TECHNICAL PAPER

The Creation of a 'Transitional Model' Depicting the Embryological Stages of Development from the Fertilised Ovum through to Closure.

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A multi-stage, mixed media 'Transitional model' depicting seven embryological stages was constructed. This 'Transitional model' serves to illustrate classically complex embryological concepts that medical students find difficulty in visualising. The model was constructed in clay on polystyrene, yielding a dynamic, 3-Dimensional model with marked coronal, axial, and sagittal cuts.

Keywords: Fertilised Ovum, Gastrulation, Neurulation, Primitive Streak, Folding, Embryology, Anatomical Teaching Aid

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INTRODUCTION

The 'Transitional model' was envisaged as a multi-stage sculptural artwork that serves to depict a process in anatomy that is notoriously difficult to visualise for the majority of students, due to the vast variety of information and easy confusion with specificities (Ward, 2012). The authors intended for the piece to serve multiple purposes: (1) to clearly demonstrate complex anatomical concepts in embryology; (2) to create an interactive piece that possesses panoramic properties, and (3) to serve medical students as a teaching aid.

Ultimately a fully handmade model depicting a series of seven progressive embryological process was produced using mixed media (figure 1). The stages modelled were as follows:

- Fertilised Ovum
- Endometrial Embedment
- Primitive Streak Formation
- Gastrulation
- Neurulation
- Folding
- Closure following Secondary Neurulation

An initial model was constructed purely from clay. The methods below describe the process by which an enhanced model was formed using a base of polystyrene with a clay overlay. The success of these alternative methods are described in relation to the original clay model in the discussion.

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Figure 1. *A photograph of the completed transitional model.*

METHODS

The construction of the model involved multiple media, chiefly polystyrene (Bahrain Polystyrene Company) and clay (Staedtler FIMO Air Basic brand). The large, specialised polystyrene shapes were selected as tall structures could be erected from this material without any restrictions on size due to weight. The shapes were carefully honed and detailed using craft knives (Stanley, TipTop), scalpels (CS England), scales (unbranded), sandpaper (unbranded), and sculpting tools (Sculpey). Painting (Liquitex), serrated edge detailing tools (Artify), and other finishing touches, namely glazing, and touch-up of unpainted areas after drying, were carried out for the final stage (Martin F. Weber Co. Prima Glazing Medium for Acrylics).

Construction

To begin, each model was constructed on a base of polystyrene, which itself was fabricated by cutting into the polystyrene shapes with a heated craft knife, scalpel and a utility knife. Sandpaper was used to eliminate rough edges. At times, the raw foam core itself was moulded with our hands, in order to achieve specialised shapes that could not be achieved with other hand tools and knives alone.

Clay was incorporated into various aspects of the piece to add a smoothing effect to rough edges and to better take up the acrylic paints used in the finishing touches. Furthermore, the addition of this clay also added a professional touch to the final piece, and prevented any potential protrusion of the sharp edges of the polystyrene core.

The authors created a smooth finish by applying wet, smoothed clay, and using flat edges of particular hand tools to achieve an aesthetically pleasing curvilinear shape. This process is known as *stropping*. Next, each model was covered, section by section, with air dry clay (Fig. 2) and was then fastidiously smoothed using water and a specialised set of sculpting tools. These included boxwood tools to provide texture, sharpness, and shape the clay without deeply gouging it; ribs, to shape and smooth rounded edges of the clay; and loop, ribbon, and wire tools, to trim hard edges and carry out special detail work. The individual detailed sections in the models were left out in a dark, enclosed space to air dry (Fig. 3). The same procedure was implemented for each section of the transitional model.

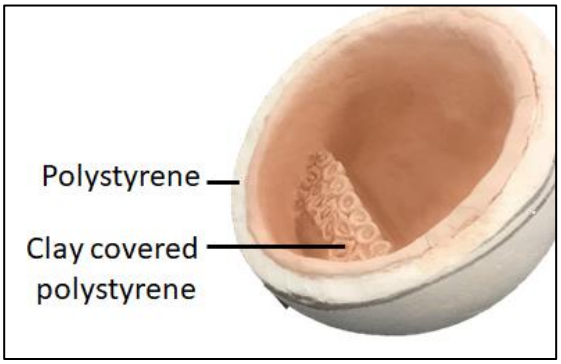

Figure 2. *A photograph showing the early stages of model construction. The polystyrene has been shaped and a layer of clay has been added*

Finishing touches, namely sanding and fine detailing with carving gouges and chisels (as displayed in the inner cell mass in figure 2), were added to the shapes once they had been formed to their final shape. Additional small pieces of clay were formed to add interest and special details, as needed, such as the carving

of individual circular forms into the base of a shape to imitate migrating cells.

