his issue’s themed tutorials commence with a guide to sculpting the female form in ZBrush. Over the next ten pages, we will explore the anatomical principles that inform an efficient modelling workflow, starting with an overview of the base mesh, then gradually refining it to recreate our statuesque cover star.

The female figure is generally smoother than the male, requiring attention to detail. The form is less about definition and more about planes, concavities and convexities. Correct volume and proportions are even more important, since there are few muscles to distract the viewer from inaccuracies.

As ever when sculpting, start with good reference material. The best reference would be a live model, but this is rarely practical for a digital sculpt. The next best option is a set of images captured from multiple angles. Working from good reference helps prevent over-generalisation of form and gives believability by introducing small imperfections that would be hard to reproduce from memory alone.

In this tutorial, I will set out two key ZBrush techniques. The first is a clay-like approach in which you work at high resolution, building up shapes much as you would using real clay. This is useful for sketching in anatomical landmarks and establishing volume. The second involves working at multiple levels of subdivision, and is used for refining the model to a smooth, high-quality finish.

The printed walkthrough assumes that you have some previous experience of ZBrush, providing a high-level overview of the process. However, screen-capture videos covering the entire sculpt can be found on the CD, while ZTL files showing the model at successive stages of refinement can be downloaded from the 3D World website at http://tinyurl.com/Surckz. Refer to these for more details.

A final word to the aspiring artist. Even an extended tutorial like this cannot cover all of the issues that arise when creating a sculpture, digital or otherwise. Even if it were possible to present all of this information, there needs to be an understanding of form on the artist’s part. This understanding is only achieved through diligent practice and experience. Commit yourself to learning something new with every sculpture, and you will progress quickly.

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Recreate our cover star with the help of our ZBrush masterclass, which sets out a robust workflow for sculpting the female form, with an emphasis on anatomical principles.
The base mesh is the starting point for models in ZBrush. Establishing sound topology at this stage makes posing and sculpting much easier. Like clay, ZBrush is a forgiving medium that enables artists to easily modify the shape of the mesh. The topology, however, remains fixed from the beginning. (There are tools for reworking topology and transferring detail, but these are beyond the scope of this tutorial.)

Like real clay, the consistency of digital clay can be smooth or lumpy, and the base topology is the critical factor in determining this. A mesh that is composed of odd-sized, triangulated polygons with irregular edge flows will sculpt like lumpy clay: it will be hard to control and difficult to refine, regardless of how many subdivisions are in the mesh.

If you are working on production meshes, establishing sound topology from the start is essential, not only for the reasons mentioned above, but also for the benefit of riggers and animators, for whom sound topology is vital to ensure that the model deforms correctly when animated.

Keep in mind that there is no one perfect topology for a figure. A general topology, like the one used here, works for most characters, but the ideal topology depends on how the figure articulates. A character that walks around with his arms at his side has a different ideal topology than a figure that, through some unknown affliction, always has his arms raised over his head.

So what should be represented in the base mesh? I generally think that a base mesh for digital sculpting should be as low-resolution as you’re able to get it. ... have to compromise occasionally to properly represent critical topological features like fingers. Take an arm as an example: ideally, its low-res topology would be just an extruded cube with equally square faces from the shoulder down to the wrist. But when you add fingers to the hand, the edge loops are propagated. The result is an arm that has multiple sides, not four.

The important thing to bear in mind when setting up your base mesh is to make sure that all the features are represented, then adjust your poly size and distribution. Here are a few things to consider when constructing your own base mesh for posing and sculpting in ZBrush.

We will cover key points such as the need to achieve even, square quads; efficient arrangement of edge loops; and the correct level of detail to use in describing different parts of the body. Overleaf, we will begin to refine this completed base mesh.
Get into the habit of putting decent edge loops in your model; they help with the sculpting process. A nicely edge-looped model requires fewer polygons to represent form, and you will never feel like you are fighting against misaligned edges. The edge loops should broadly flow along muscle groups and in the direction of deformation. I also use specific edge loops to represent critical skeletal landmarks in the figure.

