

Everybody Loves Baby Chicks:

A Demonstration on Chicken Development at the Museum of Science and Industry



MSI's baby chick hatchery. Photo: M.Leighton

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The Museum of Science and Industry (MSI hereafter), as one of the most popular museums in the USⁱ, has at its heart the mission to inspire an interest in and appreciation of science. As such, its genetics exhibit is designed to not only inform and educate its audience about this complex area of current science, but also to do so in a way that is non-intimidating and stimulating.

For practical reasons, the highly popular chick hatchery at MSI has been placed at the end of the genetics exhibition room, which it pre-dates. When we visited the museum we noticed immediately that although the hatchery attracted a lot of attention, it was not well integrated with the rest of the genetics exhibition. Our aim, therefore, was to design a demonstration that would incorporate the highly popular chick hatchery into the larger genetics exhibition that houses it.

In this report we will describe the demonstration that we created and how to carry it out, but also give a detailed account of the way in which our expectations about what we *wanted to teach* had to be modified by what we discovered the audience would be *willing to listen to*. In the process we will

describe what we learned about doing this demonstration, in order to illustrate not only how we arrived at the final product we are presenting, but also how it could be used in the future.

The demonstration message

In thinking about how to link the genetics exhibit to the chick hatchery we decided to focus on the concept of embryonic development and how it is controlled by genes. Chicken embryos provide a very good model to observe embryonic development. Since chickens lay eggs instead of giving live birth, it is easy to access embryos at many stages of development and this makes them excellent both for scientific research and teaching. In the final version of the demonstration our purpose is to explain that an embryo changes over time during development and that as embryo is able to make these changes due to information contained in their DNA which is a set of instructions. Additionally, we would like the audience to understand that embryos from chickens and humans share many similarities, especially in the early stages, and these similarities are one of the reasons why scientists use chickens to study development.

The demonstration is targeted to people of all ages who have very little previous knowledge about development and genetics.

The demonstration

The final demonstration we created involves two demonstrators with a cart, on which is placed a laptop computer connected to a microscope, a number of 4 and 6 day old preserved chicken embryos in a petrie dish, additional illustrations, and hand held magnifying glasses. One demonstrator stands behind the cart to answer initial questions and supervise the observation of the embryos, while the other demonstrator is available to answer more detailed questions with the aid of the microscope and the additional illustrations. The two demonstrators can alternate roles, but the aim is that one is able to deal with immediate questions and visitors who only stay for a short period of time, while the other is free to engage in more detailed one-to-one conversation. This ability to have two levels of interaction is a central component of this exhibit, as discussed in more detail in the next section of this paper.

The following describes the materials needed for the demonstration and an ideal procedure, however the demonstration should be flexible enough to be led by the audience's individual questions rather than

followed as an exact script.

Materials needed for the demonstration

A. A cart, situated near a power source and good lighting, ideally near or next to the chick hatchery.

B. Four hand magnifying glasses

C. Preserved 4 day and 6 day chick embryos in petrie dishes. Four and six day embryos were collected by using dissection scissors to cut an oval window in the egg, snipping the veins and the sac surrounding the embryo and using tweezers to place the embryos in Phosphate Buffered Saline (PBS)ⁱⁱ. The remaining bits of the embryo sac were removed using tweezers. The embryos were then incubated in paraformaldehyde at room temperature overnight, then dehydrated by incubating for five minutes in each of the following solutions: 25% methanol 75% PBS, 50% methanol 50% PBS, 75% methanol 25% PBS, then stored in 100% methanol.

D. Slides of early stage embryos. Whole-mounted 16 hour, 24 hour, and 72 hour embryos were obtained from Carolina (www2.Carolina.com). Additionally, slides of serial coronal sections of 48 hour and serial saggital sections of 72 hour embryos were obtained from Carolina.



E. QX5 Microscope (Figure 1). The QX5 digital microscope was obtained from ThinkGeek (www.thinkgeek.com). The microscope is capable of 10X, 60X, and 200X magnification. The microscope has a USB port and software and can be used on any computer running Windows 98 or higher. The software also is capable of image capture, video, and time-lapse photography and has some imaging processing capabilities.

*Figure 1. QX5 microscope.
Image from:
www.thinkgeek.com*

F. Additional images. A single 8 1/2 x 11 in. card showing comparative images of chicken and human embryos at various stages of development (Figure 2). Also the book *Inside an Egg*ⁱⁱⁱ has many useful images for answering questions from the visitors.

