

LIGHTING

SURFACES

VOLUMES

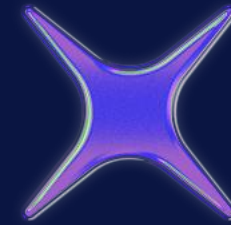
POST PROCESSING



PBR MASTERCLASS

KITSUNAKI.ME

SHADING

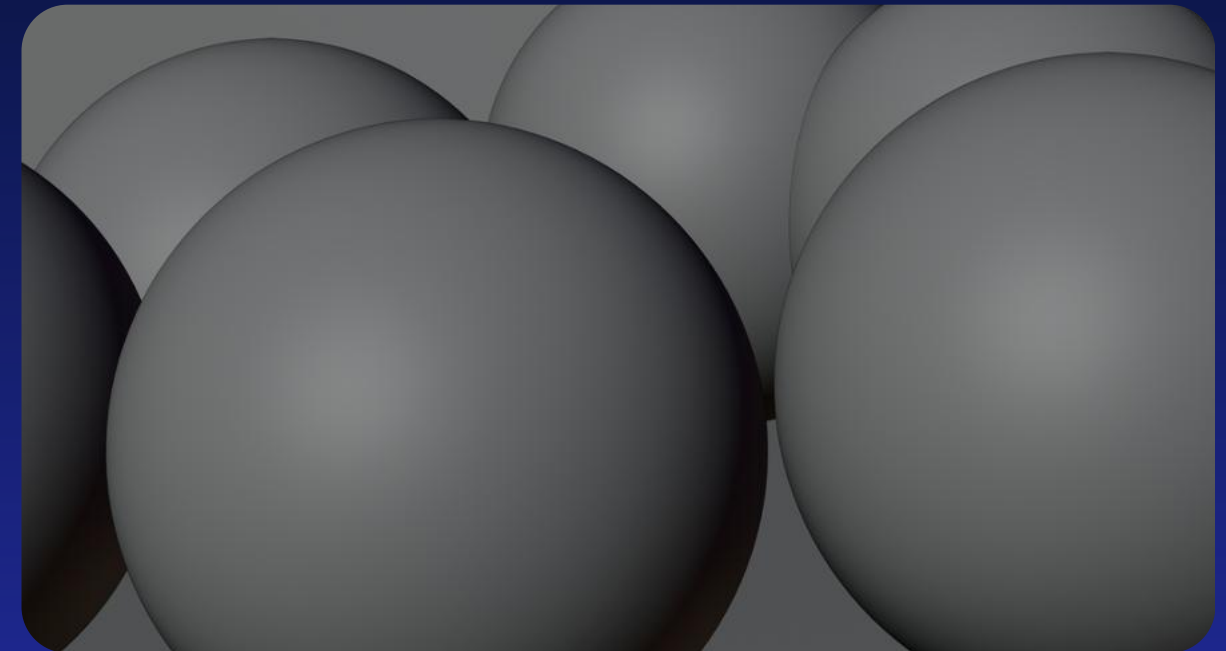


3D software uses a bidirectional scattering distribution function within a single calculation. When light strikes a surface, most of it penetrates the material while the rest is deflected.

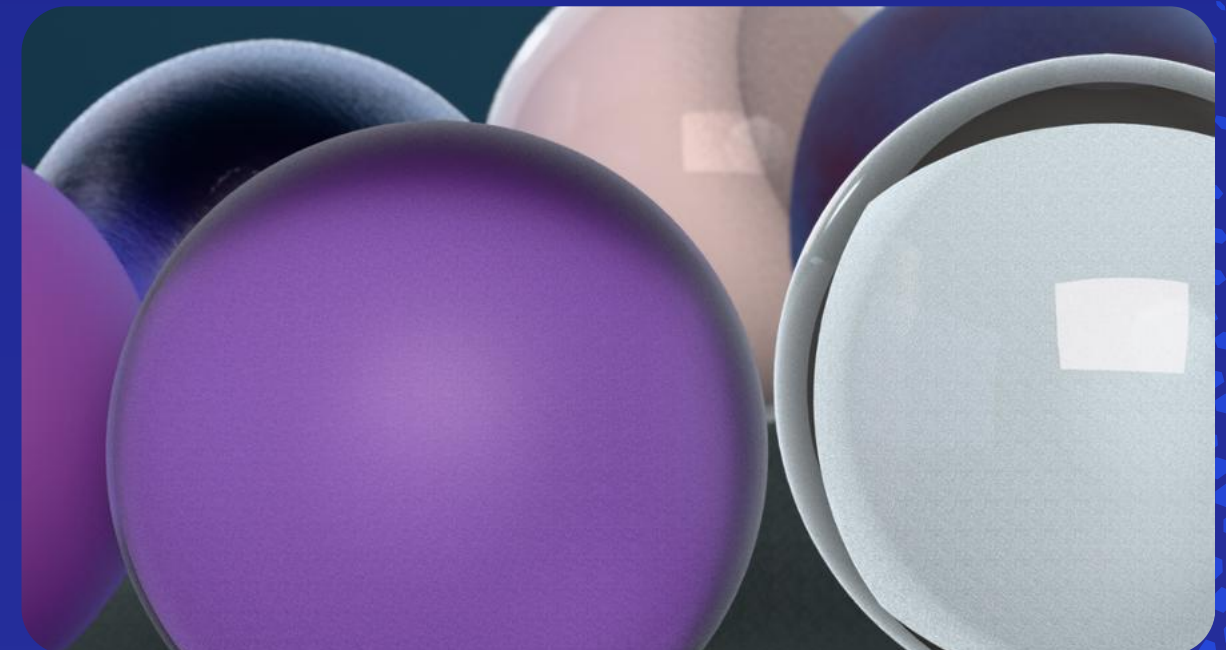
In real life, rays hitting a surface are photons that add energy to electrons, causing them to rise to a higher energy level. The electron is lazy and emits the photon at the wavelength of the quantified energy the photon was able to add to the atom's outer shell. This is the color of the surface, usually via red, green, and blue channels.

Physical Based Rendering (PBR) tries to recreate real physics simplified by a simple Principled BSDF function, while older Blender versions used a ton of different functions to shade specific surfaces. While EEVEE as a Render-Engine recently made great progress, just Cycles will provide correct path tracing for renders.

The primary workflow of shading is called Metal/Roughness, while for cheating with light preservation laws there is a Specular/Glossiness workflow. It uses a diffuse map for the transmissive rays. Roughness is inverted to glossiness. Brightness represents reflectivity, while color defines the tint of the direct reflection. Dielectrics darken the specular map, because they reflect just 2-8% directly, while metals darken the diffuse map, because they fully reflect.



THE ALBEDO CHANNEL OF A MATERIAL CONTROLS THE COLOR OUTPUT WITHOUT LIGHT INFORMATION.



LIGHT SOURCES

POINT LIGHT

**LIGHT
BULB**

A point light is an infinitesimally small light source radiating in all directions. It produces hard shadows.

Directional light has no physical size. It represents light coming from a single direction, originating from an infinitely large object like the sun. While the sun isn't actually infinite in size, the distinction is irrelevant due to its immense scale. Shadows do not lose their sharpness with distance

DIRECTIONAL LIGHT

**SUN
MOON**

SPOT LIGHT

**FLASH
LIGHT**

A spotlight constrains the point source into a fixed cone angle, creating a sharp boundary for the light.

An area light is defined by a 2D geometric shape that emits light realistically across a 180-degree arc. It produces softer shadows the larger the source of light is. But it also needs more intensity.

AREA LIGHT

**WINDOW
SOFT BOX**

LIGHT VARIANTS

MATERIAL LIGHT

LED MONITORS

Emission or material light refers to an object that emits light directly via its material. It provides very subtle indirect lighting. Natural examples would be lava or neon gases.

Light sources can be switched to *Use Nodes* within the *Object Data* Properties. They can then be controlled via the *Light* node in the Shader Editor. Applying an *Image Texture* to a spotlight creates a gobo or light cookie, allowing you to project and map patterns.

LIGHT GOBO

FOLIAGE LANTERNS

IES TEXTURE

ARTIFICIAL LIGHTS

By using the *IES Texture* node and setting it to *External*, you can directly import an IES file containing precise data on light distribution, enabling you to replicate the exact look of a specific lamp.

An HDRI is a 360° image representing an environment. It provides a simplified way to simulate the light that a real-world setting would naturally cast onto the scene, without the need to construct a complex environment from scratch.

HDRI ENVIRONMENT

FAKE SCENERY

MANIPULATION

FRESNEL FILTER

HALOS MIX SHADER

RAY PORTAL

PORTALS CAMERAS



The shallower the viewing angle relative to the surface, the stronger the reflection. At shallow angles approaching 90°, they reflect up to 100% of the light as a brilliant white glare. The refractive index controls the Fresnel curve via a grayscale value.

For camera feeds or magical portals, the *Ray Portal BSDF* is used. It tints the transmission via *Color Tint*, specifies the redirection target coordinates via *Position*, and defines the viewing angle as a vector via *Direction*.

LIGHT PASSES

LIGHT BOUNCES

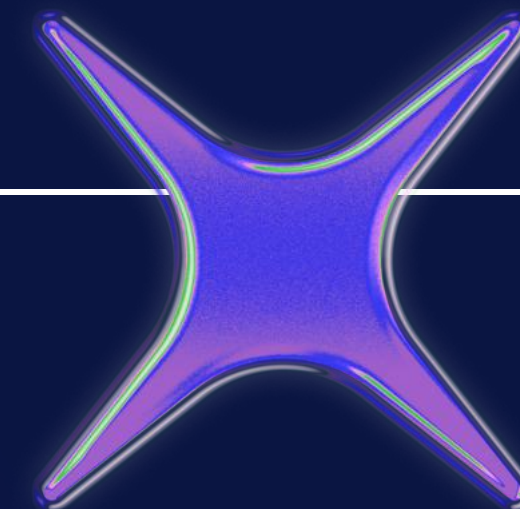
LIGHT LINKING

ADVERTISING INDIRECT LIGHT



Shadows are generally not pitch-black, because light rays undergo multiple bounces before the calculation stops. Therefor transmissive materials need more bounces, to not snuff out light.

