Everybody Loves Baby Chicks:

A proposal for a demonstration on chick development at the Museum of Science and Industry

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I. Introduction

Chickens provide a unique opportunity to observe embryonic development. Because they lay eggs instead of giving live birth, one has easy access to embryos at many stages of development. During the first four days of embryonic development, the chick heart is formed. By the third day, it is beating. Due to the size of the embryos, this is easily seen even without a magnifying glass.

At the Museum of Science and Industry, one of the most popular exhibits is the chick hatchery. On any given day, you can see many, many people watching the chicks hatch. This exhibit is currently part of the Genetics exhibition. While the hatchery no doubt draws many people into the genetics exhibit that would not normally go in, there does not seem to be a direct connection drawn between the hatchery and the subject of genetics. The hatchery sits between an exhibit on development and the demonstration area for the genetics exhibition. Creating a demonstration centered on chick development will be a way to more concretely link the hatchery to the exhibition in which it resides.

The purpose of the demonstration will be to explain that genes turn on and off to make proteins that help create specific structures during development. The demonstration will focus on heart development in the early embryo in particular because it is the first organ to start forming, is easily seen in early embryos, and the majority of early term human miscarriages are caused by abnormal heart development (which will give the public a way to relate the demonstration back to their own lives).

The target audience for this demonstration is people 10 and older. While this proposal focuses on creating a demonstration within the genetics exhibition, one could also imagine the demonstration being carried out using a media cart near the prenatal development exhibit, emphasizing some of the similarities and differences between human and chick early development, or could be part of a learning lab on embryology for high school students. Two types of demonstrations are described here, one with live embryos and one with preserved specimens.

II. Materials and Methods

*A. Live Embryo*s

Currently, the museum has access to eggs for its hatchery. For a demonstration that is done everyday, four freshly laid eggs will be obtained and kept in an incubator. The eggs

will be incubated from one to four days in the incubator. Each demonstration will use four embryos, one each from embryonic days one through four. Embryos will be removed from the shell by delicately cracking the eggs with a small sharp object then removing bits of shell using tweezers until the egg can be successfully poured into a Petri dish. The embryos will remain in the Petri dish (covered) until the end of the day, and then discarded in normal waste. If the museum does not wish to use it's own eggs, it may obtain them from an organic farmer.

B. Preserved Specimens and Slides

A set of six preserved chick embryos and slides of whole mounted early embryos (chick embryos at 24 hours, 33 hours, 48 hours, 72 hours, and 96 hours) will be obtained from Carolina (www2.Carolina.com).

C. Observing Live Embryos

The embryos will be presented to the public in covered Petri dishes. To see fine detail, the demonstrator will use a Proscope (www.x-tremegeek.com) connected to an ordinary TV (Fig. 1). The Proscope is a digital microscope capable of 200X magnification that connects to any TV using an RCA feed.

Figure 1. Proscope [1]

D. Observing Preserved Specimens and Slides

The demonstrator will use the Proscope to show the slides of the early embryos to the public. The public may examine the preserved later stage embryos using magnifying glasses.

E. Program

The demonstrator will start by explaining that DNA has genes that code for proteins that carry out the function of the gene. S/he will then explain the idea that genes turn on and off to make certain structures in the body. The demonstrator will then briefly discuss

chick heart development, drawing parallels to human heart development. The demonstrator will then use the Proscope to show the audience the heart in each of the four live embryos or on the slide. Finally the public will be invited to come look at either the live embryos or the preserved specimens using a magnifying glass or the Proscope.

III. Budget

A. Both Demonstrations

Equipment	Cost
Proscope Tv, 200x handheld video microscope (X-tremegeek.com #142-0866)	$99.99
TV, 24" (Circuit City)	$140-$180
Megalens magnifying glasses, 10 (Carolina # 95-3807)	$50.00 ($5.00 each)
Total	$290-$330

B. Live Embryos

Equipment	Cost
Four fertilized eggs each day	Negligible if obtained from the museum
Glass Petri dishes, 100 x 15mm, pack of 12, reusable (Carolina #72-1134)	$47.40
Gloves, box of 100 (Carolina, various sizes # 70-6380, 70-6381, 70-6382)	$14.95
Total	$63.35