Strive for correct proportions in the base mesh, but don’t be overly concerned with the shape. The main thing is to have the large features represented and the major proportions correct. If you don’t have good measurements of the proportions of the model in your reference, match a classical canon of proportions in which the height of the body is 7 to 7.5 times that of the head.

As much as possible, create ‘square’ quads rather than long rectangles. Working with rectangles is awkward because they retain their original aspect until subdivided. Subdividing the short side also subdivides the long side, which retains its original aspect ratio. This can make for very awkward geometry, especially on the faces and hands, which should be squared off. To do this, add a couple of extra edge loops to square off the quads.

Avoid over-describing details in the base mesh. Small features, like fingernails and toenails, should not be described in the base mesh, as they will subdivide into millions of polygons. If you know you are going to have a disproportionate amount of detail in a particular area, you want to add a denser base mesh in that area, like the hands or the feet. You can also use ZBrush’s Geometry HD feature.

Modelling the female form | TUTORIALS
STAGE TWO | Establishing a pose

01 Load the 01_baseMesh.ztl Tool. Create a new layer via Tool > Layers > New, and call it 'transpose'. This layer is going to store all the posing edits so that you can turn the transformations on and off as necessary to revert back to the original bind pose. It's a good idea to add layers for each significant edit you perform. This way, the workflow becomes non-destructive and flexible.

02 [Ctrl]-select the upper half of the body to mask it. Next, transpose the legs forward to 90 degrees, establishing the sitting pose. This helps to position the hips and rib cage. Tilt the pelvis by transposing with no mask. Counter-rotate the rib cage to maintain balance. Do this by masking the lower body up to the waist, then rotating the upper body so the spine is bending forward.

03 Transpose the legs. They rotate on a point midway up the hip, where the femur articulates with the pelvis. The left leg requires a simple, but extreme, rotation to get it into position. The right leg requires an axial rotation, with the rotation bone in the centre of the leg and the mask gradually softened in strength, along the length of the upper leg. [Alt]-click and drag the end of the action line.

04 Transpose the arms into place using Rotate. Twist the forearms by masking halfway down, placing your Transpose bone in the middle of the forearm and twisting using the middle rotate handle. This is a 'naïve' twist that can collapse the volume of the arm. You will need to go back in and restore some of this volume.

05 Use the Move Brush on the lowest Subdivision Level to re-establish the feeling that there is bone underneath the mesh. The Transpose tool can give round bends on limbs depending on the masking, so you need to restore the structure of the joint. This is especially important for the elbows and knees.

06 Enable the transpose layer and click Delete. This applies the transpose permanently. Now subdivide the mesh up to Level 6 (roughly two million polys) via Tool > Geometry > Divide. At Level 6, create a new layer called 'torso'. Creating your layers on the highest working Level captures all edits from all levels on that layer.

STAGE THREE | Working with the torso

EXPERT TIP

All-round reference
Reference from multiple angles makes a huge difference when posing a digital sculpture. A complex pose is like a 3D jigsaw puzzle, where the solution is thrown off if one piece is out of alignment. Carefully establish the correct joint angles from the pelvis to the extremities: the hands, feet, fingers and toes should be the last consideration. When the figure is in position, compare negative spaces in the pose with your reference to diagnose accuracy. Reassess the pose as the model progresses. You'll be surprised how much you notice.

06 Polygroups help workflow. Toggle off the transpose layer to restore the default pose. Sequentially hide the limbs: [Ctrl][Shift]-drag a selection box, then release [Shift] to hide inside the selection. Create Polygroups using Tool > Polygroups > Group Visible. Make Polygroups for the torso, head, arms, hands, legs and feet.

