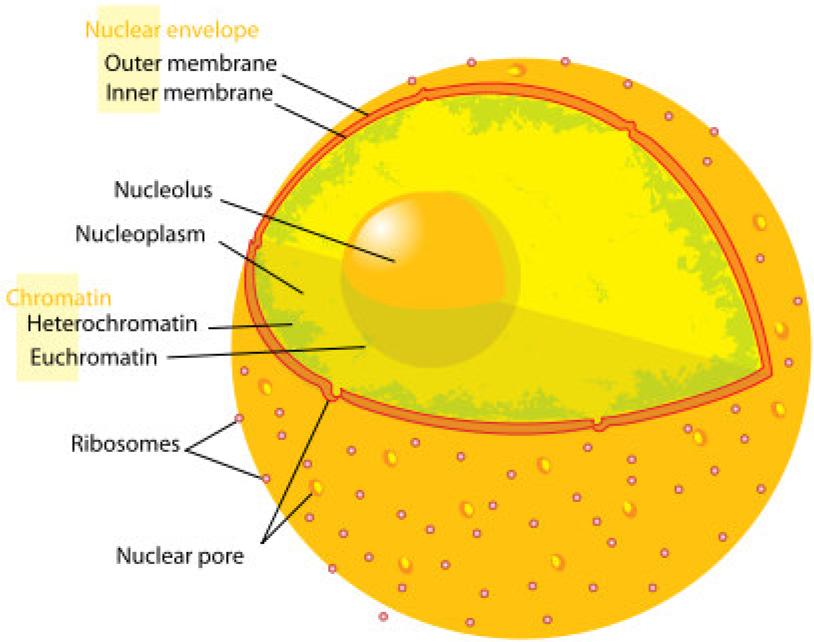
HUMAN CELL



IT STARTS WITH a single cell. The first cell splits to become two and the two becoe four and so on. After just forty-seven doublings, you have ten thousand trillion (10,000,000,000,000,000) cells in your body and are ready to spring forth as a human being.[1] And every one of those cells knows exactly what to do to preserve and nurture you from the moment of conception to your last breath.

You have no secrets from your cells. They know far more about you than you do. Each one carries a copy of the complete genetic code—the instruction manual for your body—so it knows not only how to do its job but every other job in the body. Never in your life will you have to remind a cell to keep an eye on its adenosine triphosphate levels or to find a place for the extra squirt of folic acid that's just unexpectedly turned up. It will do that for you, and millions more things besides.

Every cell in nature is a thing of wonder. Even the simplest are far beyond the limits of human ingenuity. To build the most basic yeast cell, for example, you would have to miniaturize about the same number of components as are found in a Boeing

777 jetliner and fit them into a sphere just five microns across; then somehow you would have to persuade that sphere to reproduce.

Your cells are a country of ten thousand trillion citizens, each devoted in some intensively specific way to your overall well-being. There isn't a thing they don't do for you. They let you feel pleasure and form thoughts. They enable you to stand and stretch and caper. When you eat, they extract the nutrients, distribute the energy, and carry off the wastes—all those things you learned about in junior high school biology—but they also remember to make you hungry in the first place and reward you with a feeling of well-being afterward so that you won't forget to eat again. They keep your hair growing, your ears waxed, your brain quietly purring. They manage every corner of your being. They will jump to your defense the instant you are threatened. They will unhesitatingly die for you—billions of them do so daily. And not once in all your years have you thanked even one of them. So let us take a moment now to regard them with the wonder and appreciation they deserve.

We understand a little of how cells do the things they do—how they lay down fat or manufacture insulin or engage in many of the other acts necessary to maintain a complicated entity like yourself—but only a little. You have at least 200,000 different types of proteinlaboring away inside you, and so far we understand what no more than about 2 percent of them do. (Others put the figure at more like 50 percent; it depends, apparently, on what you mean by "understand.")

Most living cells seldom last more than a month or so, but there are some notable exceptions. Liver cells can survive for years, though the components within them may be renewed every few days. Brain cells last as long as you do. You are issued a hundred billion or so at birth, and that is all you are ever going to get. It has been estimated that you lose five hundred of them an hour, so if you have any serious thinking to do there really isn't a moment to waste. The good news is that the individual components of your brain cells are constantly renewed so that, as with the liver cells, no part of them is actually likely to be more than about a month old. Indeed, it has been suggested that there isn't a single bit of any of us—not so much as a stray molecule—that was part of us nine years ago. It may not feel like it, but at the cellular level we are all youngsters.

The cell has been compared to many things, from "a complex chemical refinery" (by the physicist James Trefil) to "a vast, teeming metropolis" (the biochemist Guy Brown). A cell is both of those things and neither. It is like a refinery in that it is devoted to chemical activity on a grand scale, and like a metropolis in that it is crowded and busy and filled with interactions that seem confused and random but clearly have some system to them. But it is a much more nightmarish place than any city or factory that you have ever seen. To begin with there is no up or down inside the cell (gravity doesn't meaningfully apply at the cellular scale), and not an atom's width of space is unused. There is activity every where and a ceaseless thrum of electrical energy. You may not feel terribly electrical, but you are. The food we eat and the oxygen we breathe are combined in the cells into electricity. The reason we don't give each other massive shocks or scorch the sofa when we sit is that it is all happening on a tiny scale: a mere 0.1 volts traveling distances measured in nanometers. However, scale that up and it would translate as a jolt of twenty million volts per meter, about the same as the charge carried by the main body of a thunderstorm.

