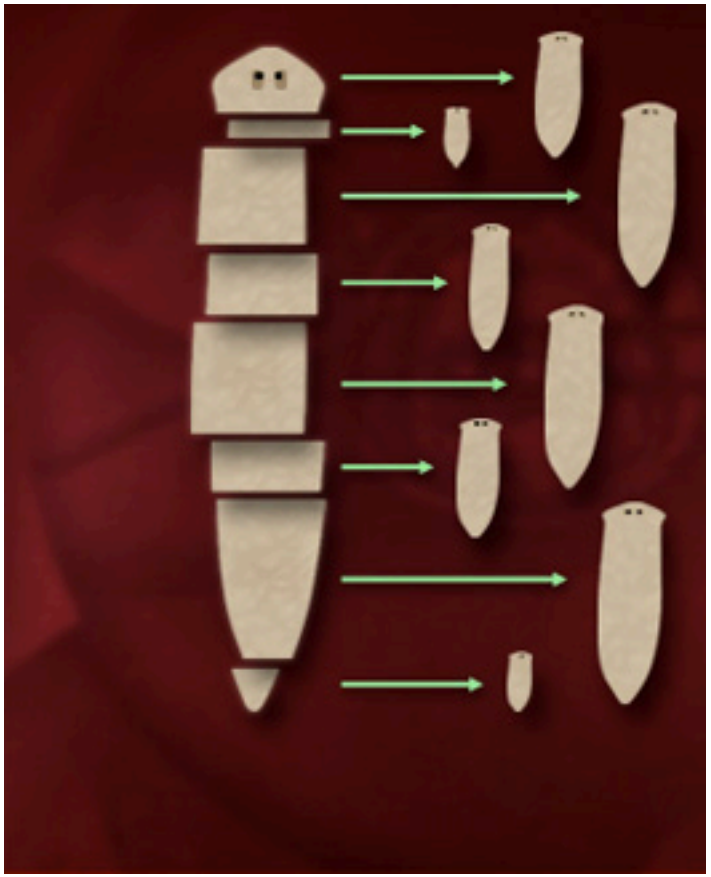
Stem Cells: Superheroes of the past, present and future

Deepa Subramanyam

National Centre for Cell Science
University of Pune Campus,
Pune -411007

Even the ancient Greeks knew about regeneration!

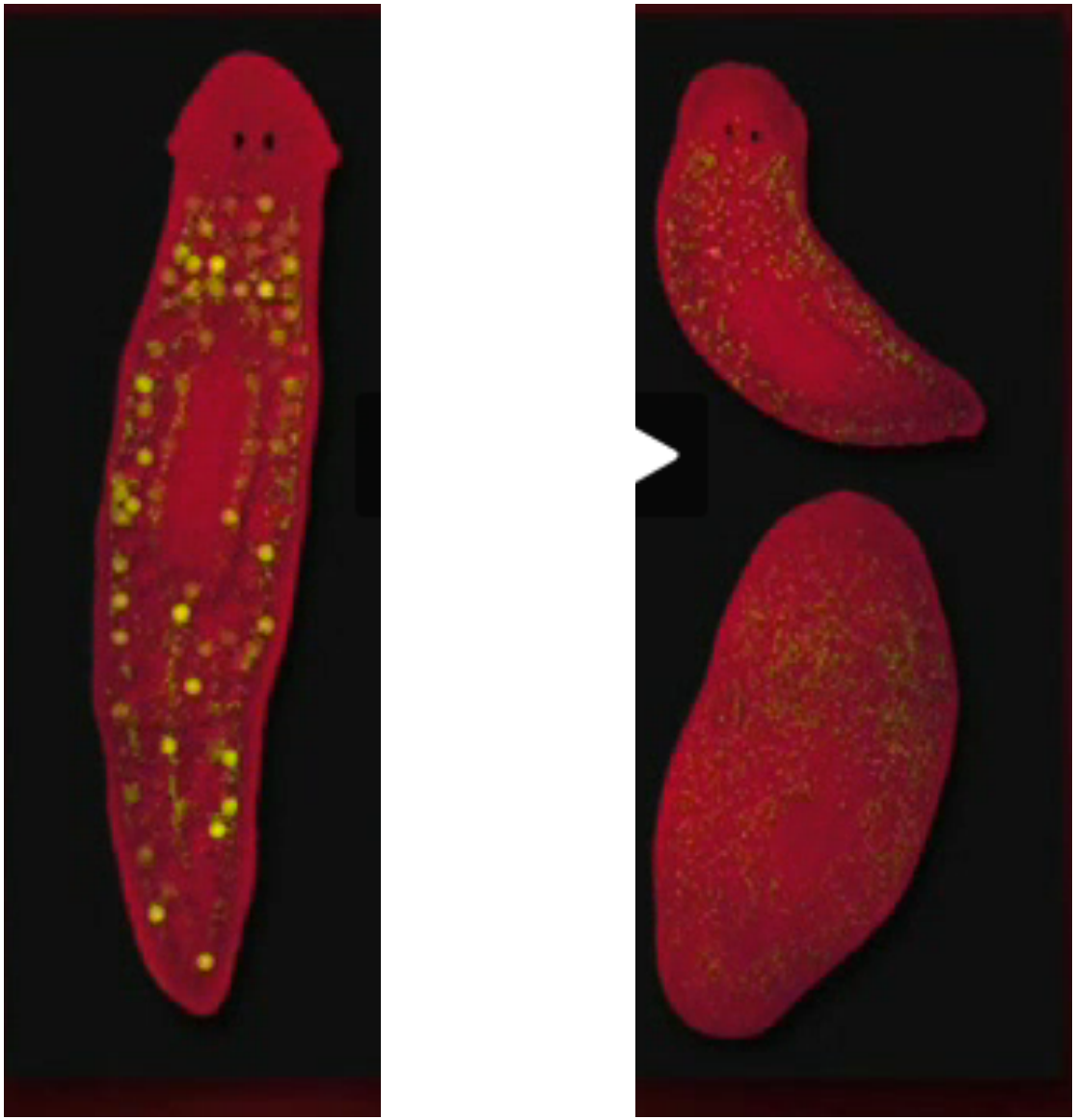
Planaria regeneration – winner of the regeneration challenge



Planaria are flatworms (Platyhelminthes) and more complex than hydras. They have a remarkable regenerative ability. When a planaria is cut in two, each fragment will regenerate a complete animal. In fact, a single planaria can be cut into dozens of small pieces, and each can regenerate a complete new animal. This amazing ability seems to be related to the relative abundance of stem cells called neoblasts.