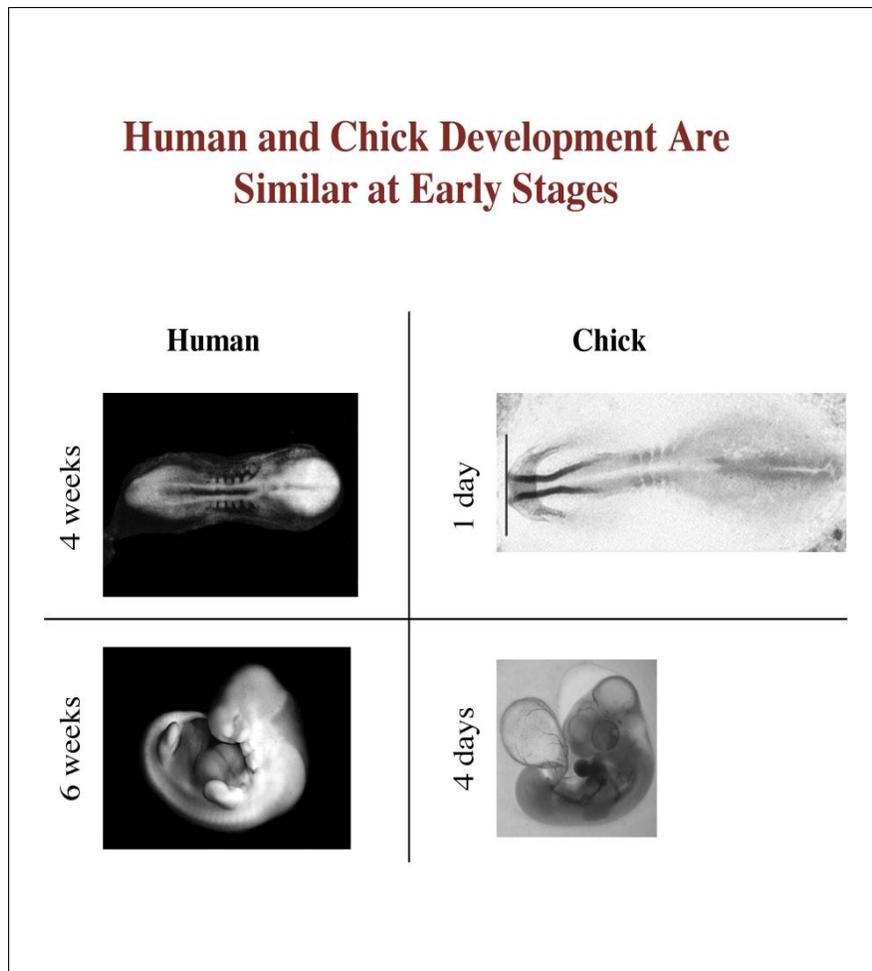


Figure 2. Human and chicken embryo images used to demonstrate the similarity between the two. Images from:
<http://embryology.med.unsw.edu.au/wwwhuman/Stages/Stages.htm> (human embryo images);
<http://www.uoguelph.ca/zoology/devobio/24hrchck/24ck1.htm> (24-hour chicken image);
<http://academic.scranton.edu/faculty/GOMEZG2/Bio351.htm> (4 day chicken image)

Procedure

1. Greet the audience and tell them you have a set of activities that are all about embryos.
2. Let them come up right away, hand them a magnifying glass, and let them inspect the larger embryos.
3. Ask them if they know what an embryo is. Can you see that there is a progression in development? Mention that there are 4-day and 6-day specimens. Do you recognize any of these chicken features (head, wings, legs)?

4. Say, “If you don’t think these look much like chickens, check out what an embryo looks like when the egg is freshly laid” (16hr). Lead them to the microscope to view early stage embryo slides. Direct their attention at the computer screen while demonstrator adjusts microscope. Because of the fragile nature of the slides, the demonstrator should have complete control over the slides and the microscope.
5. Show how embryo is at centre of sac. Not much development at all has occurred. Tell them this streak of cells already knows what to do next in the following slide.
6. **24 hour** - show where the head is going to be, point out how it’s setting up a plan for its body--lines are dividing the body into sections--groups of cells are becoming defined as certain parts of the body.
7. **72 hour** - point out heart development, eye, head, place for brain, spine, limb buds near the bottom (what will become legs in the 4 and 6 day embryos).
8. Explain that the embryo is capable of forming the structures you pointed out because it has a set of instructions contained in its DNA. DNA is a blueprint, or a plan, that the embryo uses to know where and when to form an arm, a leg, a heart, etc.
9. Direct the audience to the pictures comparing the chick and human embryos (Figure 2). Point out the similarities. Explain that because of these similarities scientists can use chickens to study developmental questions and can apply that information to humans.
10. Demonstrators can have additional charts available which detail classic examples of the benefits to humans of chicken embryo research if visitors desire extended discussion.

Our expectations and aims in creating this demonstration

Having decided on the aim of incorporating the chick hatchery through a demonstration that used chick embryos in various stages of development, we originally intended to focus on the beating heart. This, we thought, would be the most engaging way to stimulate conversation with visitors into the rather technical and often very abstractly described topic of genetics. We intended to use live chicken embryos in various stages of development that the visitor would be able to observe with a magnifying glass.

Our first re-evaluation came when we discovered that MSI was not comfortable with us using live chicken embryos. We therefore undertook our first round of evaluations using concept boards in part to discover if their fears were founded, but also to test whether the idea of a demonstration on genetics,

development, chicks and the heart would be of any interest at all to our audience. During our concept board testing (described in more detail below) we found that most visitors would be interested in seeing live embryos, rather than upset by it, however we agreed to change to using preserved embryos when it was clear the museum did not want to take the risk of using live embryos. We also realized that the logistics of preparing live embryos would be too complicated, particularly for demonstrators who did not have a biology background, and that ready prepared and preserved embryos would be far more practical.