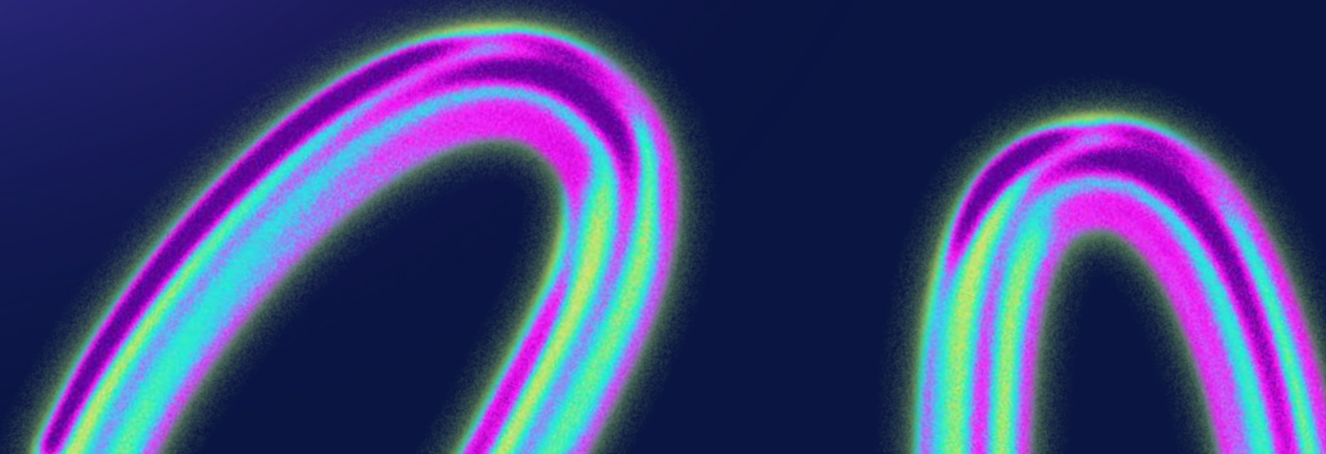
By default, a light source illuminates everything in the scene that is not occluded. Using *Shading -> Light Linking*, you can drag in specific objects or collections so that the light illuminates only the selected items rather than others.



3 POINT LIGHTING

The key light defines the object's form and directs the viewer's attention; it is usually positioned close to the camera. The fill light softens shadows, though shadows remain crucial for defining shape. Therefore, the fill light is positioned 45–90° away from the key light and is about half as intense. A back light (or rim light) accentuates the silhouette and creates a glowing outline.

A shadow is the absence of light, which is why it is darker behind an object. The camera casts a test ray at an object, and from there, a shadow ray is projected toward the light source. If the test ray strikes an opaque object on its way to the light source, the point remains unaffected.



CAMERA

PERSPECTIVE

STANDARD



The human eye has a focal length of roughly 35mm. Close-ups often use 60-80mm lenses, which slightly compress depth, whereas very short focal lengths severely distort shapes. Check your depth of field settings. The lower the aperture closure (F-stop), the blurrier everything out of focus.

Orthographic view eliminates all perspective distortion, making everything appear flat on a single layer. Technically you get infinite focal length and infinite zoom, so light reaches the sensor absolutely parallel.

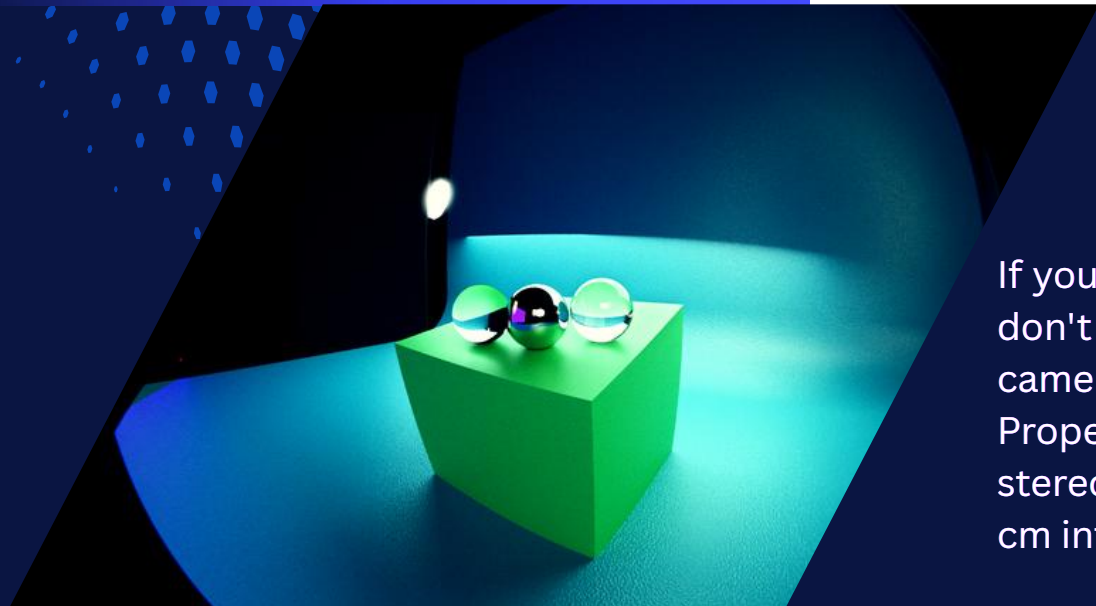
ORTHOGRAPHIC

BLUEPRINTS
RETRO GAME



PANORAMA

FISHEYE
VR RENDER



By switching the camera type to Panoramic, you can render wide-angle fisheye shots or full 180° and 360° environments.

If you want to view your scene inside a VR headset, you don't even need to manually set up two separate cameras. Simply enable Stereoscopy in the Output Properties. Blender will automatically render a perfect stereoscopic 3D view using an industry-standard 6.5 cm interpupillary distance.

FOCAL LENGTH

ZOOM
DEPTH



REFLECTIONS

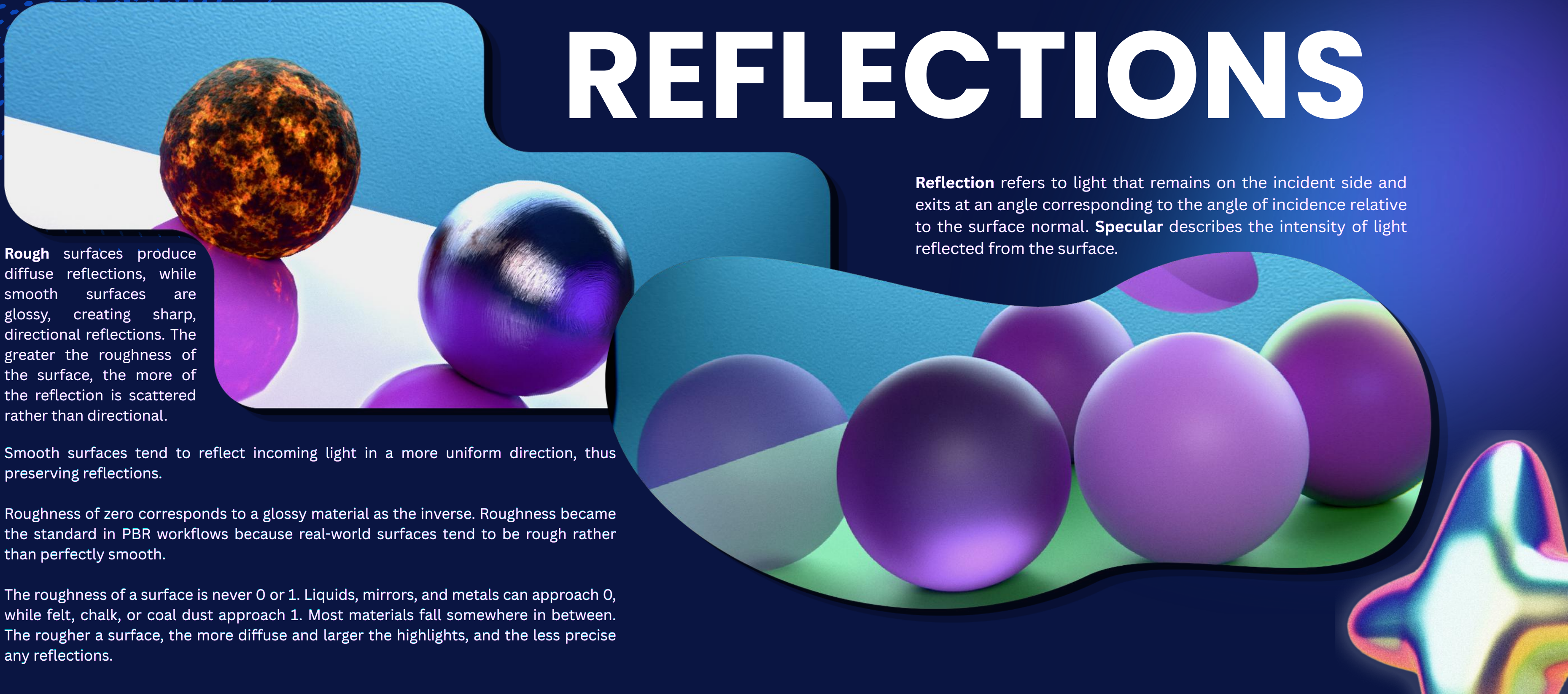
Rough surfaces produce diffuse reflections, while smooth surfaces are glossy, creating sharp, directional reflections. The greater the roughness of the surface, the more of the reflection is scattered rather than directional.

Smooth surfaces tend to reflect incoming light in a more uniform direction, thus preserving reflections.

