Thomas Pesquet, the current star of French scientific research: *"If we could unlock the key to aging and figure out how to reverse it, that would be super convenient."* (translation)

Theme of the month: Regeneration

All living beings are capable, at different levels, of repairing damage to their organism.

In biology, regeneration is the capacity of living organisms to rebuild themselves after a natural or accidental destruction of a part of themselves.

Stem cells: the key to regeneration?
Regeneration can involve cells, organs or functional parts of certain living beings. The ability to regenerate is mainly carried by cells of the body that will reprogram themselves to replace the damaged tissue or organ. Some of these cells called "stem cells" are generated either by the bone marrow and can circulate in the body, or by the tissues themselves.

Regeneration in humans

The human body is constantly subject to cell death and regeneration. However, this regeneration is not exactly the same depending on the type of organs and cells.

Some cells are completely replaced by new ones in a very short time. For example, the cells of the intestines and stomach are only used for a few days before being evacuated by the body. The skin is completely renewed in a few weeks due to external aggressions. Some cells even live only a few hours, like white blood cells.

On the other hand, some cells are renewed slowly. For example, it takes about ten years for bones to be completely regenerated. Heart muscles regenerate by only 1% each year after the age of 20.

But our body also contains cells that never regenerate! This is the case of oocytes or certain neurons in the cerebral cortex.

We must not confuse regeneration and healing, even if they can be observed together, they are two very distinct phenomena. Healing is only a partial repair of the cells, but does not allow an identical reproduction.

We certainly cannot regrow a leg or an arm, but some animals can regenerate whole parts of their body!

Regeneration in living beings

The regeneration capacities of certain plants, notably trees, are remarkable. But the genetic and physiological functioning is so different from that of animals, and therefore also from that of humans, that there is no prospect of application against human senescence appearing conceivable in the short or medium term.

The ascidian, a curious small marine invertebrate in the shape of a wineskin, has the ability to renew its tissues very quickly after serious injuries. Other invertebrates, such as the flatworm and the planarian, can regenerate their head from a tail fragment and vice versa. These invertebrates are not the only animals with such regenerative powers.

Among vertebrates, too, we can find experts in regeneration. The axolotl, a small amphibian that can regrow its limbs, organs and even parts of its brain. The zebrafish regenerates its heart tissue without needing stem cells. Salamanders regenerate their limbs, heart, tail, eyes, kidneys, brain and spinal cord throughout their lives.

How do these animals with regenerative abilities manage to regrow such complex structures?

Understanding the regeneration process

After an amputation, stem cells accumulate at the site of injury in a structure called the blastema. A major part of current research focuses on how signals from the injury site indicate to stem cells to form the blastema and begin dividing to rebuild the missing structure.

But what happens at the level of the stem cells themselves? Do the animals use a single type of blastema stem cell that can differentiate into multiple tissues? Or do different groups of stem cells produce the different tissues required to form the new organ?

Recent research in animals with regenerative abilities has shown that stem cells use a variety of strategies to reconstitute missing body parts from multiple tissues, such as muscle, nerve and skin.

In this 2014 study, scientists combed through the 23,000 genes of Anolis carolinensis, a lizard about 20 centimeters long. Its complete genetic sequencing had already been completed in 2011. But this time, the study's researchers scanned all the genes during tail regeneration to isolate those responsible. The result: at least 326 genes are activated in the phenomenon, a real "recipe" in the lizard's DNA.

Another group of scientific researchers in the United States recently solved the mystery of planarian worm regeneration. They discovered that adult individuals have pluripotent stem cells that can make all types of cells in the animal's body.

In addition to stem cells, the regeneration process uses differentiated cells that have stopped dividing and "start" to multiply again to replace lost tissue. This phenomenon is present in zebrafish where a heart muscle cell divides to reconstitute the missing tissue. This regenerative process has also been demonstrated in the heart of young mice, but it quickly disappears as the animal grows.

Future Research and Challenges: Enabling human rejuvenation through regeneration

As adults, humans can regenerate certain organs such as the liver or skin. Unfortunately, many other human tissues do not have this ability. One of the goals of regenerative medicine is to find ways to stimulate tissue regeneration or make replacement tissues. One day, this could be one of the ways to "cure" humans of aging.

In December 2018, the scientist Michael Levin from Tufts University, demonstrated that by changing the electrical pattern between cells in the planarian worm this resulted in activation of cells indicating to the body its shape by guiding regeneration.

How to limit growth to what is useful (avoid cancerous growths)? How to "start", "reactivate" these mechanisms to allow the regeneration of organs that arenot destroyed, but senescent? This research requires a better understanding of the genetic and molecular mechanisms of regeneration.

Progress in the use of stem cells, gene therapy, and the knowledge of genetic mechanisms linked to regeneration open up considerable perspectives. This could well be one of the avenues studied by the USA in the framework of the initiative announced below.

Good News of the Month: U.S. President Joe Biden Announces Advanced Health Care Agency in First Address to U.S. Congress

"The Department of Defense has an agency called DARPA (Defense Advanced Research Projects Agency), whose mission is to develop advances to strengthen our national security. This agency gave birth to the Internet, GPS and many other things. The National Institutes of Health, NIH, should create a similar agency for advanced research projects in the health field. To develop breakthroughs - to prevent, detect and treat diseases like Alzheimer's, diabetes and cancer.

This is a personal issue for many of us. I can't think of a more worthy investment. And I don't know of anything more bipartisan. Let's end cancer as we know it. It's within our power." (Source)

The DARPA agency specializes in "disruptive" technologies. So this new agency could quickly target "disruptive" research in health and anti-aging.

To learn more about it:

- *See in particular:* heales.org, sens.org, longevityalliance.org *and* longecity.org.
- Source of the image