Based on earlier survey work we had done for another project, we realized that the average museum visitor's understanding of genetics was very basic, and a large motivation for this demonstration was our desire to fill in the gaps in their knowledge in a stimulating way. We found, however, that we would have to compromise what we wanted to *teach*, because of what our visitors would be willing and interested in *listening to*. Through the concept boards we discovered that visitors were less likely to be interested in learning basic principles of genetics than in seeing 'when development goes wrong' images. This was further reinforced by our later experiences of giving the demonstration, where we realized that the message we were trying to convey, which focused on the mechanical aspects of embryonic development, was far less interesting to



Visitors looking at the embryos. Photo: P. Oikonomou

our audience than being able to look for themselves at the objects we presented and to ask their own questions. We were, however, pleasantly surprised at how willing some visitors were to interact on a one-to-one basis, and how the presence of an 'expert' was utilized by some visitors to ask their additional questions

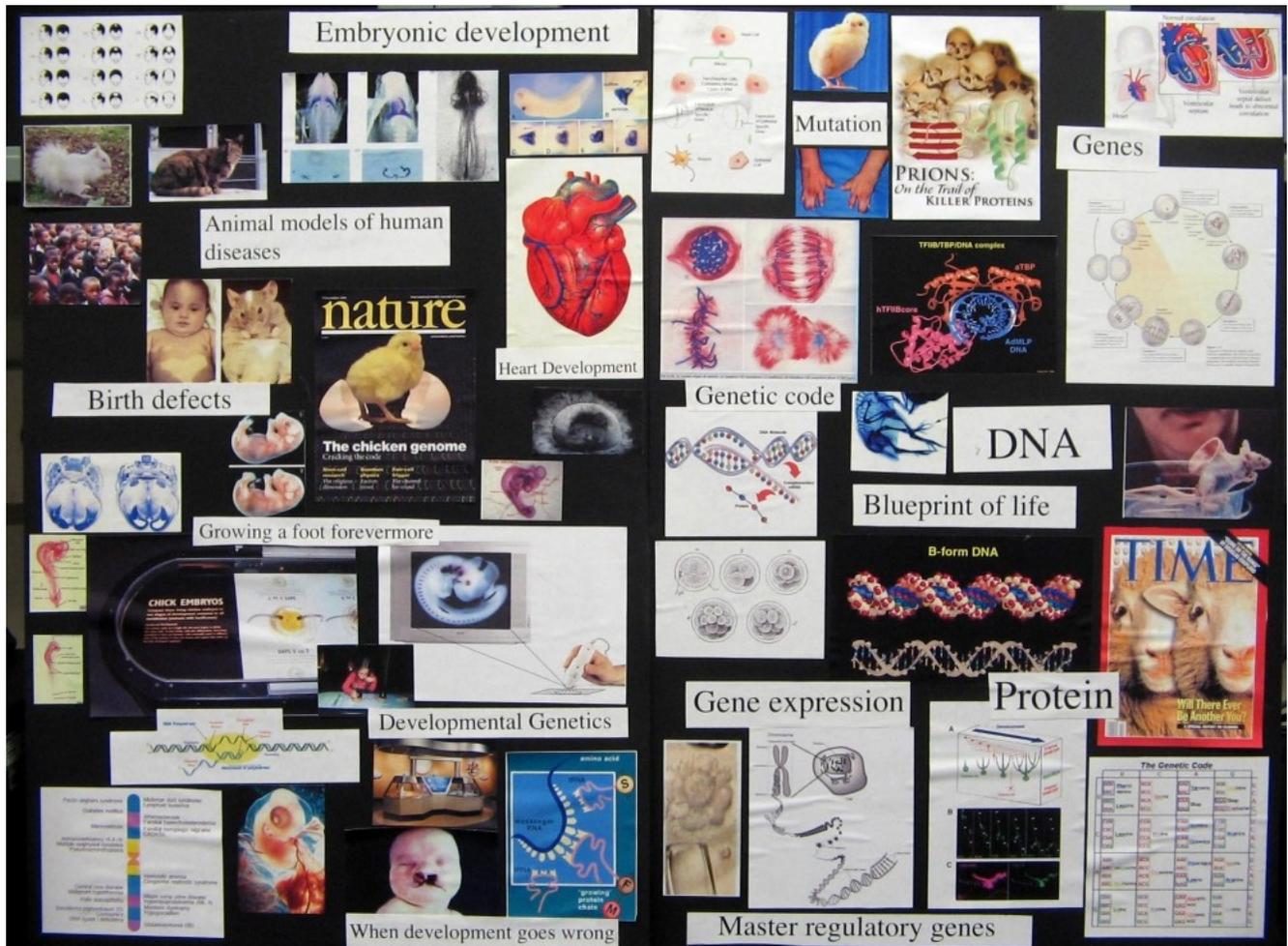
The following describes in more detail the results of the concept board testing.