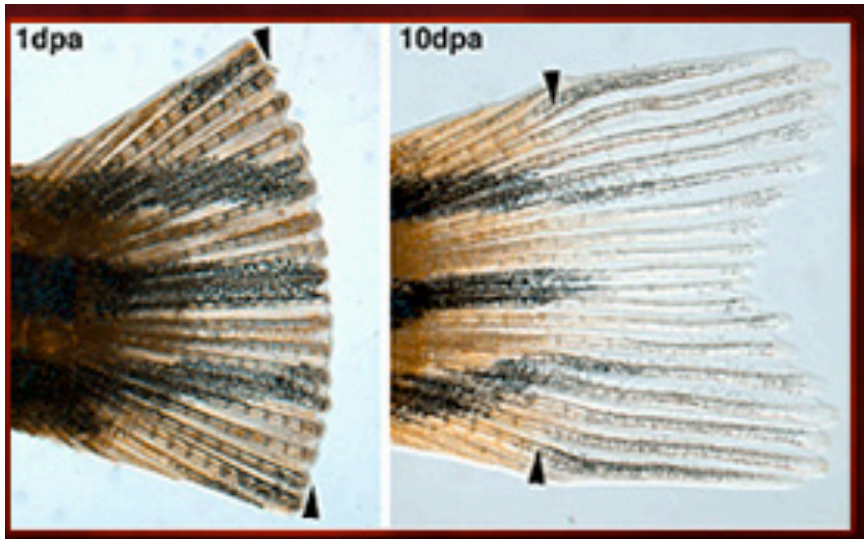
HHMI Holiday lectures, 2006

Planaria regeneration



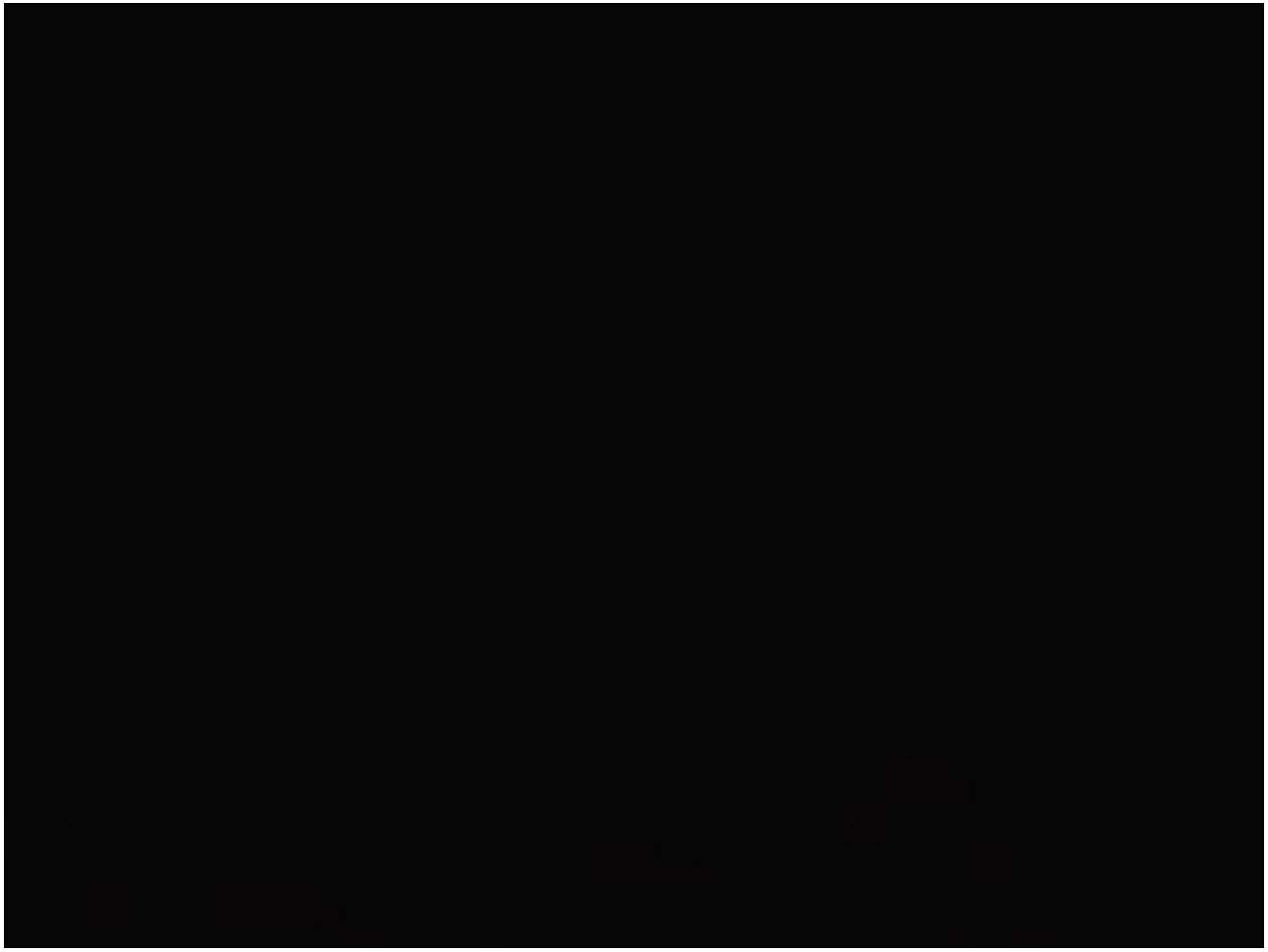
HHMI Holiday lectures, 2006

Zebrafish fin regeneration



HHMI Holiday lectures, 2006

Newt limb regeneration

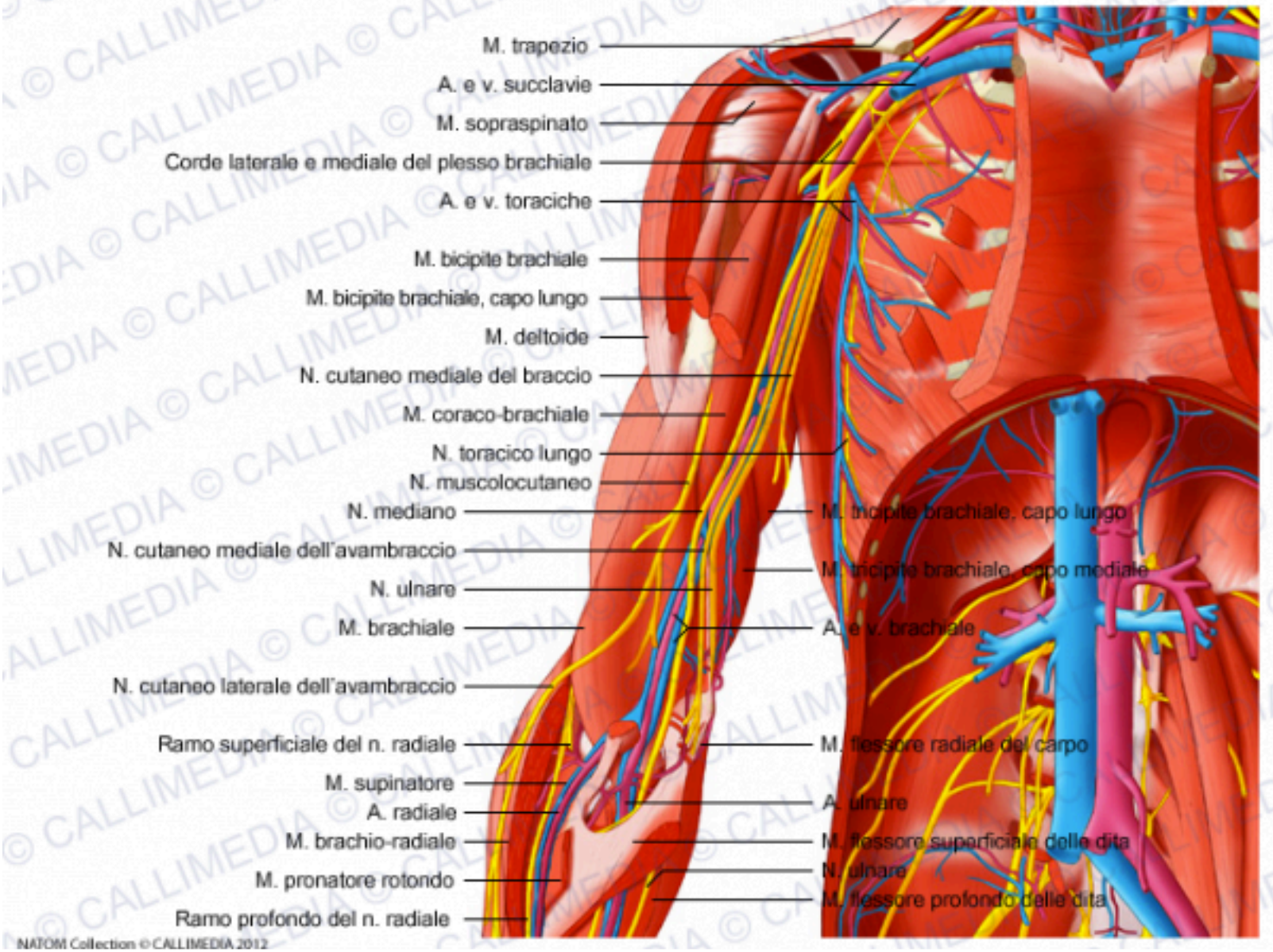


Why do we have such limited regenerative capacity?

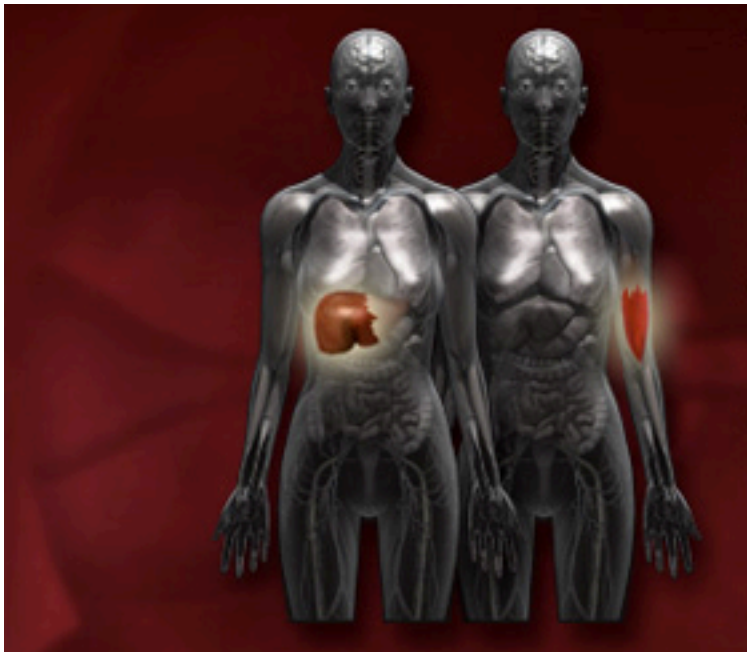
Complexity of our body.

Protection against cancer.

Have we lost the capacity to regenerate or is it suppressed?



Healing vs regeneration