07 Enable the transpose layer and click Delete. This applies the transpose permanently. Now subdivide the mesh up to Level 6 (roughly two million polys) via Tool > Geometry > Divide. At Level 6, create a new layer for the torso. Creating your layers on the highest working Level captures all edits from all levels on that layer.
Switch back to Subdivision Level 1. With the Move Brush, refine the edge loops for the torso. Pay special attention to the edge loops for the scapulae (shoulder blades) and under the armpit. These suffered a bit of damage during posing, and need to be restored to their appropriate shapes before we can start sculpting.

The clavicles (collar bones) form an elongated S shape, starting at the pit of the neck and curving out to the points of the shoulders, where they attach to the scapulae. In this pose, they are rotated forward from their ‘joint’ at the upper edge of the sternum (breastbone). Use the ClayTubes Brush to sketch in the gesture of the clavicles.

In this pose, the scapulae have slid laterally and forward along the rib cage. Here, the major evidence of them is their inner border. Locate these on your model. They appear as a relief on the back and need to be massed in. If you are not comfortable doing this, find an anatomy book and study the shape of the scapula. This will help you understand the upper back.

Use the Polygroups to hide the legs and arms, leaving only the chest and ribcage visible. Use the ClayTubes Brush to sketch in the arch of the rib cage. The costal cartilage of the ribs projects forwards slightly, and the abdominal muscles transition this plane downward. Sketch in the planes of the costal cartilage and abdominals, building up as much volume as necessary.

Next, you need to establish the volume relationship between the hips and the rib cage on the model. Try to imagine the actual bone structure underneath the skin and sculpt the mesh out to fill this volume. It’s important as you do this to maintain the appearance of a coherent skeletal mass underlying the smaller forms. Pay particular attention to where the rib cage is rotated forwards, creating a crease between the hips and the ribs: there is a compression of muscle and skin on top of the rib cage and pelvis. Creating believable transitions where the skin folds around this area requires a delicate touch, plus detailing at a later stage. Use the ClayTubes Brush to establish the volumes, then refine with the Standard Brush.
Locate the deltoid muscle area on the shoulder. It originates on the outer third of the clavicle and wraps around the point of the shoulder to the back (on the scapula). It also inserts halfway down the upper arm on the outside. Use the ClayTubes Brush to sketch marks on the model for both these locations.

On both arms, the shoulder is rotated inward, causing the humerus (the upper arm bone) to rotate axially. The result is that the elbow now faces outward and not rearward, while the insertion of the deltoid faces forward. The mass of the deltoid needs to 'twist' to accommodate this. Mass in the twisting form using the ClayTubes Brush.

The deltoid overlaps the biceps and triceps on the upper arm. Neither is noticeably defined here, but they still contribute critical volume to the arm, so the fact that they are relaxed and acted on by gravity must be captured. Use the Standard Brush at a low Subdivision Level to capture this subtle form.

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Working down the arm, concentrate next on the bones of the elbow. There are three bony points exposed on the bent elbow - the olecranon (elbow bone), and the medial and lateral epicondyles. Together, they make an inverted triangle. Locate the area and build these up on your model.

Working down to the forearm, trace the length of the ulna (one of the two long bones) from the elbow down to the wrist on the pinky side of the hand, where the bone terminates in a small bump. Sculpt both of these bony landmarks onto the model. Depending on the pose, the length of the ulna creates a furrow on the outside of the forearm; it’s not too evident here.

You need to often re-employ the Transpose tool to bend fingers believably. Position the edge loops at Level 1 to get the proportional relationship between the joints correct. Then step up to Level 3 for sharper topological masking, and use the Transpose tool to bend the joints into position. Pay attention to how much each joint articulates in relation to the previous one.

Use the Transpose tool on the right foot to rotate it at the ankle so that the top of the foot starts to face downward. You also need to transpose the outside half of the foot (the metatarsals and toes 3-5), as they are pressed against the floor and have rotated to accommodate, leaving a longitudinal crease down the bottom of the foot.

