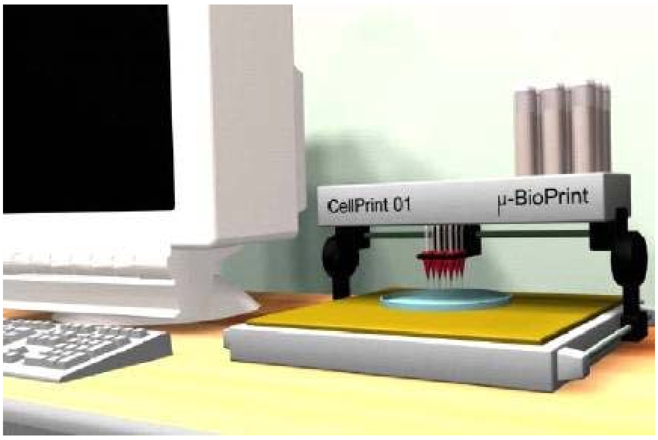
Ink Jet Printers That Produce Living Tissues

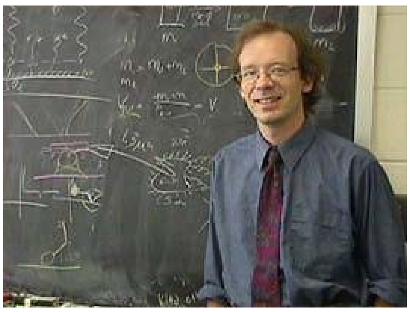


Ink jet printer modified to contain cells, proteins and other biological molecules,
instead of colored inks. The goal is to pinpoint specific biological units in precise X and Y
coordinates on plastic sheets to grow tissue, in the same manner that ink jet printers distribute dots
of color on paper. Photograph © 2003 by Thomas Boland, Ph.D., Clemson University, Clemson, South Carolina.

January 25, 2003 Clemson, South Carolina - According to bioengineer, Thomas Boland, at Clemson University in South Carolina, a future is coming in which ink jet printer technology will provide hospitals with full grown organs for transplant into diseased patients - starting from a flat sheet!

Dr. Boland was born in Dinslaken, West Germany and traveled to Toulouse, France, to study chemical engineering. Then in 1995, he completed his chemical engineering Ph.D. at the University of Washington in Seattle. He began working for Clemson University in 1999 and began his research with ink jet printers to produce tissues with great skepticism. Today, he thinks the process will help pharmaceuticals test drugs on various organs, human or animal, and ultimately will provide fresh, whole organs for the growing transplant demand.

Interview:



Thomas Boland, Ph.D., Asst. Prof. of Bioengineering,
Clemson University, Clemson, South Carolina.
Photograph provided by Professor Boland.

Thomas Boland, Ph.D., Asst. Prof. of Bioengineering, Clemson University, Clemson, South Carolina: "When I started this work maybe a year and a half or two years ago, we were thinking of using ink jet printers to print biological molecules instead of ink. These molecules could be proteins, DNA and some others.

BUT WHY AN INK JET PRINTER?

Because they are an affordable means to pattern particular proteins or molecules on a surface. And we were interested in studying patterns of cells, for example.

IS IT BECAUSE HEAT IS INVOLVED IN AN INK JET PRINTER?

No. It is just a convenient way for us to reproducibly place molecules in a certain X and Y position on a support. Ink jet printers do just that. We actually - in our experiments - turn off the heat because it will damage the cells. We just use pressure that is put on the cartridges. In fact the mechanism is pretty much the same as an ordinary ink jet printer.

WHAT IS IT THAT YOU PUT THROUGH THE INK JET PRINTER?

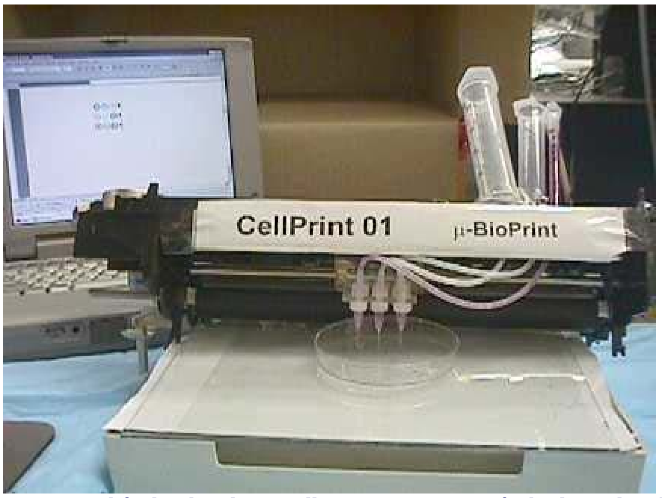
I usually empty out the cartridges and clean them very thoroughly and then we fill the cartridge with whatever we would like to print for a particular experiment. Sometimes we use proteins or other molecules. Sometimes we use cells, depending upon the structure we would like to do. We have the printer hooked up to a computer and we open up a file, like a Power Point file, and make a design of what we would like to print and then print.