The purpose of healing is to limit damage and prevent death from an injury. Cells respond to injury by producing factors that halt bleeding, fight infection, and close the wound. Healing involves limited production of new cells—mostly cells connected with scar formation. Regeneration is a much longer process that follows initial healing. Unlike healing, regeneration involves the production of vast numbers of new cells of many different types. To re-form a new limb, for example, the cells essentially need to reenact development.

HHMI Holiday lectures, 2006

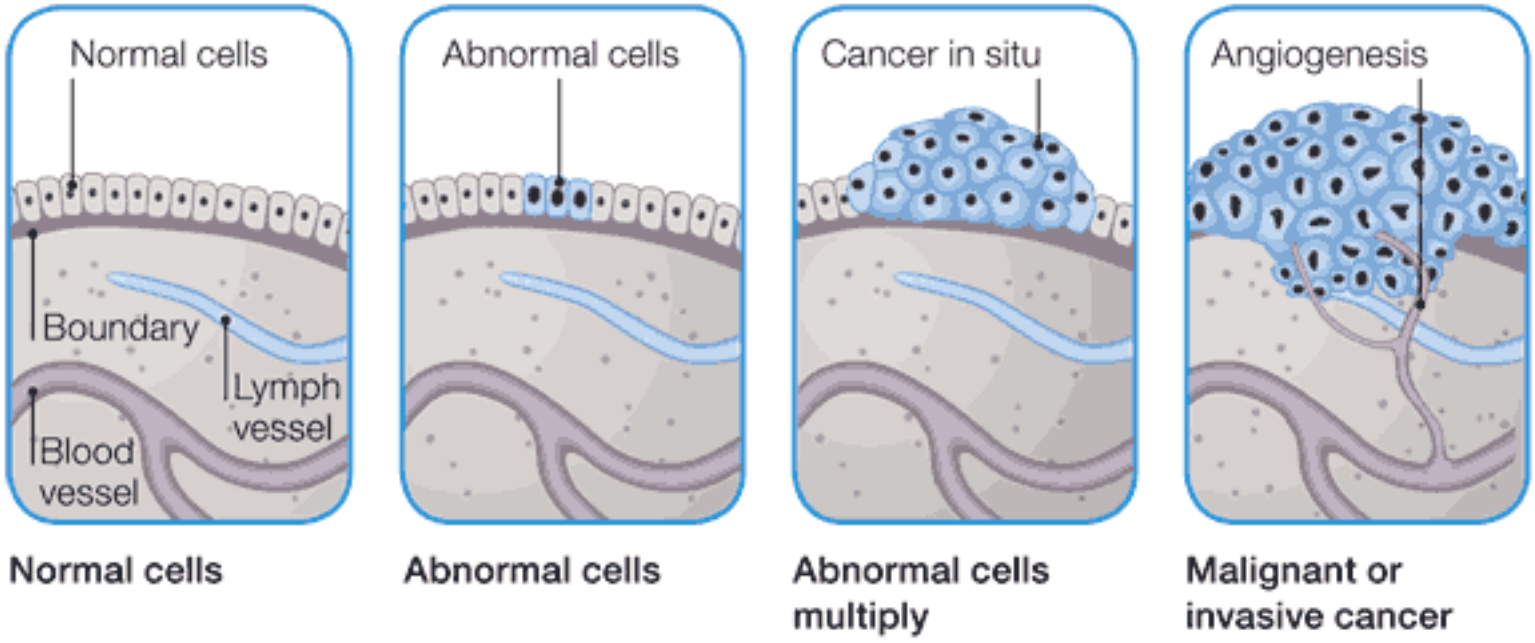
Why do we have such limited regenerative capacity?

