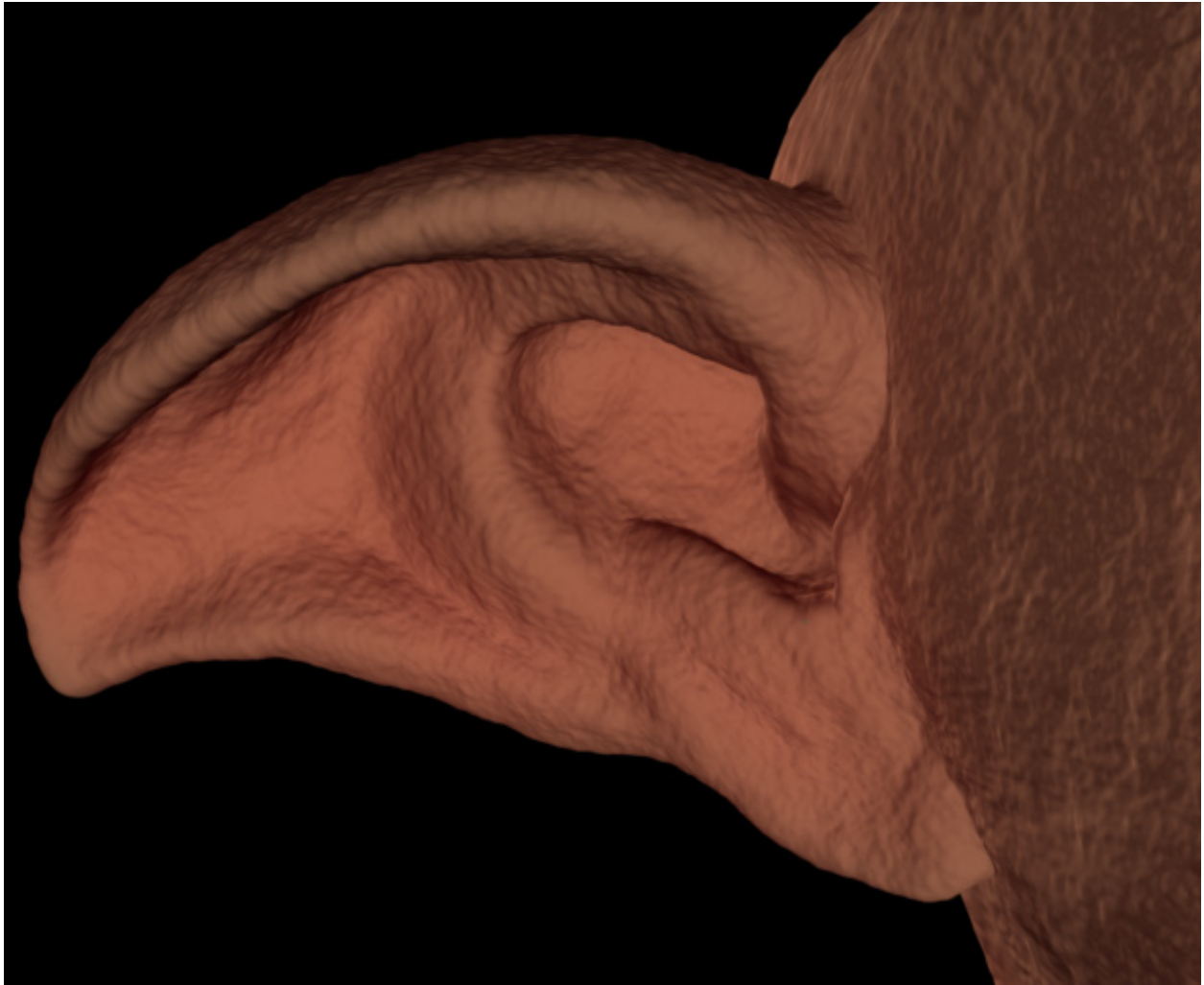


3.5 SUB-SURFACE SCATTERING & DISPLACEMENT

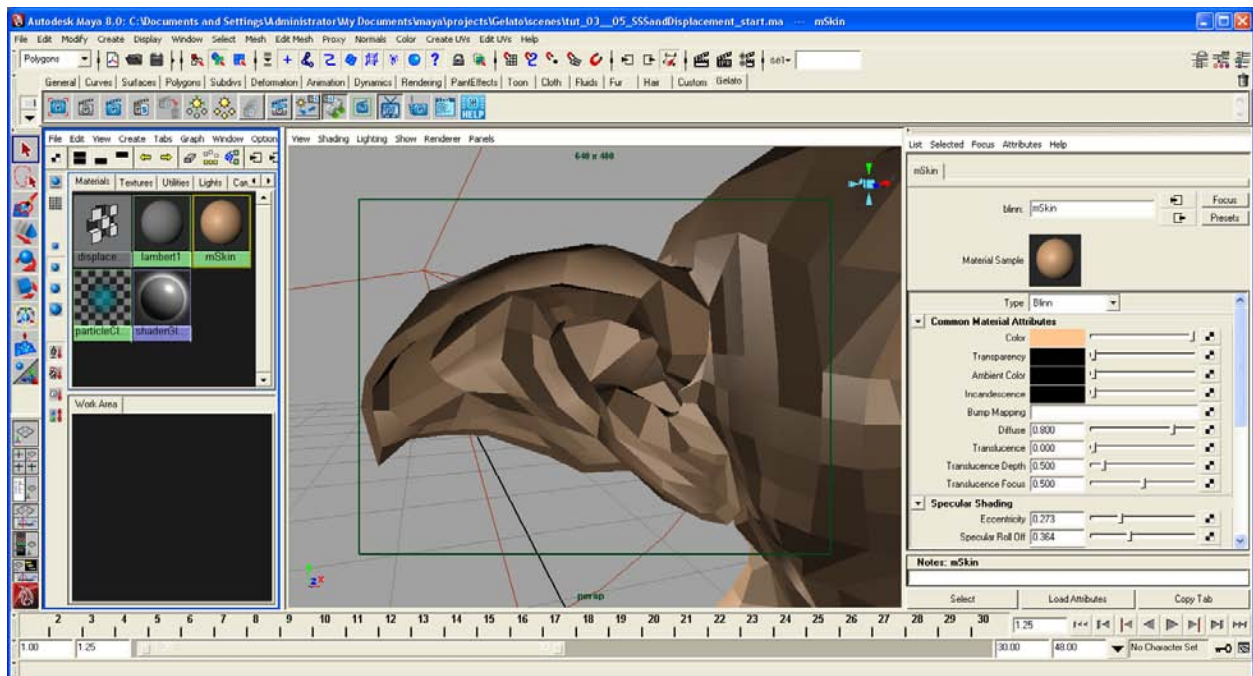


This is the companion to the movie, tut_03_05, part 5 of the 8 NVIDIA® Gelato® Advanced Tutorials.

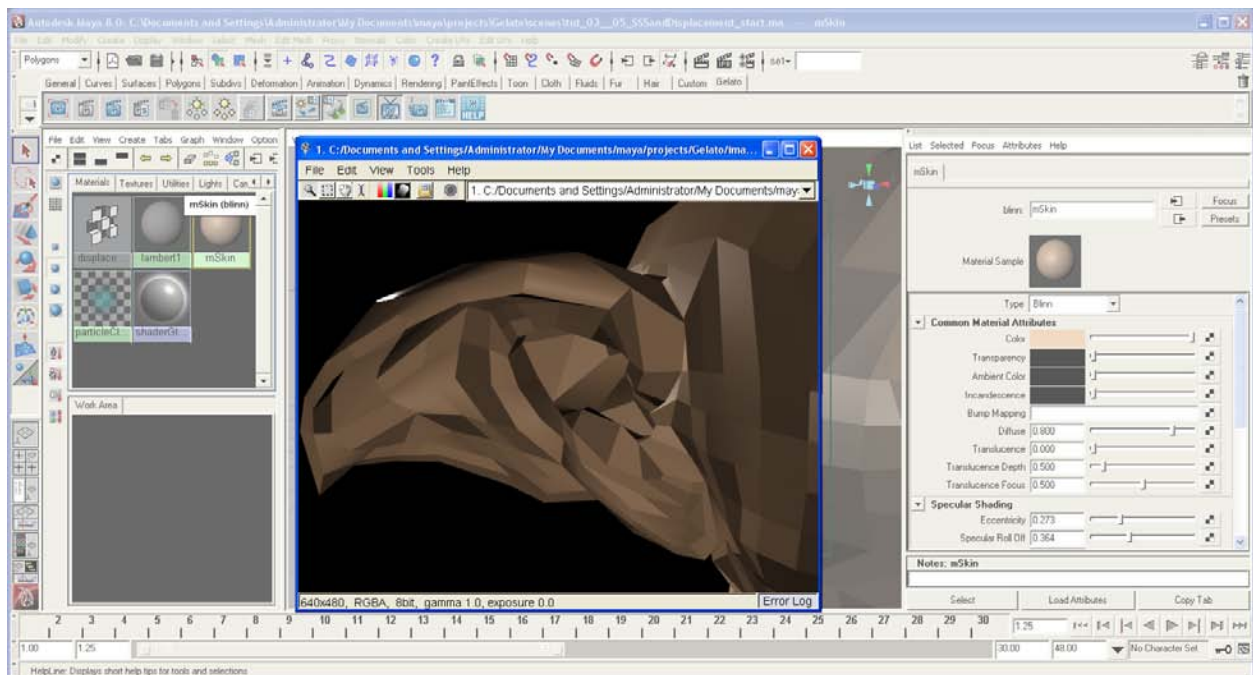
In this tutorial, we are going to cover subsurface scattering and displacement. Subsurface scattering occurs when light penetrates a surface which has some translucency, is scattered around under the surface of the material, then is bounced back out. This is seen in liquids like milk and certain stones and minerals, such as marble. When light hits skin, another substance which exhibits subsurface scattering, it bounces through the skin and interacts with the blood and tissue below the skin.

Displacement, unlike bump mapping, which fakes changes in surface geometry, will actually cause a physical change in the mesh.

In this project, we are going to first set up the subsurface scattering, then we'll temporarily disable that to do some displacement, and finally, we'll turn the subsurface scattering back on to complete the final render.

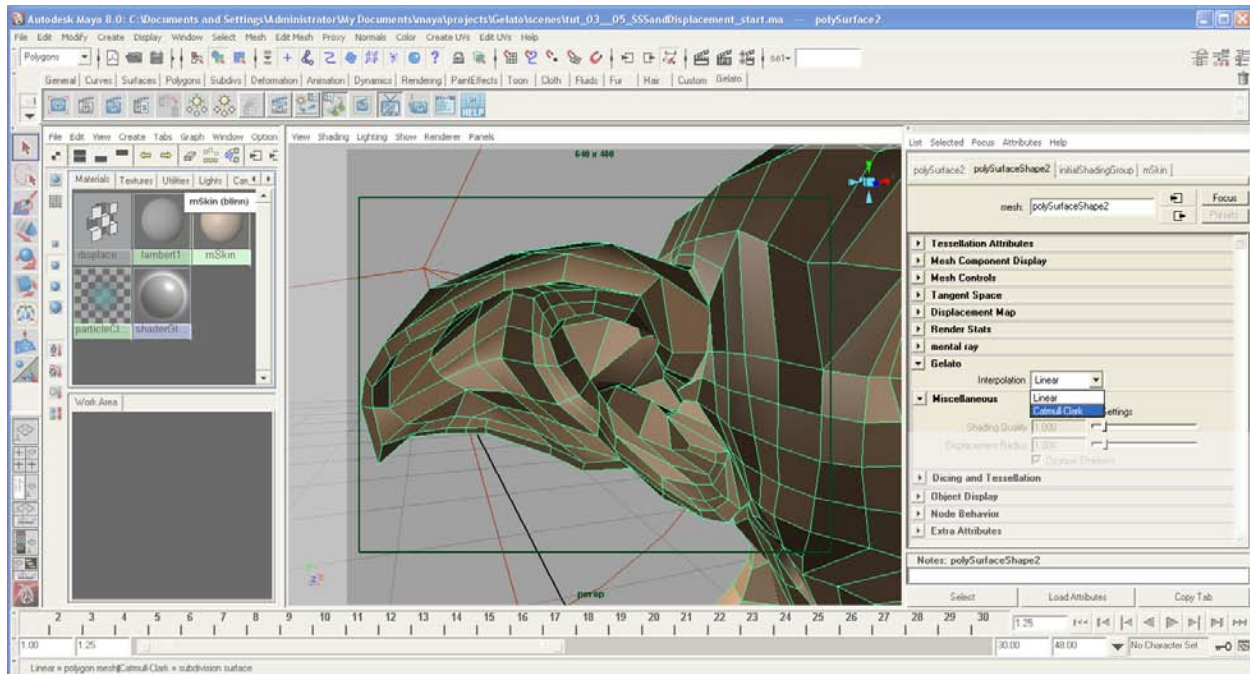


- Open “tut_03_05.”
- Gelato Render.

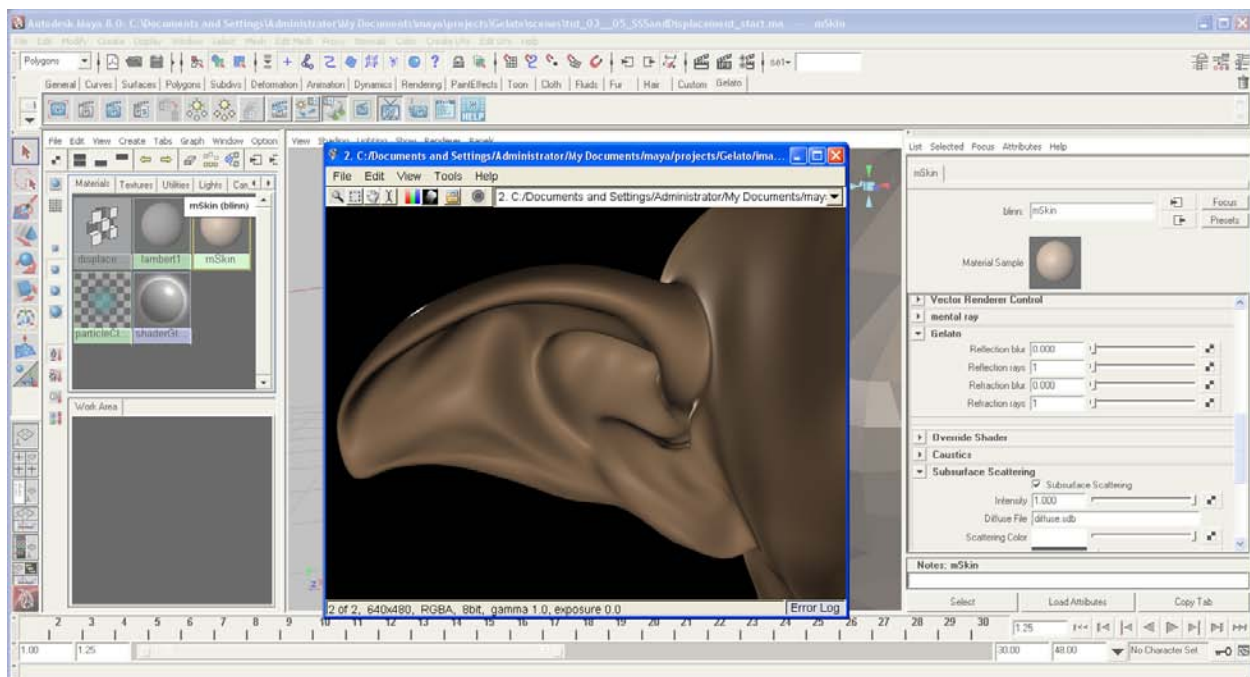


The model is very rough-looking – we can see all the polygons.

