I was watching a program on the Discovery Channel about how scientists were attempting to gain a better understanding of how genetics by trying to reverse-engineer a chicken into something more dinosaur-like. One thing that the scientists on the show accomplished was to have embryonic chicks develop tails by repressing certain genes. Could you better explain to me how they accomplished this?

Hello Daniel. What a great question. Doesn't the dino-chicken project sounds like a real-life version of Jurassic Park?! Actually, the main scientist behind the project, Jack Horner, served as the technical advisor for the Jurassic Park films. He is interested in how embryological development in chickens can help us understand dinosaur DNA. You see, chicken DNA contains remnants from their dinosaur ancestors. If scientists can control the expression of some genes, and basically silence chicken-specific development, they can essentially uncover the remnant ancestral dinosaur genes, and see what grows during this altered chicken development. It's almost like unlocking the secret dinosaur growth patterns within a chicken embryo.

It's strange to think that these ancient dinosaur traits are lurking silently in birds. Actually, birds have latent abilities to grow teeth, scales, hands and even tails with lots of vertebrae! And, if you look at a chicken embryo through even a fairly low magnification microscope, you can see that it goes through a stage of development when it has a dinosaur-like tail. In the normal course of chicken embryo development, something stops the growth of this tail, so that the chicken ends up with a stunted structure called the pygostyle instead. Over the course of evolution, from dinosaur days to modern day chicks, the growth and purpose of this hodgepodge of dinosaur tail bones was redirected. Nowadays, scientists can use molecular genetic techniques to ask which genes changed during this evolutionary time period, and eventually caused the tail to go away. Essentially, scientists can turn back the evolutionary clock, through the specific study of the genetic switches that control development.

So, here is a general overview of how you can do such an experiment with a chicken embryo, and what the molecular genetic manipulation techniques are. First of all, you need a chicken embryo. This is basically just an undeveloped egg that you know has been fertilized. With these eggs, you can carefully remove part of the shell to create a window onto the embryo. As long as you keep this window covered, and keep the egg under sterile conditions, the embryo will continue to grow normally. This window not only allows you to observe the embryo as it grows, but it also allows you to manipulate something, then continue to watch how the embryo changes or grows differently after your manipulation!

To experimentally turn genes on or off in a chicken embryo, you need to introduce something that will interact with the chicken embryo's DNA. This is usually extra genetic material, such as a gene sequence that codes for a protein called a transcription factor. When this extra genetic sequence is introduced into

the chicken embryo, it will be read by the cells there and the transcription factor protein will be produced. When a transcription factor changes the expression of certain genes during embryonic development, this can have a potent effect on the way an embryo is shaped. Scientists already know what some of those shape-controlling genes are (transcription factors or other regulatory genes), so they basically go after those first. They can either turn those genes on or off, which will indirectly control the expression of different sets of other genes. So how do you introduce extra genes into a chicken embryo? To do this, you have to do something called transfection.

Transfection is when you introduce nucleic acids (extra DNA or RNA) that will disrupt expression of a certain gene. To perform transfection, scientists create transient holes in the cell membranes of the chick embryo, through which the genetic material can pass. These holes can be created chemically, with calcium phosphate or cationic lipids, or electrically, by passing a small amount of electric current through the embryo. When these holes open up, the genetic material can pass into some of the embryo's cells and, with some luck, will become incorporated into the animal's nucleus. There, they will control the expression of the chicken embryo genes.

Horner's lab can use techniques like these to experiment with different on / off switches for gene expression. Through trial and error, and watching how the embryo turns out after each transfection experiment, they can eventually figure out which genes control tail development. Ultimately, these types of experiments could have a broader impact than just telling us how chickens may have evolved from dinosaurs (though that's pretty interesting in itself!). The results could illuminate spinal cord development in general, and direct scientists to therapies that are relevant for human spinal cord injury.

To learn more about making windows on eggs for scientific experiments, check this out:
http://www.jove.com/index/details.stp?ID=306

The Larsson lab at McGill University is doing amazing research on this front: http://redpath-staff.mcgill.ca/larsson/home.htm.

For more on embryology, development, and evolution, see:
http://www.nature.com/scitable/topicpage/Atavism-Embryology-Development-and-Evolution-843

For more on Jack Horner's research, check out his book, *How to Build a Dinosaur*, or visit his lab website:
http://www.montana.edu/wwwes/facstaff/horner.htm.