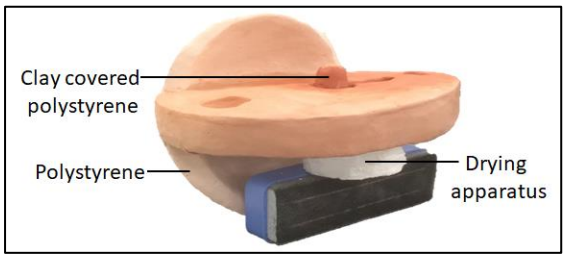

Figure 3. *A photograph showing the clay covered polystyrene model being left to air dry.*

Mounting

The model-building team had determined that the finished piece would have panoramic properties, that is, the capacity would be appreciated from 360 degrees, and thus the team opted to elevate the different models of the piece with short joists.

Cylindrical bamboo mounts. Bamboo handles from 2 shovels (Kraft Tool) were used as the cylindrical materials for holding each of the models. The wooden handles were cut down to seven smaller cylinders. Each of the seven cylinders measured 3.5 cm wide and had a length of 21 cm, except for the one used in the second stage (Endometrial Embedment), where a 12 cm cylinder was used due to the closeness of the model to the base. Each of these cylinders were individually spray painted a matte black (Amasco All-Purpose Interior and Exterior Rust resistant CFC-free spray).

Thereafter, the models were adhered to the cylinders with the use of Carpenter's glue (Emibond General Purpose Wood Glue). In some models a small, slightly wider, centrally-hollowed polystyrene cylinder (5.55cm in diameter) was added to the base of the individual model, also using Carpenter's glue. These wider polystyrene cylinders served to ensure solid fastening of the foam core base of the models to the bamboo cylinders. The piece was allowed to dry overnight, upside-down, or with some weight directly on top of it, to ensure binding.

Wooden bases for models. For the shorter, wooden bases, a slab of plywood with a height of 1.8 cm was chosen and cut down to yield seven square blocks (19.05cm^2). These seven short wooden bases were individually spray painted in a teal blue shade (Scot All-Purpose Interior and Exterior Rust resistant CFC-free spray), until completely lacquered. Once completely dry, carpenter's glue was applied to the unused side of the now model-attached bamboo cylinder, and the centrally-placed cylinder on the wooden base was kept overnight to dry. Once completely dry, carpenter's glue was applied to the underside of the short wooden bases, which thereafter were attached to the larger wooden platform just behind the area reserved for the placard. This composite structure was left to dry for a 2 days. Bases were made for all models.

Large plywood bases. A large Plywood slab (142 x 45cm) was acquired to hold each of the seven models steadily, as well as support each of seven accompanying placards discussed later in this section. The platform was cut down into seven smaller bases of equal size (20 x 45cm), each designed to support the smaller wooden bases with the attached models as well as a placard. Rough edges and stray splintered wood were levelled off using sandpaper. Each of the larger plywood platforms were individually spray painted a matte black shade. Once dry, three small screws were drilled into either side of the inner 5 platforms (Bosch GSB 10 RE Home Tool Kit). Three additional small screws were drilled into the two outer platforms. Small hooks were attached to the screws on the left side of every platform. These hooks can be fastened and unfastened to allow the finished models to detach from their larger bases and enable enhanced three-dimensionality.

Finishing touches: paint and varnish

To ensure an aesthetically pleasing view from all vantage points, the team opted to add more paint to the models and finish each with a layer of varnish. Once again, the team used a water-

based acrylic paint, *viz.* To protect the previously painted model components, the team partially covered the piece with large garbage bags. Fine detailing was obtained with rounded detailing brushes; base coats of paint were applied with straight-edged brushes; corners and divots were filled using angled brushes; and finally feathering and other detailing was achieved with specialised filbert and rigger brushes.

When all parts of the model had been saturated with colour and dried, the team varnished those parts with a glaze (Martin F. Weber Co. Prima Glazing Medium for Acrylics) advertised to be safe for use on acrylic-painted clay and Styrofoam material.