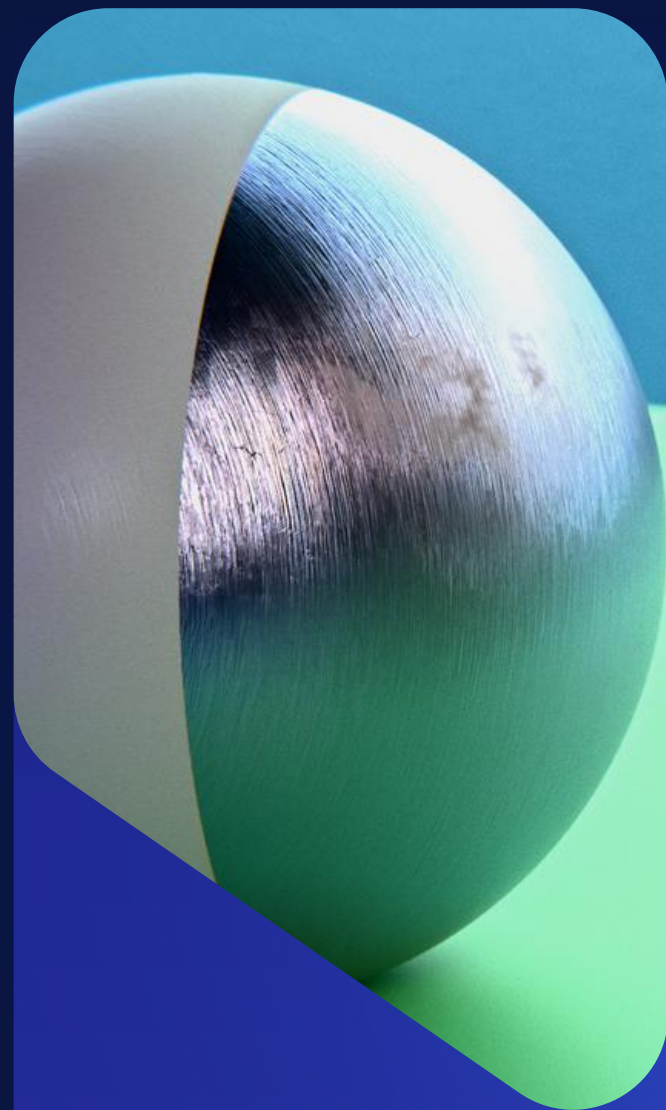
Roughness of zero corresponds to a glossy material as the inverse. Roughness became the standard in PBR workflows because real-world surfaces tend to be rough rather than perfectly smooth.

The roughness of a surface is never 0 or 1. Liquids, mirrors, and metals can approach 0, while felt, chalk, or coal dust approach 1. Most materials fall somewhere in between. The rougher a surface, the more diffuse and larger the highlights, and the less precise any reflections.

Reflection refers to light that remains on the incident side and exits at an angle corresponding to the angle of incidence relative to the surface normal. **Specular** describes the intensity of light reflected from the surface.



METALS



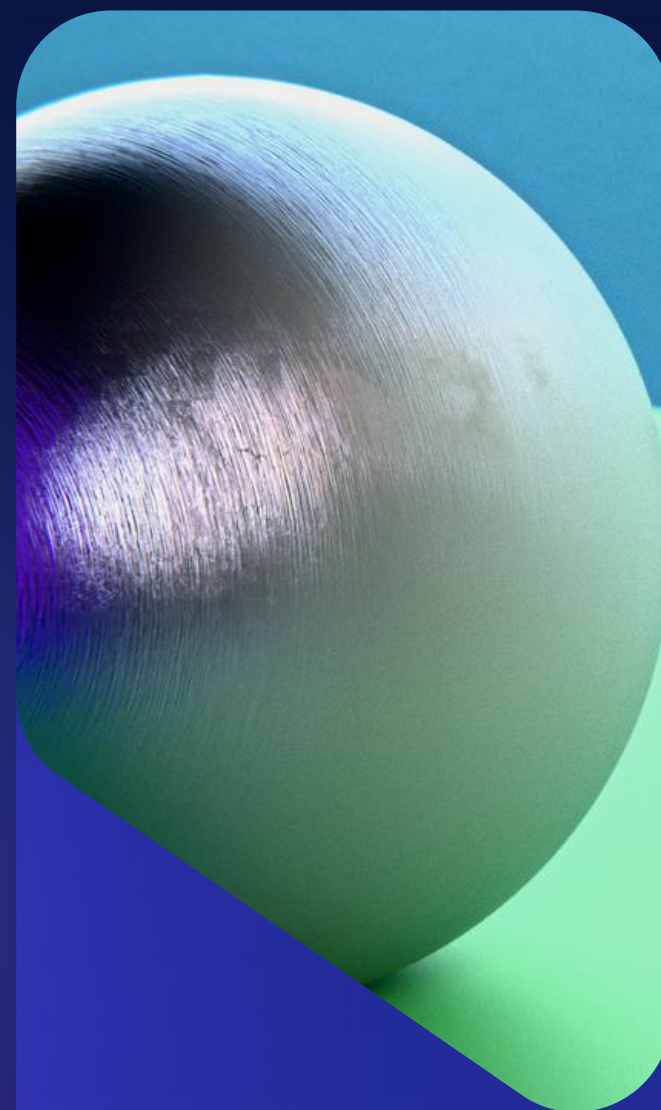
COLORLESS

Reflections on materials are white, and light splits into reflected and transmitted components. Metals do not exhibit internal scattering. Light strikes the surface, is absorbed, and is immediately reflected. Specific wavelengths are absorbed in the process, depending on the metal's crystal lattice structure. Consequently, reflections are not white but tinted and darker.



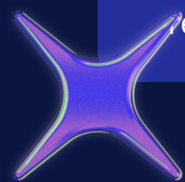
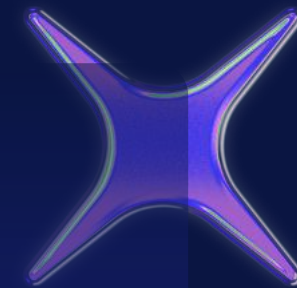
ISOTROPY

Dielectrics capture a significant amount of ambient light and scatter it in all directions, resulting in more uniform illumination of the object. Metals, by contrast, absorb some energy directly and reflect light in a sharply directional manner, making them appear darker. The visual effect of metals relies on reflection rather than direct illumination. They're flat in empty scenes.

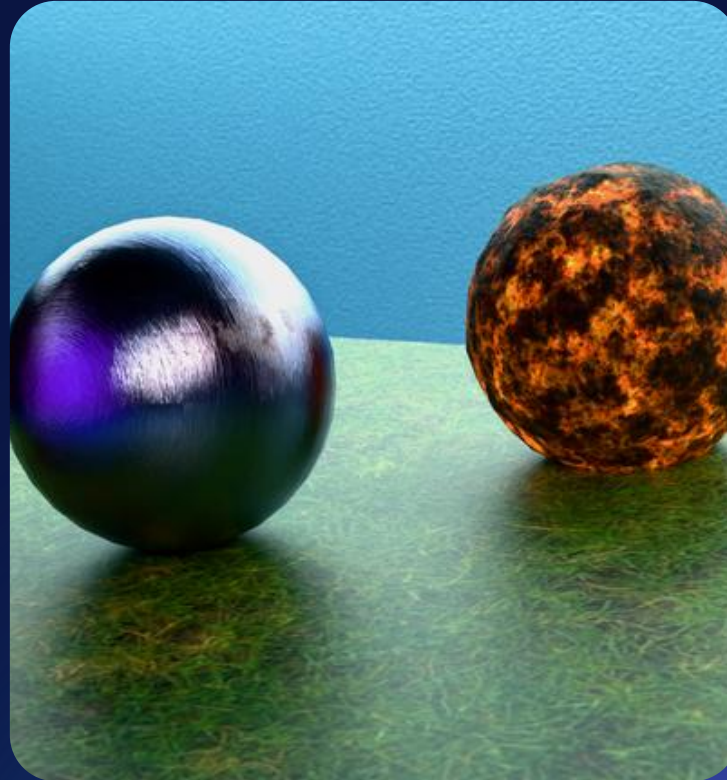


SEMICONDUCTORS

An object is typically either metallic or non-metallic, meaning the "Metallic" value is set to either 0 or 1. While a BW mask can be used to exclude areas like rust spots or paintwork on metal, the *Metallic* setting generally remains at 0, as most objects are dielectric. Towards shallow angles metals transition to dielectric reflection style due to Fresnel law.



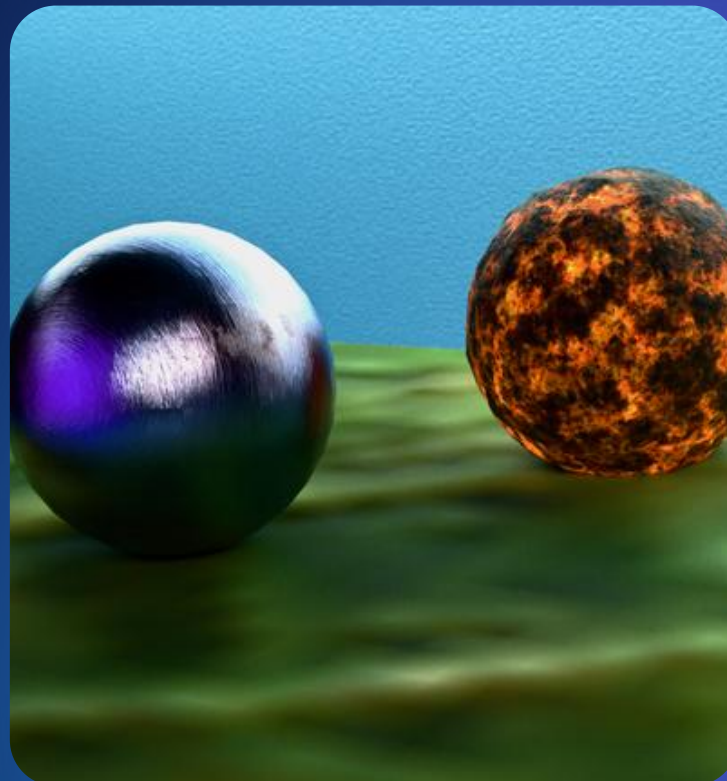
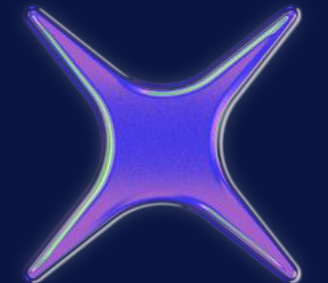
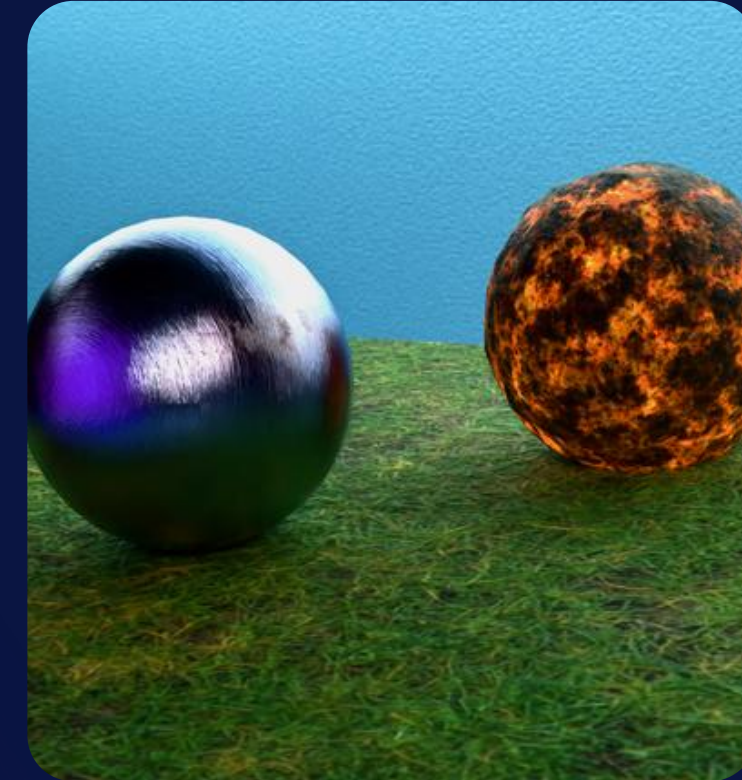
TEXTURING



