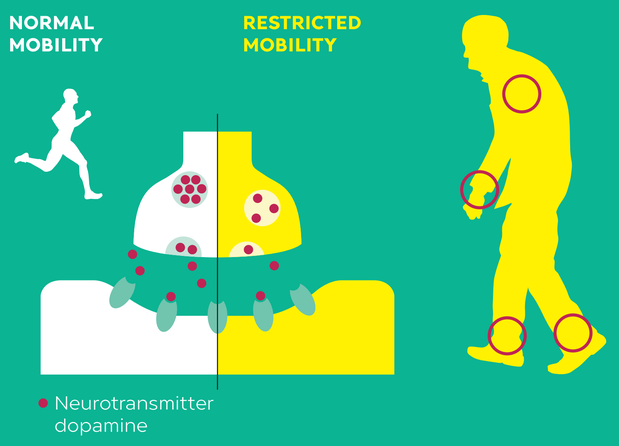
What do we know?

Parkinson's disease is caused by the premature death of nerve cells in the substantia nigra region of the brain. These nerve cells produce the neurotransmitter dopamine, which is important for communication between nerve cells.
Parkinson's disease is attributed to a genetic cause in only about 5% of all patients with the disorder. The reasons for the disease in the other 95% are still unknown.

What are we investigating?

Scientists are using stem cells to study what causes Parkinson's disease and what possibilities exist for generating new nerve cells from stem cells and transplant them into the brain as replacement cells.
Nerve cells grown from human stem cells in a laboratory have already been used successfully.
In animal experiments the transplanted cells survived and alleviated the motor deficits.

Nerve cells and dopamine



USING STEM CELLS TO STOP THE DISEASE PROGRESSION

Parkinson's disease

Parkinson's disease affects millions of people worldwide. Its signs include impaired movement, stiff muscles, and muscle twitching. While the disease symptoms are treatable, Parkinson's disease cannot be cured. Stem cells may open up new treatment paths.

WHAT DO WE WANT TO ACHIEVE?

With the help of stem cells, we may be able to understand and treat Parkinson's disease better in the future. It would then also be possible to develop stem cell therapy for patients.

1 Understanding unknown causes and mechanisms of the disease

2 Developing new drugs and treatments

3 Replacing dead or diseased nerve cells

4 Stopping the disease progression or curing the disease

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Blood and leukemia

WHERE DO WE STAND?

What do we know?

Blood stem cells are able to form all cell types of our blood. Depending on the treatment, they can be obtained in different ways: from bone marrow or directly from the bloodstream. But using stem cells in the treatment of blood cancers such as leukemia or lymphoma is also associated with risks. Rejection reactions and the necessary immunosuppression can be dangerous for patients.

What are we investigating?

At present, scientists are studying how obtaining blood stem cells, which is primarily dependent on donors, can work in treatment-related standards in the laboratory. In the future, we want to be able to replace defective genes with healthy DNA using gene therapy. Research on the causes of leukemia and comparable diseases promises additional insights that can be harnessed for developing new treatment methods.

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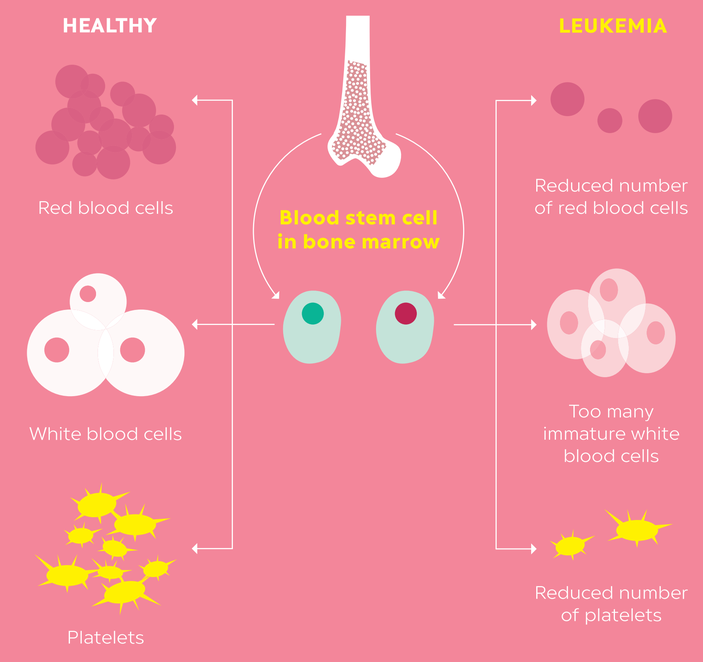
What happens in patients with leukemia



HOW STEM CELLS HAVE SAVED LIVES FOR DECADES

Modern stem cell research was launched with the discovery of blood stem cells in the 1960s. Starting with this milestone, many new areas branched out in this discipline. Today, thousands of patients with leukemia, of all ages, undergo stem cell treatment.

WHAT DO WE WANT TO ACHIEVE?

Producing blood stem cells in the laboratory takes a great deal of time and effort. However, they would not only reduce the risks for patients, but could also be used to manufacture blood for transfusions.

1. Investigating malfunctions of blood stem cells
2. Minimizing risks to patients
3. Making blood stem cells from the laboratory more usable
4. Developing more gentle treatment methods

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WHERE DO WE STAND?

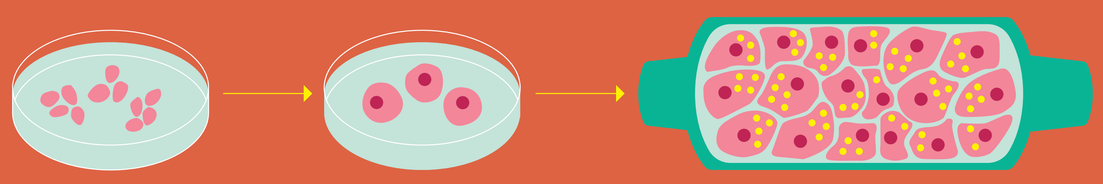
What do we know?