Complexity of our body.

Protection against cancer.

Have we lost the capacity to regenerate or is it suppressed?

Cancer development



Normal cells

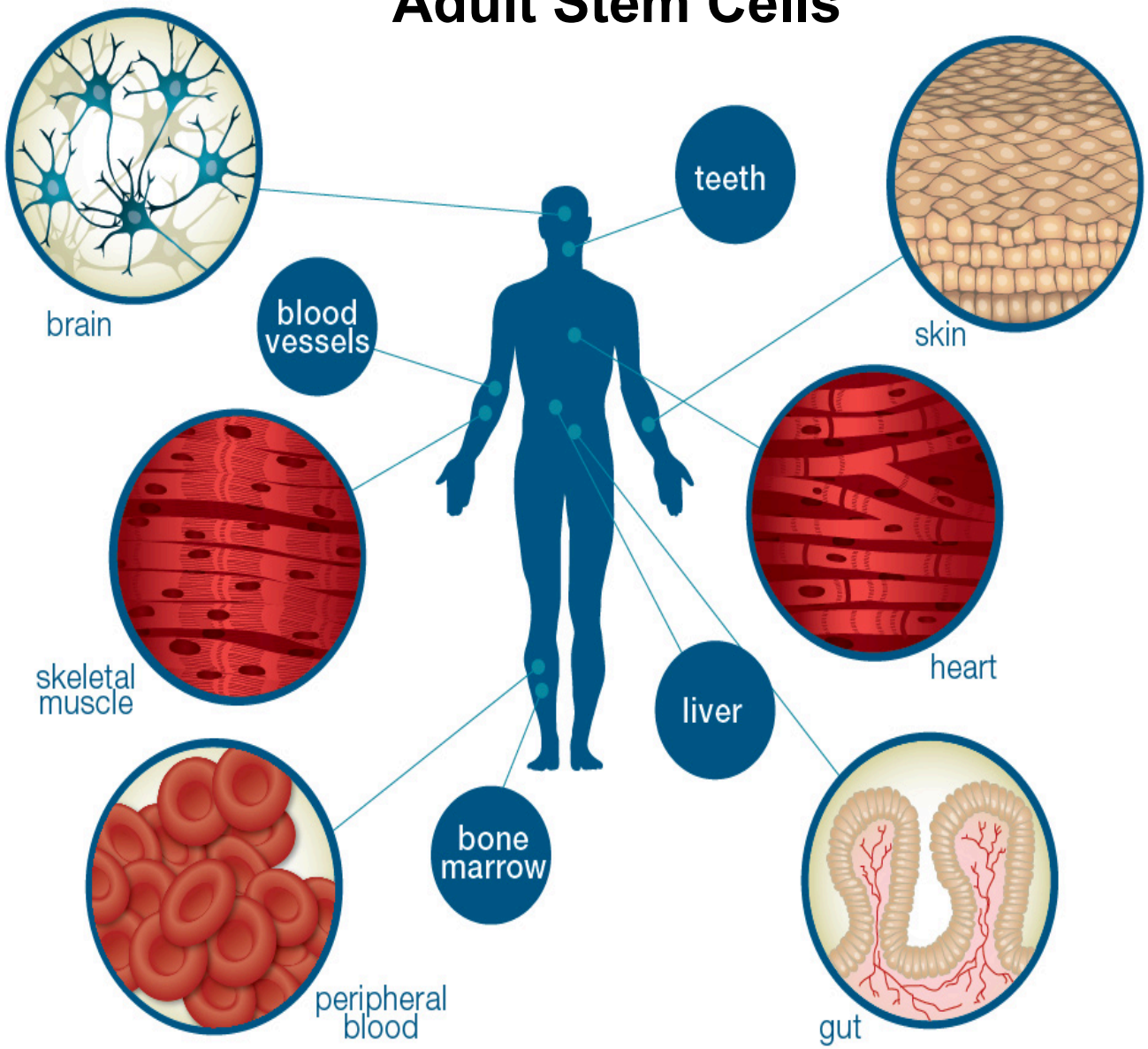
Abnormal cells

Abnormal cells multiply

Malignant or invasive cancer

Cancercervix.org.au

Adult Stem Cells