SHADER > MATERIAL > CHANNEL

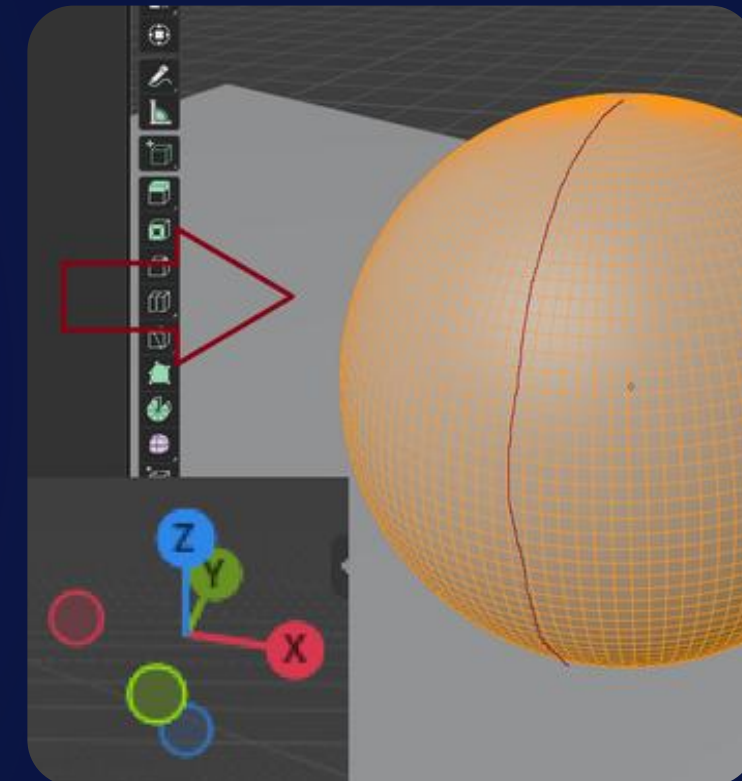
Materials represent the surface, while individual channels contain values or textures. Textures can represent differences like scratches, images, or grain patterns, while individual values are more dependent on the object, its environment and the lighting. Procedural textures use mathematical formulas to introduce variation to the surface via noise distributions.

To the right you see the difference of a fully setup PBR material versus a simple albedo texture on the left side. Surface detail scatters the reflected light more chaotic what illuminates the texture more chaotic and less parallel.



TEXEL DENSITY

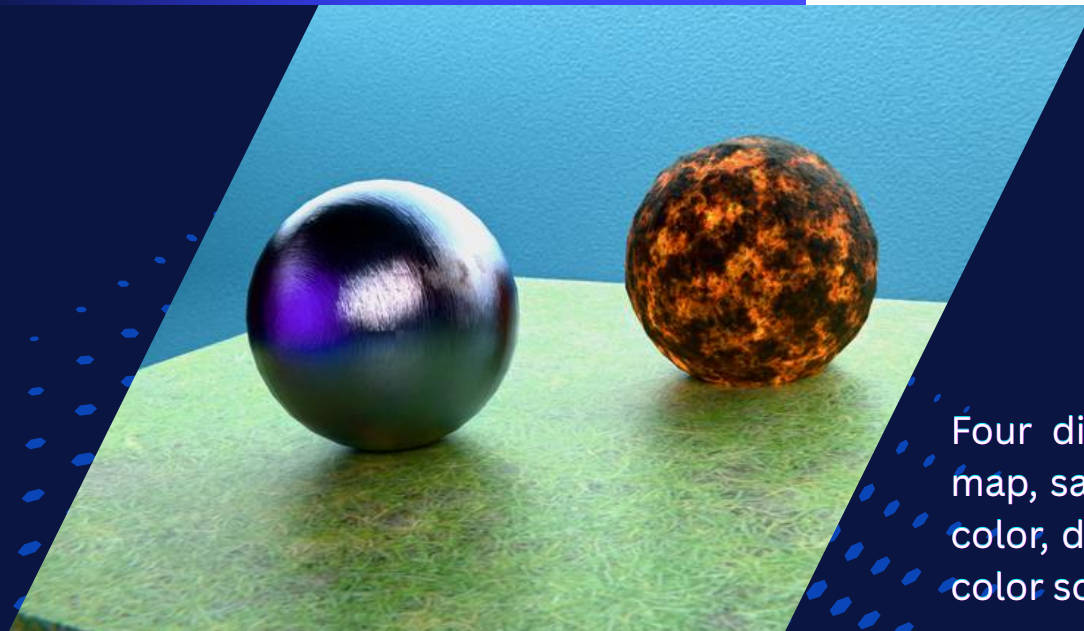
Higher resolution textures provide more detail and less artifacts, but doubling the resolution is quadrupling the file for each texture, so it's always a trade-off. In general, it's important to keep the same resolution, not on texture, but on screen. Tiny objects need less resolution than vast objects. Hard baked textures need higher resolution than tiled textures that'll repeat. The tiling factor depends on the size of the object within the world. The goal is to have not too few pixels of texture for pixels on screen to not look washed out or uneven. That is called texel density.



COLOR SPACE

ALBEDO (NON-COLOR)

**BAD
GAMMA**

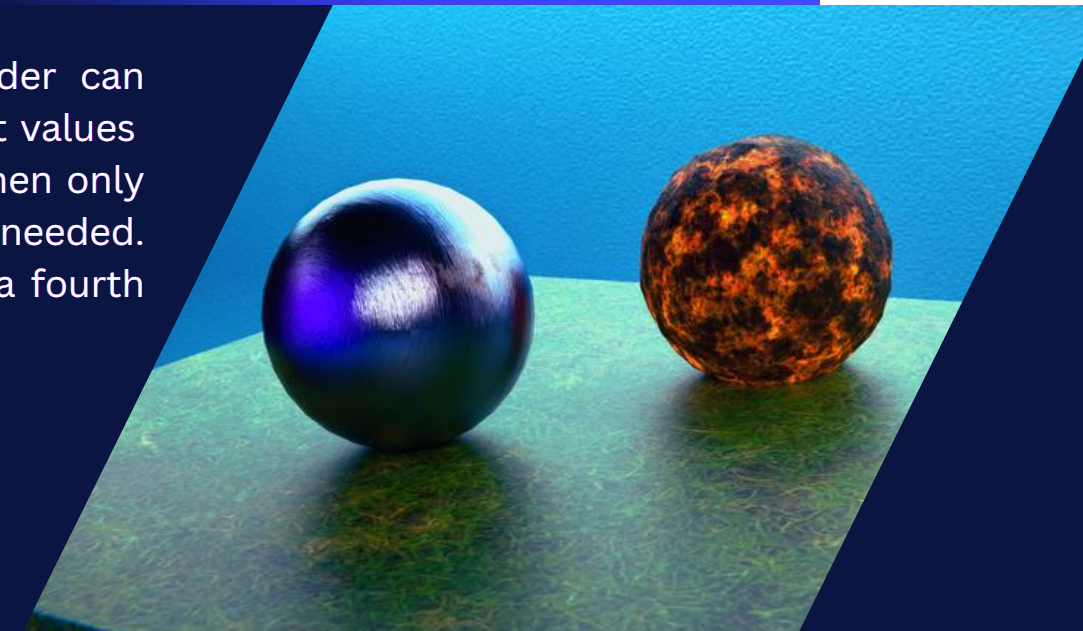


Individual channels of a texture in the shader can access red, green, and blue and store different values in them. If there is only one grayscale level, then only one such channel (metallic or roughness) is needed. PNG textures can also store transparency as a fourth channel (alpha).

Four different values can be combined into a detail map, saving memory. While pure surface color (albedo, color, diffuse) is converted to sRGB, textures with pure color scales must be specified as non-color (linear).