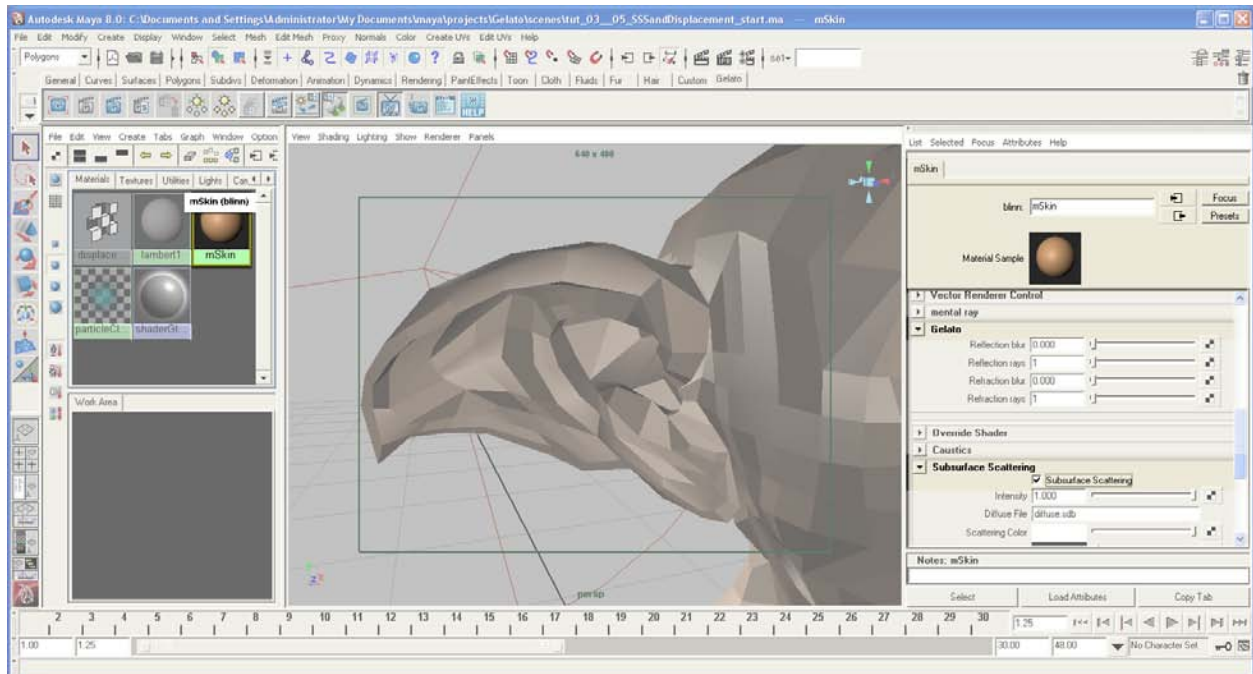
In folding skin, subsurface scattering will be more obvious, so that's why we are working with this example. To make this model look more like an ear, we need to turn on the Catmull-Clark interpolation for this exercise to smooth out the surface.



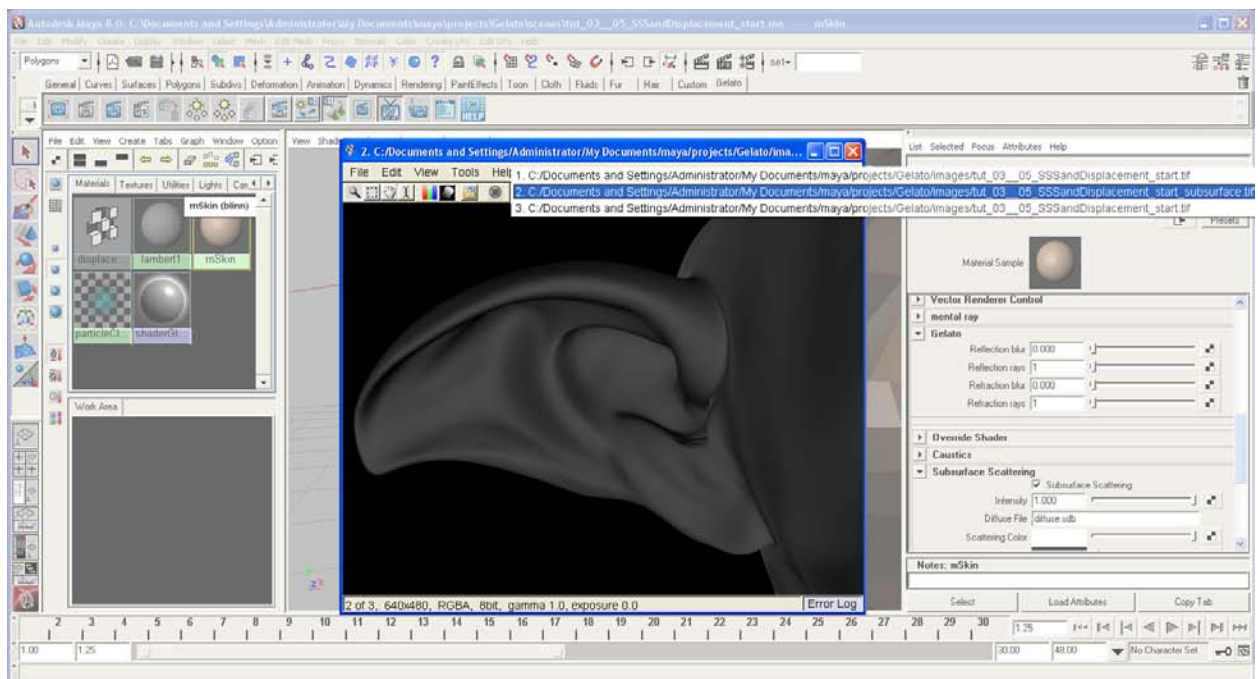
- Select the model.
- polySurfaceShape2 > Attribute Editor > Gelato > change Interpolation to Catmull-Clark.
- Gelato Render.



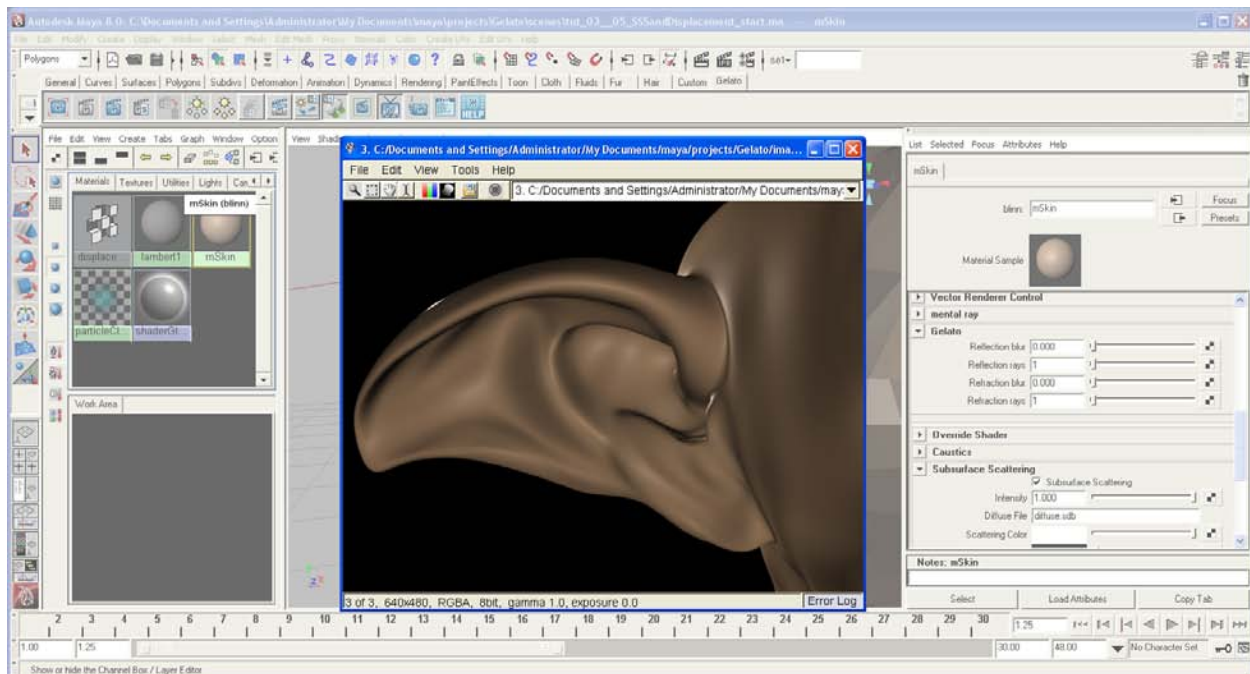
Now that the render is nice and smooth and very ear-like, let's enable the sub-surface scattering on the material...



- mSkin material > Attribute Editor > Gelato > Subsurface Scattering > enable Subsurface Scattering.
- Gelato Render.



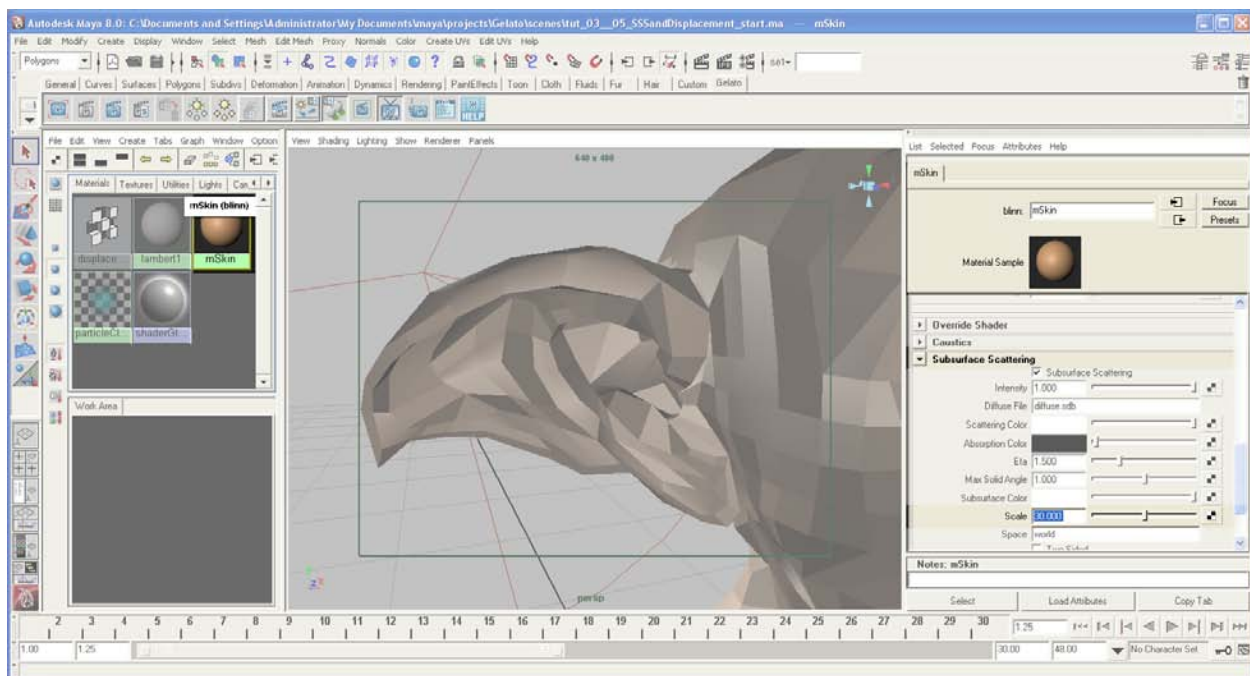
Pass 1



Pass 2

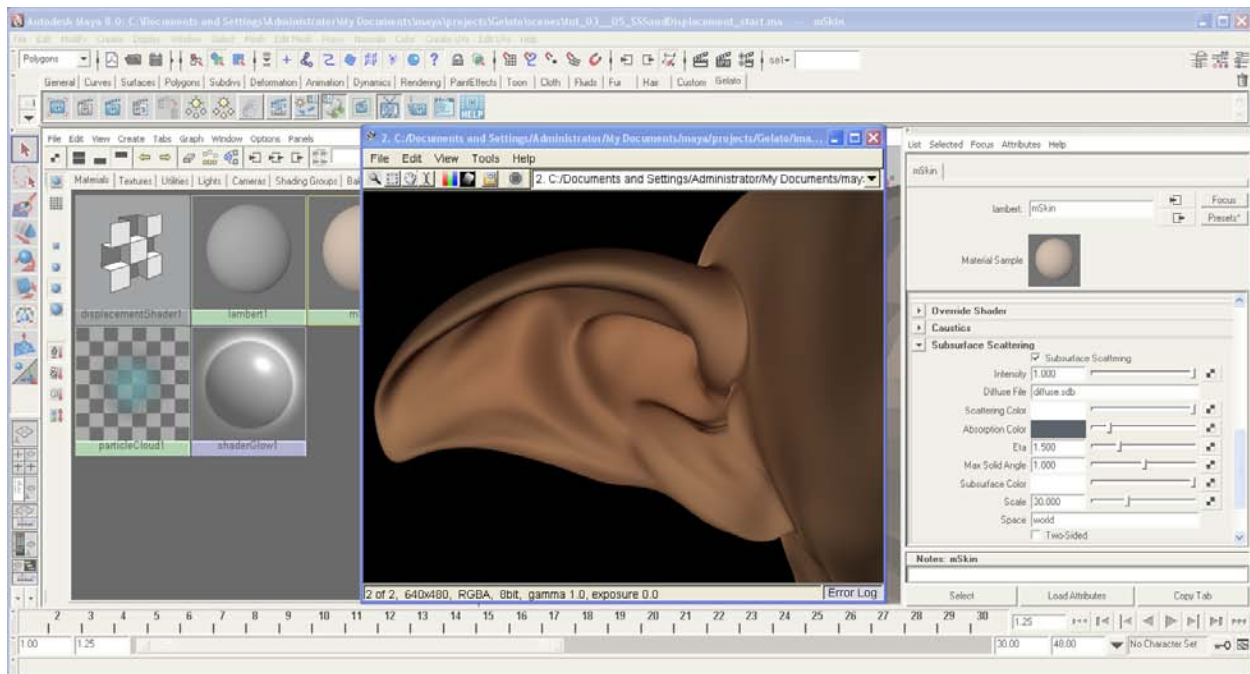
* If you were watching, two passes occurred with this render. The first pass is the subsurface scattering pass; the second is the composite pass.

* Some shadow areas are a bit more visible now, but we're not seeing any big difference



• mSkin's Attribute Editor > Gelato > Subsurface Scattering > change Scale to 30.

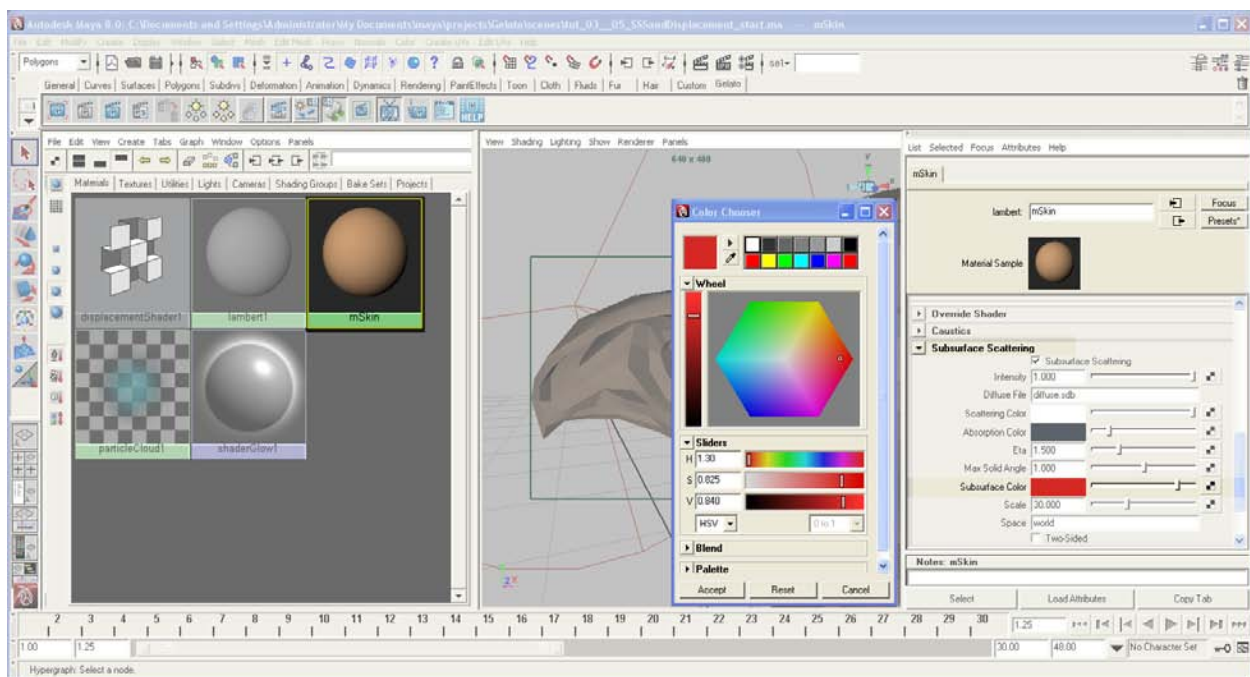
Smaller objects are not going to have as much subsurface scattering going on because they have less volume. The Scale adjustment is used when we have objects in the scene which are not real-world scale, such as the model in this scene.