C. Preserved Specimens and Slides

Equipment	Cost
Chick embryo set from Carolina including poster of entire 21-day development cycle (#22-7952)	$46.40
Chick, 24-hour whole mount slide (#31-1520)	$12.20
Chick, 33-hour whole mount slide (# 31-1562)	$12.10
Chick, 48-hour whole mount slide (#31-1592)	$11.95
Chick, 72-hour whole mount slide (#31-1634)	$12.25
Chick, 96-hour whole mount slide (#31-1632)	$21.20
Total	$105.10

D. Total Start-up Costs

Live Embryo Demonstration (including cost of a TV)	$353-$393
Live Embryo Demonstration (not including TV)	$213
Preserved Specimen Demonstration (including TV)	$395-$435
Preserved Specimen Demonstration (not including TV)	$255

IV. Ethical concerns in using live embryos

Embryos do not fall under the jurisdiction of an Institutional Animal Care and Use committee and there are no USDA or NIH rules regarding their use in science experiments. Further, chick embryos have not developed a brain by day four and have no neural function; they cannot feel pain and are not cognizant of their surroundings. Therefore, objections due to animal rights or cruelty are negligible. The public may be concerned about what happens to the embryos. If asked, the demonstrator should explain that the embryos will not survive to hatching. If further questioned, the demonstrator can explain the lack of neural development [2].

V. Scientific Background

While most people know that there are such things as genes and that these genes have some control over how we look, a large number of people do not understand the actual process by which a gene influences our looks. The Central Dogma states that DNA contains genes and that the information from these genes is "transcribed" into a second molecule known as messenger RNA. From this mRNA the genetic information is "translated" into a protein that then carries out the function of the gene (Figure 2). Simply put, the gene codes for a protein that carries out its function.

A common misconception is that genes are always "on", that it is always necessary for their functions to be carried out. However, this is not the case. While it is true that some genes are on all of the time, some genes are only on during certain phases of an organism's (any living being's) life cycle and off the rest of the time.
This phenomenon is most clearly observed during development (the process by which a living thing goes from a fertilized egg to an adult). This new life is constantly changing—moving cells, creating structures. This involves turning on many different genes at different times, but equally important is turning genes off at important times. If a set of genes is important for creating a foot, it is important to turn those genes off or the organism will continue growing a foot forevermore.

Development starts with a single cell—a fertilized egg. This single cell divides into two cells, those two cells divide into four cells, and so on until all of the cells in an organism are present. The original single cell has all the information and the potential to become any cell in the organism. However, once the cell starts to divide, the daughter cells become limited in their potential. As cells continue to divide, the potential number of

structures each cell can become decreases. For instance, that first single cell can become part of the head, the heart, the arm—anything—but after division only one of the daughter cells can become part of the heart. This is called differentiation. Cells become more and more differentiated as time progresses until each cell can only be one kind of cell—they are terminally differentiated (example: in an adult organism, a heart cell can only be a heart cell, it cannot become a brain cell) [2]. This differentiation occurs through the process of genes turning on and off at specific times.

So, how do genes turn on and off? Let us consider the anatomy of a typical gene (Figure 3). A gene is made up of a stretch of double-stranded DNA. DNA has directionality; each strand has a 5' (five prime) end and a 3' (three prime) end. DNA is always read 5' to 3'. If something is located on the 5' side of the gene, it is "upstream" and if it is on the 3' side, it is "downstream". A portion of the gene has the instructions for creating the protein that carries out the function of the gene. This region is known as the coding sequence. Upstream of the coding sequence is the primary regulatory region of the gene, known as the promoter (there are other regulatory regions in genes, but for simplicity's sake I will only describe the most important one). This region is like a switch. Think for a minute about your kitchen light fixture. The purpose of the fixture is to provide light when you are in the kitchen. Therefore, when you are in the kitchen, you want this light to be on, and when you are not in the kitchen, you want the light to be off. This is accomplished by means of a switch that allows you control over the light fixture. It's on when you want it on and off when you want it off (barring any difficulties with the electric company!).