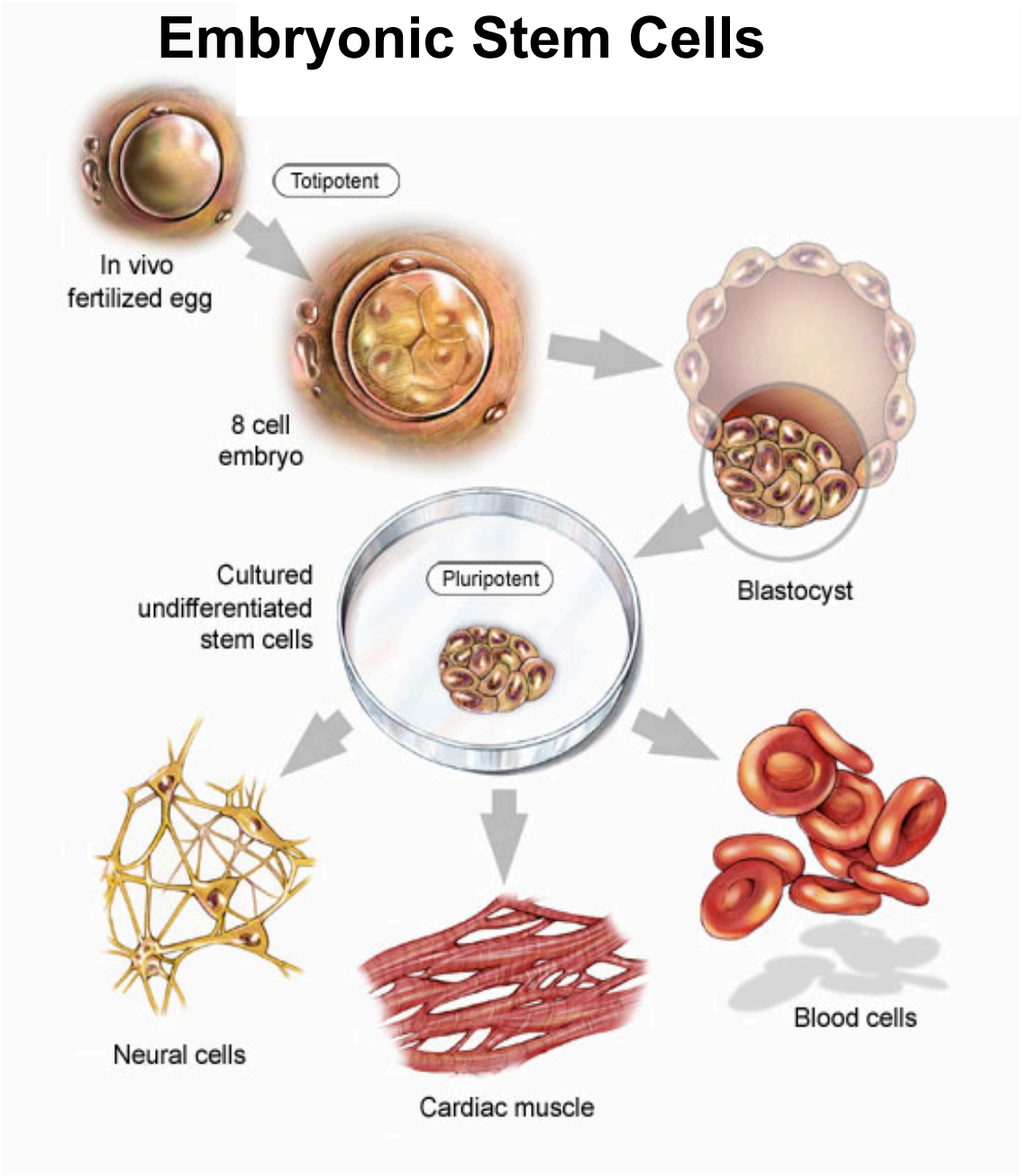
Adapted from learn.genetics.utah.edu

Normal development – how does it happen? We never think about it until something goes wrong!

Mice vs humans – model for mammalian development

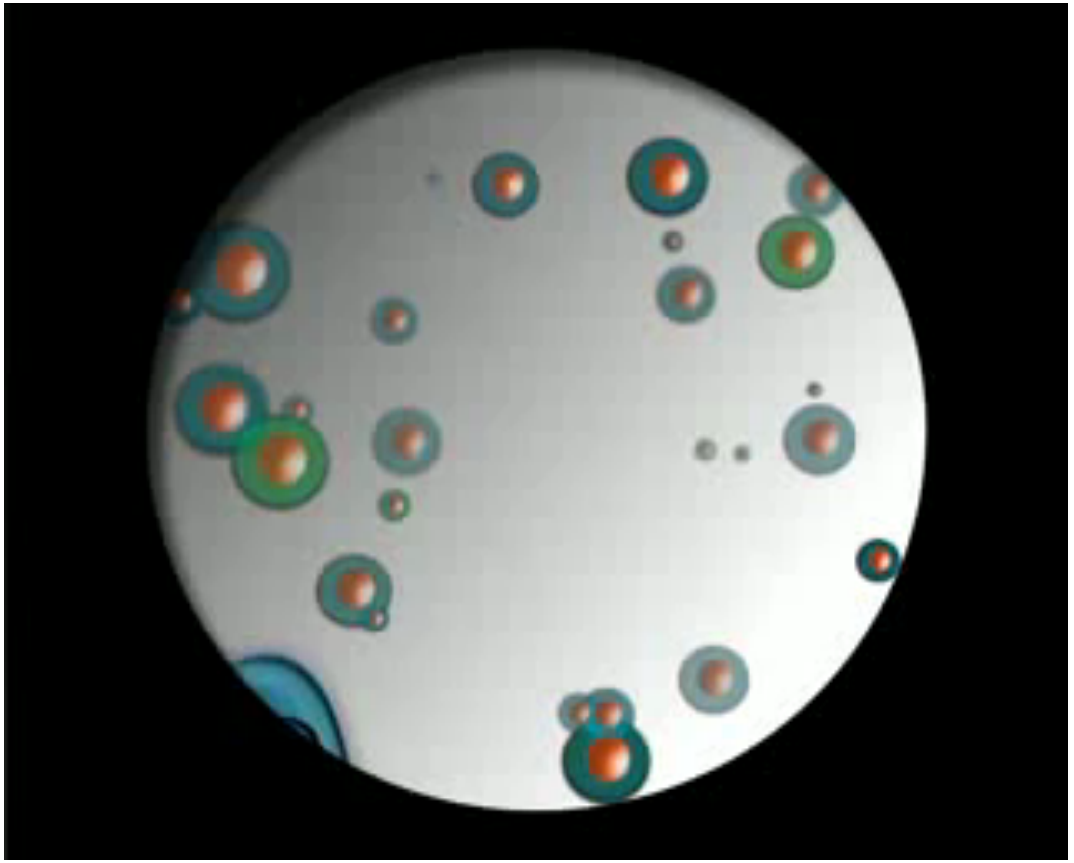
How does life start? Where do stem cells come into the picture?

