A few years ago, meat and poultry industries were rudely shocked at the outbreaks of mad cow disease and bird flu. At the same time demand for healthy meat is growing. A global survey says that China's meat demand is doubling every ten years and consumption of poultry products in India has doubled in the last five years. It is estimated that world's meat consumption would double by 2050 and there would not be enough livestock to meet this demand.

Is there any alternative to the disease-prone, farm-based meat production? Scientists feel that in the long run cultured meat, that is, meat grown in the laboratory may be the answer. More than five decades ago, cell biologists laid the foundation of stem cell research by growing mammalian cells in the laboratory. With the discovery of embryonic stem cells, tissue engineers have been able to apply cell culture techniques to grow human organs such as bladder for organ transplant. Now food technologists have used the same techniques to demonstrate the feasibility of growing meat in vitro, that is, in the laboratory. In fact, NASA scientists had succeeded in culturing turkey muscle cells and goldfish cells as a potential way to feed astronauts on long space missions.

In a seminal paper published in the journal *Tissue Engineering* (Vol. 11, No.5/6, 2005) researchers discussed alternatives for producing cultured meat. They found that the most practical cell source for culturing meat would be either myoblasts or skeletal muscle cells called satellite cells. Both are quiescent cells that live on the edges of muscle fibers. Since partly differentiated, they are already on their way to becoming muscle cells and can be more easily directed along that path.

The production of cultured meat begins by taking a few satellite cells from a farm animal and multiplying them in a liquid medium that provides glucose, amino acids, minerals, vitamins, etc. They are then attached to a scaffold and grown in stationary or rotating bioreactors for further proliferation and differentiation. Two types of scaffolds, made out of edible material such as collagen, have been designed. One of them is a grooved biofilm and the other comprises of porous micro spheres.

At this stage cells fuse into myotubes that differentiate into muscle fibers. The process of differentiation is further stimulated by stretching the scaffold just by ten percent at a time, by changing the temperature or pH of the growth medium. Stretching also helps in giving a structure to the cultured muscle fiber as in a well-exercised animal. While myofibers grown on sheet scaffolds can be laid over one another to a substantial thickness for

In vitro cultured meat will address the growing demand for meat in the future, minus the cruelty inherent in producing it.

Most animal meat is made of skeletal muscle tissue, which is a completely differentiated tissue. Differentiation is a process by which cells mature to become functional cells of a given type. In the process they lose the capacity to proliferate. Hence, skeletal muscle cells cannot be directly cultured in a laboratory. Embryonic stem cells can be coaxed to become any type of cells. Though they have an infinite capacity to proliferate they have a long way to go before turning to skeletal muscle cells. Besides scientists have not been able to understand the exact cues that direct them towards becoming a particular cell type. The next choice is to look for adult stem cells – undifferentiated cells found in many tissues. They can also multiply to renew their population and also differentiate to regenerate the tissue in case of damage or disease.

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use in hamburgers, those grown on microspheres can be processed to make sausages.

**Advantages of Cultured Meat**

This technology has a number of advantages. In theory, cells taken out from a hand full of animals without sacrificing them could produce the world’s meat supply.

Currently, farm animals are inhumanly bred for the sole purpose of making them as fat as possible. New born calves are separated from their mothers, deliberately made anemic, denied roughage, kept stacked like mailbags in stalls so narrow that they cannot move. In USA alone 9 billion animals are killed every year to produce meat! In vitro meat production puts an end to all such cruelty. Furthermore, the meat produced will be free from animal infections caused by Salmonella, Campylobacter, E. coli, and so on.

Add to this the direct environmental impact of farming animals for food – the cropland, water and pesticides for growing farm feeds, the input required to house, transport and slaughter animals. In fact, breeding animals for meat is considered to be one of the most energy inefficient processes. Farm animals will have skin, legs, bones, digestive organs, etc which are not edible and are thrown out as waste. They also produce a significant amount of greenhouse gases.

The nutritional value of the meat can be more easily controlled. Jason Matheny, one of the authors of the above paper says, “Most meats are high in the fatty acid omega-6, which causes high cholesterol and other health problems. With in vitro meat one can replace the fat cells with those that produce omega-3, which is healthy fat.”

**A Million Dollar Question**

The technology, however, is not ready to place a piece of steak on the dinner plate. Prof. Mark Post of the University of Netherlands, who is in the forefront of research on in-vitro meat production, announced last December that he has been able to grow pieces of cow muscle about 2 cm long, 1 cm wide and 1 cm thick – some 3000 such pieces are required to make one hamburger! He hopes to produce the first hamburger with beef grown in a laboratory. Even then it will be a proof of concept showing how stem cells can be used to make a product that looks, feels and, hopefully, tastes like meat.

Hamburgers and sausages are processed meat. The greater challenge is to produce highly structured meat like steak, chicken breast etc. One of the approaches would be to seed the bioreactor with small tissue explants, like growing crystals in a physics laboratory, to grow thick, structured muscle chunks. Explants have the advantage of containing, in the right proportion, all types of cells composing muscle.

However, the biggest problem is in ensuring constant supply of nutrients to the growing cell mass, without which the cells will die. While it is accomplished in live animals by blood circulating through fine capillaries, scientists are yet to figure out a suitable scaffold structure that can take nutrients to all cells.

Another important aspect is cost of production. Prof. Post’s first laboratory grown hamburger will be produced at a cost of US $ 345,000. But that does not mean that in vitro meat will remain just a fantasy. The organization known as People for Ethical Treatment of Animals (PETA) has announced a prize of US$ one million for any one who can develop a commercially viable procedure for in vitro meat production. “In vitro Meat Consortium” – a group formed by international researchers interested in this technology – held their first international conference in Norway in April 2009 to discuss commercial possibilities of producing in vitro meat at affordable cost. As of 2012, more than 30 laboratories around the world are working on in vitro meat research.

Prof. Post’s cost estimation of his first hamburger includes the money that has gone to develop the laboratory. Experts assure that with further developments in biotechnology and as more meat is produced on an industrial scale the cost will come down. Ultimately it may be about twice the cost of conventionally produced meat – a small price we have to pay for all the advantages that come with the use of in vitro meat.

They cite examples of “technologies now found in virtually every house hold – computers, the Internet, freeze-dried foods and so on that originally cost too much for mass acceptance. So, why not cultured meat? Scientists at New Harvest – an organization actively engaged in promoting cultured meat – envisages a counter-top device, like a bread machine, which could produce the meat we need in our own kitchens.

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