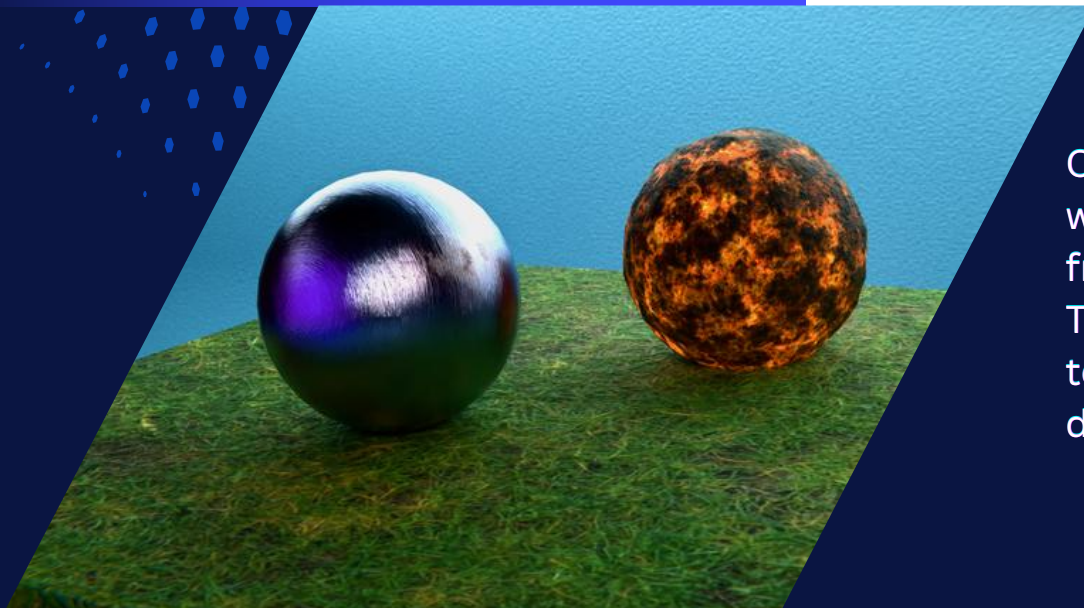
ALBEDO (SRGB)

**CORRECTED
GAMMA**



NORMALS (NON-COLOR)

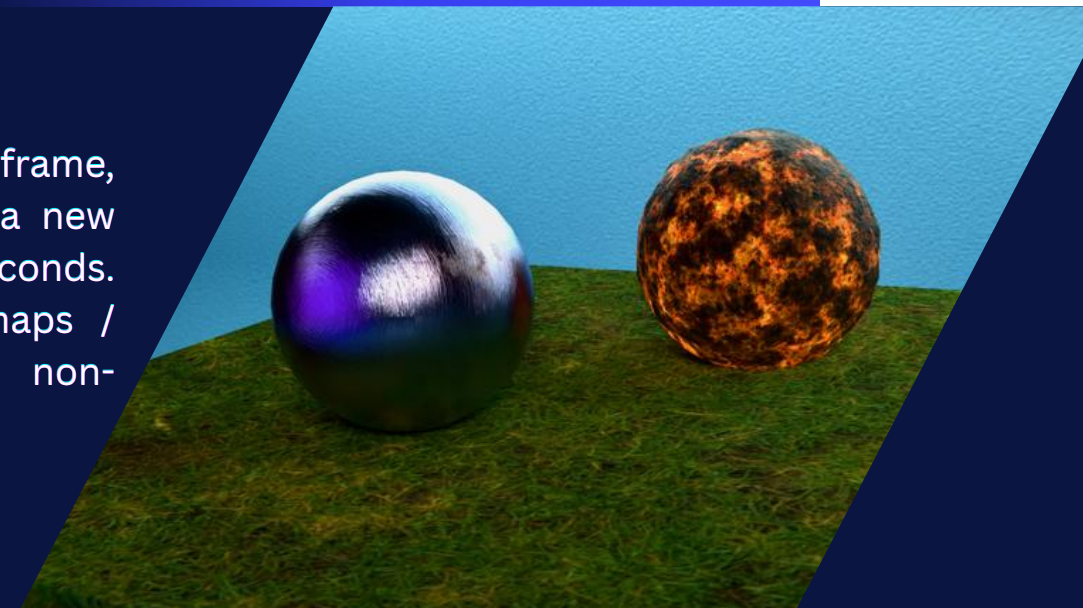
**RGB TO XYZ
TRANSLATION**



CGI rendering can take seconds or minutes per frame, whereas achieving 60 FPS in games requires a new frame to be rendered every 16.7 milliseconds. Therefore many information is baked into maps / textures, while the original files are saved non-destructively in chunky folders.

NORMALS (SRGB)

**CORRECTION
KILLS**



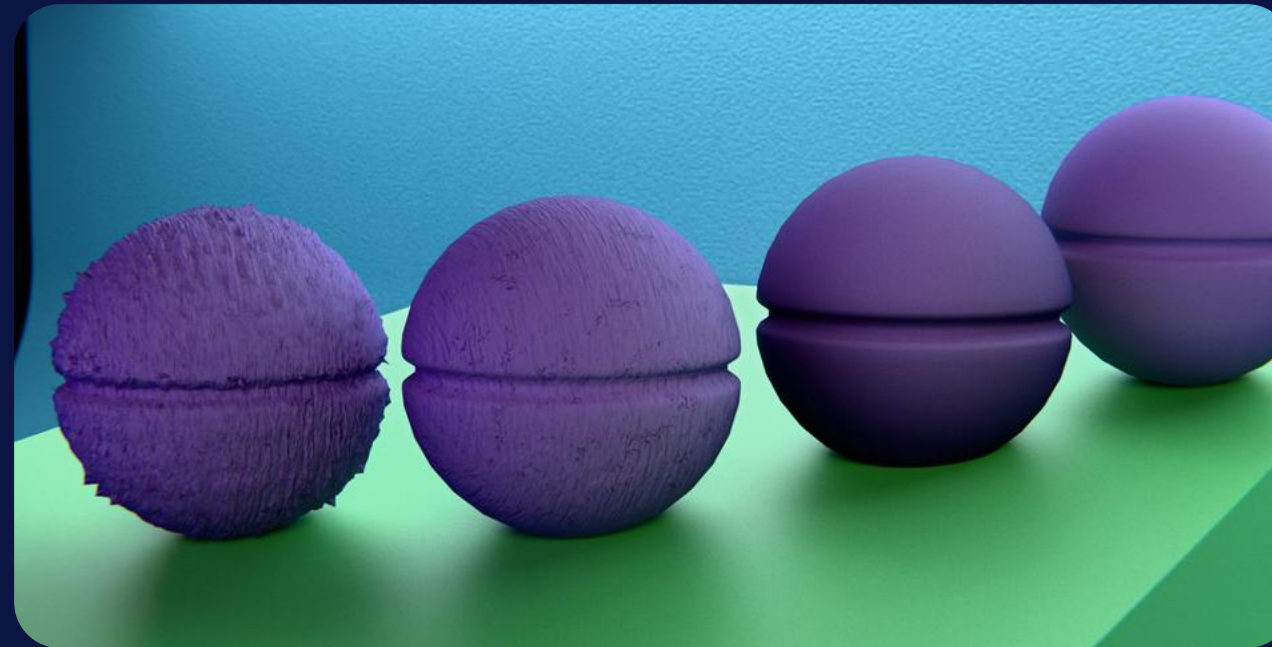
SURFACE DETAIL

A **Normal Map** is a blueish purple texture containing surface detail. Normals are the directions in which single pixels of a texture are pointing. The x, y and z direction the surface is pointing in, are translated into red, green and blue colors. It's often used to bake high poly mesh's details onto low poly versions of them, faking the details with said pixel displacements. Faking the detail with shader magic is easier to compute than having super high poly assets in your scene.

Blender uses OpenGL format, while other programs can use DirectX (Unity), what turns the green channel (y-direction) into minus and therefore a crevice could appear like a bump if not inverting the correct channel before.



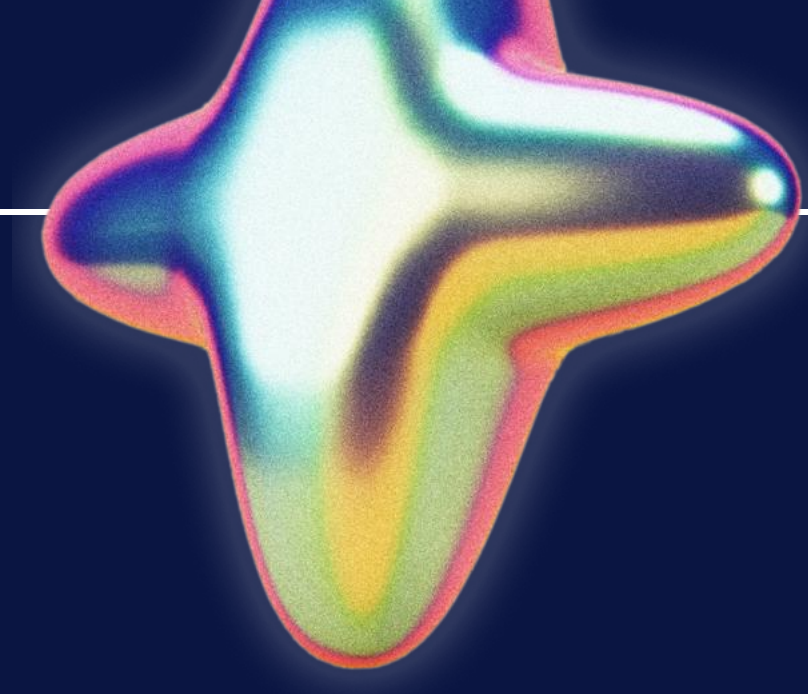
If the reflection is bent in a direction, the surface is **anisotropic**. The value of anisotropy will bend the specular reflection to mimic materials like brushed metals. Usually, you control the rotation and intensity of anisotropy.



Ambient Occlusion describes the characteristics resulting from scratches, crevices, or other indentations on objects. In Blender, an existing AO texture is typically multiplied with the albedo map using a *Mix Color* node, although such maps can also be generated directly within Blender using the *Ambient Occlusion* node.

Height maps use a greyscale to create a parallax effect of the distance of pixels from the mesh to fake surface bump. The name of that trick was bump mapping in the beginning, when it shifted even the normals, but just with greyscale. Grey is 0.5 and thus on the surface, while white is 1 and thus higher and black is 0 and thus deeper into the mesh. Sometimes those maps are called displacement maps.

Having this effect really changing the geometry of the mesh is **displacement** mapping and just used in CGI software, not in engines. Though tessellation can create similar effects.