Embryonic Stem Cells

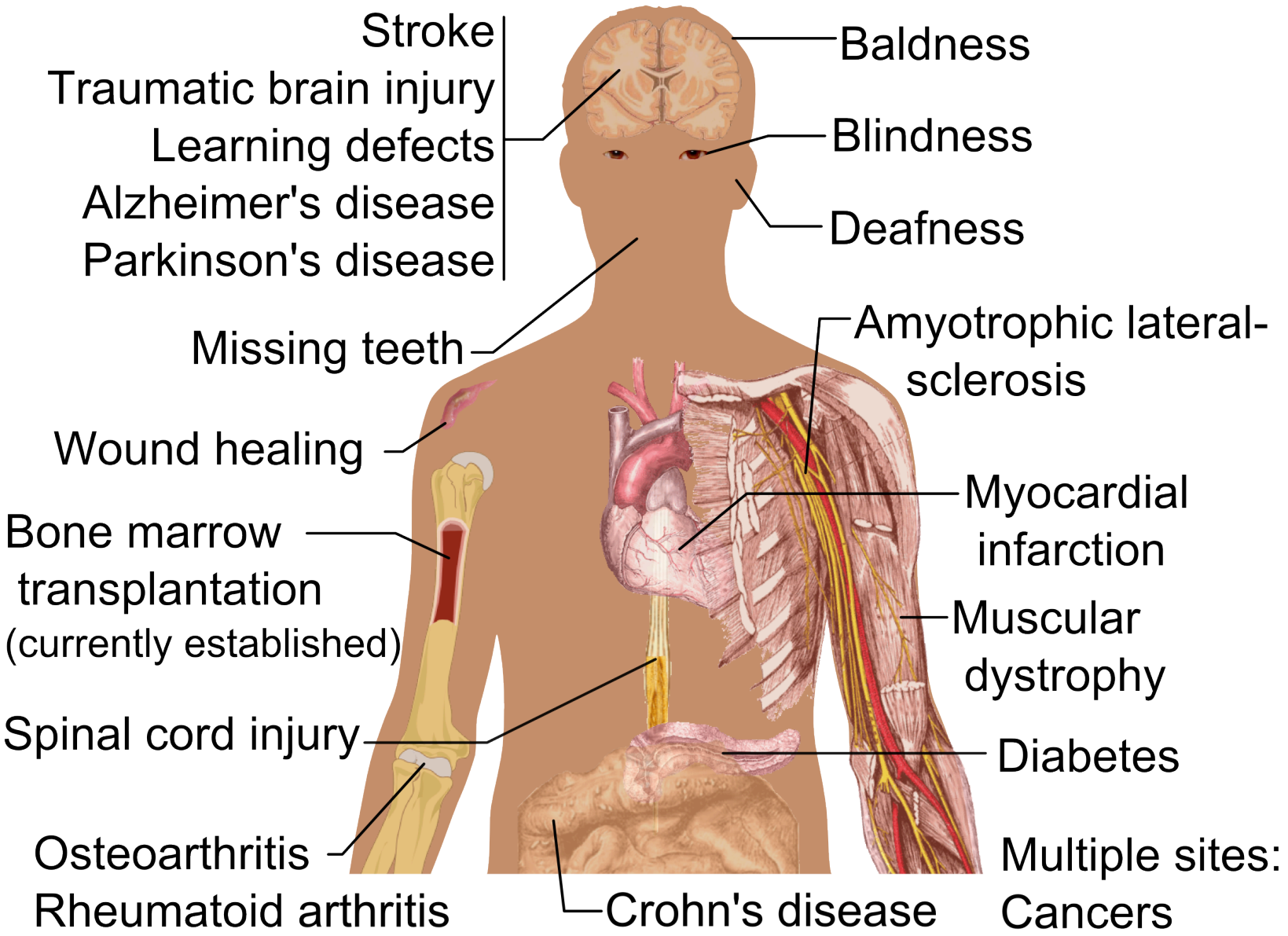


Adapted from: hjhsstemcells.yolasite.com

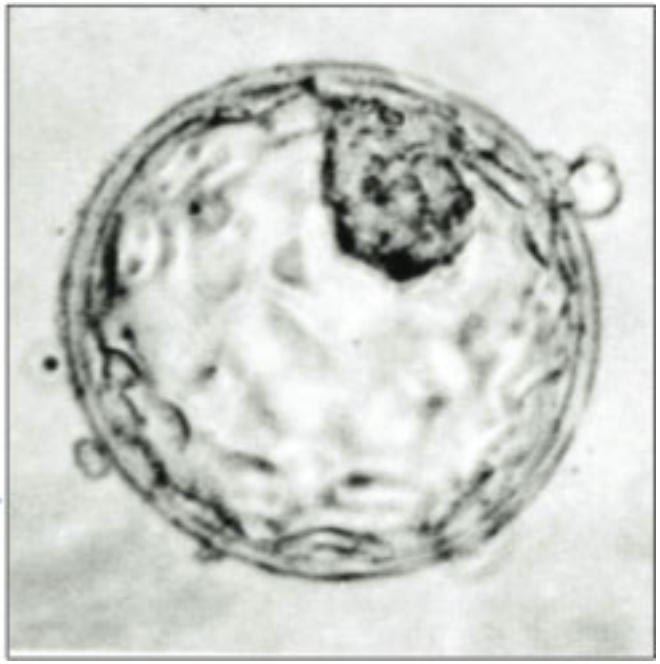
But what can stem cells do?



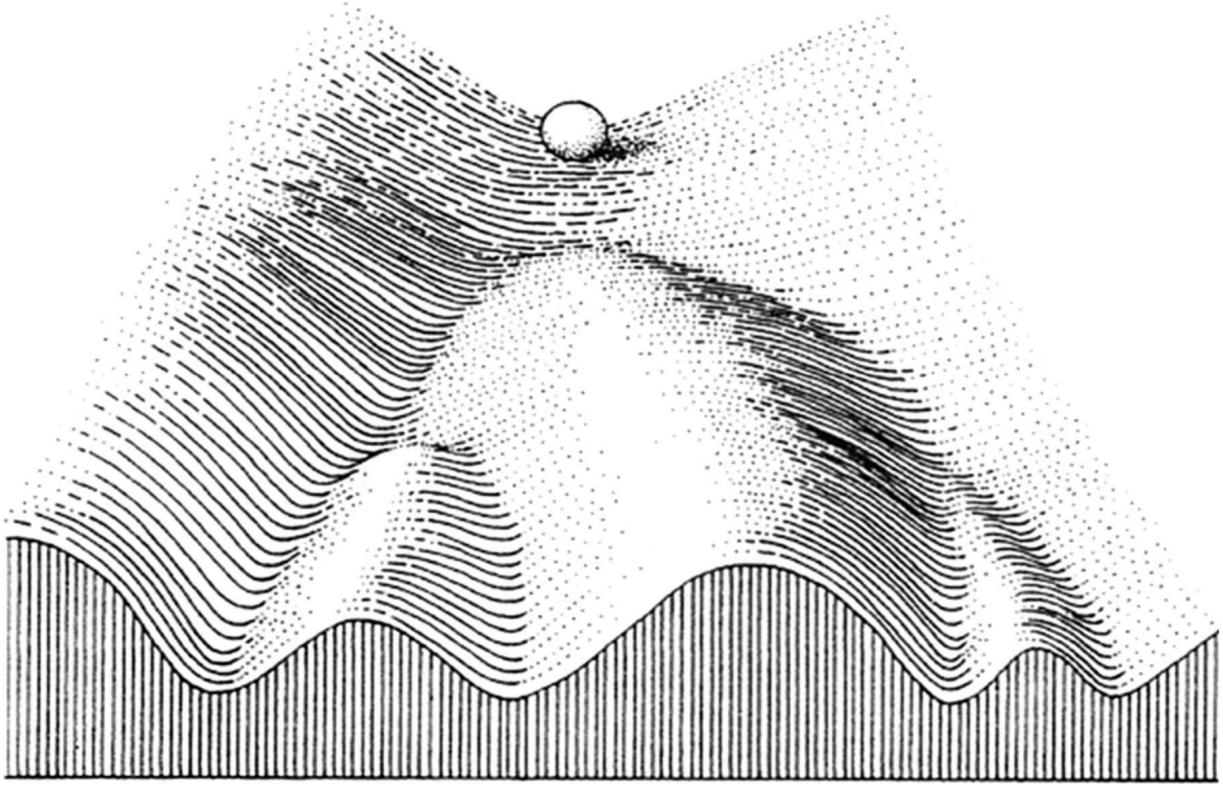
What can we do with stem cells?