- Gelato Render.

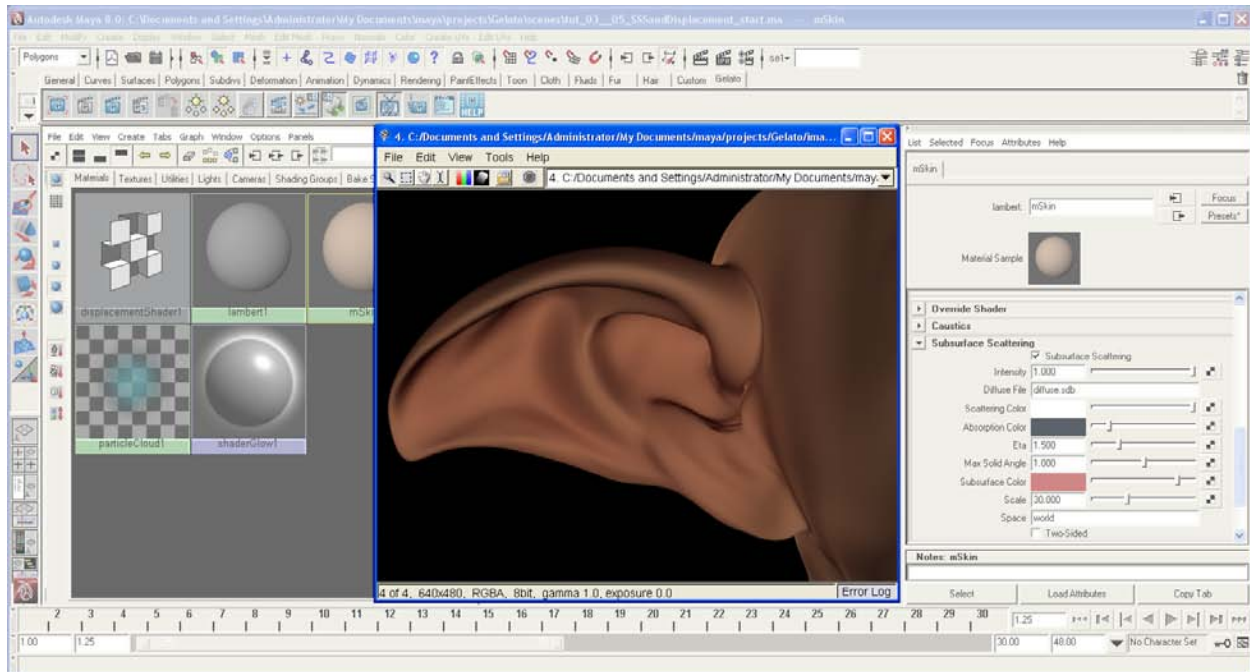
* When we compare this to the previous render, we can see that the effects of the subsurface scattering are much more dramatic.

* The color isn't quite right. Blood would lend a reddish hue.



- mSkin's Attribute Editor > Gelato > Subsurface Scattering > **[CLK]** color field of Subsurface Color.

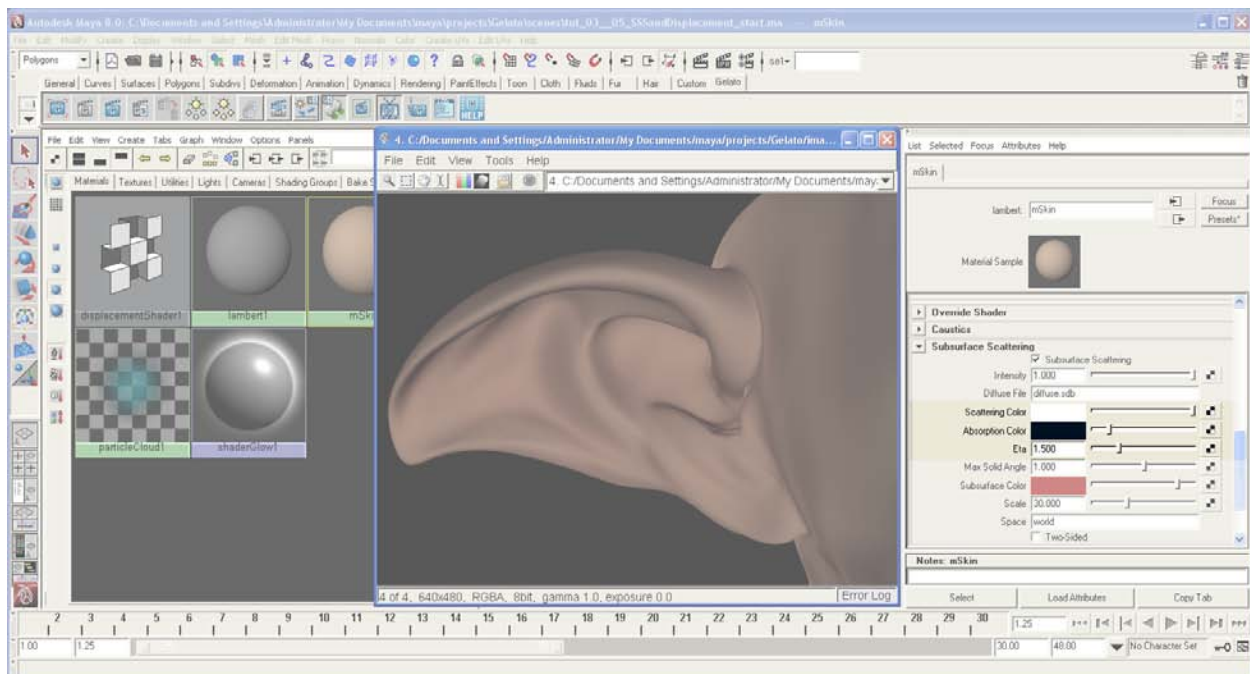
- Choose a reddish color (though we are choosing a color; this could also be a texture map, with veins and such.)



- Gelato Render.

* The colors are now more dramatic.

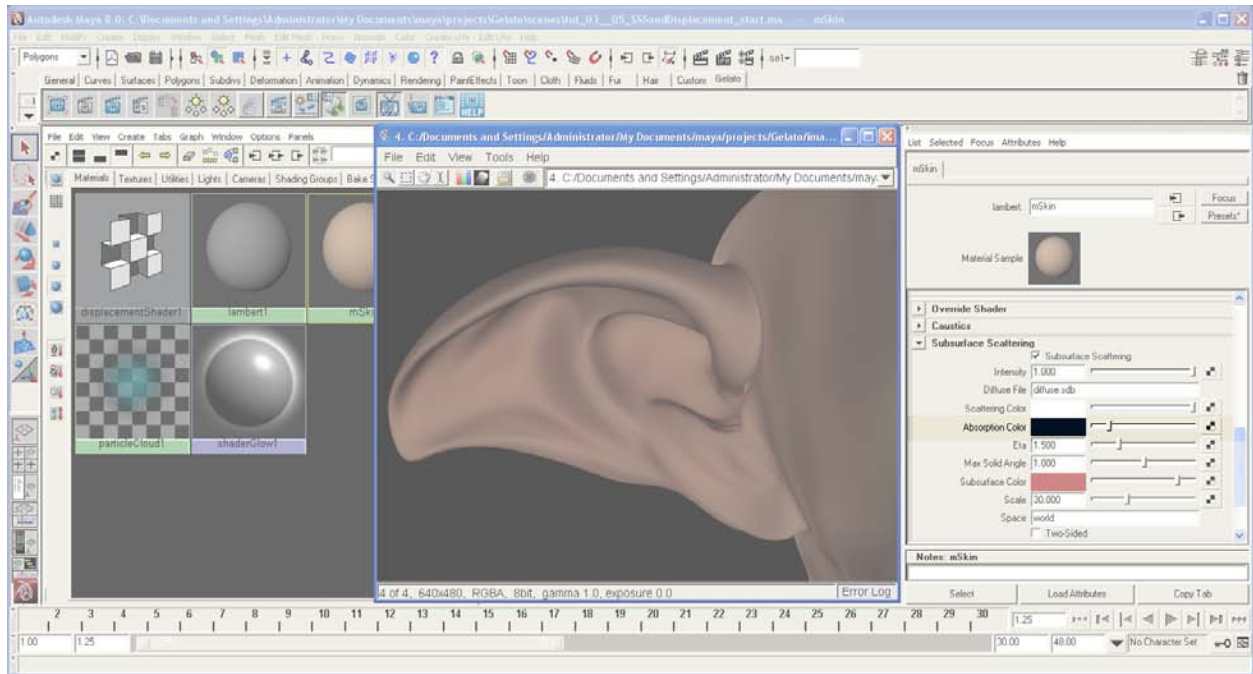
* There are obvious areas where the subsurface scattering is coming through.



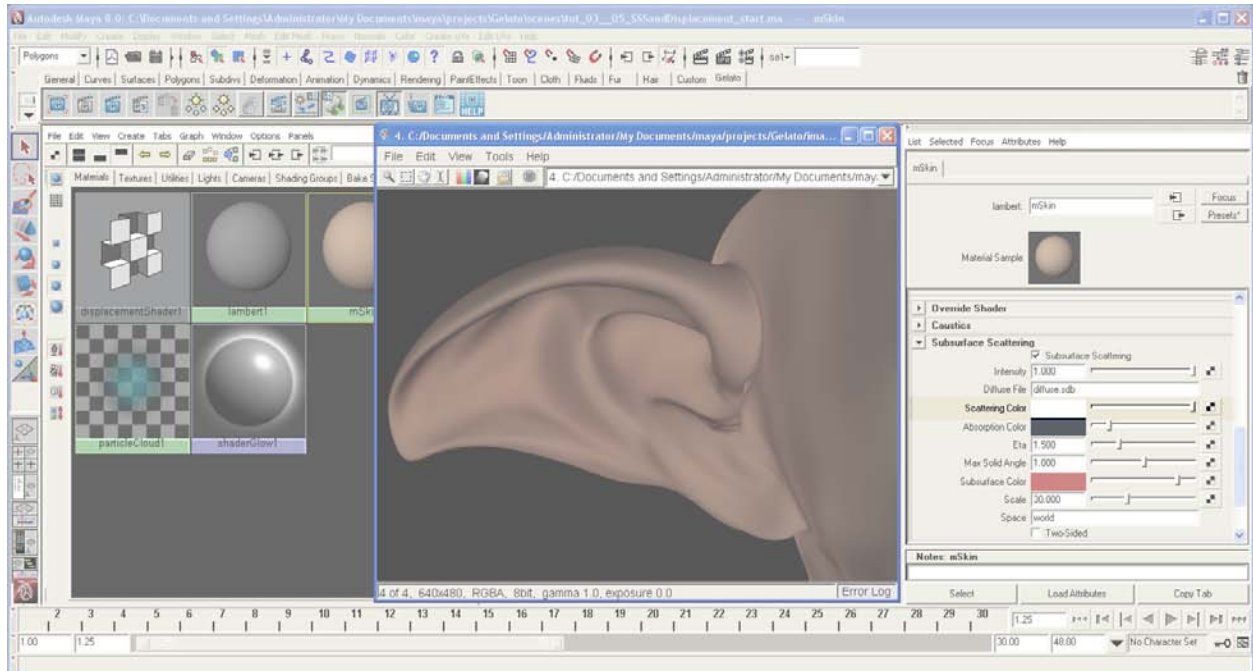
Let's now discuss some of the subsurface scattering parameters...

Eta is a subsurface scattering index, a physically accurate number.

Scattering Color and **Absorption Color**: These colors control how the light is scattered through the surface and how much is absorbed in its passage through the surface. The tricky parts about these values is that while they are represented by RGB colors, they are not RGB values.



The Absorption Color defaults to black (0,0,0). The higher this value gets, the more absorption.



The Scattering Color defaults to white (1,1,1). The lower this value gets, the less the scattering.

Autodesk Maya 8.0 - Mozilla Firefox

Getting Started Latest Headlines

Controls accuracy-versus-tuning for the subsurface scattering reconstruction. You should generally not need to adjust this parameter unless you are having quality issues.

Space. Names the coordinate system in which the baked irradiance data are stored. You should not need to change this unless you are purposely overriding the default methodology for baking irradiance.

The tricky part of using subsurface scattering is that although the *scattering* and *absorption* have separate values for red, green, and blue, they are not actually colors. The following table gives some sample values for *scattering*, *absorption*, and *eta* (index of refraction) for several measured real-world materials. We suggest starting with these and *tweaking*, rather than simply guessing.

Table 6.1: Selected measured subsurface material parameters, from Jensen, et al., "A Practical Model for Subsurface Light Transport," ACM SIGGRAPH 2001.

Material	scattering (σ_s , in mm^{-1})	absorption (σ_a , in mm^{-1})	eta (η)
Marble	(2.19, 2.62, 3.00)	(0.0021, 0.0041, 0.0071)	1.5
Cream	(7.38, 5.47, 3.15)	(0.0002, 0.0028, 0.0163)	1.3
Skim milk	(0.7, 1.22, 1.9)	(0.0014, 0.0025, 0.0142)	1.3
Skin1	(0.74, 0.88, 1.01)	(0.032, 0.17, 0.48)	1.3
Skin2	(1.09, 1.59, 1.79)	(0.013, 0.070, 0.145)	1.3

The scattering and absorption values in the table above are physically accurate for those materials if the scene units are mm. It is easy to compensate for different modeling units by using the *scale* parameter. If the scene units are in cm, set *scale*=10. If the scene units are in meters, set *scale*=1000. If the scene units are in inches, set *scale*=25.4. And so on. It's also fine to tweak *scale* to achieve the amount of translucency you desire, regardless of whether it is physically accurate.

Here are some additional tips on subsurface scattering:

- Consult the *Gelato Technical Reference* for more information on how subsurface scattering works in Gelato, as well as for a

Selected Focus Attributes Help

lambert: mSkin

Material Sample

Override Shader

Caustics

Subsurface Scattering

Intensity 1.000

Diffuse File diffuse.sdb

Scattering Color

Absorption Color

Eta 1.500

Max Solid Angle 1.000

Subsurface Color

Scale 30.000

Space world

Two-Sided

mSkin

Select Load Attributes Copy Tab

28 29 30 1.25

30.00 48.00 No Character Set

- **[CLK]** on the Gelato Help icon in the Gelato Shelf to bring up the Gelato documentation.
- Mango > Materials > Subsurface Scattering > Table 6.1.

A paper at the 2001 Siggraph presented physically accurate settings that subsurface scattering studies have produced. While in the 3D world it's not always necessary to be physically accurate, it is suggested that we use these as starting points, then tweak from there.