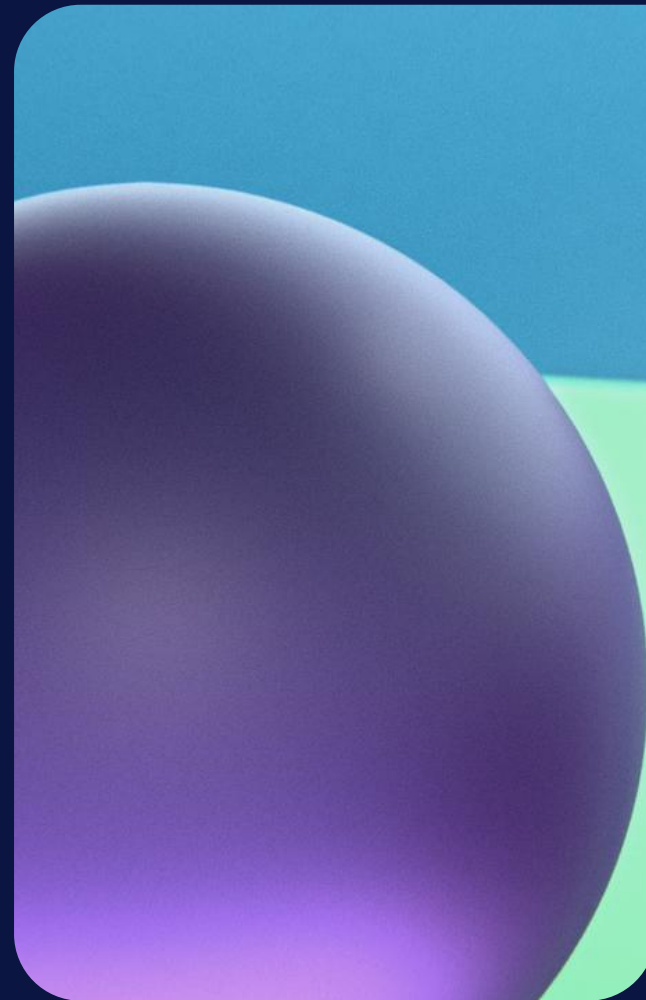


IOR is the often-mentioned index of refraction and tells how clearly the reflected image will be. Usually, it's at 1.5 for most materials and you can change it. Gold has 0.5; gases have 1; Water or alcohol have 1.33; Gems have 1.77; diamonds and zircon have 2.4; Iod crystal, chromium or copper oxide have 3.3.

The refractive index determines the speed of light within a medium and, consequently, the shift in the light's directional angle. Especially where two different IOR are connected, light bends.

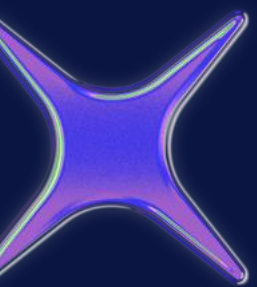


Transmission involves light penetrating a material, going through and exiting the material again. **Transparency** refers to light simply shining through. This is often handled via alpha masks for glass surfaces, resulting in no shadows. True transmission can involve the volume absorbing (darkening) light, redirecting it (refraction), or absorbing different wavelengths to varying degrees (subsurface scattering). For instance, skin primarily reflects red tones, plants reflect green tones, and wax reflects green and red slightly more strongly than blue.



Subsurface scattering allows light to penetrate volumetric objects, where it is partially absorbed before re-emerging, particularly in thinner areas.

Thin Wall is a newer addition designed to handle objects that lack volume, consisting of only a single plane, which otherwise could not be calculated correctly. Thin Wall calculates translucency rather than transmission. It does not calculate light striking the entry side, but rather highly scattered light emerging from the opposite side. This effect is significant for curtains, leaves or paper.

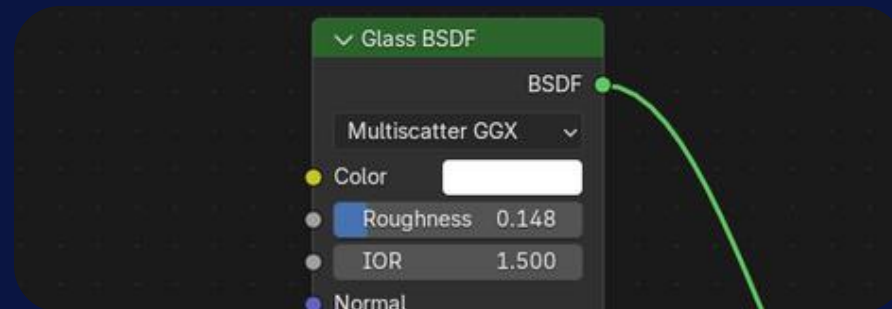


TRANSMISSION

GLASS



In Blender, the **Refraction BSDF** simulates refraction without reflection.



The microfacet distribution models used by specialized shaders include the Beckmann distribution, which works perfectly for smooth surfaces. GGX employs a long-tail approach, allowing highlights to taper off softly for a less artificial look. Multiscatter GGX calculates additional intermediate steps, particularly for rough surfaces, to prevent light from being erroneously absorbed.

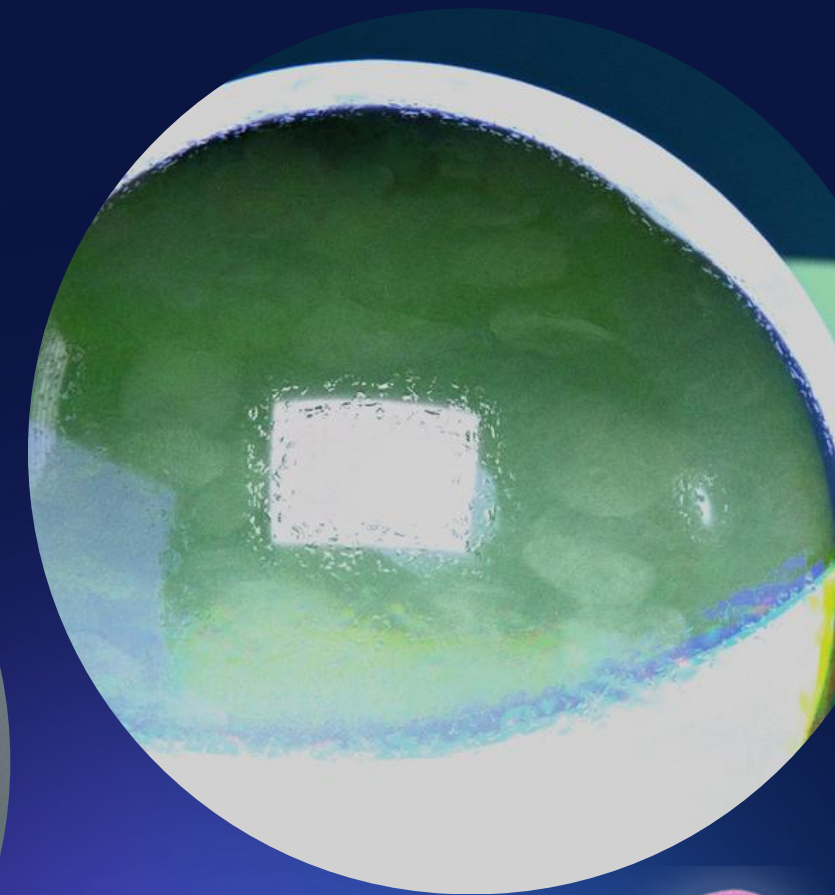


The **Glossy BSDF** simulates reflection without refraction or transmission, seeming metallic due to the complete reflection.

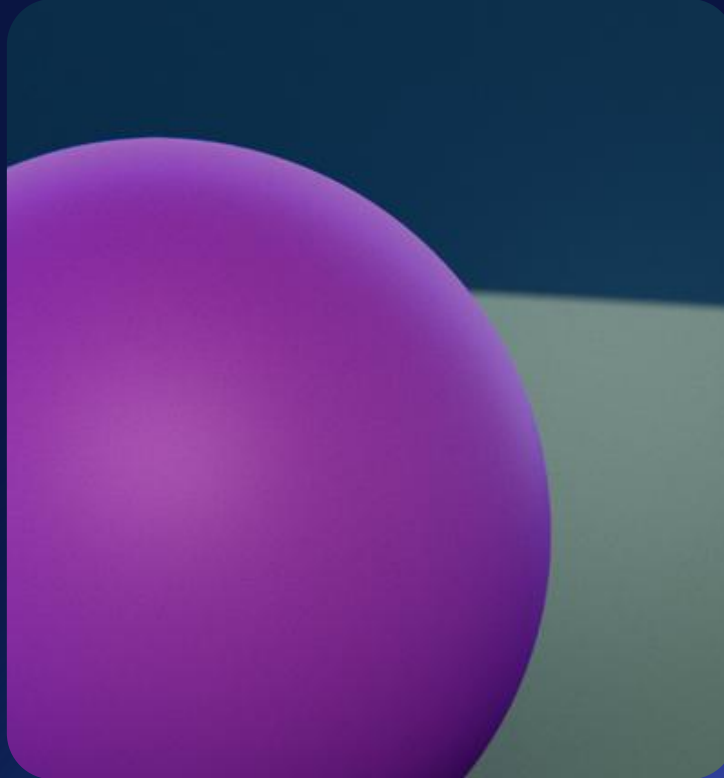


The **Glass BSDF** combines both shaders using a Fresnel mask, as surfaces angled away from the viewer's perspective typically shift toward white in their reflection.

The upper right ball uses the **Principled BSDF** (Transmission 1 - Roughness 0.025 - IOR 1.45 to 1.55 - MNEE) and I added dark fingerprints as a roughness texture. Also I mixed different glassy shaders and even added 3 glass shaders (R, G, B) with different IOR values for nice effects.



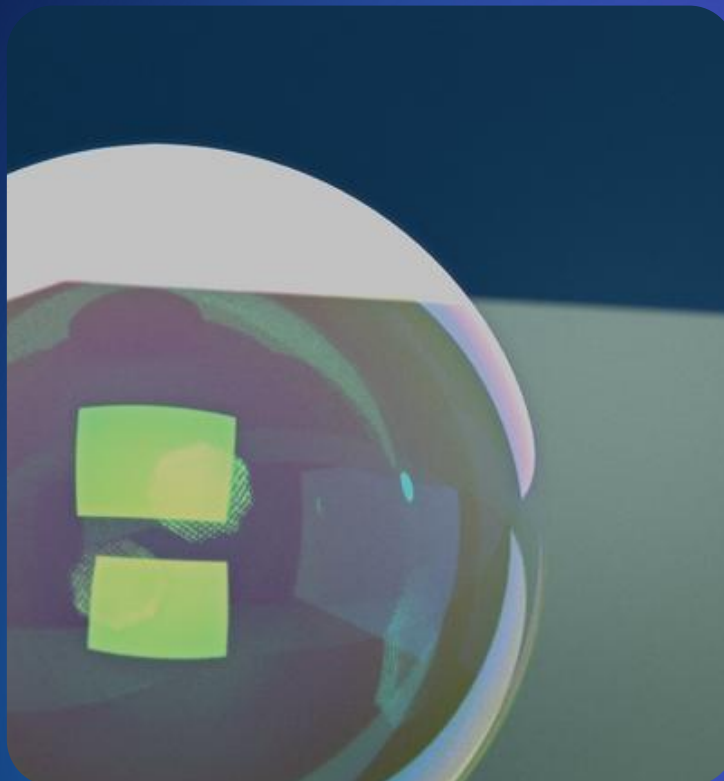
LAYERED SURFACES



SILK AND FURNISH

Sheen can add reflectiveness to the rim of an object to scatter light and blur said rim light a bit. Fabrics can tint that sheen to their base color to create silk effects.