Concept board testing

Concept Testing Interviews (CTI hereafter) provide exhibit designers a quick, inexpensive way to expose their ideas to the public and gauge interest. The exhibitor can put images, slogans, technical

terms or themes drawn from their proposed exhibit on a poster board and use it as a means of stimulating reactions and responses from museum visitors. The poster boards are highly visual and serve as a useful means of organizing particular concept areas of a proposed exhibit. Through the use of a short survey (see Appendix 1) along with the visual poster boards, the exhibitor attempts to understand not only what ideas or concepts might interest or bore the visitor, but also what misconceptions a visitor might have about the intended exhibit material, and what other areas of the topic might be of interest to the visitor that had not been considered yet by the exhibitors.

The evaluation department at MSI has used the CTI method to gauge the public's interest in their proposed multi-million dollar Body Human exhibit, which intends to focus on aspects of the human body and/or health care technology. Because of the positive use of this technique in shaping the continuation this major exhibit design, we felt it would be equally appropriate in our own evaluations.



Concept boards used for testing visitor reactions

Since our own topic, chicken embryonic development, could seem convoluted to a non-specialist audience, it was essential that we spent some time evaluating the public's understanding of some of our initial ideas. Also, our intended exhibit hoped to incorporate the use of live chicken embryos to provide a living illustration of embryonic development. Because the use of live animal embryos could potentially be a sensitive issue for some museum visitors - as it was already a sensitive issue for the museum - we wanted to allow visitors the opportunity to see what a living embryo would look like through the use of a DVD-rom. This way, through the use of the DVD-rom visuals, visitors could offer their opinions and concerns on the matter before we pushed to have live embryos on the museum floor.

During two different sessions at the MSI, we conducted 15 separate CTIs with a variety of museum visitors. One of our poster boards was more technical in nature, with diagrams and images of DNA, protein sequencing, and ultrasound images of developing embryos. The other had a more sensational element: it included images of chickens, human and animal birth defects, and hot-topic issues such as cloning and genomes. Visitors that agreed to partake in the five minute interview were shown both posters simultaneously as they were questioned by one member from our team using the survey that is shown in appendix 1, while another team member recorded the answers on a separate clipboard.

After completing all the interviews, we reviewed each survey to identify what, if any, were common responses for each question. Ideally, common answers would help us decide where to narrow our focus for the exhibit. If the visitors surveyed had wildly different reactions and responses, it might indicate to us that we would need to re-think what we might want to present in the exhibit.

In general, the majority of visitors surveyed expressed interest in issues concerning development and genetic defects, and did not express much interest in actual images of proteins, genes, cloning, charts, and the more technical side of development presented on the two posters. A few people pointed to the larger, more colorful images from our posters, irrespective of content, and simply replied they were most interested in those items because they were the most colorful or eye-catching. From an aesthetic standpoint, this information was useful, as it suggested that some visitors are drawn to what might look cool, colorful, or exciting, even if they do not have background knowledge or interest in the topic. Clearly, our final demonstration set-up should be visually enticing to attract visitors towards us who might otherwise have limited interest in the topic. In the future, a follow-up survey that focused more on exhibit design scheme might be useful before finalizing our demonstration set-up to identify colours/words/objects that may spark the most interest in the casual visitor in order to broaden the

initial appeal of our demonstration to most audiences.

Interestingly, when the visitors were asked what topics from our poster boards were important for other people to learn about when they came to a museum, those same visitors who themselves were not interested in the technical side of development pointed to the technical images and expressed that these were topics that were important for other people to learn about. This implied to us that museum visitors probably would not mind some technical details about a topic, as long as those details were not overwhelming, or possibly just optional. Because our eventual demonstration became more open-ended, it was good to have some additional technical information available on hand to readily discuss with those visitors who might be interested. For example, because of the two-part nature of our eventual demonstration design, one of the two demonstrators staffing the exhibit cart can discuss some of the more specific mechanisms involved in embryonic development by incorporating the use of some more technical charts and real-life research examples, that second demonstrator can delve into greater detail about the developmental processes at work on each microscope slide.

Even though the museum decided not to allow us to incorporate live embryos into our demonstration, the majority of visitors - 86% - surveyed were in favour of having live embryos on the floor. The reasons visitors gave as to why they would like to see live embryos were that living embryos would provide them with a rare opportunity to see development as it happens, and living embryos would be an interesting variation on the usual presentation style of the museum. Since the museum remains sensitive to this type of floor exhibit, and since the set-up of the live-embryo display could require some technical expertise, the museum may want to consider testing the use of live embryos in an enclosed, learning-lab setting. A learning-lab would provide the majority of visitors with the desired opportunity to see living embryos, but contain the entire experience in a discreet setting.

The Demonstration Process

In creating this demonstration we learned a great deal about how to design and give demonstrations that challenged our assumptions about what our audience would be willing and interested in listening to. In this section we will discuss our findings, along with an evaluation of how this enabled us to create a demonstration that catered to the widest possible audience and to multiple levels of audience participation.