But what about stem cells for myself?

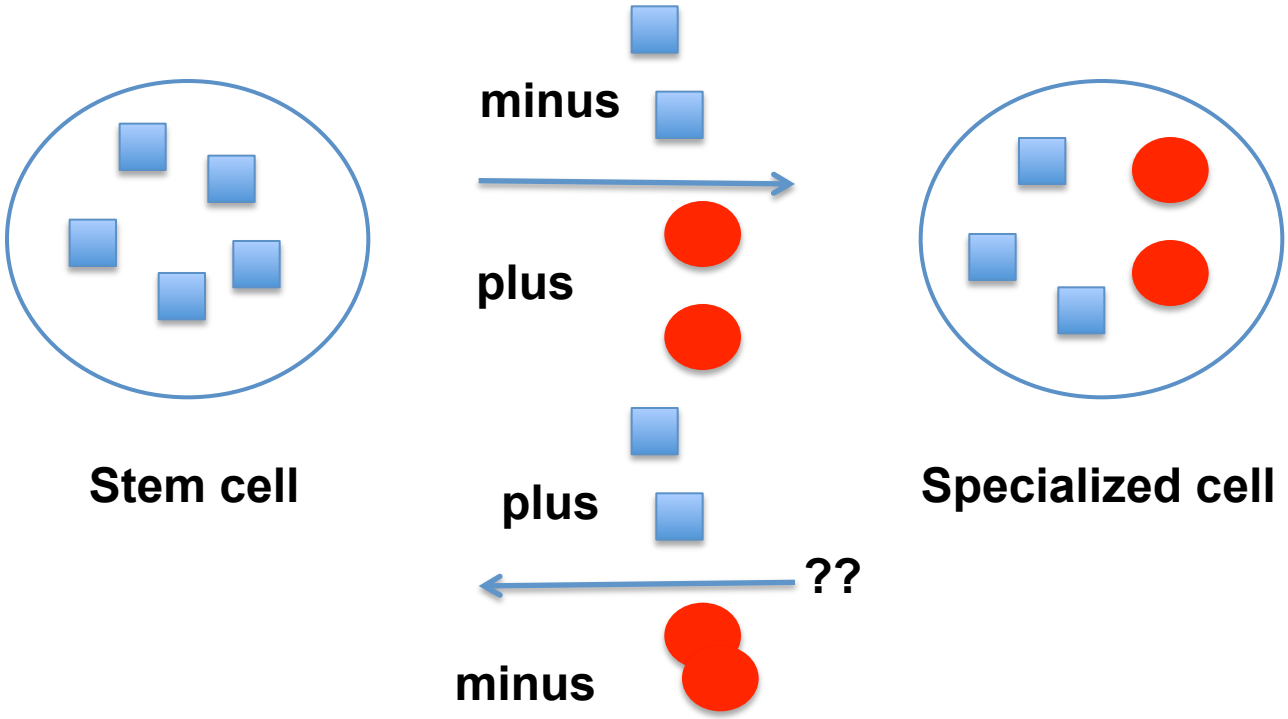


We can imagine a ball rolling down a hill, but back upwards?



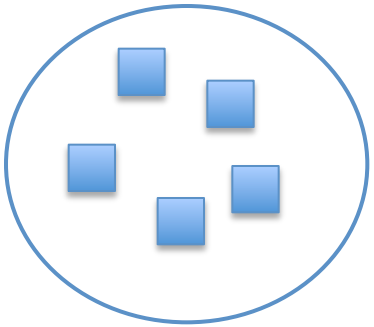
Is it possible to take a cell that is already performing a specific function and take it back to a state where it does not have a fixed role – aka stem cell state?

But how can we get stem cells from ourselves? Is there a magic solution?



Is this reversible? Can we subtract and add specific components to get back a stem cell?

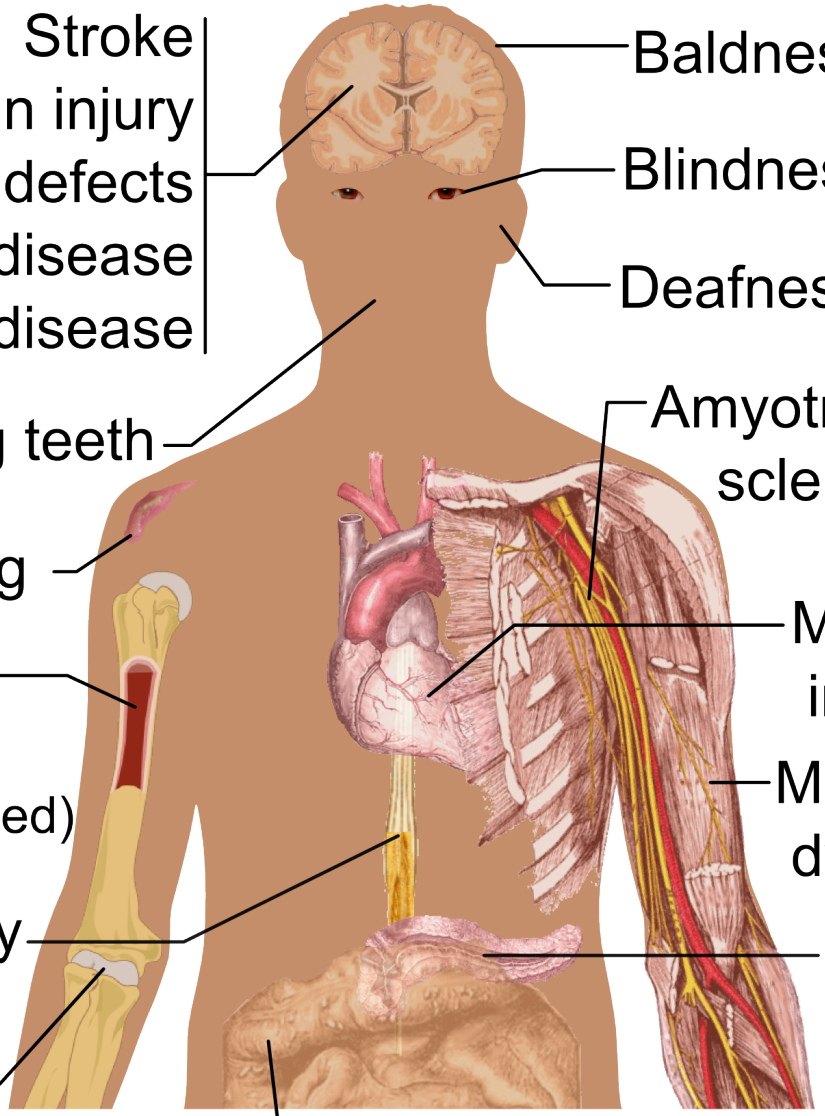
Yes! Now I can make stem cells from my own body cells by addition and subtraction



Stem cell

Reprogramming!