Autodesk Maya 8.0: C:\Documents and Settings\Administrator\My Documents\maya\projects\Gelato\scenes\stut_03_05_SSSandDisplacement_start.ma ... mSkin

File Edit Modify Create Display Window Select Mesh Edit Mesh Proxy Normals Color Create UVW Edit UVW Help

General Curves Surfaces Polygons Subdivs Deformation Animation Dynamics Rendering PartEffects Toon Cloth Fluids Fur Hair Custom Gelato

File Edit View Create Tabs Graph Window Options Panels

Materials Textures Utilities Lights Camera Shading Groups Bake Sets Projects

displacementShader1 lambert1 mSkin

particleCloud1 shaderGlow1

View Shading Lighting Show Render Panels

640 x 480

List Selected Focus Attributes Help

mSkin

lambert: mSkin

Material Sample

Override Shader

Caustics

Subsurface Scattering

Intensity 1.000

Diffuse File diffuse.sdb

Scattering Color

Absorption Color

Eta 1.300

Max Solid Angle 1.000

Subsurface Color

Scale 30.000

Space world

Two-Sided

Notes: mSkin

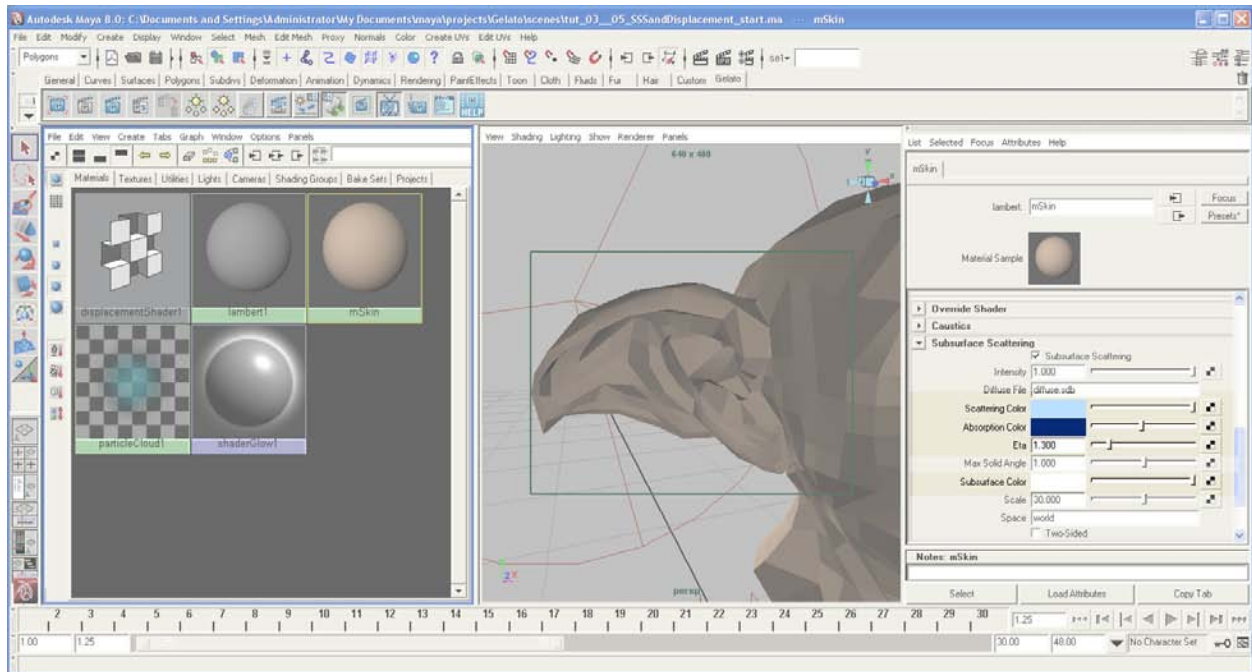
Select Load Attributes Copy Tab

28 29 30 1.25

30.00 48.00 No Character Set

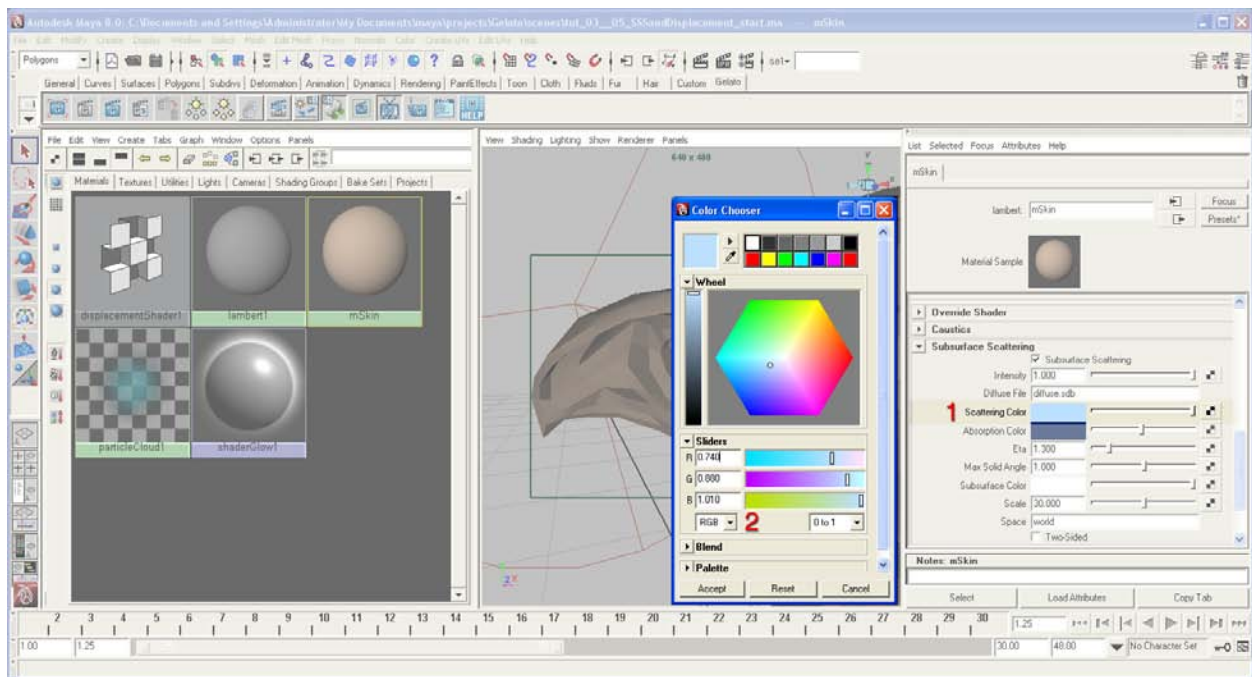
A preset has been made for this tutorial:

- mSkin Attribute Editor > lambert > Presets* > SSS_Skin > Replace.

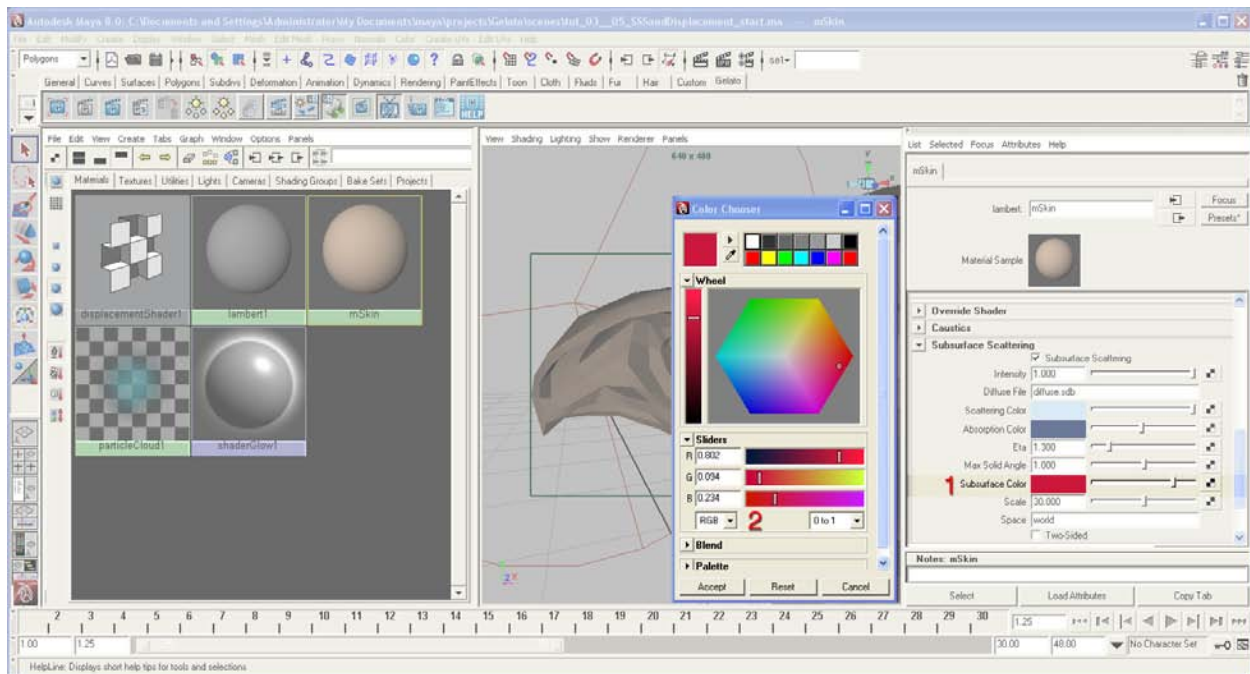


- Notice that: Different values have appeared for Scattering Color, Absorption Color, and Eta
Subsurface Color has reverted to white

Remember that though the scattering and absorption colors are now lovely shades of blue, for this use, they are **not** being used as RGB colors, but are setting the amount of the scattering and absorbing.

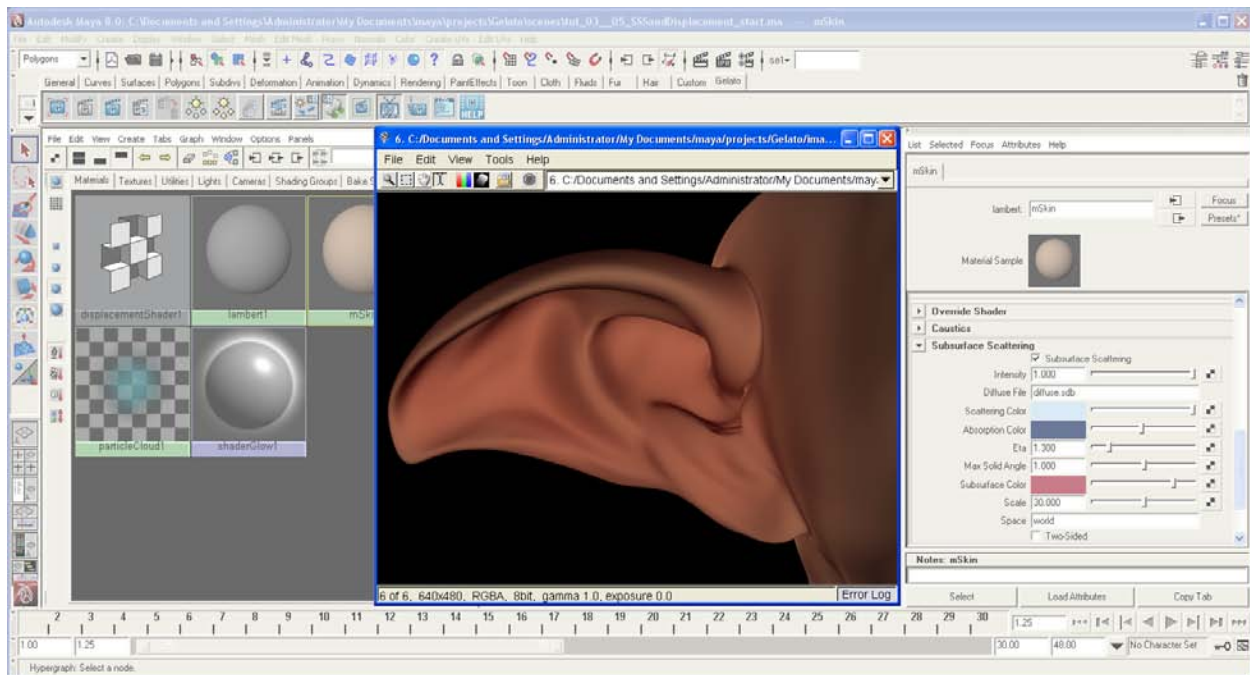


- **[CLK]** on the Scattering Color field to bring up the Color Chooser.
- Change to RGB color.
- Notice that you can have values greater than 1.

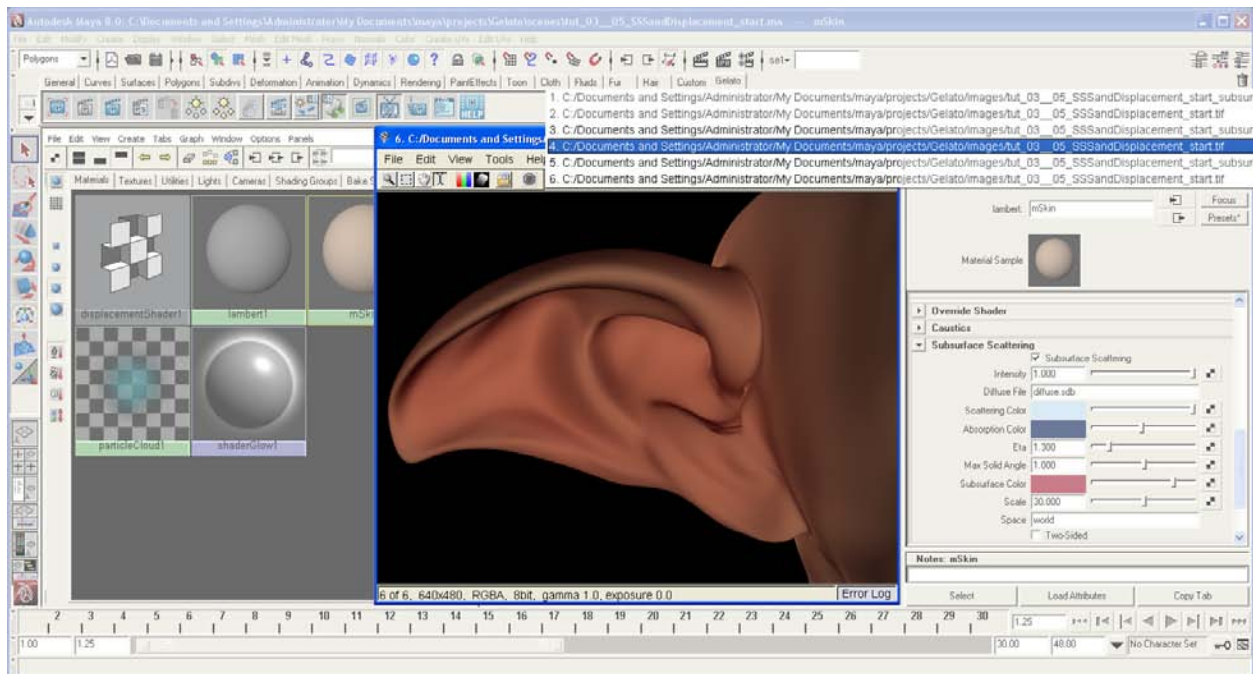


We need to change that Subsurface Color back to a red.

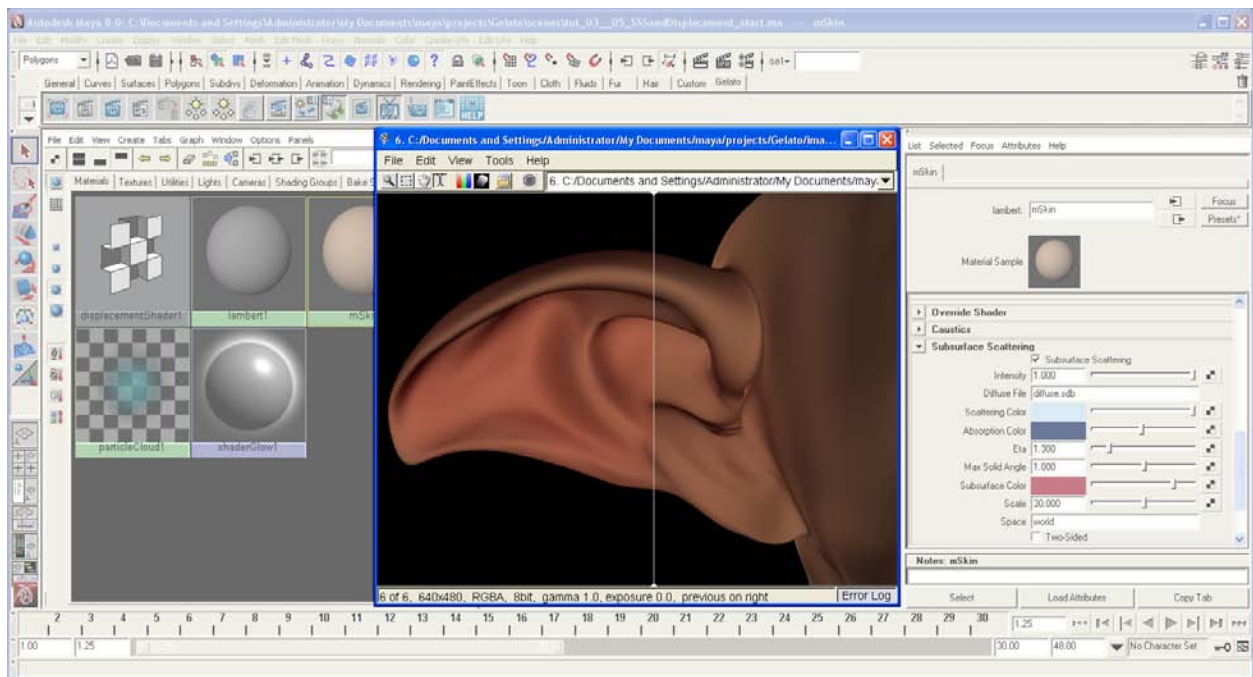
- Subsurface Color > **[CLK]** its color field.
- In the resulting Color Chooser, pick a red color.