What we discovered about how to do the demonstration

Logistically the placement of the demonstration just outside of the genetics exhibition and next to the chick hatchery was good for catching people walking past and for making connections between the living chicks and the embryos. The only draw back of this placement was the lack of good lighting.

In terms of the content that we were attempting to convey, looking at the embryos was far more interesting than listening to the demonstrator deliver a memorized script, and many visitors were happy to be able to just look at the embryos without an explanation. The information being given over the cart was therefore very light, and instead we tended to encourage questions which would then allow the visitor the possibility of being drawn into a more detailed conversation. This was an ideal situation when there were two demonstrators, the first standing over the cart with the embryos and the second next to the screen attached to the microscope with the slides, ready to answer more detailed questions and engage in more in-depth conversation. Additionally, having two demonstrators had the practical advantage of allowing one to focus on monitoring the petrie dishes, which both adults and children tended to try to handle.

The questions being asked by visitors focused around people's own experiences, for instance pointing out the similarities between chicken and human embryo development. Also, there were a large number of questions about the difference between a fertilized egg that would turn into an embryo and eggs that are eaten. In general, people were impressed that the earliest stage embryo (24 hours), which essentially looks like two red streaks, developed into the largest embryos on display in a matter of only four days.

What we discovered about group interaction with the demonstration during our evaluations

While observing visitors interacting with the demonstration on two separate occasions, we were able to notice a number of strengths and weaknesses relating to the way in which the demonstration either attracted or alienated groups of adults or adults with children. These observations will be discussed here in terms of a) group dynamics and how it affects adult and child willingness to engage with the demonstrator, b) the limitations and advantages of having two parts to the demonstration, but which both only cater to small groups.

a) Adult and child willingness to engage with a demonstration

The most common group that approached the demonstration at MSI consisted of one or two adults with one or two young children. In this group the children were the main focus and the adults either encouraged the children to come forward and look at the display, or the adults stood back as the children came forward themselves. When there were children in the group the adults tended to hang back, possibly because they were visiting the museum itself as part of entertaining the children on a day out, rather than because they are there for their own interest.

Groups consisting only of adults were also frequent, although not so common as those with children, but we found that this did not necessarily mean that the adults would always be more eager to engage in conversation or action with the demonstrator. In fact, some of the adults with children appeared to use the excuse of the child to engage with the demonstration, prompting the child to look and ask questions they would have felt more uncomfortable asking themselves.



Children and adults interacting with the demonstrator. Photo: P. Oikonomou

From these observations we began to pay attention to the way in which visitors were willing or reluctant to engage with a demonstration, thereby taking a less passive role than required by more traditional museum exhibits. As our demonstration included a large component of one-to-one visitor-led interaction, the level to which a visitor would be comfortable doing this was of importance. In general people were interested in looking at the embryos, but needed prompting to do so. They may have had a single question, but usually were happy

to just look, ask what it was, and then leave after one or two minutes. Those who went over to talk to the demonstrator who was standing with the laptop willing to answer questions stayed longer, generally becoming engaged in a detailed one-to-one conversation. Not everyone was willing to do so, however, and we interpreted this as an unwillingness to take an engaged/interactive role in the museum experience as opposed to the passive/viewing role of traditional museum visiting. The younger adults and adolescents in particular did not want to be drawn into this kind of situation, but lacked the social ability that older adults possessed to be able to extract themselves from the situation and walk away. We realized that allowing people to just look at the embryos on their own was a way of encouraging people to be active, and at the same time allowed the demonstrators to be available for those who

wished to engage further in a very non-threatening way. Gradually we found, particularly after introducing the screen attached to the microscope, that a good balance could be struck between having a visual component that required little interaction (the slides shown on the screen), a physical component that could cater to those who were happy engaging more actively (the embryos), and a social aspect that allowed visitors who were comfortable and interested in gaining more information to talk to the demonstrator directly (the one-to-one conversation) and observe the additional charts/technical information available on-hand.

To elaborate on this point a little further: The embryos needed to be viewed with a magnifying glass, which the audience member had to take in his or her hand, and could then only be seen if the visitor stepped in closely and bent down to look at the embryos on the cart. This involved engaging with the demonstration and usually the demonstrator, which usually made the visitor, particularly adults, cautious in case they would be unable to extract themselves from the situation later. The slides on the screen, on the other hand, can be seen from further away and can be looked at passively without any commitment from the viewer or engagement with the demonstrator. The visitor can always walk by after a brief look at the computer screen, maintaining a small distance away from the demonstrator. Once interest had been established and the visitor was comfortable, he or she had the option of engaging in a one-to-one conversation that could then be further illustrated using the slides and human embryo comparison charts.

The interaction with the demonstration often varied depending on the make up of the group – in general when there were children in a group the adults encouraged them forward first and only joined in themselves afterwards, after standing back to let the demonstrator talk only to the child. A group of adults with no children was often more reluctant to come forward themselves, not having the intermediary of the children. The child, more used to interacting with teacher/authority figures and being in such learning situations, and because they often have little choice once their parents encourage them forward, were less likely to be shy about engaging in the demonstration.

