Ground, Path, and Fruition: Teaching Zebrafish Development to Tibetan Buddhist Monks in India

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Abstract

In June 2018, I traveled to India to teach in a Tibetan Buddhist monastery under the auspices of the Emory-Tibet Science Initiative (ETSI), a program that brings aspects of science education to the three major Tibetan monastic universities in exile. My role was to teach developmental biology to the monks over a 9-day period, and I found zebrafish development to be an excellent vehicle for introducing them to both the wonder of embryonic development and to some of the most advanced findings in the field of developmental biology. I describe here my experiences, observations, and thoughts about how the monastic system will need to change if the monks are really to develop the ability to think like scientists.

Keywords: teaching developmental biology, Buddhism, Tibetan monks

The Emory-Tibet Science Initiative Program

THE EMORY-TIBET SCIENCE INITIATIVE (ETSI)* originated when the Dalai Lama invited Emory University to collaborate with the Library of Tibetan Works and Archives to create a modern scientific curriculum for use in the monastic institutions, including the Gelug school, which is the largest of the four schools of Tibetan Buddhism. A major aspect of this overall project is to bring university-level science faculty to India to teach the monks studying for the Geshe degree, which is the highest degree in the Gelugpa school of Buddhism and approximately analogous to the western PhD, although the students are selected for this degree from among the top students at their monasteries at the age of 15, and the total program lasts for a minimum of 20 years. In addition, ETSI brings consecutive cohorts of six monastics to Emory University for 2 years of undergraduate science education and pedagogy training. These students will become the future science teachers at their monasteries, and so providing them with the major foundations of western science will allow them to teach science, and potentially become future collaborators with western scientists who are interested in combining Buddhist contemplative methodologies with western analytical approaches. Impressively, the introduction

of western science represents the most significant change to monastic education in 600 years, and beginning in August of this year all Geshe examinations will contain questions about science as well as Buddhism.

ETSI serves three monastic college systems: Drepung Gomang and Drepung Loseling, with ~4000 monks, Sera Jey and Sera Mey with ~6000 monks, and Gaden Jangtse and Gaden Shartse, where I taught, with ~3000 monks, all located in the Karnataka state in southern India. Currently, there are 503 monastic students from Drepung, 513 from Sera, and 270 from Gaden, enrolled in the ETSI program. All three monasteries were originally located in Tibet, with Gaden as the oldest of the three. Gaden was first established by the founder of the Gelug school, Tsongkhapa, in 1409, with Drepung and Sera established by Tsongkhapa's disciples in 1416 and 1419, respectively.¹ The locations in India were established in 1966 to accommodate the large number of Tibetans, both monks from Tibetan monasteries and laypeople in surrounding villages, who were and still are fleeing from the Chinese occupation of Tibet, on land donated by the Indian government. While ETSI is currently primarily focused on the three monastic colleges, it has recently begun a pilot program to teach 55 nuns from various nunneries all over India using the facilities at Drepung Meditation and Science Center, which is consistent with the needs of the community as well as the Dalai Lama's progressive views. Likewise, the current cohort at Emory includes two nuns and four monks.

*More information about ETSI can be found at <https://tibet.emory.edu/emory-tibet-science-initiative/index.html>

The commitment of the Tibetans to science education is most clearly shown in the large financial contributions from Emory and the John Templeton Foundation to make science a permanent addition to monastic education. Gaden, for example, has a 5-story science center built in 2015, with classrooms, housing, and dining facilities, for the faculty. Sera has a similar facility, and Drepung has a beautiful new, and much larger, science center that was inaugurated in late 2017, which includes housing for both visiting faculty and 50 rooms for students in study abroad programs, as well as laboratory space and a meditation and science center that seeks to use research-based methods to examine the benefits of meditation.

Under the ETSI program, the monks are taught four areas of science for 9 days each: biology, physics, neuroscience, and philosophy of science. All except the latter are a 6-year curriculum, while the philosophy of science is only taught for 1 year. Except for the philosophy class, the other areas of science include primer textbooks for each year, distance-learning videos, and an intensive summer curriculum of lectures and laboratory-based activities. I taught in year 4 of the biology program, which covers development and physiology, with my excellent coteacher, Jacob Shreckengost (Georgia State University), teaching physiology. The challenge in this program is that while the monks are very bright since the Geshe students are selected from the top students at the monastery, and very mature since they are in their 20s and 30s, they enter the program having had very little or no instruction in modern science. This is beginning to change as the elementary schools in the monasteries and Tibetan settlements are now teaching modern science, but this is not the background of the current Geshe students. Thus, ETSI offers an opportunity to educate the future monastic teachers, but also represents a major challenge for the faculty members who have to teach in a very different way than they would at a western university.