- Gelato Render.



- Image Viewer > Document Field > choose the previous composite render, 2 passes back.

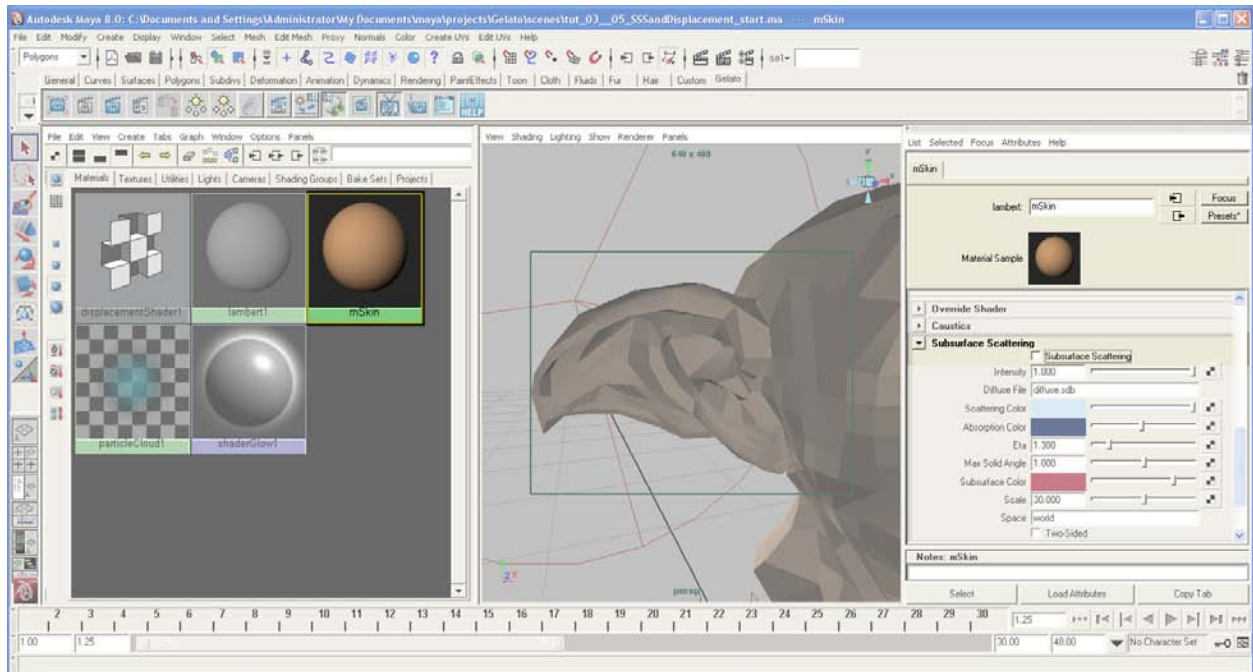


- Image Viewer > Document Field > most recent render.
- Use the Wipe tool. Now when we use this tool, we can compare the most recent render to the last.

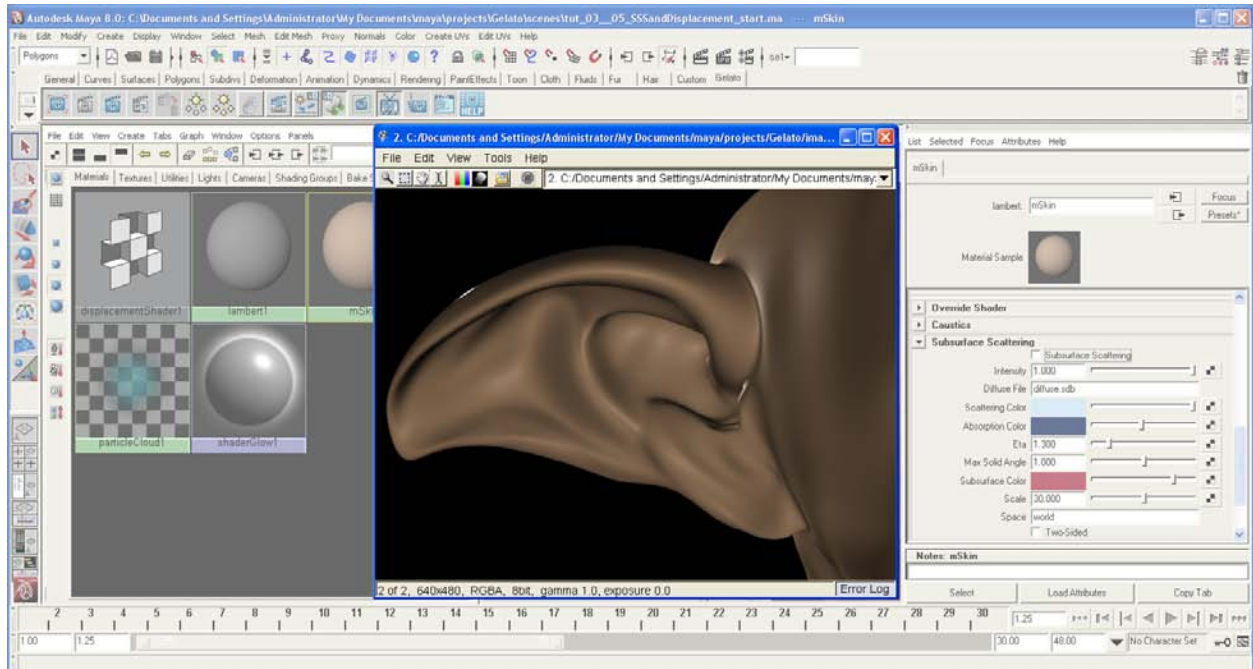
There is more scattering going on here and we can see more red in areas where the skin is thinner.

We are going to leave things as they are and move on to displacement.

These settings are just a starting point. We could continue to tweak the scattering and absorption to get higher contrasts from the subsurface scattering, to get more realism – how much we tweak things depends on the degree of realism we are looking to achieve.



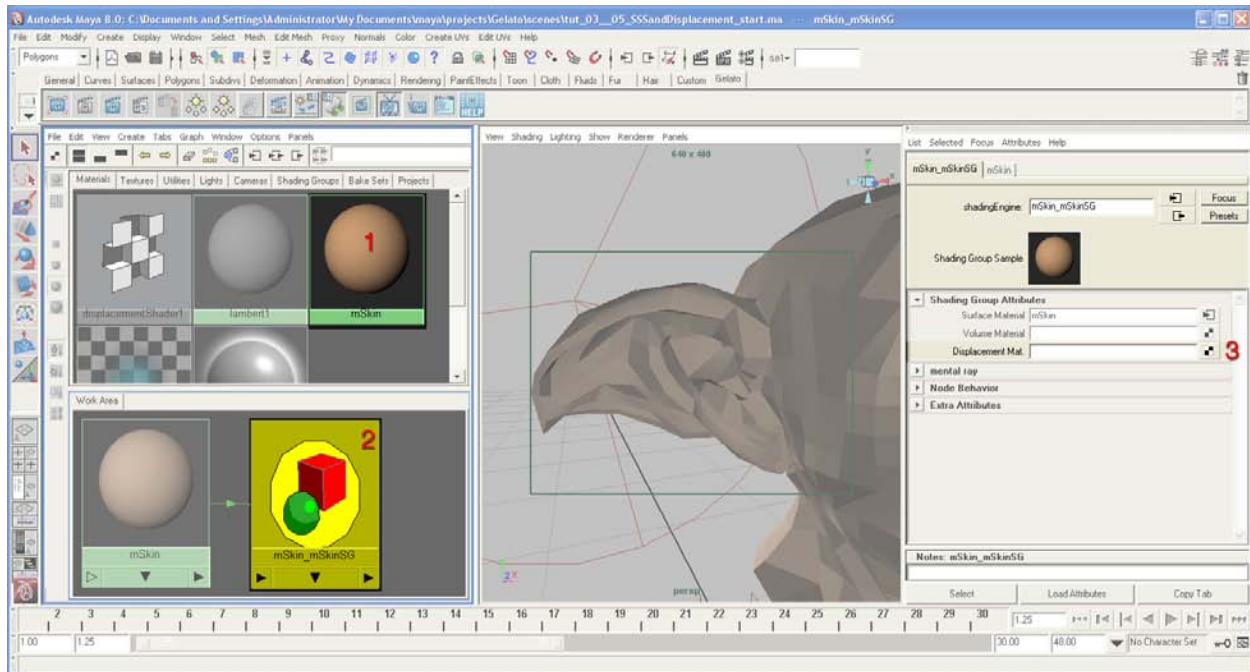
- mSkin Attribute Editor > Gelato > Subsurface Scattering > disable Subsurface Scatting.



- Gelato Render.

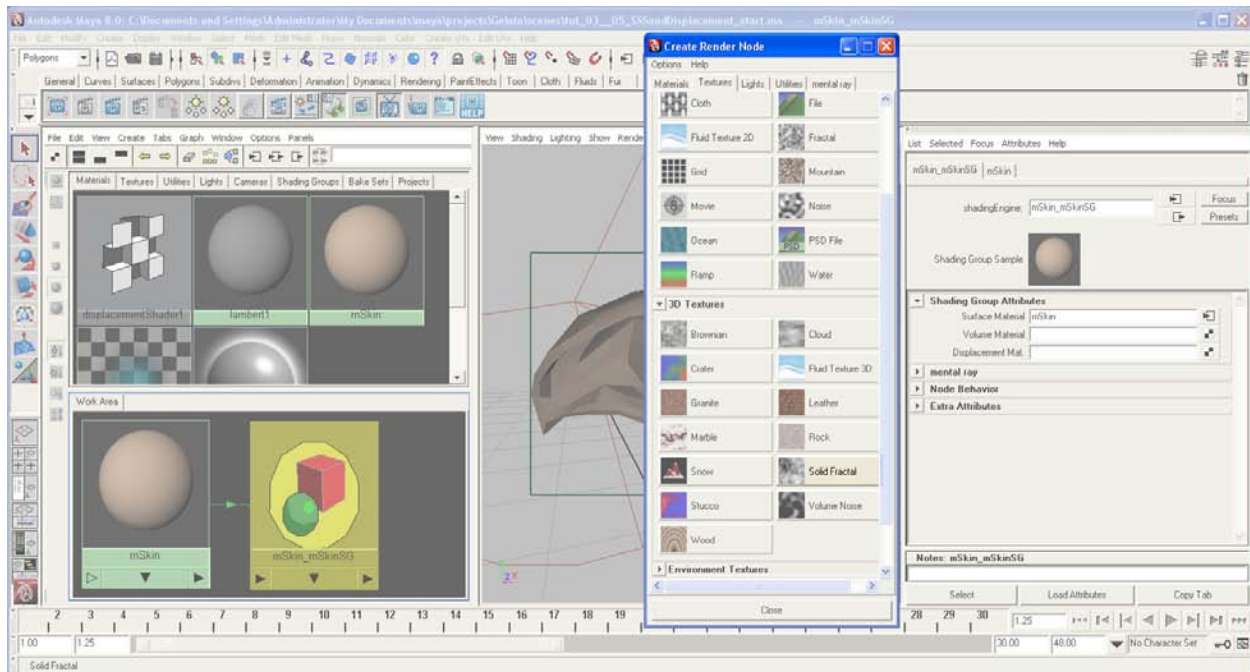
We're back to our pre-subsurface scattering state.

Dealing with displacement by itself will allow our tweak renders to move along much faster and will allow us to more easily see the effects of our displacement, making it easier to fine-tune this.

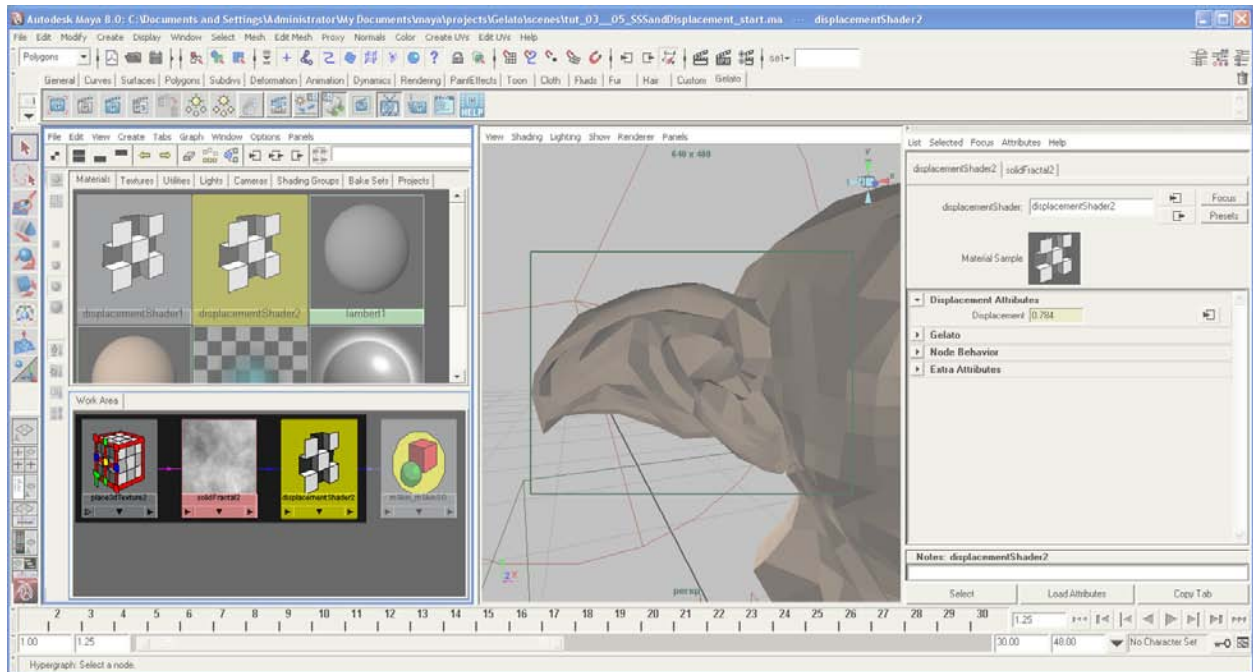


We're going to add a 3D fractal node to the shading group.

- mSkin > mSkin_mSkinSG > Attribute Editor > Displacement Material > **[CLK]** checked box.