As an example, here is a description of a family consisting of two young children and two adults, presumably their parents, from the 14th of April 2006. The children were a little shy, but were encouraged forward by their parents who seemed pleased that they were engaging in something with a person from the museum. The children only leaned in to look at the embryos and pick up the magnifying glasses when prompted to by the demonstrator. The mother leaned in to look as well, but

only over the shoulders of the children, and was mostly watching and listening to the demonstrator. The father was standing a little back from the group, watching but not engaging with the group or the demonstrator. The children began to look a little bored but the mother became more interested and started to ask questions herself. After a while the father came forward and started to look at the slides on the screen, gradually becoming more involved and asking questions, particularly about the human embryo images. This was a fairly typical pattern, whereby the parents assume the demo is for the children, and push them forward, but then became involved themselves, primarily through the screen or by listening to what is being said to the children, often after the children themselves have become bored.

For groups with no children, the typical behaviour is that the adults need more encouragement to come forward. As such we found that it was often better to attempt to engage them through the slides, which involve less commitment, and then encourage them to look at the embryos. Of course, ultimately some people are interested and some are not. There were groups where everyone got involved and asked questions, and some where they are obviously trying to find an excuse to move away. But this was most likely due to personal interest on the part of the audience as well as the level of comfort they had in a demonstration situation.



Visitors looking at the embryos. Photo: P. Oikonomou

b) The limitations and strengths of aiming for a small group

The strength of the demonstration is that it is organized so that a lot of information could, potentially, be conveyed based on the visitor's individual interest, but it also provides something physical for the visitor to engage with that has a distinctly scientific feel to it. On many occasions when a particular audience member had become interested and engaged in a conversation with the demonstrator, they would draw in other members of their group and recount the information they have just learned, or point out to the others features on the embryos. Being able to pass on this knowledge seemed to be something the visitors enjoyed, and therefore it is a strength of the demo that this level of knowledge –

particularly because it can be customized to the visitors' particular interests – can be quickly imparted to the extent that they were immediately able to pass it on to one another.

When there were a large number of people gathered around the cart, other people passing by became interested and stopped to see what was happening. Because the embryos are small and require an individual to look closely at the embryos this was not really a spectator demonstration, and we were worried that we ought to make it more accessible to a larger audience. Those passing by who could see the crowd could not actually see what was happening. We found that when a large crowd was gathered, interested passers-by would either be drawn in and push their way through to the cart with the embryos, or would go over to the area where a demonstrator was showing images on the screen that could be seen by a larger audience. Here, however, the demonstrator was generally engaged in one-to-one conversations, and passers-by were not able to get involved and generally walked away. (Although some listened to the discussion involving the slides and then moved in to inspect the embryos when they had some room.)

We decided that this was not necessarily a problem. Many people walked past simply because they were looking for something in particular or because they did not want to engage with a demo situation. Some of those walking past did wait until there was a space where they could come forward and look at the embryos themselves. When there was no-one at the cart people were less inclined to stop, especially when they were being watched intently by three museum volunteers! Having objects on a cart and the images on the screen visible from a distance certainly helped attract people forward when there was no crowd, because they could see what was going on and become curious about the objects without too much commitment, rather than having to engage straight away with a person.

As mentioned above, however, even though there were two sets of embryos and two magnifying glasses available, it was often the case that the adults with children would focus on showing the children what was happening rather than looking themselves, or that only one adult in a group would engage in the first instance. Having more specimens available would allow more people to look, but bearing in mind that the interaction between members of the (usually small, no more than 4 people) groups was a very important part of the process, only allowing one group to interact at a time may not be a disadvantage. Looking as a group as opposed to looking as an individual was less threatening and therefore we had to balance giving people space to see what was happening with not spreading everything out so much that groups had to split up to get involved in the first instance. Also, the use of

additional specimens would require additional monitoring, making the demonstrators less capable of delving into some of the additional material.

To summarize therefore, the limitations on the number of people who could engage with or see the demonstration at any one time worked to our advantage, in facilitating the personal nature of the demonstration but maintaining inter-group interaction.

Initial information gained from brief survey evaluations

We undertook brief surveys to evaluate the audience's reaction to the demonstration, however we feel that these are of very limited use because of the tendency of the respondents to tell us only what they thought we wanted to hear. We asked eight people who had seen the demonstration to tell us what they enjoyed and did not enjoy, and what they thought the message of the demonstration had been. Only two respondents volunteered to tell us what they did not enjoy, although interestingly given our earlier concerns about showing live embryos, a middle aged female visitor said in answer to what she did not enjoy that it would have been more interesting to see the heart beating, but only if it would not involve killing the embryo. On this occasion of giving the demonstration we also had our first negative reaction to the use of embryos themselves, in the form of a young man who told us he did not want to see the demonstration if it involved animals that had been killed. Because the overwhelming majority of reactions to the demonstration had been positive, we considered this a very unusual reaction, however it remains a possibility that a small percentage of visitors will be offended by the use of animals in a museum.

