Cell Division

Case Study – Mitosis

Your Body is Younger than You Think by Nicholas Wade New York Times, August 2, 2005

Whatever your age, your body is many years younger. In fact, even if you're middle aged, most of you may be just 10 years old or less.

This heartening truth, which arises from the fact that most of the body's tissues are under constant renewal, has been underlined by a novel method of estimating the age of human cells. Its inventor, Jonas Frisen, believes the average age of all the cells in an adult's body may turn out to be as young as 7 to 10 years.

But Dr. Frisen, a stem cell biologist at the Karolinska Institute in Stockholm, has also discovered a fact that explains why people behave their birth age, not the physical age of their cells: a few of the body's cell types endure from birth to death without renewal, and this special minority includes some or all of the cells of the cerebral cortex.

It was a dispute over whether the cortex ever makes any new cells that got Dr. Frisen looking for a new way of figuring out how old human cells really are. Existing techniques depend on tagging DNA with chemicals but are far from perfect. Wondering if some natural tag might already be in place, Dr. Frisen recalled that the nuclear weapons tested above ground until 1963 had injected a pulse of radioactive carbon 14 into the atmosphere.

Breathed in by plants worldwide and eaten by animals and people, the carbon 14 gets incorporated into the DNA of cells each time the cell divides and the DNA is duplicated.

Most molecules in a cell are constantly being replaced but the DNA is not. All the carbon 14 in a cell's DNA is acquired on the cell's birth date, the day its parent cell divided. Hence the extent of carbon 14 enrichment could be used to figure out the cell's age, Dr. Frisen surmised. In practice, the method has to be performed on tissues, not individual cells, because not enough carbon 14 gets into any single cell to signal its age. Dr. Frisen then worked out a scale for converting carbon 14 enrichment into calendar dates by measuring the carbon 14 incorporated into individual tree rings in Swedish pine trees.

Having validated the method with various tests, he and his colleagues have reported in the July 15 issue of Cell the results of their first tests with a few body tissues. Cells from the muscles of the ribs, taken from people in their late 30's, have an average age of 15.1 years, they say.

The epithelial cells that line the surface of the gut have a rough life and are known by other methods to last only five days. Ignoring these surface cells, the average age of those in the main body of the gut is 15.9 years, Dr. Frisen found.

The Karolinska team then turned to the brain, the renewal of whose cells has been a matter of much contention. Prevailing belief, by and large, is that the brain does not generate new neurons after its structure is complete, except in two specific regions, the olfactory bulb that mediates the sense of smell, and the hippocampus, where initial memories of faces and places are laid down.

This consensus view was challenged a few years ago by Elizabeth Gould of Princeton, who reported finding new neurons in the cerebral cortex, along with the elegant idea that each day's memories might be recorded in the neurons generated that day.

Dr. Frisen's method will enable all regions of the brain to be dated to see if any new neurons are generated. So far he has tested only cells from the visual cortex. He finds these are exactly the same age as the individual, showing that new neurons are not generated after birth in this region of the cerebral cortex, or at least not in significant numbers. Cells of the cerebellum are slightly younger than those of the cortex, which fits with the idea that the cerebellum continues developing after birth.

Another contentious issue is whether the heart generates new muscle cells after birth. The conventional view that it does not has recently been challenged by Dr. Piero Anversa of the New York Medical College in Valhalla. Dr. Frisen has found the heart as a whole is generating new cells, but he has not yet measured the turnover rate of the heart's muscle cells.

Although people may think of their body as a fairly permanent structure, most of it is in a state of constant flux as old cells are discarded and new ones generated in their place. Each kind of tissue has its own turnover time, depending in part on the workload endured by its cells. The cells lining the stomach, as mentioned, last only five days. The red blood cells, bruised and battered after traveling nearly 1,000 miles through the maze of the body's circulatory system, last only 120 days or so on average before being dispatched to their graveyard in the spleen.

The epidermis, or surface layer of the skin, is recycled every two weeks or so. The reason for the quick replacement is that "this is the body's saran wrap, and it can be easily damaged by scratching, solvents, wear and tear," said Elaine Fuchs, an expert on the skin's stem cells at the Rockefeller University.

As for the liver, the detoxifier of all the natural plant poisons and drugs that pass a person's lips, its life on the chemical-warfare front is quite short. An adult human liver probably has a turnover time of 300 to 500 days, said Markus Grompe, an expert on the liver's stem cells at the Oregon Health & Science University.

Other tissues have lifetimes measured in years, not days, but are still far from permanent. Even the bones endure nonstop makeover. The entire human skeleton is thought to be replaced every 10 years or so in adults, as twin construction crews of bone-dissolving and bone-rebuilding cells combine to remodel it.

About the only pieces of the body that last a lifetime, on present evidence, seem to be the neurons of the cerebral cortex, the inner lens cells of the eye and perhaps the muscle cells of the heart. The inner lens cells form in the embryo and then lapse into such inertness for the rest of their owner's lifetime that they dispense altogether with their nucleus and other cellular organelles.

But if the body remains so perpetually youthful and vigorous, and so eminently capable of renewing its tissues, why doesn't the regeneration continue forever?

Some experts believe the root cause is that the DNA accumulates mutations and its information is gradually degraded. Others blame the DNA of the mitochondria, which lack the repair mechanisms available for the chromosomes. A third theory is that the stem cells that are the source of new cells in each tissue eventually grow feeble with age.

"The notion that stem cells themselves age and become less capable of generating progeny is gaining increasing support," Dr. Frisen said. He hopes to see if the rate of a tissue's regeneration slows as a person ages, which might point to the stem cells as being what one unwetted heel was to Achilles, the single impediment to immortality.

Conclusion Questions:

1. Which parts of your body are the “youngest” (they are replaced more than the other parts)?

2. Which parts of your body are the “oldest” (they are not replaced often or at all)?

3. What do you think we would be like if the brain divided as frequently as the liver?

4. This article addresses normal cell division in a human body. How would you refer to abnormal cell division in an organism?

5. Chemotherapy is treatment that cancer patients undergo. It kills cells, and prevents cells from dividing, hopefully killing the cancerous cells in the patient’s body. Why do you think a person’s hair falls out when they are undergoing chemotherapy to treat cancer?