Teaching Zebrafish to the Monks

While there was a pre-existing set of materials produced by previous teachers, I knew after some reflection that I wanted to teach development in a somewhat different way. I began with the fascinating question of how something as simple as a sperm and egg can create something as complex as an animal, and ended with what I think is one of the major current moral issues in developmental biology: whether it is wise to edit the human genome in embryos. I wanted the monks to deal with this issue on their terms, since one of the core strengths of the monastic Buddhist education is its emphasis on ethics and morality. I believe that they can contribute a great deal to this discussion if they can understand the underlying science.

To be able to understand the process of gene editing, the monks needed to understand human development. I felt that zebrafish would be an excellent system for this (Fig. 1), not only because fish development is somewhat easier to understand, but more importantly because there are many excellent videos produced by members of the zebrafish community that beautifully reveal the development of the embryo in a way that no amount of words or pictures can match. In addition, zebrafish, as well as plants, are excellent systems for creating laboratory-based activities in an environment like Gaden monastery, which has no actual laboratory facilities (Fig. 2) and is located so far from any major city that I had to bring every item except water for each activity. With help from Tom Schilling, I planned to do the alcian blue/alizarin red staining of zebrafish embryos,² which required only that I bring a lot of fixed embryos (7, 14, and 30 days postfertilization), a small collection of liquids including the concentrated stain solutions, various tubes and volumetric measurement aids such as pipettors and tips, and an inexpensive (US\$40) digital microscope that connects to the USB port of a laptop computer, providing both power and the ability to image through the laptop screen. Although we

FIG. 1. Why study fish? The classroom at Gaden monastery. Shown is the author, the monk Thupten Gyaltzen, from the Library of Tibetan Works and Archives, interpreting, and the students. Not shown is the fact that the power to all but the projector was often off, and the room was frequently very hot and humid. Photo reproduced with permission.

FIG. 2. Laboratory class at Gaden. Jacob examining the growth of *Arabidopsis* seeds using a magnifying glass, with Tenzin Kunkyang interpreting. Photo reproduced with permission.

ran out of time to actually do the staining experiment, I knew from my repeated trials in Seattle that this protocol would have worked very well in the monastery setting.

A second major tenet of my approach was to try to connect Buddhist philosophical approaches to embryonic development as I felt that the monks would feel a much greater connection to the material if they could see how it related to their world view. This is not as much of a stretch as it might seem at first, and indeed developmental biology is very well suited to this approach. For example, impermanence (the idea that everything is constantly changing) is a central concept in Buddhist philosophy, and when I showed the monks the various movies of the developing zebrafish embryos, they could easily see how the embryo is constantly undergoing dramatic changes. In addition, Buddhism often describes the journey to enlightenment as a series of steps that are referred to as ground, path, and fruition. The ground is the place you start each time, the path are the steps along which you move forward, and the fruition is the result of these steps. Thus, for example, I referred to the pluripotent stem cells that make up the mid-blastula embryo as the ground, the cell signaling and changes in gene expression that cause cell differentiation as the path, and the various differentiated cells that make up the embryo as the fruition. I was very gratified that the monks, unsolicited, told me that they really appreciated this approach since it made them feel much more connected to the underlying biology. It has long been known in western science education that understanding science relies on integration of new information into an existing conceptual knowledge framework.³ By relating development to Buddhist philosophical principles, we were able to tap into students' conceptual framework to reinforce biological principles. Hopefully, this will have a positive impact on their knowledge retention as well.

Buddhist Monks as Science Students

The monks were incredible students to teach, very attentive and engaged, and highly appreciative of the opportunity to learn science. Moreover, whereas in western classrooms it is often hard to get undergraduate and graduate students to answer questions because of the fear of getting the answer wrong, when the monks are asked a question the response is typically a cacophony of answers, such that the interpreters would struggle to identify a single response. And if the monks were told that their answer was wrong, they would readily accept that without feeling embarrassed that they had made a mistake in front of their teachers and the rest of the class, likely rooted in the fact that Buddhism has a huge emphasis on letting go of ego. In this regard especially, I feel that the monks have a lot to teach the western scientific community.