We noticed when collecting the responses to the question of what the message of the demonstration had been, that almost without exception the respondent would repeat whatever they had been told last by the demonstrator. While this was frustrating in terms of the survey, it was a useful lesson for us on how important it is to stress the 'take home' message at the end of the demonstration.

When asked what they enjoyed about the demonstration, the respondents again tended to reference something that they personally had asked about or engaged with – for instance a young girl who had asked a series of questions about the structure of the egg and how the embryo survived in the shell said that learning about the structure of the egg had been the most interesting part of the demonstration. The responses to the survey therefore were less informative in themselves as raw data, but interesting in

terms of illustrating for us the extent to which people were able to use and interact with this demonstration in a very personal, and surprisingly variable, way.

Information for Repeating the Demonstration

In this section we will provide background scientific information for this demonstration, along with a budget and additional resources.

Scientific background

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).



Figure 3. 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

In order to develop properly, the embryo needs a set of instructions. These instructions are primarily contained in the DNA of the developing embryo^{iv}. In each cell only a certain subset of genes in the DNA have been “turned on”, that is, the gene has been “told” to transcribe the DNA into mRNA which is translated into protein which is what really does the work of the gene in the cell (Figure 3). As soon as the gene has carried out its function, it is then turned off and the protein is no longer produced. During development, the turning on and off of sets of genes leads to differentiation. For example, if a cell is supposed to become a brain cell the genes involved in making a brain cell are turned on in a particular order and also turned off in a particular order. If a cell is destined to become a heart cell, a different set of genes will turn on and off in a particular order. The information that determines how

many heart and brain cells an organism will need is preprogrammed into the DNA. The very early stages of chick development look much the same as in most animals—the embryo looks like a large ball of cells (Figure 4A). As development continues, cells start to move and more identifiable structures begin to form. In the chicken the first stages of development occur before the egg has been laid. Sixteen hours post fertilization, the egg is laid. At this point, the embryo can only be seen with a microscope and looks like little more than two streaks; however, cells within the embryo have already started to become differentiated. By 24 hours, the embryo still looks like two streaks, but it has started to divide into segments (known as somites) (Figure 4B). These segments will later define particular regions of the body. By 72 hours (three days), the embryo has a clearly identifiable head, tail, limb buds (areas that will become the legs), and eye, and even a primitive heart in the form of a two chambered tube^v which can be seen beating in live embryos (Figure 4C). The heart is the first major organ to develop. The heart is needed at such an early stage in order to pump nutrients through the embryo. Defects in heart development have serious consequences for embryos and are responsible for most human early stage miscarriages.

At 96 hours (four days), the embryo has grown large enough that it is easy to see without a microscope and you can identify features using a magnifying glass. The heart is more like an adult heart and the

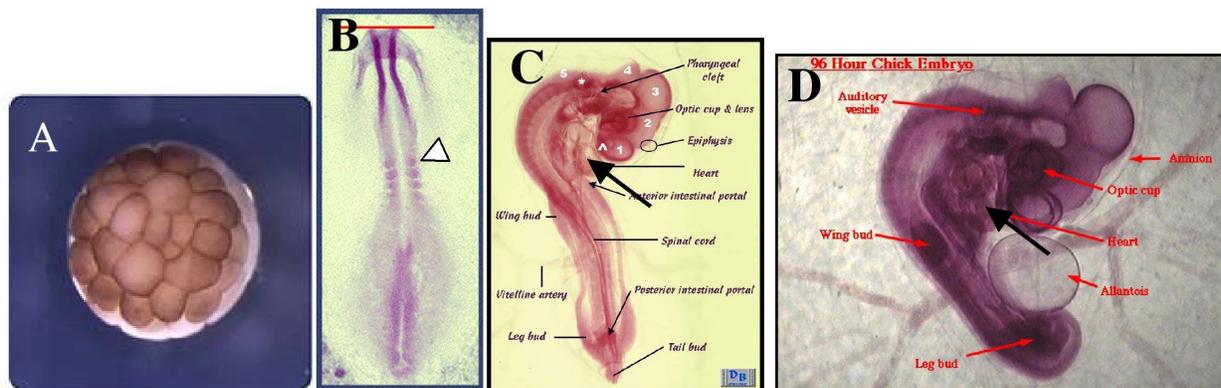


Figure 4. Different stages of an embryo.

A. A very early stage embryo looks like a ball of cells. Image from:
www.learner.org/channel/courses/biology/images/archive/textbook/1982_tb.jpg.

B. 24 hour chick embryo. Black arrow indicates cells that will eventually move to become the heart, white arrow indicates somites. Image from:
www.uoguelph.ca/zoology/devobio/24hrchck/images/24cktb01.gif.