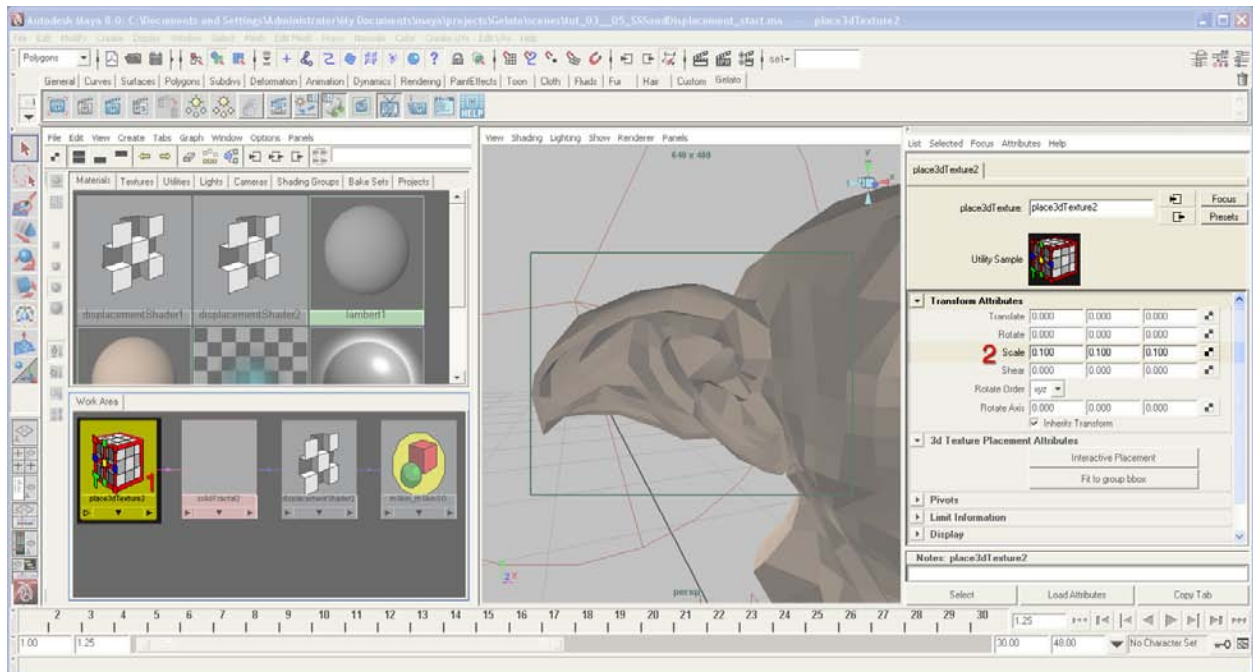


- In the resulting Create Render Node dialog, **[CLK]** “Solid Fractal”

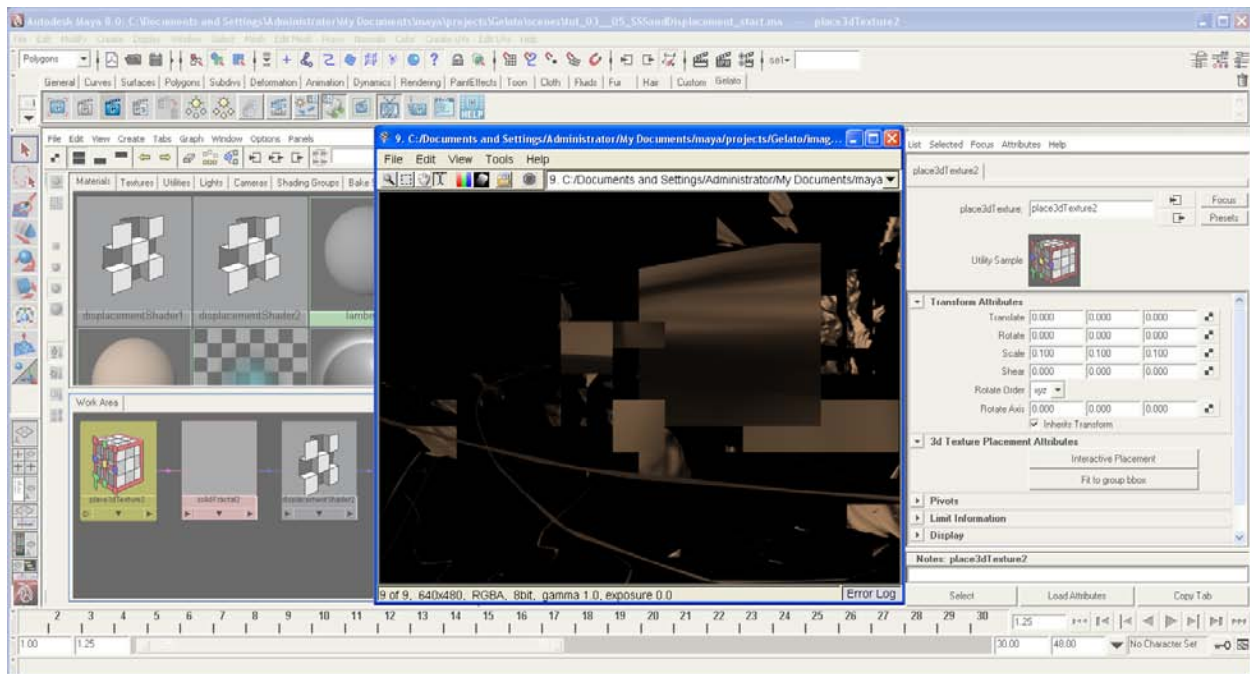


This brings in 3 nodes: place3dTexture2, solidFractal2 and Displacement (your nodes may be numbered 1, that's ok).

The fractal group is connected to the shading group through a displacement node.

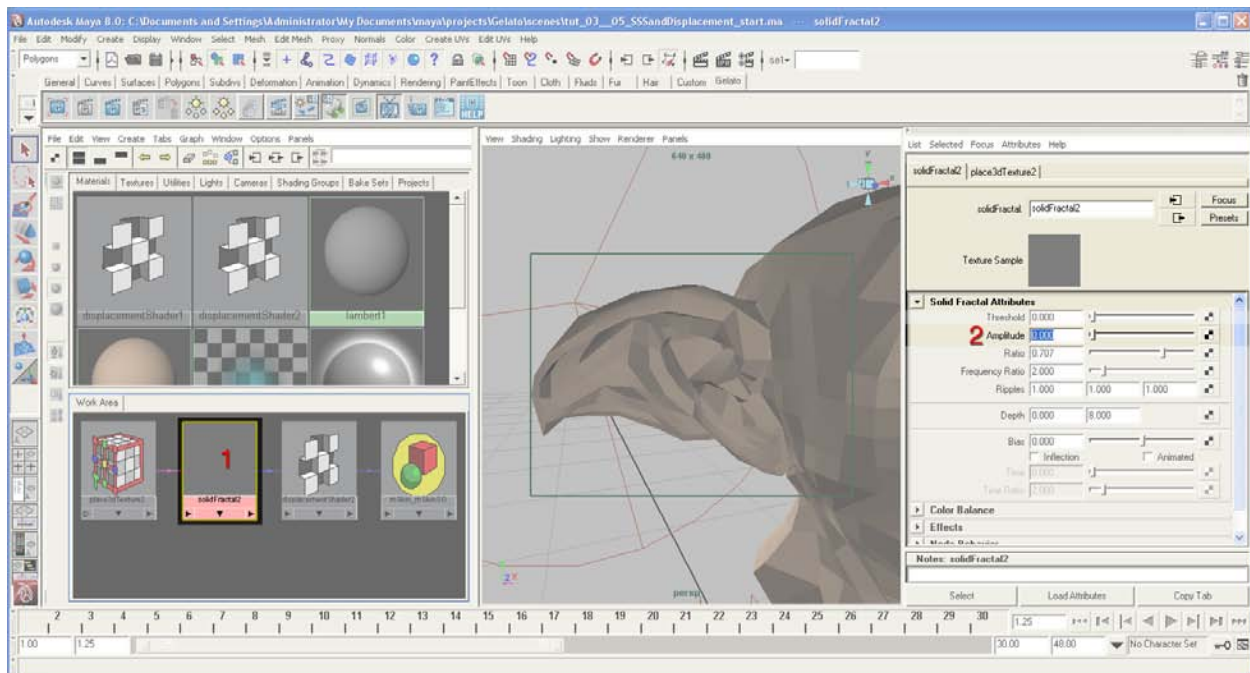


- place3dTexture2 > Attribute Editor > Transform Attributes > Scale.
- Change x,y and z all to 0.100.

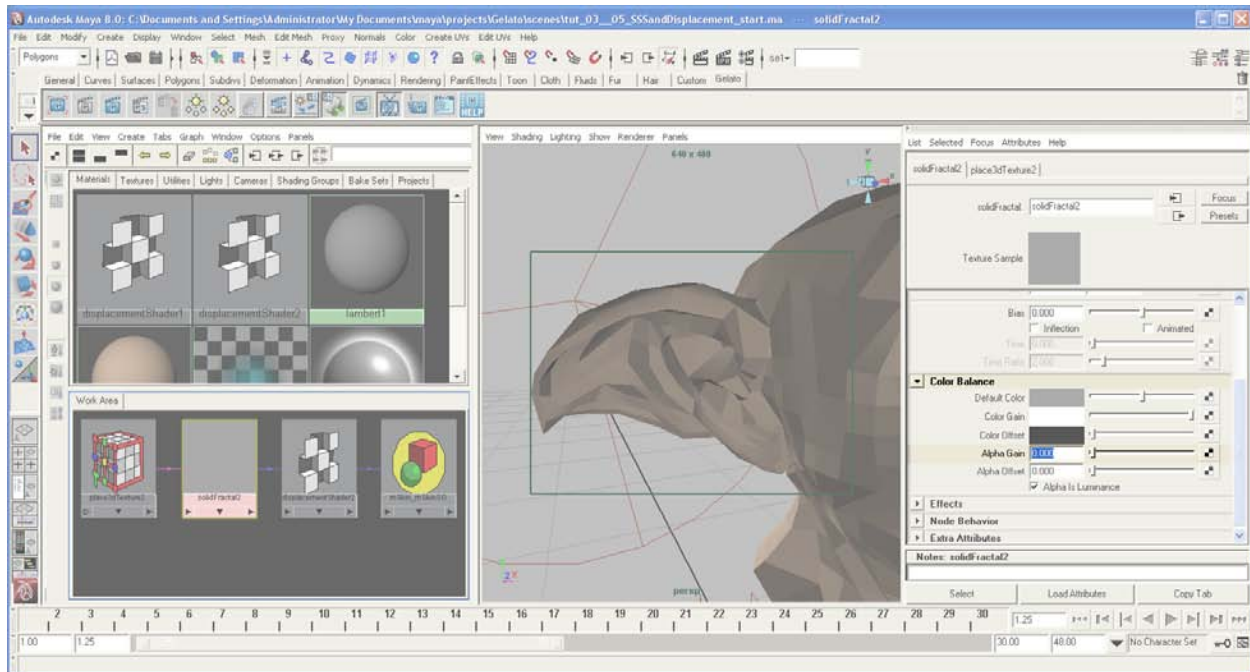


- Gelato Render.

Not a pretty picture.... The effects of the displacement are so huge that the geometry went flying everywhere. Let's tame this effect...

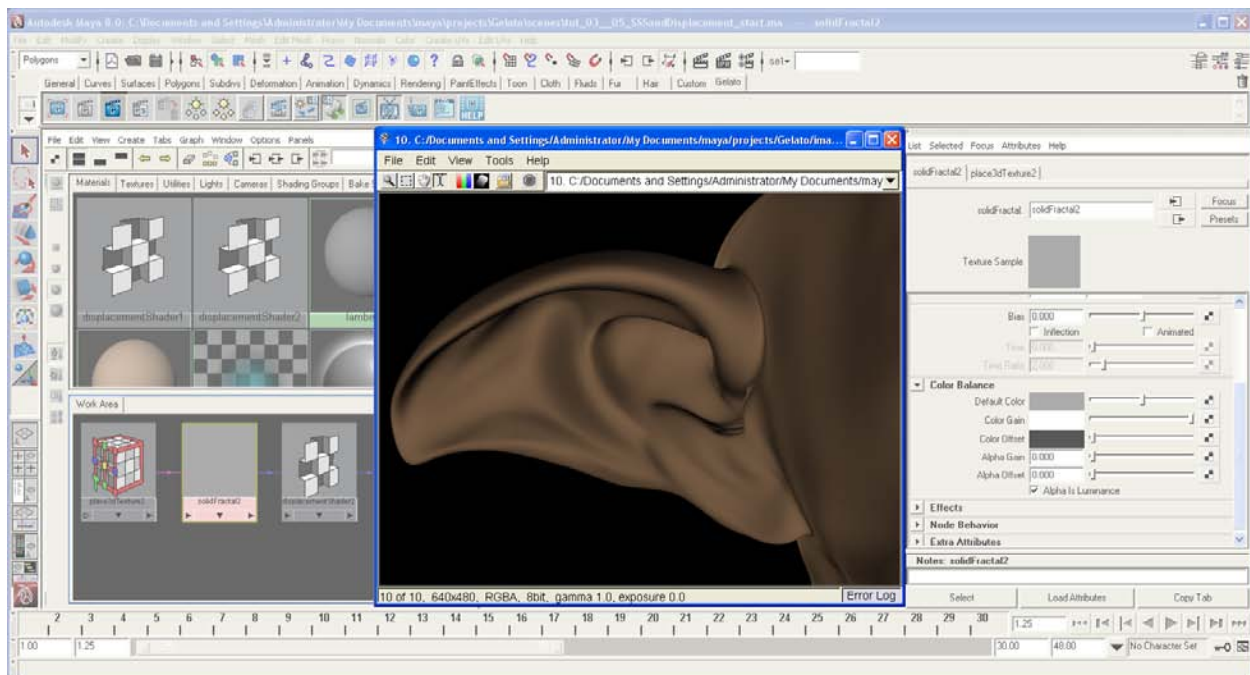


- solidFract2 > Attribute Editor > Solid Fractal Attributes > change the Amplitude to 0.000.



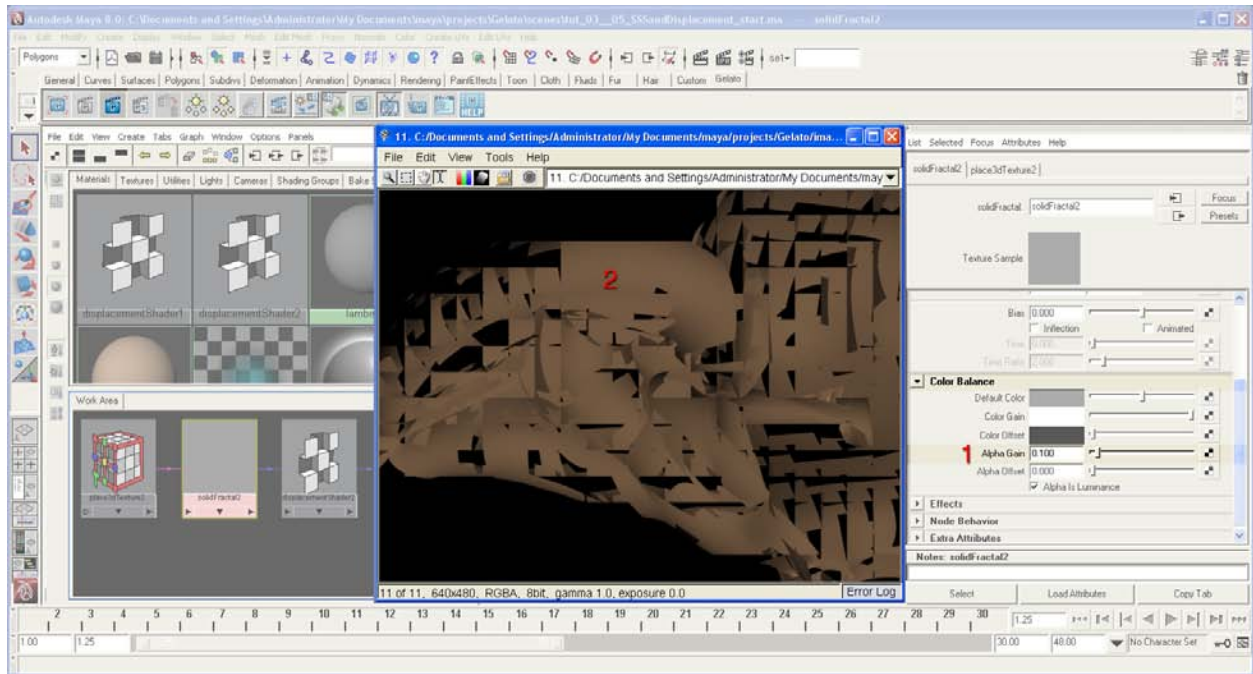
- Scroll down to the Color Balance section.
- Change the Alpha Gain to 0.000.

We want to determine the range in which the geometry will be displaced when the texture is applied; we're going to rely on the Alpha Gain adjustment to do this.



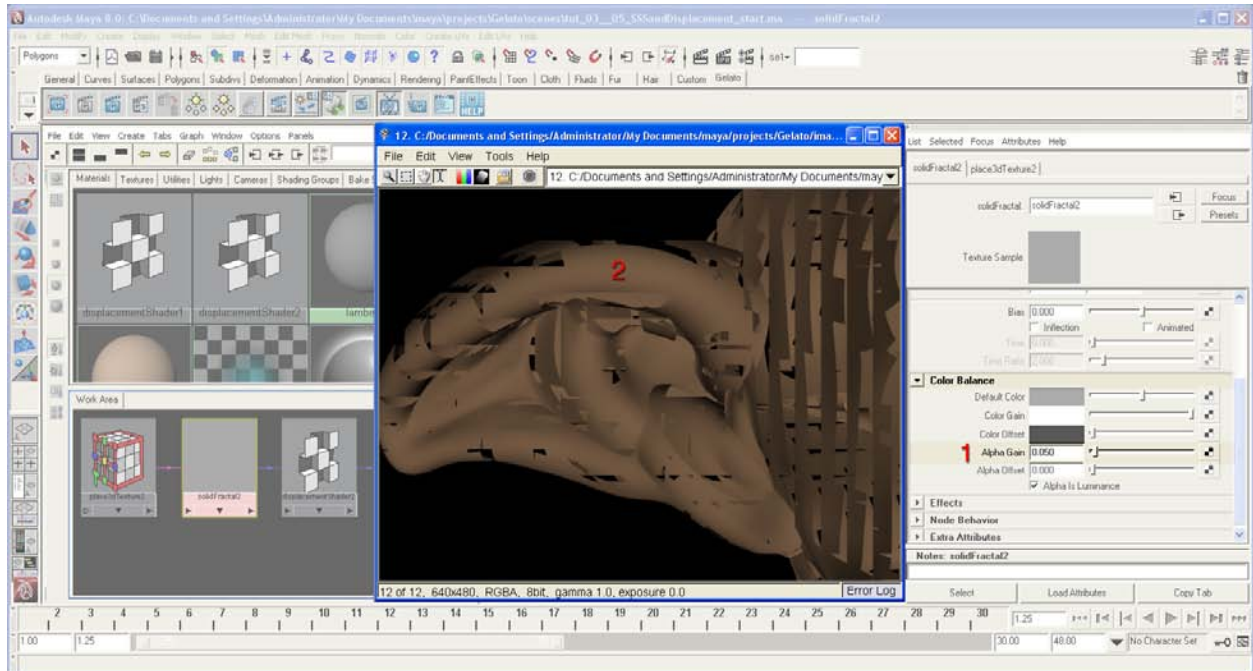
- Gelato Render.