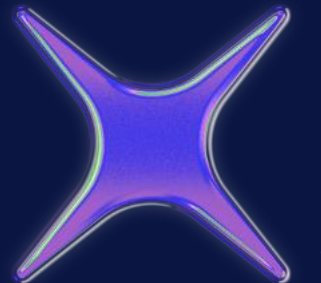
Clearcoat is an extra layer on top of a material, that can differ in gloss and reflectiveness to mimic a clear painted surface like furnish. You control roughness and IOR of that clearcoat and decide the intensity of the applied effect. Clearcoat sits on top of a material like glass, adding a razor-sharp reflection to a rough surface where needed.

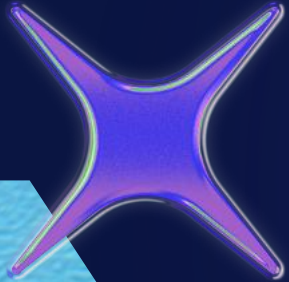


BUBBLES AND OIL PUDDLES

Thin Film is also an extra layer on top of a material but rather designed for oil. You control the thickness and IOR of said liquid. Thin Film simulates a nanometer thin layer of moisture on objects, causing light rays to interfere and potentially cancel each other out, creating iridescent effects. Keep the thickness within the wavelength of visible light.

Manifold Next Event Estimation allows light sources to produce caustics. Objects can then either generate or receive caustics. Shadows are refracted, and light wavelengths are delayed and focused. The system is forced to calculate the direct path through the object. Light may undergo dispersion, depending on the refractive index.

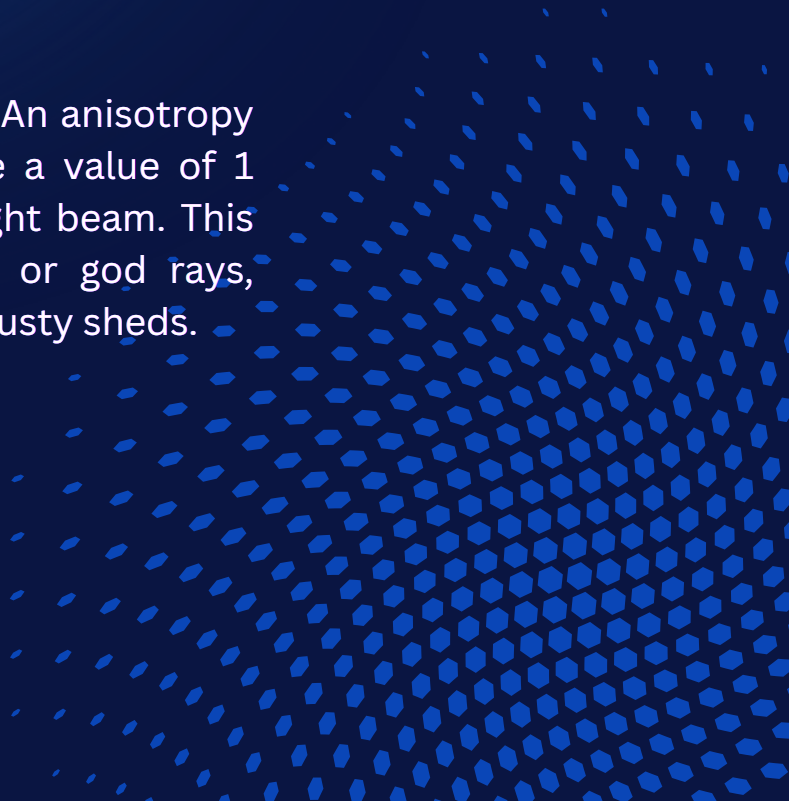




REAL VOLUMES



Volume effects are heavier. If your GPU is too weak to render the image, check *Edit > Preferences > System* if enough VRAM is accessible for Blender. If that is not helping, try allowing access to the CPU in *Preferences > System* and set the Render Tab to CPU. It takes much more time like this, but the CPU has access to the DRAM, what is way more than the GPU's VRAM. New versions of Blender usually try to share memory between GPU and DRAM if both CPU and GPU are allowed in System Preferences.



Volume Scatter disperses light more intensely. An anisotropy value of 0 results in chaotic scattering, while a value of 1 directs the scattering along the path of the light beam. This allows for the control of volumetric lighting or god rays, effects that enhance scenes like nightclubs or dusty sheds.

VOLUME BSDF

LOW DENSITY

**MIST
STEAM**

HIGH DENSITY

**FOG
CLOUDS**

If the Volume shader output is used instead of Surface, a Volume BSDF shader is required; this is because the object is no longer a hollow volume with properties defined by surface calculations, but rather a particle cloud without a defined surface.

Colored volumes absorb certain wavelengths stronger. The thicker the volume, the more light is absorbed. This is controlled by the Volume Absorption setting. It is effective for rendering thick glass, dust, smoke or clouds.

COLD BLACKBODY

**CANDLE
LIGHT BULB**

HOT BLACKBODY

**SUN
FLOODLIGHT**

The Principled Volume shader includes a built-in Blackbody emission effect, using Kelvin values to control thermal radiation and accurately render the colors of glowing or burning objects. Since flames consist of glowing gases, this shader is ideal for explosions.

Cooling or smoldering objects typically reach around 1000K, burning or exploding objects around 2500K, and welding torches or the sun exceed 5000K.

ANISOTROPY

0.0

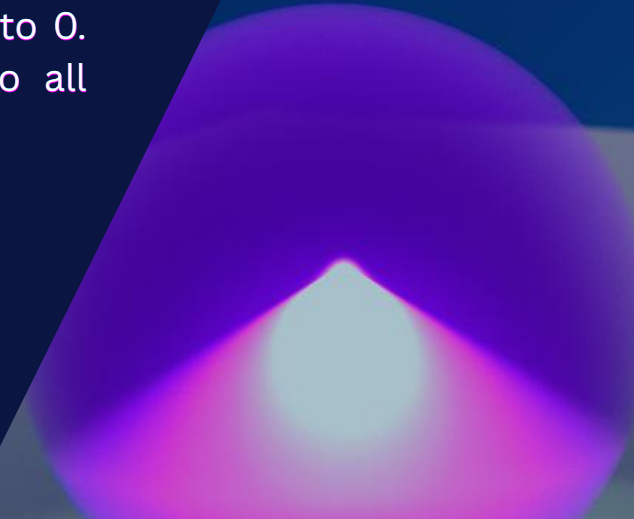
ISOTROPY



Within the Volume BSDF you can also alter the anisotropy of the medium, which usually is set to 0. That means, light is scattered homogenously to all directions, starting from the light source.

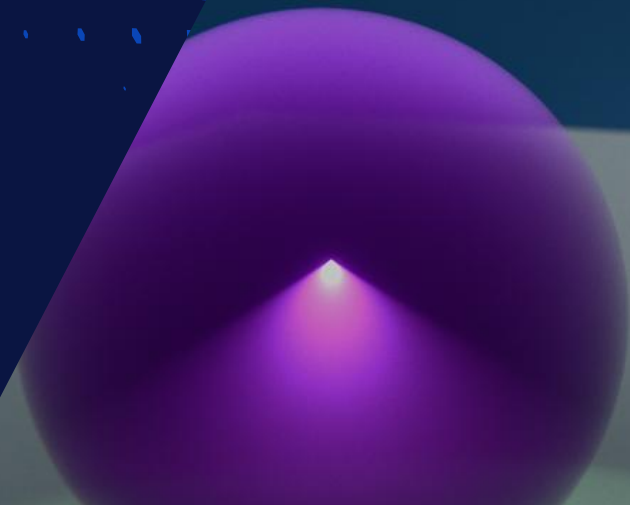
Using natural values between 0.4 and 0.8 will direct the light and create god rays, komorebi effects and similar shenanigans.