C. 72 hour embryo. Black arrow indicates heart. Image from:
www.uoguelph.ca/zoology/devobio/210labs/72hrwm.GIF.

D. 96 hour embryo. Black arrow indicates heart. Image from:
www.umanitoba.ca/faculties/science/biological_sciences/lab14/images/chick96.jpeg.

rhythm of the heartbeat is similar to that of a hatched chick. The embryo itself is more curled up and wing and leg buds are visible (Figure 4D). By six days, the embryo is substantially larger and primitive legs and wings (which look remarkably like arms) are readily visible.

Development of the embryo continues until 19 to 21 days when the chick hatches. The length of development depends on the breed of chick. By the time the chick is ready to hatch, it fills the entire egg.

Frequently asked questions

During our demonstration, several questions come up repeatedly. The most popular was whether the eggs you buy at the grocery store could ever become chickens. The answer is no. These eggs have never been fertilized and therefore, an embryo cannot develop. This leads to the tricky question of what fertilization is. Many times the visitors are young children who may or may not have been taught about reproduction, therefore, it is important to answer the question to the best of your ability without confusing the children or offending the parents. Therefore, if a child asks about the differences between an egg that becomes a chicken and the ones you get at the store, you can begin by saying that in order for an egg to develop into a chicken, something special called fertilization has to happen. This answer is usually satisfactory to the visitor. If, however, they ask what fertilization is, you could tell them that fertilization is something that occurs before the egg is laid and it is what starts development. In order for fertilization to occur, it is necessary for the egg to receive information from a male chicken. We have never had a visitor ask questions beyond this regarding fertilization. However, we suggest taking cues from the adults with the children if such a thing occurs.

Another set of questions is about the parts of the egg. The yolk is a source of nutrients for the developing chick. The egg “white” is also used for food, but additionally it forms a protective layer for the developing chick. By the end of the egg incubation period, both the yolk and the white are completely used up. There are also little white string-like things attached to the yolk. These are called the chalaza and help the embryo remain at the top of the egg when the egg is turned^{vi}. They are not part of the embryo proper); the chalaza is present whether or not there is an embryo. Many people have mentioned that they see these parts in eggs from the store and expressed concern that they may be eating embryos—they are not.

Because of the proximity of the genetics demonstration area to the hatchery, people often have

questions about the chicks in the hatchery. Many of the chicks in the hatchery are from a rare breed of chicken and the museum is involved in a conservation effort to increase the numbers of these birds. These chicks are sent to a farm when they leave the museum. The eggs are kept in incubators near the genetics exhibit. A chick may take several hours to hatch. Two hours after hatching, the chicks have dried and resemble the fluffy chicks in the exhibit.

Budget

Equipment	Cost
QX5 digital microscope, and software	\$80
4 and 6 day embryos	\$0
Slides: 16hr, 24hr, 72hr	\$60
Magnifying Glasses	\$6
Glass Petri dish for embryos	\$0
Preserved Specimens (not used)	\$47
Total	\$193

Appendix 1: Concept Testing Interviews form

Everyone ♥ Baby Chickens Concept Interviews

1. What are you drawn to, what stands out to you on the posters? Why?
2. What do you think is the main message these posters are trying to communicate?
3. Which of the concepts/things are you most interested in learning about or seeing presented in a new exhibit?
4. Which or the concepts/things are you least interested in learning about or seeing presented in a new exhibit?
5. What thoughts, words, or phrases come to mind when you look at this poster?
6. Which concepts/things do you think are most important for other people to learn about or see presented in a new exhibit on embryo development?
7. What other topics would you be interested in seeing covered in a new exhibit on embryo development?
8. Take a look at the computer screen. Would you like to see live chicken embryos at the museum – why or why not?
9. Any additional comments or concerns? Demographics (age range, gender, profession)

- i Cole, C 1993; "Sex and Death on Display: Women, Reproduction and Foetuses at Chicago's Museum of Science and Industry" *The Drama Review*, 31:1 43-60
- ii Phosphate Buffered Saline: 137mM NaCl, 2.7mM KCl, 10mM Na₂HPO₄, 1.8mM KH₂PO₄.
 - a. For 1 litre of solution: 8g Sodium Chloride (NaCl); 0.2g Potassium Chloride (KCl); 1.44g Sodium Phosphate, dibasic, anhydrous (Na₂HPO₄); 0.24g Potassium Phosphate, monobasic, anhydrous (KH₂PO₄) in 800 ml distilled water. Lower the pH to 7.2-7.4 using hydrochloric acid. Once you have obtained the required pH, bring the volume to 1 litre with distilled water. Solution should keep indefinitely (especially when kept at 4 degrees Celsius).
 - b. Chemicals may be obtained from Sigma Chemical.
- iii Johnson, S. A. 1982 *Inside an Egg*. Lerner Publications Company.
- iv Some information for development may be received from the mother in the form of mRNA (messenger RNA; DNA is transcribed into mRNA which is translated into protein which is what does the work of the gene in the cell) in the very early stages of development.
- v Gilbert, Scott F. *Developmental Biology* 6th ed. 2000. Sinauer Associates, Inc. p. 472-475
- vi Johnson, Sylvia A. *Inside an Egg*. 1982. Lerner Publications Company