The very early stages of development look much the same in most animals—the embryo looks like a large ball of cells (Figure 4). However, as development continues, cells start to move and more identifiable structures begin to form. In the chick embryo, very basic structures are formed at 24 hours and certain cells have already been chosen to become heart cells (Figure 4A) [4]. By 72 hours, a primitive heart is present in the form of a two chambered tube [5] and can be seen beating in live embryos (Figure 4B). At 96 hours, the heart has looped so that the atria will be above the ventricles (Figure 4C)[6]. By 21 days, the chick embryo is ready to hatch.

Figure 2. Central Dogma. The code for a gene is transcribed from the DNA to the mRNA. The information contained in the mRNA is then translated into protein which carries out the functions of the gene in the cell.

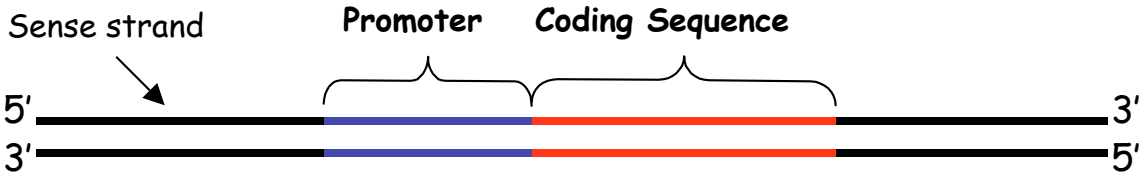

Figure 3 Anatomy of a gene. DNA is composed to two strands which are read in the 5' to 3' direction. The top strand is called the sense strand. It is from this strand that the mRNA is transcribed and therefore, it is this strand that one always refers to when discussing placement of the promoter and the gene. The promoter (blue) is the primary regulatory region for the gene. The coding sequence (red) is the part that codes for the actual protein.

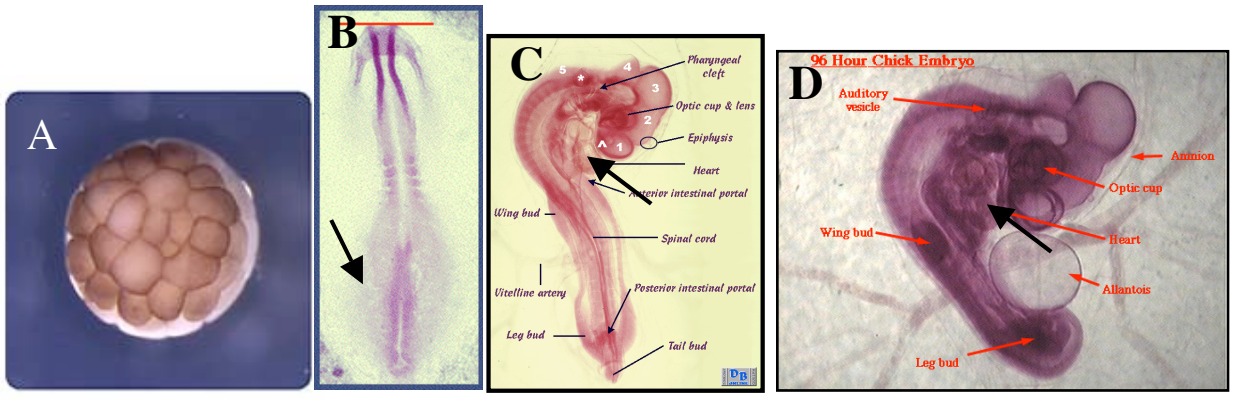

Figure 4. Different stages of embryos. A. An very early embryo looks like a ball of cells [7]. **B.** 24-hour chick embryo, black arrow indicates cells that will eventually move to become the heart [8]. **C.** 72-hour chick embryo, black arrow indicates heart [9]. **D.** 96-hour chick embryo, black arrow indicates heart [10].

VI. Assessment

A. Formative Evaluation

Two types of formative evaluations will be done on a prototype demonstration using preserved specimens.

1. Observation

Visitors will be observed during the demonstration to assess the general reaction of the public to the demonstration. Behaviors that will be watched:

1. Of the people who walk past an in-progress demonstration what percentage stops to watch? (Does the demonstration grab people's attentions?)
1. What percentage of participants leave before the end of the demonstration? (Is the demonstration too long or the language too complex?)
1. What percentage of participants asks questions? (How interested have the participants become?)
1. What is the overall mood of the crowd (intrigued, amused, bored, repulsed, etc.)?