No displacement is visible.



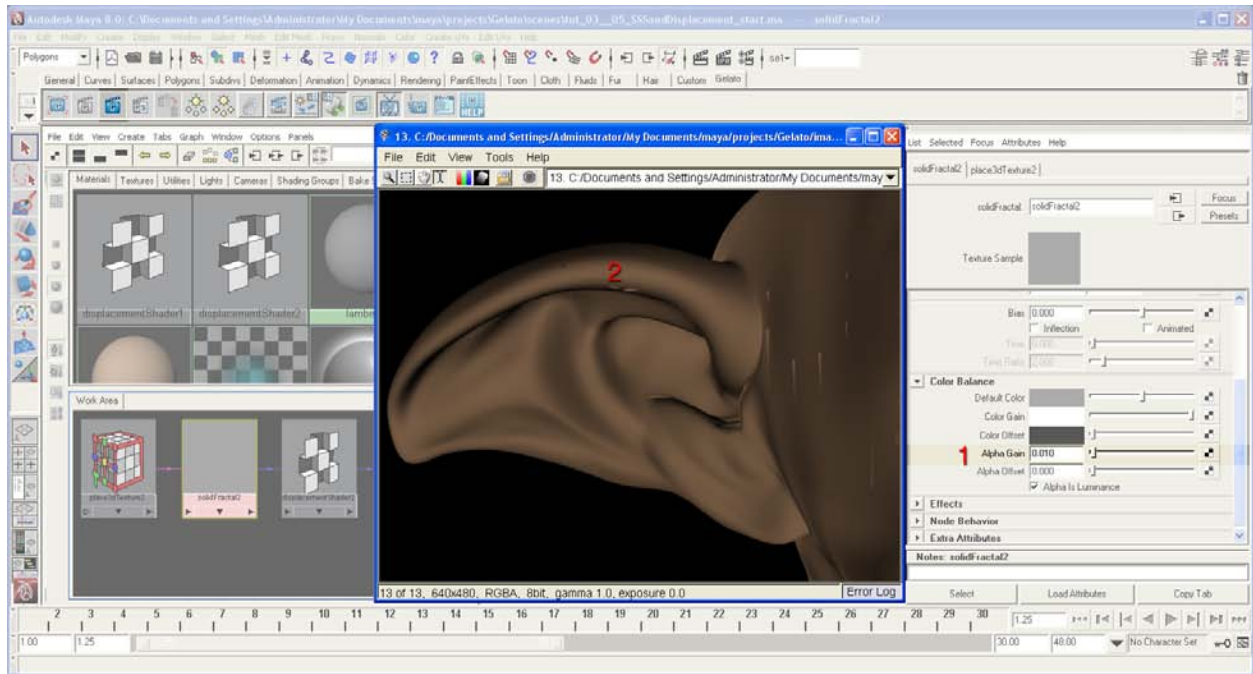
- Change the Alpha Gain to 0.100.
- Gelato Render.

We can see that the radius has increased and we are getting displacement, though too much.



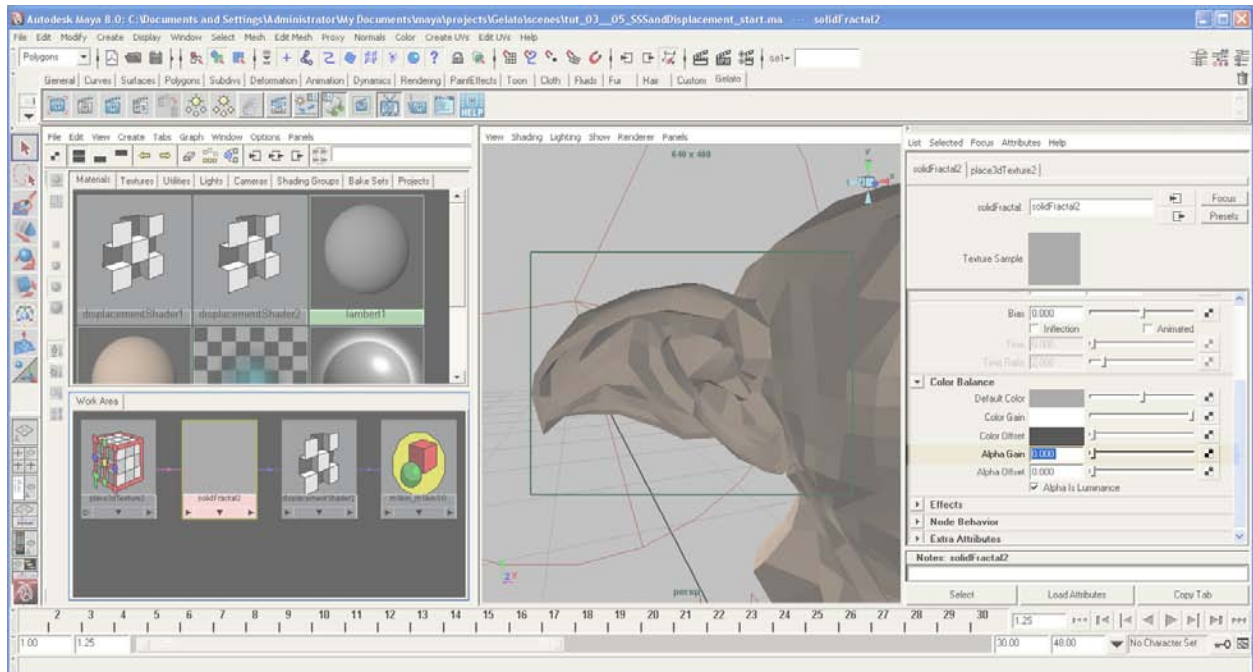
- Change the Alpha Gain to 0.050.
- Gelato Render.

The displacement still looks rather high. The surface is still being broken up.



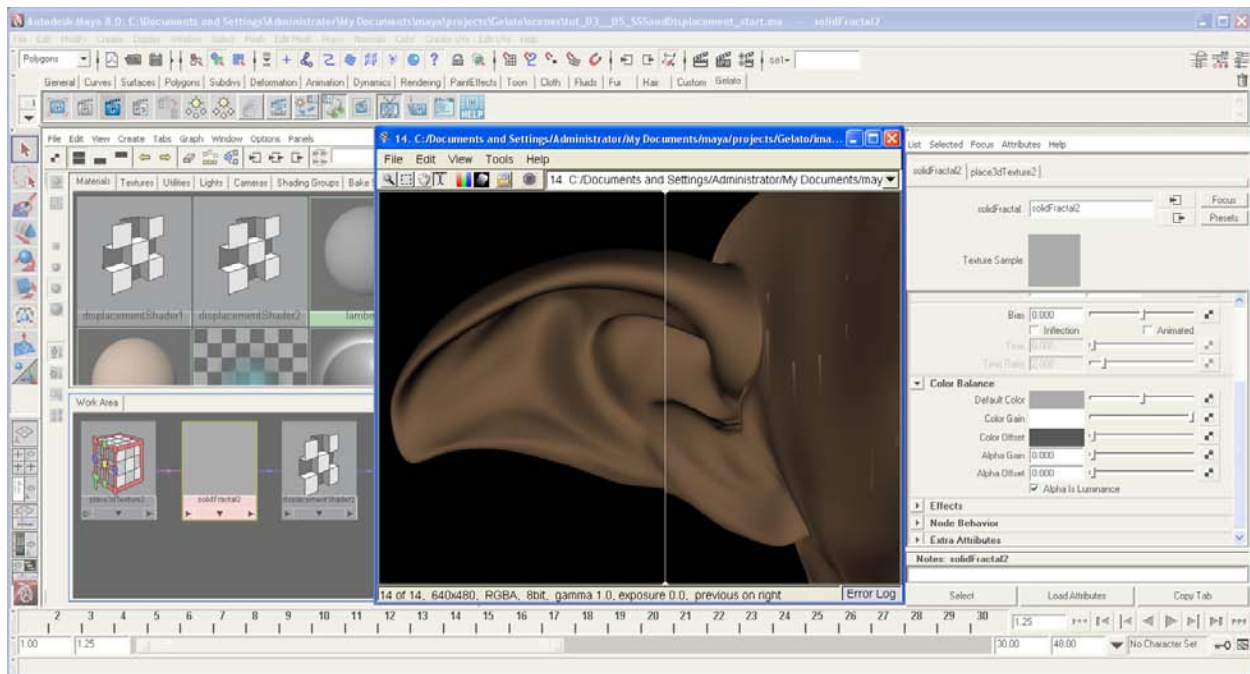
- Change the Alpha Gain to 0.010
- Gelato Render.

This looks better. There are a few artifacts, those little tears, but we'll take care of those later.



- Change the Alpha Gain to 0.
- Gelato Render.

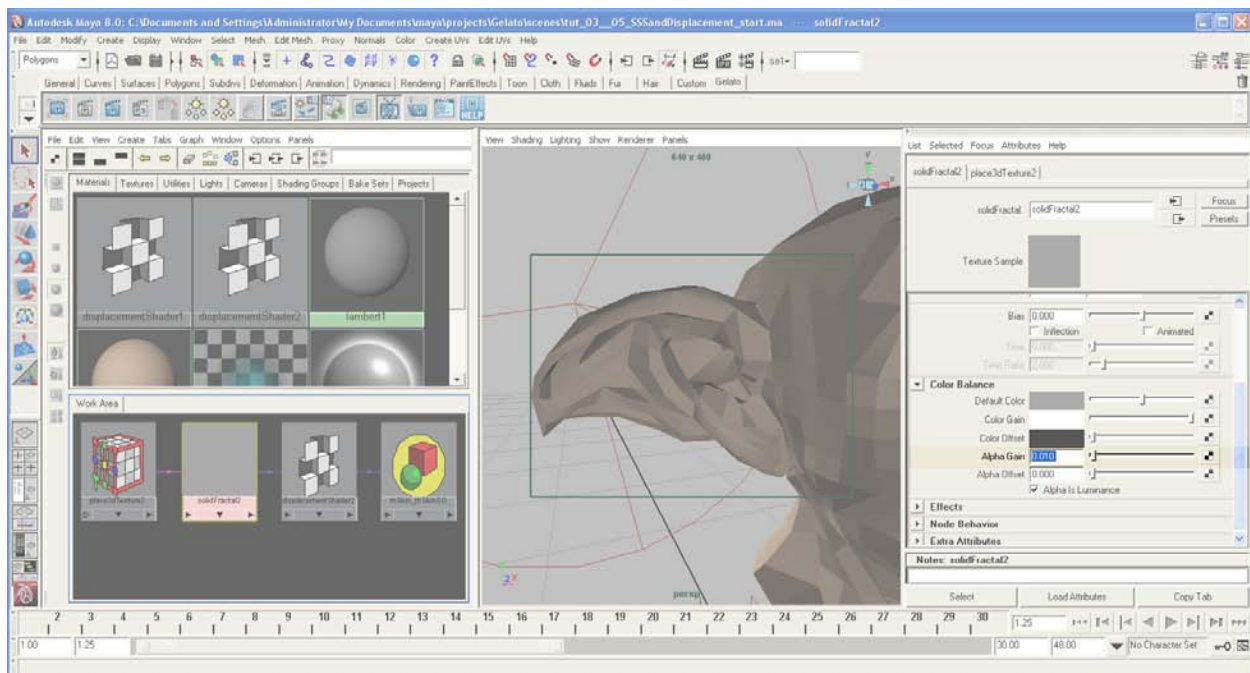
We are going to compare “no displacement” to the 0.010 setting.



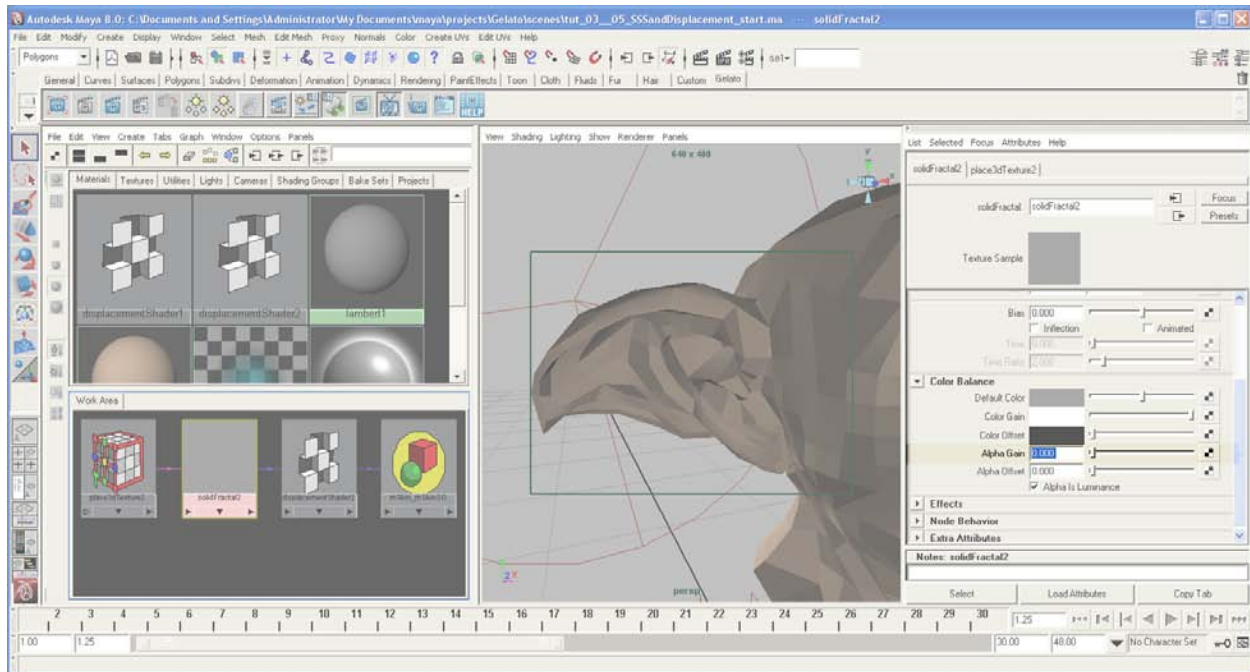
- Use the Wipe Tool to compare no displacement to the previous render with slight displacement.

*We can see that the ear looks fatter in the previous render – the radius is increased because of the displacement, which now looks to be in a good range.

