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[Music]

Hello, and welcome to Open Science.

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I'm Angel Otero from NASA Headquarters in Washington, DC.

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Today, I'm pleased to introduce Dr. Eduardo Almeida and Dr. Liz Blaber from the Ames Research

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00:00:19,950 --> 00:00:22,300

Center in California's Silicon Valley.

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Your team is doing exciting work with stem cells in space.

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First of all, Eduardo, tell me about stem cells.

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Well, stem cells are cells in the body that are responsible for tissue regeneration.

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That is adult stem cells.

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And so, we have reservoirs of these cells in the bone, in muscle, in the intestine,

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in the skin.

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And as our tissues wear out, those cells rebuild

the tissues.

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They repair fractures in bone.

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They remake the skin.

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They remake your red blood cells.

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They remake your immune system.

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So, those stem cells are really important for health because they are responsible for

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maintaining the body during adult life.

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Thank you.

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And what is tissue regeneration, and how do stem cells assist maintaining tissue health

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in bone, muscle, and immune systems?

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Well, that's precisely what I was talking about.

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Tissue regenerative health is the process by which, let's say, the bone marrow produces

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these lineages of cells that go on to remake
the tissue.

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00:01:29,509 --> 00:01:35,680
So, for instance, if you do not have good
regenerative health in the bone marrow, you

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may have an immune dysfunction, or you may
not make enough blood, or your bone may not

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00:01:40,619 --> 00:01:43,890
be repaired at a normal rate.

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So, the importance of stem cells is in maintaining
regenerative health in the whole body throughout

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00:01:50,460 --> 00:01:51,530
adult life.

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00:01:51,530 --> 00:01:52,960
Thank you.

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Liz, how does space flight affect tissue health
and stem cells, and how is the process of

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00:01:57,659 --> 00:01:59,890
tissue regeneration affected by space flight?

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So, when we talk about space flight, we're
really talking about two main factors, radiation

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00:02:05,640 --> 00:02:07,909
and exposure to microgravity.

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So, radiation is--primarily causes breaks in the DNA, or DNA damage.

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And--but, our main research area is looking at microgravity or mechanical unloading, so

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removing the load from the organism.

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So, we first started looking at this a few years ago with the Russians on Foton-M2 and

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00:02:29,379 --> 00:02:36,249

Foton-M3, and we were looking at stem cell-based tissue regeneration in an amphibian, the newt.

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And what Eduardo did in this experiment was he cut the newt tail off and then sent the

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animals to space.

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00:02:43,799 --> 00:02:50,859

And what the newts do in space is they de-differentiate and form a stem cell pool in the tail that

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can then re-differentiate and form all the lineages that are required in the tail.

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So, that's, you know, the bone, the muscle, the blood vessel, nerves, everything in the

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00:02:59,390 --> 00:03:02,099

tail.

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00:03:02,099 --> 00:03:08,489

And what we found was that the newts that were sent to space actually had a less differentiated

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00:03:08,489 --> 00:03:10,540

tail than the ones on the ground.

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00:03:10,540 --> 00:03:16,779

So, normally in stem cell differentiation and in tissue-based regeneration, what happens

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is that the stem cell will first proliferate and renew itself, and then it will produce

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00:03:21,459 --> 00:03:24,680

progeny cells that then go on to differentiate.

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00:03:24,680 --> 00:03:30,079

And what we found was that in the newt tails, a lot of the cells that were there were at

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00:03:30,079 --> 00:03:31,589

a more stem cell-like state.

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So, they were proliferating still as a stem cell, not as a differentiated progeny cell.

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So, in the newt tails that were on the ground, they had pigment.

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00:03:42,139 --> 00:03:43,489

They had a downward slope.

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They had a cartilage ridge.

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And the ones in space were still at an earlier stage of regeneration.

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And we also studied this process in both embryonic stem cells on experiments on STS-131 and STS-135,

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and also in a whole organism, a mammalian organism, the mouse.

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And what we found in both the embryonic stem cells and the adult stem cells from the mouse

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bone marrow was the same story.

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So, we found that the stem cells stayed as stem cells, and instead of differentiating,

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00:04:14,790 --> 00:04:20,419
they maintained their pluripotency or their ability to maintain stem-ness.

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And so, what we think is that some of these--you know, because the stem cells form all the

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00:04:26,810 --> 00:04:33,289
lineages in an organism, so for the adult stem cells, you have pools of stem cells that

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conform, for example, in the bone marrow.

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Bone marrow has mesenchymal stem cells and hematopoietic stem cells.

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These stem cells form the bone, the muscle, the cartilage.

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The hematopoietic stem cells form red blood cells, white blood cells, and so on.