Figure 4. *A photgraph showing a painted and varnished model mounted on its base with an information placard attached.*

Information placards

To accompany the polystyrene and clay models, a set of seven laminated placards (16 x 19 cm) were included (figure 5). These placards were completed using pen, ink, high-quality colored markers (Prismacolor), and CorelDraw 10 computer software (CorelDraw 10 Graphic Design Software) for enhancement of saturation, sharpness, brightness, and positioning. The information included on the placards aimed to aid learning around the stages depicted on the models. The finished placards were included alongside each of the relevant phase sculptures within the piece.

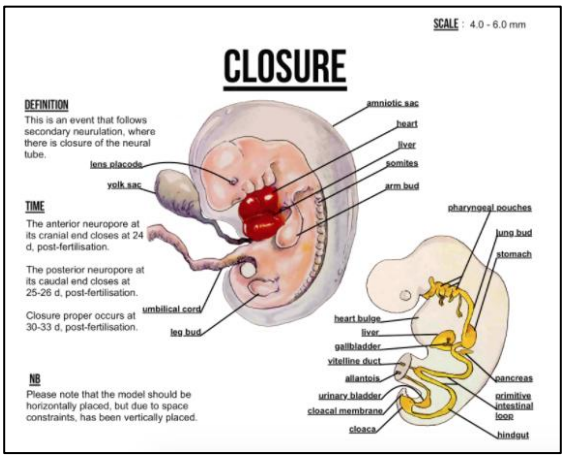

Figure 5. *An exmaple of the information placard designed for the final stage of the model.*

DISCUSSION

As described in the introduction to this article, an original method used clay alone to attempt to construct a multi-stage 'Transitional model' The methods described in this article aimed to improve upon the previous model. The benefits of this new method will be discussed here in relation to those used to form the older model.

The use of heavy clay in the initial model limited it to only one plane for viewing and a low height. The materials incorporated in this newer model allowed the models to be built higher as they were not limited by weight. The team opted to use polystyrene materials here but also to include a layer of clay to maintain the aesthetic aims of the original model.

The prior model was built flat along a surface, and could only be viewed aerially. The ability to

view embryological models panoramically is important for the understanding of 3D anatomy (Azer and Azer, 2016). Furthermore, although the primary organs featured in the original model were well formed, they did not protrude significantly from the model, which gave the appearance of sinking within the finished piece. This ultimately 'flattened' the piece. The new model improved upon this in five important ways: (1) multiple cuts through the principal structures included in each phase of the piece were incorporated (2) the sculptures formed were elevated above their supporting platform, giving the piece depth; (3) the sheer magnitude of the finished piece was greatly enhanced, which makes the model more enticing at first glance, (4) the weight of the model was significantly decreased, which meant that vertical building was not hindered by weight, and (5) the addition of the foam core rectified the previous issue of an overall flattened appearance found in the prior model.

Following discussion of the shortcomings of the building process for a previous iteration of a different model created in 2016 (a cross-sectional artistic view of the lesser sac at T12), the team realised that various alternatives were available for the materials used in this model, and respectively could serve the same purpose. In this way, the model-building team was much more flexible and adaptable in the creation of this second, larger scale piece. This flexible approach led to the discovery of a good use for household materials, reduced costs of the overall model, and developed spontaneity of thought in planning. For example, instead of using expensive SOMSO anatomical model-derived metal pipes to elevate the structures, the team considered using dense plastic water pipes, sturdy walking sticks, bamboo skewers, metal skewers, and even the handles of common items such as broomsticks, and shovels. The team also pondered alternatives to traditional air-dry clay, namely, paper-based clay for a smooth texture that would reduce fissure formation. Further, as an alternative to specialised sculpting tools, the team considered using tableware materials, such as forks, knives and spoons, could be used to incorporate fine detail work. Finally, the team discussed the merits of incorporating Tupperware materials, bookshelf bases, wooden doors, and also table tops into the final project, to serve as alternatives to a wooden platform. As the methods described in this article describe, some, but not all, of these ideas were incorporated in the final piece.

By incorporating hooks into the final design of this piece, each of the component parts of the model can now be successfully detached from their bases. The model-building team is confident that this "detachability" feature will play into each student's engagement with the piece, as it enables a more hands-on and accessible experience with the model supplementing their knowledge and helping them learn *actively* (Khoddam et al., 2014). Ultimately, the student's learning experience is more intimate.

This model was much more complex in its conception; the model-building team strove to challenge itself to create a model that was technically elaborate, yet visually elegant. We wanted to depict a process that is notoriously difficult for most students to envisage, in a manner that delivered the essential concepts in a simple, 3D manner.

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