After observing three demonstrations, adjustments to the demonstration will then be made based on observations. For example, if a high percentage of people are leaving prior to the end of the demonstration, the demonstration might be shortened. If people generally appear to be bored, then the focus of the demonstration might be changed.

2. Interviews

Once improvements on the prototype demonstration have been made, a revised version of the demonstration will be conducted for the public. Visitors will be interviewed immediately following the demonstration. Questions that will be asked:

1. What did you like most about the demonstration? (What are we doing well?)
1. What did you like least about the demonstration? (What can we improve upon?)
1. What do you think the purpose of the demonstration was? (Are we meeting our objectives?)
1. Is there anything you would like to see added to the demonstration? (How can we make this material more relevant to the participants?)
1. Did you feel the demonstration was presented at a level you feel comfortable with? (Are we presenting material that is too complicated?)

After interviewing 40 people, adjustments will be made to the demonstration based on the answers to the above questions.

B. Summative Evaluation

When all adjustments have been made, a final, summative interview evaluation will be done using the above interview questions.

VII. Training

Once the assessment has led to a format of the demonstration is successful, training materials will be developed to train museum employees to conduct the demonstration. These materials will include a powerpoint presentation, a short manual, and a list of both paper and online resources. The effectiveness of these materials will be assessed by first using them to train another MSCOPE participant to conduct the demonstration. Revisions will be made to the materials until the new demonstrator is capable of conducting the demonstration well. When the training materials are in their completed forms, the first round of training for museum staff will be led by me.

VIII. Summary

I have proposed two demonstrations (one using live embryos, the other using preserved specimens and slides) around the concept of chick developmental genetics, focusing on heart development. These demonstrations are designed to more closely link the chick hatchery to the genetics exhibition it resides in. The objective of the demonstrations is to explain that the function of a gene is carried out by a protein and that genes are turned on and off during an organism's development in order to make proteins that help create certain structures such as the heart. The start-up costs for each of these demonstrations could be under $300 if the institution already has a TV it is willing to use for the Proscope. The only disposables are the gloves and the eggs in the case of the live embryo demonstration, therefore there will be very little cost to the museum after the initial investment in equipment and specimens.

In developing the program for the demonstration, two types of summative evaluations (observations and interviews) will be done on a prototype demonstration. After the program has been finalized, a final summative evaluation using interviews will be conducted. Training materials will be developed and evaluated by other MSCOPE participants with the first training session for museum staff led by me.

Finally, while this demonstration will work very well in the genetics demonstration area, the demonstration could also be reworked and shown by the human prenatal exhibit, or could become part of a learning lab on embryology for high school students. Regardless of the venue, adding this demonstration will improve the general public's understanding of how genetics influences development and will have a positive impact on the experience of museum visitors.

Notes and References

1. Image taken from www.x-tremegeek.com.
2. The Exploratorium in San Francisco has a permanent display using live chick embryos. I was able to speak to one of the people in charge of the exhibit at a recent conference. The Exploratorium does not receive any complaints about the embryos from the public, though once in a while someone writes a letter asking what happens to the embryos. On a personal note, when I visited the exhibit, a woman and her daughter were looking at the embryos. When the daughter asked about the baby chicks hatching, the mother replied that she didn't think these chicks would be hatching. Neither appeared very concerned about this. They were, however, fascinated by the beating hearts of the embryos.
3. This is what makes stem cells so valuable. They are cells that have not yet become terminally differentiated and therefore can still become several different kinds of cells. This also explains why people are so eager to get them from embryos. While adults have a few certain kinds of stem cells (bone marrow cells that make blood cells, for example), embryos are stuffed full of them and the earlier the embryo, the less differentiated the cells are.
4. Gilbert, Scott F. *Developmental Biology* 6th ed. 2000. Sinauer Associates, Inc. p. 472-475
5. Ibid
6. Ibid
7. Image taken from www.learner.org/channel/courses/biology/images/archive/textbook/1982_tb.jpg.
8. Image taken from www.uoguelph.ca/zoology/devobio/24hrchck/images/24cktb01.gif
9. Image taken from www.uoguelph.ca/zoology/devobio/210labs/72hrwm.GIF
10. Image taken from www.umanitoba.ca/faculties/science/biological_sciences/lab14/images/chick96.jpeg.