Refine the volume of both feet using the Move Brush at Subdivision Level 1. When blocking in the volume of a foot, think about the shape of a footprint, and how the outside edge of the foot rests on the ground while the instep is elevated. Also remember that the main contact points with the ground are the heel and the balls of the toes.

EXPERT TIP
Talking hands
Hands are second only to the face in expressiveness, conveying a wide range of emotions depending on their gesture. Because of this, we are very attuned to reading these gestures and can easily spot hands that don't look right. Therefore, you need to spend time and attention making sure the proportion and articulation of the hand and fingers are correct. For female hands, few artists captured them better than Alphonse Mucha (www.muchafoundation.org). A good exercise for learning the subtlety of gesture is to copy the hands from his drawings.
STAGE FOUR (Continued) | Working with the limbs

EXPERT TIP
Anatomy of the knee
Knees require an understanding of the bones and joint to sculpt. Get familiar with the shape of the end of the femur: there are two protrusions, or condyles, that show when the knee is bent. Between these is the patella, or kneecap, which slides into the cavity between the condyles when the knee is bent. All this sits on top of the bony plateau that is the enlarged end of the tibia, the main bone of the lower leg. The plateau edges are directly under the skin and taper as they descend, eventually turning into the ridge of the shin.

21 Detail the forms of the knees using the Standard Brush at higher Subdivision Levels (4 and 5). The main points to emphasise are the condyles of the femur, the patella and the kneeling point of the tibia (see Expert Tip for more on the anatomy of the knee). These are small planes, so subtlety is required.

22 Use the Inflate Brush to emphasise the crease in the bent legs, where the hamstrings are pressed against the calf muscles. Remember that the inside of the bent knee shows more bulge, owing to fat and tendons. Once the faces have been inflated together, refine the end of the crease with the Pinch Brush.

23 Use the Standard Brush at Subdivision Level 4 to add a gentle curvature to the shins on both legs, as they descend from the knees to the ankles. Sitting on the inside of this curve is the mass of the calf muscle: add volume here if necessary. Legs complete, it’s time to turn your attention to the feet.

24 Adjust the toes on both feet using the Move Brush at Level 1. Constructionally, the smaller toes incline towards the second toe, which is generally the longest, or is equal in length to the big toe. The tips of the first two toes are elevated at the end, while the last three point towards the ground, almost gripping it.

25 Although the nails of the toes represent a small detail in the scheme of things, they are important for making the feet believable. They aren’t present in the topology of the base mesh (see page 45) because they would add too many polygons during subdivision, so you have to build them from your subdivided polygons. Switch to your highest Subdivision Level and paint masks where the nail beds are. With the Standard Brush, sculpt around the back half of the nail bed, raising it above the level of the nail itself. Now invert the mask, and sculpt the shape that makes the end of the nail, taking it slightly beyond the end of the toe. Painting a mask is a powerful tool for detailing specific forms: you’ll use it again later to help with getting the eyes right.
STAGE FIVE | Refining the head

26 Working at the lowest Subdivision Level, refine the shape of the face, paying special attention to the vertical alignment of features. (Always try to capture reference photos showing the face in profile.) Select the Move Brush with symmetry enabled (Transform > Activate Symmetry) to sculpt both sides together.

27 Check the space between the nose and the mouth. This is often exaggerated, giving the impression that the mouth is too low. As a guideline, the lips should generally be two-thirds of the distance from the chin to the bottom of the nose. Use the Move Brush at the lowest Subdivision Level to reposition the mouth and the surrounding edge loops.

28 Establish the form of the eyes by moving the edge loops into position. The upper eyelid needs to have the edges and fold established; the lower lid has an edge and transition into the cheek. Start at the lowest Subdivision Level and work your way up the Levels, keeping your creases tight. Use the Pinch Brush with Stroke > LazyMouse enabled to help you with creasing.

29 Like the other features of the face, the lips should be treated as small sculptures in and of themselves. Move the edges into place first, capturing the main lines of the upper and lower lips. Then step up to Subdivision Level 3 and use the Standard Brush to sculpt in the small volumes. Next, we’ll look at one of the most expressive parts of the face: the eyes.