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And so, what we think is that maybe some of the tissue degeneration effects that we see

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in space are due to this inability or potential inability of stem cells to differentiate into

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terminal cells and instead maintaining their pluripotency in space.

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Thank you.

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So, Eduardo, your research was in stem cells for mice.

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So, how are they similar or dissimilar to human cells?

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Well, the mouse is a model for a human, obviously.

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There are a lot of similarities, and there are a lot of things that are different.

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So, like any model, we use what we can learn from the mouse model, and a lot of the genetic

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material is similar.

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There's a lot of homology.

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And the same is true for a number of the molecular and cellular mechanisms that, let's say, are

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involved in bone loss or regenerative processes.

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But, there are differences.

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And so, one approach that we take is to use comparative physiology and comparative cell

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and molecular biology, and we look at multiple systems.

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A good example of that is the work we've done with the newt model, with the mouse model,

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with the stem cell model in culture.

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00:05:59,610 --> 00:06:05,689

And so, from all these different experiments,
you put together a puzzle that hopefully gives

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us a good perspective of what's happening
in the human in space flight.

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Thank you.

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So, Liz, why is the space biology program
interested on doing stem cells research in

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microgravity?

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: So, the space biology program really--its
goals are to understand how living organisms

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respond to space.

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00:06:25,849 --> 00:06:30,639

And, for example, in our research, we found
that, you know, stem cell differentiation

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and tissue-based regeneration is partially
inhibited in space flight.

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And this has really big consequences for long
duration space flight.

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So, a lot of our regenerative processes are
really fast.

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If you think about red blood cell turnover,
the turnover of your intestinal epithelium,

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things like that happen rapidly.

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But, some of the processes take months to
years to develop, and we found that after

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15 days, 30 days of space flight in mice that
we're seeing deficits in this regeneration

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process.

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So, this--you know, for long duration space
flight, this will have a lot of consequences

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for tissue degeneration that we can't foresee
at the moment.

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So, space biology is really helping us to
understand the fundamental response of an

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organism to space so that then we can apply
it to our future missions to keep our astronauts

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healthy and other living organisms healthy
in space.

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Thank you.

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And I think it also helps dovetail with what the human research program is doing.

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: Exactly.

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So, it's a good follow--lead in to the human research program research.

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So, Eduardo, how can the stem cell research in microgravity help us back here on Earth?

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Well, there are a lot of medical implications for regenerative health.

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So, this is a field that has exploded recently.

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There is a lot of research, a lot of important breakthroughs in regenerative medicine and

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then stem cell biology.

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And so, we're starting to understand much better than before how stem cells work, how

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they can help in repairing damaged tissues.

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So, there's great, great potential for stem cell regenerative-based regenerative medicine

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to be used for health and medicine.

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And NASA has a unique platform in microgravity to remove the mechanical stimulus of gravity

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from these stem cells and to understand really what's the importance of gravity at one g

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on Earth for maintaining health.

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We are finding that a lot of health processes depend on exercise, memory, for instance,

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muscle mass, bone mass.

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All these are linked to the regenerative processes that stem cells perform for us.

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And so, our work is pointing to a finding that gravity, mechanical stimulation from

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gravity from living here on Earth is really an important component of promoting stem cell

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health.

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And so, NASA has that platform on ISS that lets us then take away that mechanical stimulation.

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And that is a unique way of understanding the fundamental processes.

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So, it's a kind of experiment that cannot be performed anywhere else on Earth.

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Really, you require access to space and to the microgravity environment to answer the

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question, the hypothetical question, what if you take gravity away.

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What happens then to the stem cell regenerative processes?

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As Liz has indicated, we're really finding that the patterns of gene expression in stem

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cells, in the bone marrow, for instance, show that they are not progressing normally from

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00:09:42,300 --> 00:09:48,070

the stem cell to the differentiated tissue that functions in repair of the bone, let's

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00:09:48,070 --> 00:09:51,240

say, or in formation of blood and the immune system.

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00:09:51,240 --> 00:09:56,990

And so, that's really a very seminal finding because it tells us that our environment on

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00:09:56,990 --> 00:10:01,690

Earth requires that gravity stimulation for normal health.

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00:10:01,690 --> 00:10:07,370

And so, for long-term space exploration, we have to have these kind of findings in consideration

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in order to understand how to design habitats for astronauts for long-term voyages to Mars.

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And it's a part of doing basic science and understanding how life is shaped by gravity

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00:10:18,279 --> 00:10:19,279

on Earth.

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Thank you.

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Very interesting.

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Thank you both for the work being doing in your research group.

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It's great to have this exciting science being done off the Earth for the Earth.

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And thank you for joining us.