The body uses insulin to take up glucose from the blood. The pancreas produces this hormone using beta cells in the islets of Langerhans. In patients with type 1 diabetes, this process is disturbed by the immune system. In patients with type 2 diabetes, this glucose uptake of the body cells is reduced because they do not sufficiently react to insulin or too little insulin is produced.

What are we investigating?

Stem cell researchers have produced cells that react to glucose and release insulin. They are now studying how these cells can be transplanted into patients with type 1 diabetes and can be protected from their own immune system. Furthermore, scientists want to develop drugs that promote increased production of the body's own beta cells.

Stem cells become beta cells



Stem cells in nutrient solution

Synthesis of precursor cells

A protective capsule prevents the immune system from attacking the cells while, at the same time, allowing them to react to glucose and release the produced insulin into the blood.

NEW TREATMENT METHODS THANKS TO STEM CELLS

Diabetes

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People with diabetes suffer from impaired insulin production. The global disease is not curable but can be managed well. Patients with type 1 diabetes manage their disease with regular insulin injections. Stem cell treatment could eliminate the need for these injections in the future.

WHAT DO WE WANT TO ACHIEVE?

Stem cell research aims to develop less invasive treatments for patients with diabetes and enhance our understanding of the causes of diabetes.

1 Understanding why the immune system attacks the patient's own beta cells

2 Developing new transplant methods

3 Producing cells that react to glucose and produce insulin

4 Protecting transplanted cells from the patient's immune system

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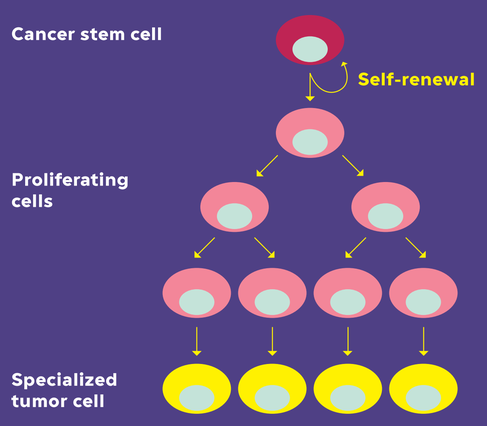
WHERE DO WE STAND?

The cancer stem cell model



What do we know?

When the cell-division process is impaired by a change in DNA, healthy cells can turn into cancer cells and form a tumor. However, scientists have observed that not all cells of a tumor contribute to its growth. To explain this observation, “cancer stem cells” are studied.

What are we investigating?

According to the current scientific model, only cancer stem cells can continuously form new tumor cells. After surgical removal, chemotherapy, or radiotherapy, however, a small number of cancer stem cells can remain and can cause the cancer to develop again, even years later (recurrence). Treatment methods that also destroy these stem cells would be highly beneficial for patients.

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A DISEASE CAUSED BY STEM CELLS?

Cancer

For patients and their families, the diagnosis of cancer is a terrible stroke of fate. Despite intensive research, a number of questions are still unanswered, especially related to the development and growth of tumors. However, the results of stem cell research could contribute to more effective treatment methods in the future.

1. Investigating the causes of cancer
2. Studying tumor growth
3. Developing new treatments
4. Preventing recurrence

WHAT DO WE WANT TO ACHIEVE?

Investigating cancer stem cells serves as the basis for treatments in which these cells can be specifically destroyed.
Such methods would dramatically reduce recurrence.

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WHERE DO WE STAND?

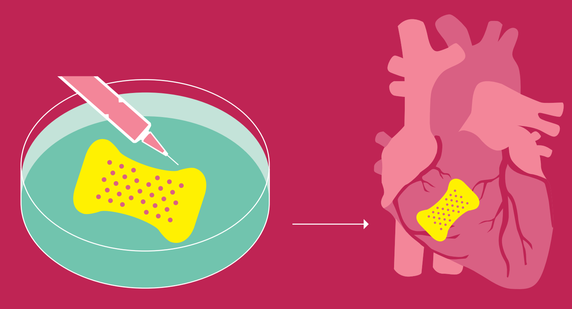
What do we know?

A heart attack causes irreparable damage to the heart tissue. Stem cell researchers are attempting to create heart tissue in the laboratory and have already been successful. A heart attack causes scarring that reduces the heart's ability to pump, thus limiting the performance level of the entire body.

What are we investigating?

Researchers want to stimulate the body's own heart cells to repair the heart independently. They are also investigating applications for heart tissue that has been generated. There are different approaches for replacing destroyed heart tissue. One approach calls for injecting individual cells into the damaged heart tissue that would develop into functioning heart muscle cells in the heart. Another approach involves constructing a "patch" from heart muscle cells from cell culture for the tissue damaged by the heart attack.

Transplanting heart muscle tissue



In the laboratory, heart muscle tissue is created from stem cells.

The "patch" that is grown is sewn on to the heart.

NEW PERSPECTIVES THANKS TO STEM CELL RESEARCH

Heart disease

Heart disease such as a heart attack is among the most common causes of death worldwide. Researchers are investigating the ability of the heart to regenerate in order to develop new treatment methods.

WHAT DO WE WANT TO ACHIEVE?

In the long term, we want to develop safe and reliable methods for generating tissue and for transplants. Findings obtained in animal studies will have to be tested for their transferability to humans.

1 Investigating the origins of chronic diseases

2 Understanding how the heart regenerates

3 Observing stem cells under laboratory conditions

4 Developing safe transplant methods for tissue

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