30 The pupil and cornea are created using the same technique as the nails. At Subdivision Level 6, paint a round mask that outlines the cornea, then invert the selection. Use the Standard Brush with a large radius to pull out the cornea of the eye. Smooth around the border of the mask to eliminate hard edges.

31 The chin and jaw line are delicate, and need subtle handling. The jaw line itself is sharp, but there are subtle transitions between the underside of the chin and the roundness of the neck, and from the back of the jaw into the ear and neck. Use the Standard Brush at Subdivision Level 3 to sharpen the jaw line, but introduce a gradual concavity to the transition into the neck.

32 Build the ears with the same approach. At the lowest Level, use the Move Brush to establish the broad shape. Move to Subdivision Level 3 or 4 and sculpt in the remaining form, using the Standard Brush. Ears are not difficult once the structure is understood. The critical thing is to sculpt them in three dimensions, giving them depth and moving them off the plane of the skull.

EXPERT TIP

Structure of the nose
The nose is a complex shape, with small planes that must be accurately described to capture its character and individuality. The nose starts where the nasal bone joins the glabella (the keystone transition to the forehead). The nasal bone extends about halfway down the length of the nose, where there is a transition to cartilage that should be described, although it’s often subtle. The ball of the nose interlocks with the lower end of the cartilage and gives a nose much of its individuality. Abutting the side are two pieces of fatty tissue that enclose the nostrils.

Proportions of the face
The relationships between features on the face are critical for creating a believable face and matching a likeness. As with the rest of the body (see page 45), it is best to start with a standard canon of proportions and only then determine how your particular face varies from that. In general, the face can be divided into thirds: the top third from the hairline to the top of the nose, the second third to the bottom of the nose, and the last to the bottom of the chin. Within this final third, the mouth sits one third of the distance down from the nose.
The female forehead has subtle plane shifts that must be captured to keep it from looking too smooth. Using the Standard Brush at Levels 2 and 3, capture the angle of the forehead and where it transitions to the hairline. Establish the break in planes along the temporal line, which generally starts above the outer apex of the eyebrow and runs diagonally backwards to the hairline.

For the hair, use the ClayTubes Brush but set the BrushMod value (Brush > BrushMod) high - around 60 - to put volume into the brush. Vary the brush size to give larger masses of hair. If you have a pressure-sensitive tablet, varying the pressure along the length of the stroke helps create the impression of wavy hair. Next, we'll sculpt the bun of hair at the back of the head.

The bun is not represented in our base mesh, so we need to block it in using existing polys. The best approach is to move down to Subdivision Level 1 and use the Move Brush to pull out a mass of hair. This gives you the base form to sculpt on at higher resolution. It stretches your topology a bit - but with six subdivision levels, you still have sufficient 'material' to model with.

Use the Move Brush at level 1 to angle the ear so that its long axis tilts slightly backwards. Turn to a rear view and use the same tool to make sure the cup of the ear stands off from the head. This makes room for the mastoid process, a prominent bony landmark directly behind the ear, where the main neck muscle attaches.

Now sketch in the neck muscles. In this pose, the neck muscles are active on the right side, turning the head. The muscles on the other side are relaxed. The main muscle, the sternocleidomastoid, forms a strap-like bridge, spanning the pit of the neck to just behind the ear. These forms require a medium level of detail, so sculpt them with the Standard Brush at Level 4.

Finally, go back and do one last check of planes and proportions. Many small problems will have been noticed and corrected working through the various stages of construction, but new problems may have been introduced as well. Check the final size of the head and the relative lengths of the limbs. Compare this against your reference. Also check the overall balance and weight of the pose: have you put too much mass in one place? Vary the material and lighting conditions on your model to help diagnose the planes and continuity of surfaces. Fix any problems you encounter, and continue to iterate until you are happy with the result.