What can we do with these reprogrammed stem cells?



Stroke
Traumatic brain injury
Learning defects
Alzheimer's disease
Parkinson's disease
Missing teeth
Wound healing
Bone marrow transplantation (currently established)
Spinal cord injury
Osteoarthritis
Rheumatoid arthritis
Baldness
Blindness
Deafness
Amyotrophic lateral-sclerosis
Myocardial infarction
Muscular dystrophy
Diabetes
Crohn's disease
Multiple sites: Cancers

2 Nobel prizes – one for stem cells and one for reprogramming.

Physiology or Medicine 2007

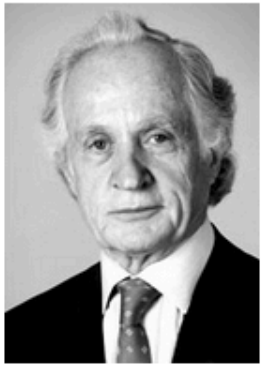


Photo: U. Montan

Mario R. Capecchi

Prize share: 1/3

Photo: U. Montan

Sir Martin J. Evans

Prize share: 1/3

Photo: U. Montan

Oliver Smithies

Prize share: 1/3

The Nobel Prize in Physiology or Medicine 2007 was awarded jointly to Mario R. Capecchi, Sir Martin J. Evans and Oliver Smithies *"for their discoveries of principles for introducing specific gene modifications in mice by the use of embryonic stem cells".*

The Nobel Prize in Physiology or Medicine 2012

Photo: U. Montan

Sir John B. Gurdon

Prize share: 1/2

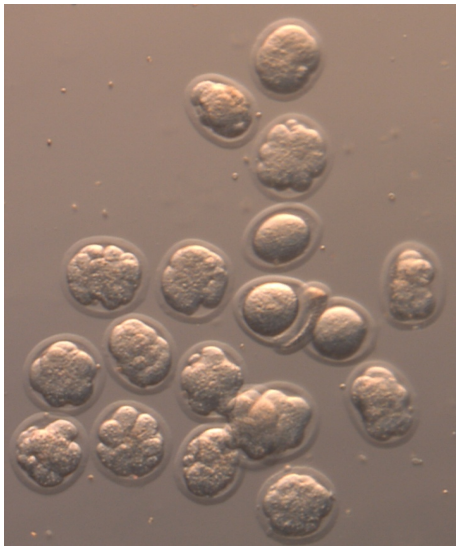
Photo: U. Montan

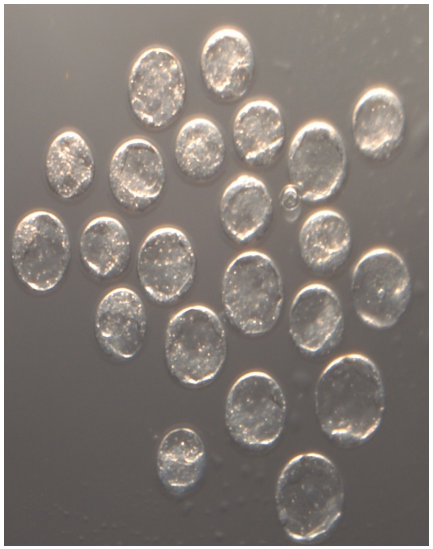
Shinya Yamanaka

Prize share: 1/2

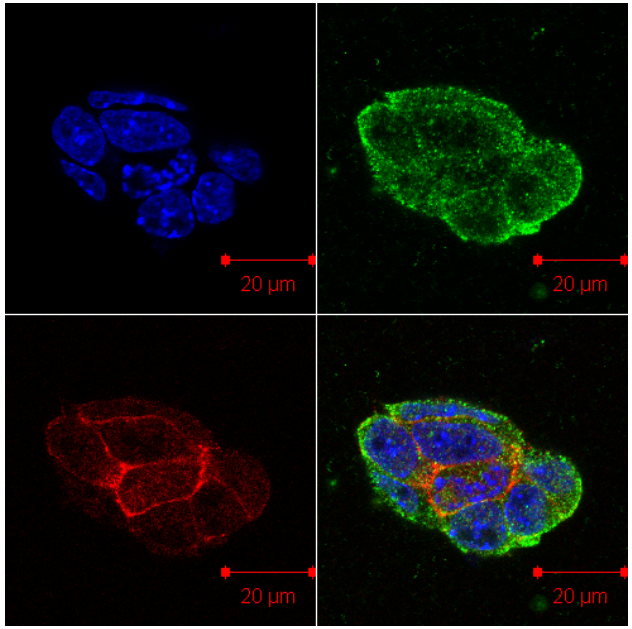
What is scientific research all about?

What do we do in our lab?





We study how embryos develop.



We study how stem cells become specialized cells.

The main question we ask is, whether moving molecules around within a cell affects what a cell becomes.

My trajectory to becoming a scientist

Completed school with Maths, Physics, Chemistry, Biology and English –ISC - 1996

BSc in Biochemistry-1999

Integrated MS-PhD from National Centre for Biological Sciences, TIFR, Bangalore-2005

Postdoctoral research from University of California at San Francisco-2012

Faculty at NCCS, Pune – since 2012.

Science as a career option- early options

1) IISER model – Integrated BS/MS- straight after class 12.
2) Fellowships such as KVPY, DST-Inspire.

Bhopal Kolkata Mohali Pune Thiruvananthapuram Tirupati

Science as a career option- slightly later options

1) Masters by research – Tata Institute of Fundamental Research, Mumbai.
2) Integrated MS/PhD –straight after BSc – NCBS Bangalore, Indian Institute of Science Bangalore, IISERs.
3) PhD – after MSc or BE, BTech – all research insitutes.

The important thing is not to stop questioning; curiosity has its own reason for existing – Albert Einstein

Thank you!