The students are also heavily trained in logical thinking since the first 2 years of the Geshe degree is solely focused on logic, and since the monks participate in nightly debates to sharpen their skills in logical analysis. Thus, the debate that we staged among the monks in our very last activity session about whether to edit the human genome was outstanding, and demonstrated how effective the monks are as thinkers once I had presented the underlying science and the issues involved. And despite the fact that when they come to the West, they often seem very quiet and serious, in the monastery, they are very boisterous and willing to try anything. As one example, while I taught them gastrulation using slides and videos, I wanted them to truly understand how the embryo changes in time and space during this complex process. I hit upon the idea of having them actually act like cells of the various germ layers, to understand how the zebrafish embryo essentially changes from three vertical layers at the start of gastrulation to three tubes by the end of the gastrula stages. While I expect it would be hard to get western graduate

students to try this, the monks had no reservations about this exercise, and I believe it helped them understand the process. What was particularly interesting was that after several “gastrulation failures” as we tried to get the choreography to work, I began to appreciate the importance of strong intra-germ layer adhesion and weaker inter-germ layer adhesion, and once I understood that we were able to get them to successfully gastrulate. Jacob’s film of the end result is publicly available (<https://youtu.be/uN6zB9dRTxo>).

However, one of the real problems with the traditional training of the Geshe students is rooted in the intensive use of debate as a way of learning and refining their understanding of Buddhist philosophy. Every day they spend many hours memorizing enormous amounts of scripture and commentary on the scripture by Tsongkhapa and his disciples, so that they can draw on it at will during the debates. Whereas quoting from these ancient texts are the ways the monks make winning points during the debates, coming up with one’s own ideas is called self-creation, and this is considered a very bad thing to do, as I gradually learned from my monk interpreter, Thupten Gyaltzen. Thus, when Jacob and I ran an exercise that we had very high hopes for in which we asked the monks to make their own connections between Buddhism and western science, it went poorly because it involved self-creation and this was very hard for the monks to do. Therefore, while I expect that the monks can become good teachers of science, for them to make their own intellectual breakthroughs is going to require a serious change in their way of thinking. I am optimistic that this can occur given the proper encouragement, since at the very end of the last class one of the monks asked us if we had any suggestions for improvement, and I raised exactly this point. The monks were all nodding their heads during my response, demonstrating that they could also see the problem. However, it is clear that they will need strong reinforcement of the importance of novel hypothesis generation, which is the very driver of western science, but which goes so strongly against their own training in the monastery.

Buddhism and Developmental Biology

One of the things I learned, which I expect very few western developmental biologists know, is that the Buddhist understanding of embryonic development was initially far more advanced than in the West. In *Nanda’s Sutra on Entering the Womb* (*Nandagarbhavakrantinirdesa-sutra*), written in the first century AD, an impressive week-by-week morphological description of the development of the human embryo from the first week of gestation is provided, which must have been based on direct observation of postmortem embryos. A comparison of modern photos of human embryonic development to text from the sutra is shown in Supplementary Figure 1; Supplementary Data are available online at www.liebertpub.com/zeb.⁴ Similar descriptions in the West of human development did not occur until the 20th century, and instead attention was focused on such strange propositions such as the preformation or homunculus idea.⁵

And *Nanda’s Sutra on Entering the Womb* is not some obscure piece of Buddhist scripture, but was well known by the Geshe students. Had I known this from the outset, I could have pointed out that they already had a strong connection to developmental biology and built upon that foundation.

Conclusions

ETSI is a valuable program for bringing western science to the Tibetan monastic community, which is a major goal of the Dalai Lama. The monks are very bright and enthusiastic about science, particularly when they can see how it intersects with their own epistemological beliefs. This is important since the monks (and nuns) could provide a unique perspective on science, as well as contributing important insight into research on the value of the meditative and contemplative practices of Buddhism. However, for this to occur, the educational system will need to adjust to encourage the teaching and practice of hypothesis-based science alongside the traditional ways of understanding.

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