HOW ARE YOU GETTING THE CELLS OR THE PROTEINS OUT OF THE ROLLER ON TO A VERY PARTICULAR PART OF IS IT PAPER OR PLASTIC?

It's plastic. We are using plastic. The cartridges themselves have actually been ordered, so it's at the bottom of the cartridge where your ink or in our case, the cells would come out. And the cartridge sits on top of a horizontal, usually a horizontal bar that can move right and left. Then the roller just moves the paper. In our experiment, we have sometimes taken the rollers off and reassembled them so the rollers are now moving a glass slide or Petri dish or sometimes a transparency, a plastic sheet, onto what we would like to print.

BUT YOU CAN'T PUT A PETRI DISH THROUGH AN INK JET PRINTER.

Right. In the case of Petri dishes, we actually disassemble the entire printer and reassemble it so that instead of having to feed a sheet we just have everything laid out flat in front of us and the only movement that the paper does, or our Petri dish does, is move back and forth underneath the cartridge and the cartridge moves on top in the other direction, X and Y.



Ink jet printer modified to lay down cells, proteins or specific biological molecules
in precise patterns with X and Y coordinates on a Petri dish.
Photograph © 2003 by Thomas Boland, Ph.D.

SO, WHAT YOU ARE DOING IS MOVING THE PLASTIC MATERIAL AGAINST WHATEVER IS IN THE PETRI DISH TO GET IT TO CLING ONTO THAT PLASTIC?

Correct. Sometimes we would just use the rollers to move a sheet such as a transparency slide and we would glue our Petri dish on top of that. And so as the paper is moved by the rollers, the Petri dish moves as well and then another thing on top shoots down into the Petri dish.

WHY ARE YOU GOING TO ALL OF THIS TROUBLE TO USE PROTEIN AND CELLS IN INK JET PRINTERS?

One of the current challenges in tissue engineering which is the growing of organs and tissues to replace diseased organ is that at this point not more than one cell type be ordinarily seated onto a scaffold to make an organ. However, you need many cell types that would function in conjunction to have a functioning organ.

Now, using an ink jet printer, because just as the printer has the ability to print different colors out of different cartridges, we can fill each cartridge with a different cell type or different protein or different growth factor and then deliver these to the specified locations (on the plastic sheet that goes through the ink jet printer).

AND ONCE YOU'VE GOT THE DIFFERENT CELLS AND PROTEINS ON THIS SHEET OF PLASTIC THAT CAN GO THROUGH THE INK JET PRINTER, HOW DO YOU GO FROM THERE TO PRODUCING AN ORGAN?

Yes, that is a big challenge! So far, we have shown that when we take these cells and have them go through this process, the cells will stay alive. That was our main goal to find out can we actually do this. So, we have proven that they not only stay alive during this process, they tend to fuse and aggregate which shows some biological function. Much work still needs to be done to find out what other changes the cells go through biological changes that we haven't measured yet.

Also, there is a challenge in how to do this in 3 dimensions. Right now, what we do is have the cartridge move back and forth over the same areas, and you can kind of layer the cells, but there is a limit to how thick we can layer it. So, it is a huge challenge of extending this (process) into the 3rd dimension which requires a lot of work.

I would think ink jet printing, if this technology works out, may be used for organs that are have a distinct 3-dimensional shape such as a kidney or liver and profuse with blood by the blood vessels.

YOUR GOAL IS TO TRY TO MAKE THESE KINDS OF ORGANS BECAUSE THERE IS SUCH A DEMAND FOR ORGANS IN TRANSPLANTS?

One of my collaborators is interested in this. I personally think there is a lot of interest not only in human transplantations, but in drug companies using these tissues as test beds for some of the drugs they are working on. They can make them it's a computer-controlled machine, so they can make many of them which are all fairly consistent.

HOW LONG DO YOU THINK IT IS GOING TO BE UNTIL YOU SEE A 3-DIMENSIONAL ORGAN GROW UP FROM THIS PLASTIC SHEET?

Right now, we are getting a network of capillaries formed in 3 dimensions. I think this will take us until the end of this year or into next year to do this. then after that, if this works successfully it is everyone's guess, depending on the kind of collaborators and expertise we can assemble and the organ we concentrate on it might take another year or two to finish that work.

IN TWO OR THREE YEARS, IF YOU ARE SUCCESSFUL IN GROWING THE 3-DIMENSIONAL ORGAN, WHAT HAPPENS NEXT?

Well, I haven't thought about that yet. My primary goal is to overcome other limitations of tissue engineering at this point. I'm just looking at the technical side of it. I would imagine there will be many - let's say this works out, many hospitals would probably have this technology on hand where if a patient would need a particular organ, they would just go and collect a sample of the patient's cells and have them grow into an organ and re-implanted (in the patient).

IT'S ALMOST LIKE THE HOLODECK ON STAR TREK?

Yes, that's how I describe it to my graduate students. If they a machine called a "replicator," basically that's kind of what we are doing.

IT'S AMAZING.

Yes, it is. And we were skeptical at the beginning, but so far it is amazing to us just to think that you can print it (cells and proteins) out on an X & Y axis."

Websites:

http://www.ces.clemson.edu/bio/people/boland/boland.htm

Credits