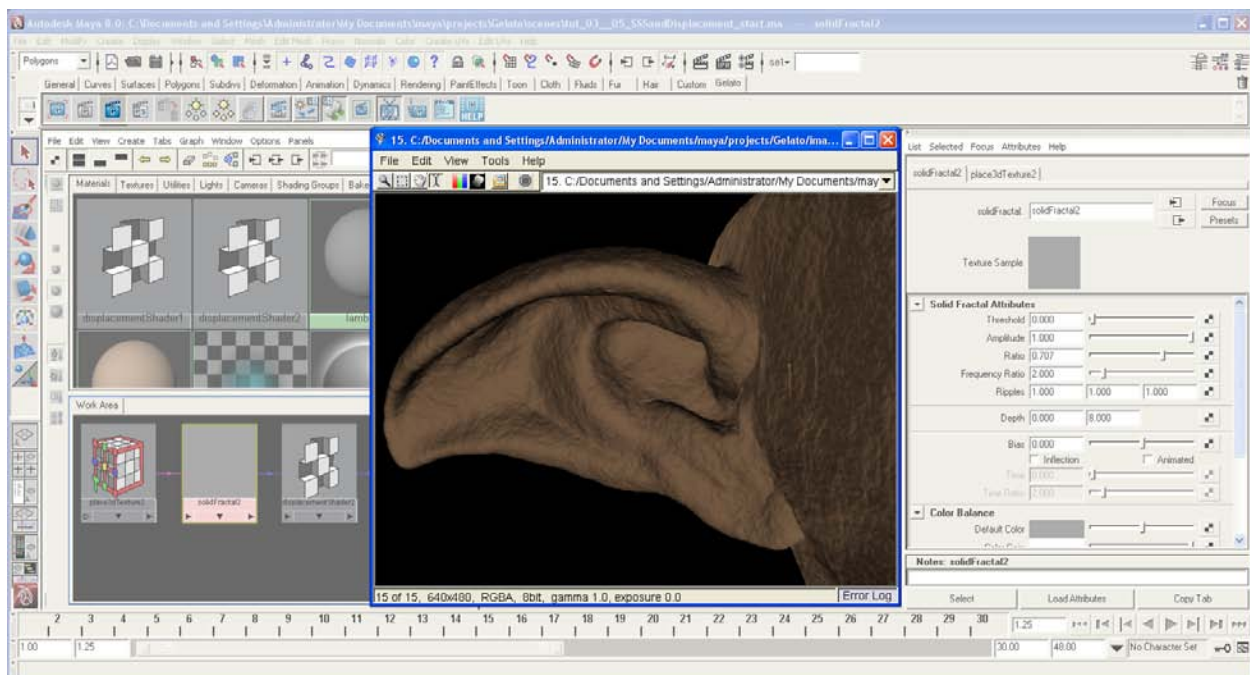
* Again, we can see that the displacement did give rise to artifacts.



- Change the Alpha Gain back to 0.010.



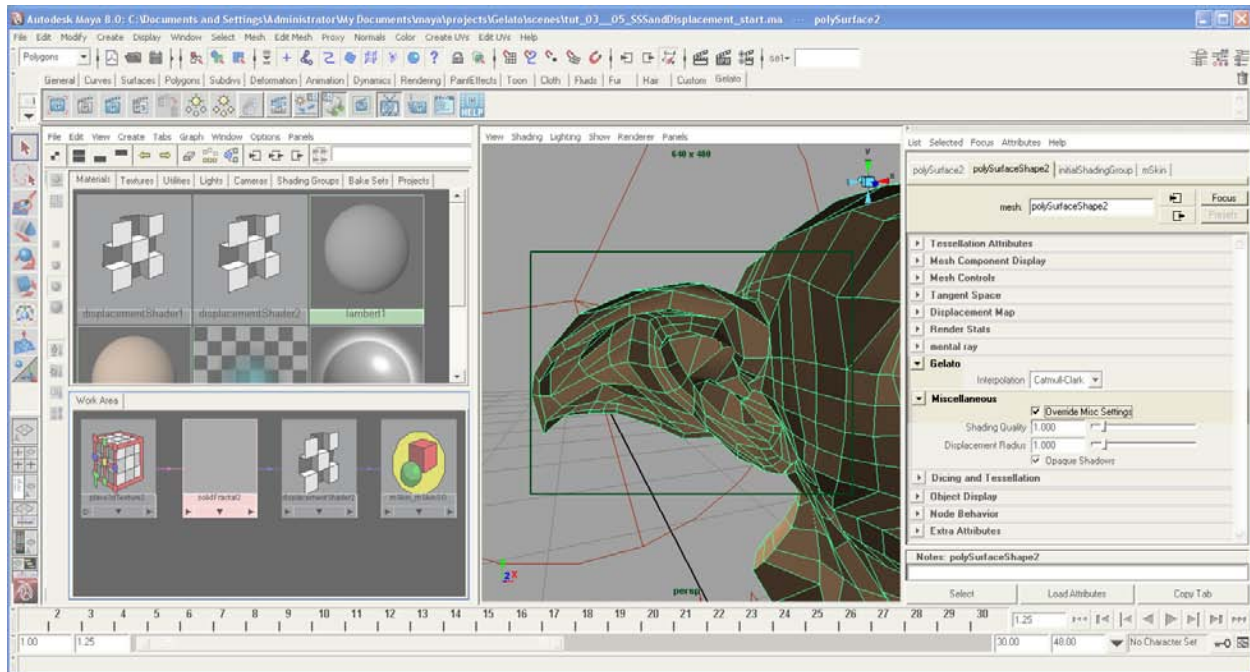
- Scroll back up to the Solid Fractal Attributes.
- Turn the Amplitude back up to 1.000.
- Gelato Render.



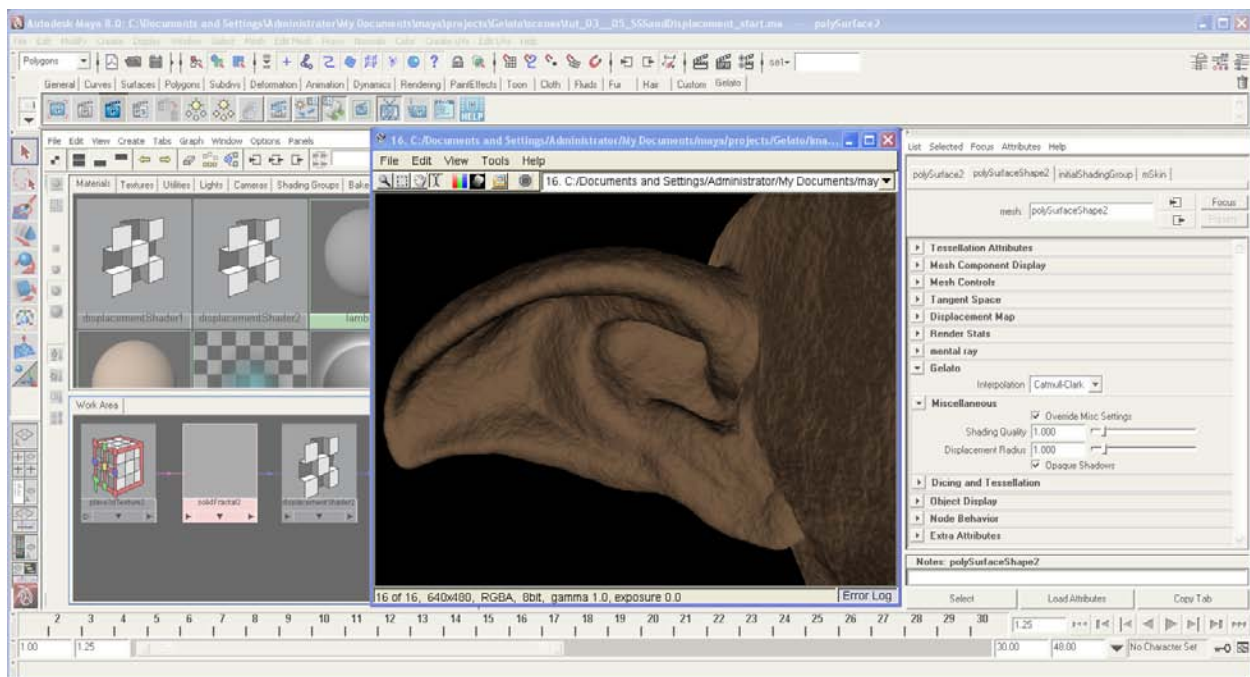
We can now see our texture map.

This is looking good. We could make the Alpha Gain smaller if we would like this to be more subtle, or we could adjust the contrast of the map by playing with the Amplitude settings or some of the other Solid Fractal Attributes. If a texture map is used, its contrast could be adjusted in Photoshop.

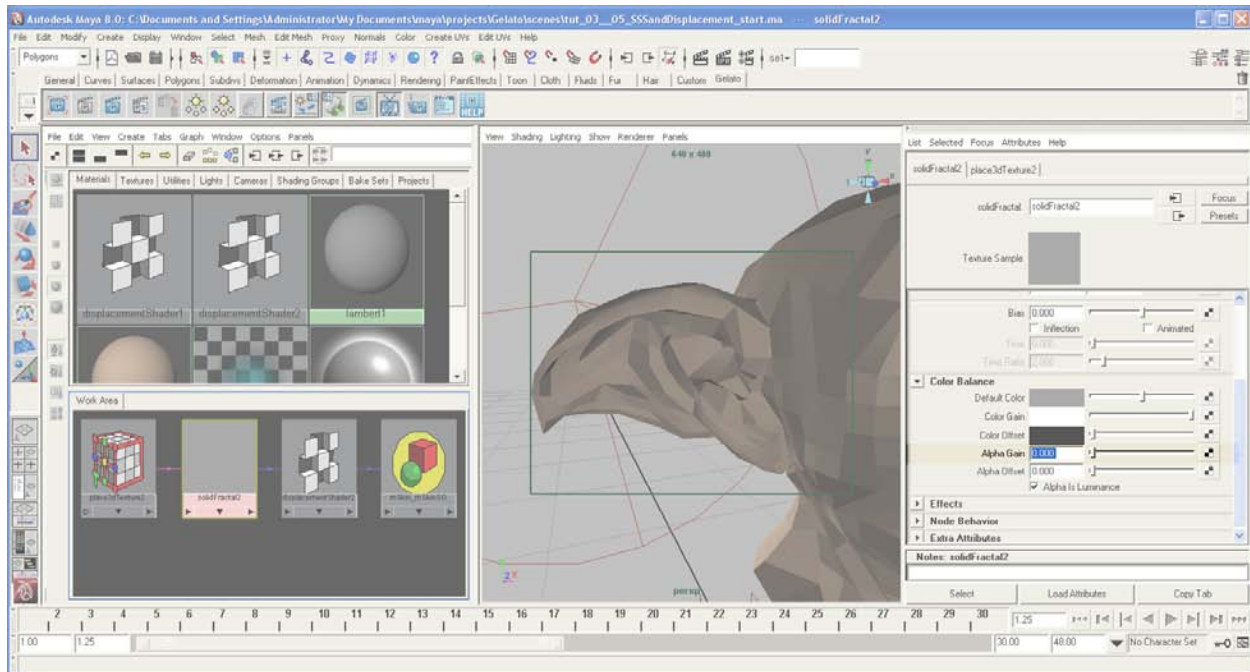
Let's now switch our attention to the artifacts, those visible tears...



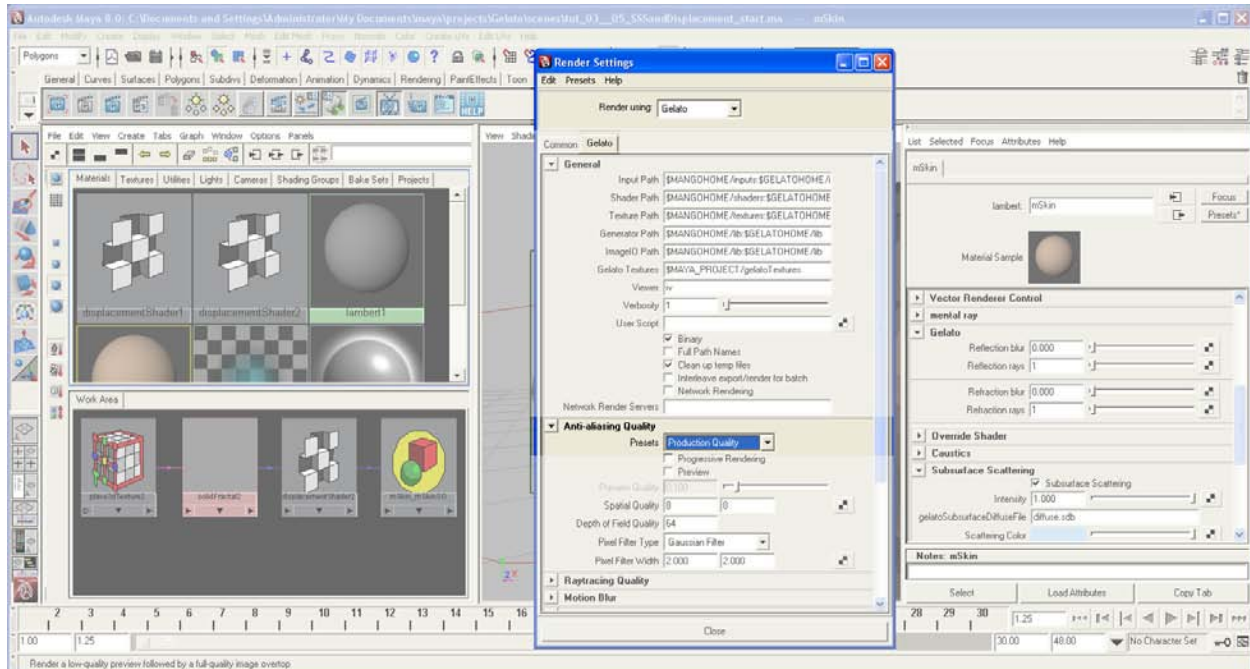
- “polySurfaceShape2” (the model) Attribute Editor > Gelato > Miscellaneous > enable Override Misc Settings.



- Gelato Render.
- Use the Wipe Tool to compare this image to the last.
- * It takes longer to render.
- * Artifacts look better – as we wipe back and forth over the image, we can see that those little tears have been fixed.

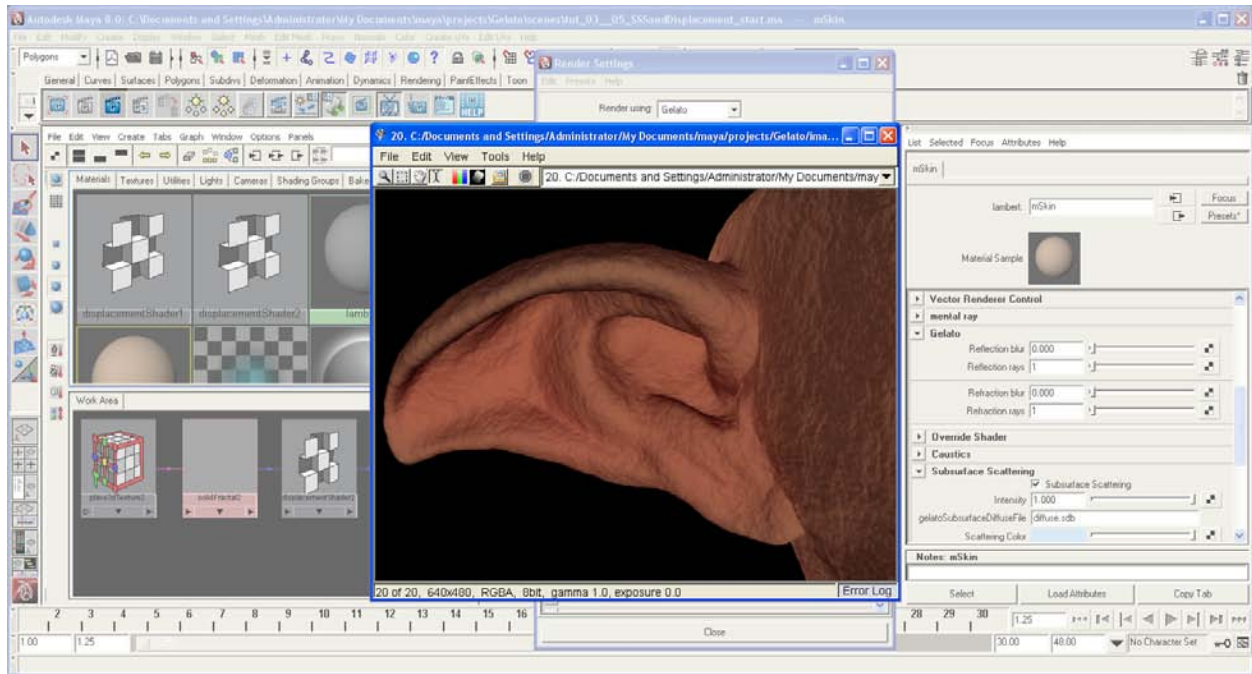


- Select the mSkin Material and go to its Attribute Editor.
- Enable “Subsurface Scattering”



- Open the Render Settings dialog.
- Change the Anti-aliasing Quality preset to Production Quality.

Changing the Anti-aliasing Quality will help render out the edge artifacts.



- Gelato Render.

We have subsurface scattering, displacement and have dealt with the artifacting.

The next tutorial will deal with motion blur and depth of field.