If you could visit a cell, you wouldn't like it. Blown up to a scale at which atoms were about the size of peas, a cell itself would be a sphere roughly half a mile across, and supported by a complex framework of girders called the cytoskeleton. Within it, millions upon millions of objects—some the size of basketballs, others the size of cars—would whiz about like bullets. There wouldn't be a place you could stand without being pummeled and ripped thousands of times every second from every direction. Even for its full-time occupants the inside of a cell is a hazardous place. Each strand of DNA is on average attacked or damaged once every 8.4 seconds—ten thousand times in a day—by chemicals and other agents that whack into or carelessly slice through it, and each of these wounds must be swiftly stitched up if the cell is not to perish.

The proteins are especially lively, spinning, pulsating, and flying into each other up to a billion times a second. Enzymes, themselves a type of protein, dash everywhere, performing up to a thousand tasks a second. Like greatly speeded up worker ants, they busily build and rebuild molecules, hauling a piece off this one, adding a piece to that one. Some monitor passing proteins and mark with a chemical those that are irreparably damaged or flawed. Once so selected, the doomed proteins proceed to a structure called a proteasome, where they are stripped down and their components used to build new proteins. Some types of protein exist for less than half an hour; others survive for weeks. But all lead existences that are inconceivably frenzied. As de Duve notes, "The molecular world must necessarily remain entirely beyond the powers of our imagination owing to the incredible speed with which things happen in it."

But slow things down, to a speed at which the interactions can be observed, and things don't seem quite so unnerving. You can see that a cell is just millions of objects—lysosomes, endosomes, ribosomes, ligands, peroxisomes, proteins of every size and shape—bumping into millions of other objects and performing mundane tasks: extracting energy from nutrients, assembling structures, getting rid of waste, warding off intruders, sending and receiving messages, making repairs. Typically a cell will contain some 20,000 different types of protein, and of these about 2,000 types will each be represented by at least 50,000 molecules. "This means," says Nuland, “that even if we count only those molecules present in amounts of more than 50,000 each, the total is still a very minimum of 100 million protein molecules in each cell. Such a staggering figure gives some idea of the swarming immensity of biochemical activity within us.”

It is all an immensely demanding process. Your heart must pump 75 gallons of blood an hour, 1,800 gallons every day, 657,000 gallons in a year—that’s enough to fill four Olympic-sized swimming pools—to keep all those cells freshly oxygenated. (And that’s at rest. During exercise the rate can increase as much as sixfold.) The oxygen is taken up by the mitochondria. These are the cells’ power stations, and there are about a thousand of them in a typical cell, though the number varies considerably depending on what a cell does and how much energy it requires.

You may recall from an earlier chapter that the mitochondria are thought to have originated as captive bacteria and that they now live essentially as lodgers in our cells, preserving their own genetic instructions, dividing to their own timetable, speaking their own language. You may also recall that we are at the mercy of their goodwill. Here’s why. Virtually all the food and oxygen you take into your body are delivered, after processing, to the mitochondria, where they are converted into a molecule called adenosine triphosphate, or ATP.

You may not have heard of ATP, but it is what keeps you going. ATP molecules are essentially little battery packs that move through the cell providing energy for all the cell’s processes, and you get through a lot of it. At any given moment, a typical cell in your body will have about one billion ATP molecules in it, and in two minutes every one of them will have been drained dry and another billion will have taken their place. Every day you produce and use up a volume of ATP equivalent to about half your body weight. Feel the warmth of your skin. That’s your ATP at work.

When cells are no longer needed, they die with what can only be called great dignity. They take down all the struts and buttresses that hold them together and quietly devour their component parts. The process is known as apoptosis or programmed cell death. Every day billions of your cells die for your benefit and billions of others clean up the mess. Cells can also die violently—for instance, when infected—but mostly they die because they are told to. Indeed, if not told to live—if not given some kind of active instruction from another cell—cells automatically kill themselves. Cells need a lot of reassurance.

When, as occasionally happens, a cell fails to expire in the prescribed manner, but rather begins to divide and proliferate wildly, we call the result cancer. Cancer cells are really just confused cells. Cells make this mistake fairly regularly, but the body has elaborate mechanisms for dealing with it. It is only very rarely that the process spirals out of control. On average, humans suffer one fatal malignancy for each 100 million billion cell divisions. Cancer is bad luck in every possible sense of the term.

The wonder of cells is not that things occasionally go wrong, but that they manage everything so smoothly for decades at a stretch. They do so by constantly sending and monitoring streams of messages—a cacophony of messages—from all around the body: instructions, queries, corrections, requests for assistance, updates, notices to divide or expire. Most of these signals arrive by means of couriers called hormones, chemical entities such as insulin, adrenaline, estrogen, and testosterone that convey information from remote outposts like the thyroid and endocrine glands. Still other messages arrive by telegraph from the brain or from regional centers in a process called paracrine signaling. Finally, cells communicate directly with their neighbors to make sure their actions are coordinated.

What is perhaps most remarkable is that it is all just random frantic action, a sequence of endless encounters directed by nothing more than elemental rules of attraction and repulsion. There is clearly no thinking presence behind any of the actions of the cells. It all just happens, smoothly and repeatedly and so reliably that seldom are we even conscious of it, yet somehow all this produces not just order within the cell but a perfect harmony right across the organism. In ways that we have barely begun to understand, trillions upon trillions of reflexive chemical reactions add up to a mobile, thinking, decision-making you—or, come to that, a rather less reflective but still incredibly organized dung beetle. Every living thing, never forget, is a wonder of atomic engineering.

Excerpts from
A short history of nearly everything- by Bill Bryson
Courtesy – A.K.Otta

For further information please visit:
http://people.eku.edu/ritchisong/RITCHISO/301notes1.htm