0.7

GOD
RAYS

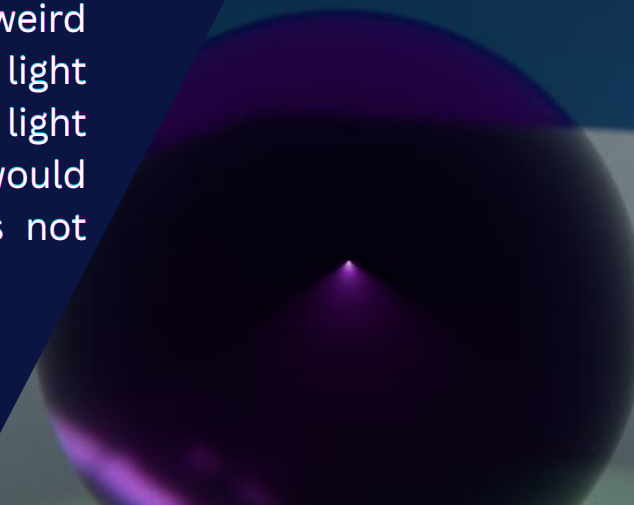
0.97

UNNATURAL

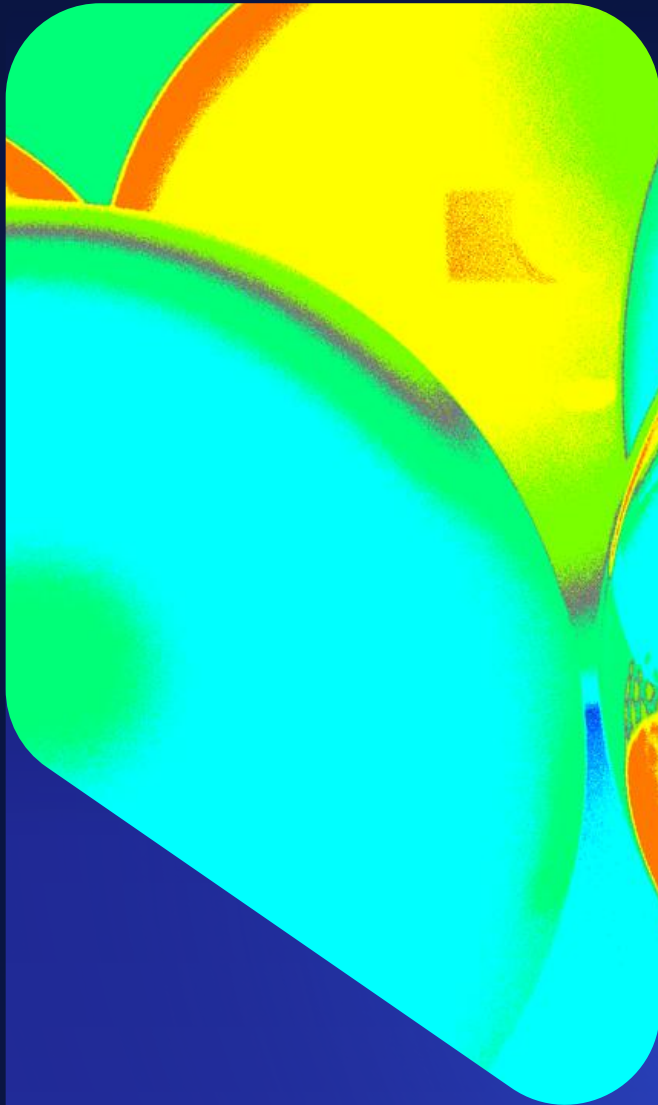
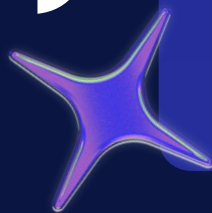


Using extreme values above 0.9 or -0.9 will create weird physics glitches. Positive values will scatter light forwards, while negative values will scatter light backwards (towards the source). Reaching -1 or 1 would hypothetically scatter the light infinitely, what's not possible.

-0.99

LIGHT
ABSORPTION

COLORS



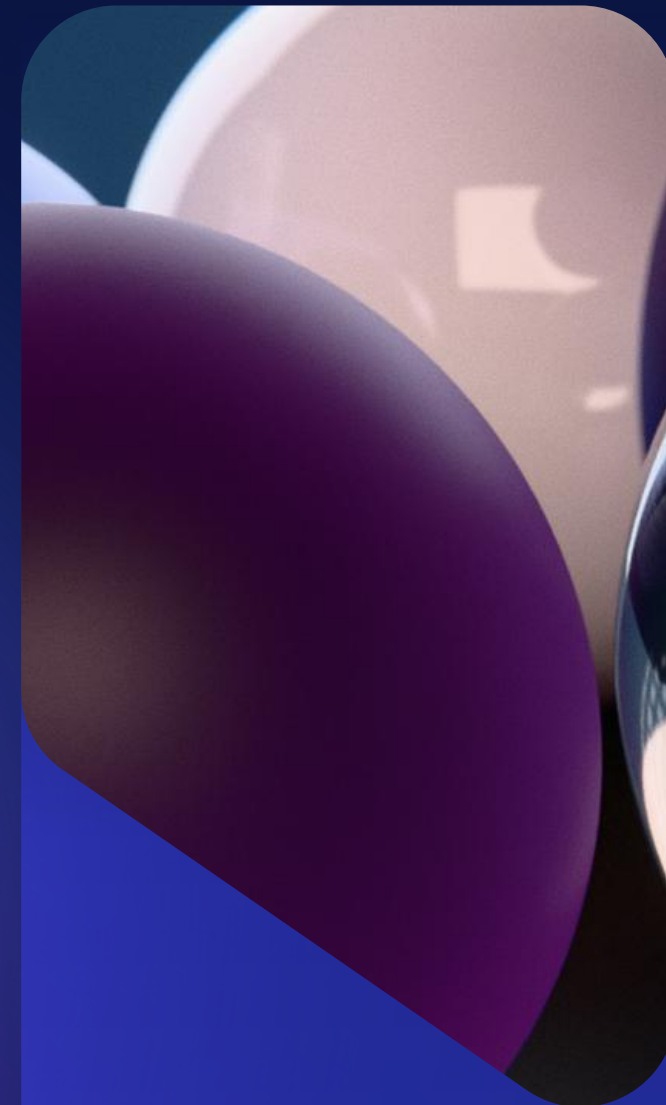
FALSE COLOR

Before you render, set the View to *False Color* and check that most of your image is within light green and grey colors. Warmer colors (orange, red, white) mean your image will be overexposed and darker colors (blue, purple, black) will be underexposed. The exposure slider within *Color Management* fixes that instantly. Some shadows of course can stay blue to give some contrast to the image, but avoid white or black areas, because those are completely clipping.



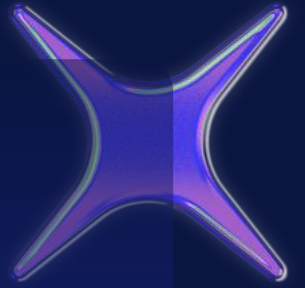
COLOR VIEW

Filmic often bends colors neon like, while *AgX* since Blender 4.0 is struggling in dark scenes and in general tends to wash colors into a pastel mush. *Khronos* since Blender 4.2 does a gamma correction which preserves real color, so you've full power in *Compositor* mode. *AgX* can still look pretty if your scene is fully lit and HDR. *Filmic* and *AgX* trying to mimic chemical film cameras.



COMPOSITOR

Activate the *Compositor* in *Color Management* and switch to the Compositor Tab to see your *Group Input* node, what is your rendered Image. It goes into the *Group Output*, but you can manipulate the image in between, what is called post processing. It photoshops your image after the render process.



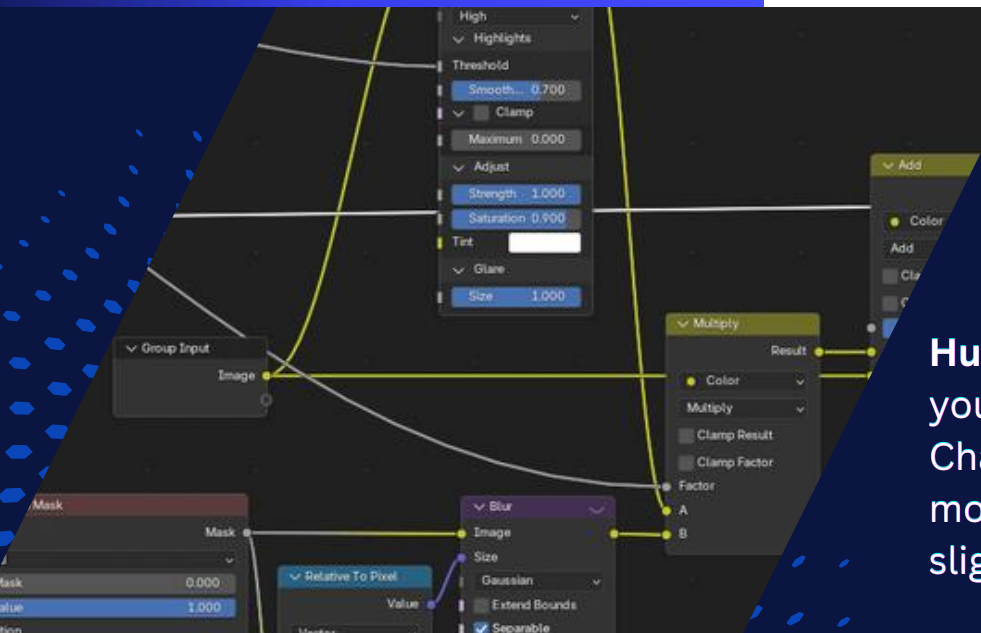
POLISHING

BLOOM

GLOWY HIGHLIGHTS

COLOR GRADING

LUT CONTRAST



You can multiply a blurred Ellipse mask with a **Fog Glow** to let highlights bloom and shine more. Add the multiplied result with factor 1 to the render to achieve a glow that isn't washing out your colors.

Hue/Saturation/Value lets you color correct or grade your render. I usually add 2% to the Hue as grading. Changing the Hue 2% clockwise will turn skin tones more vibrant, sky tones more teal and it brings in a slight push for teal orange what seems more cinematic.



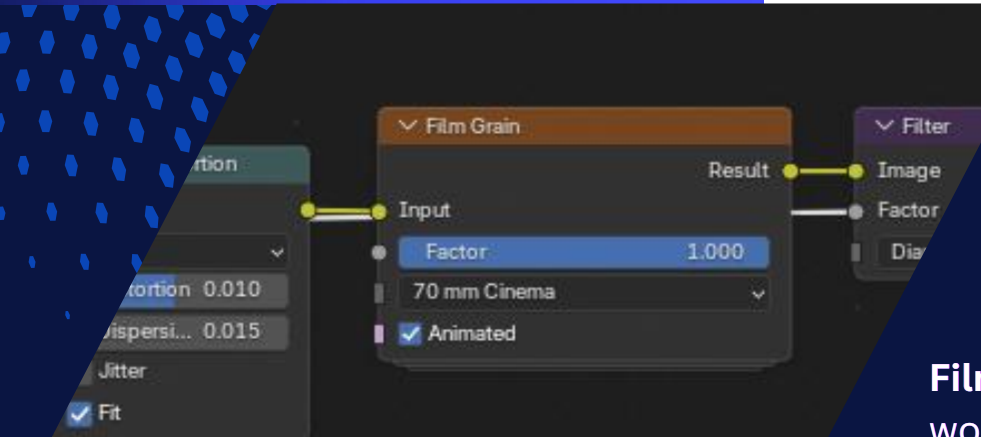
LENSE BARREL

DISTORTION DISPERSION

Filter node set to **Diamond Sharpen** before the output can bring some crispness to your image. Keep it below 0.5 to not seem too grainy. It adds nicely to the film grain.

COMPOSITOR SETUP

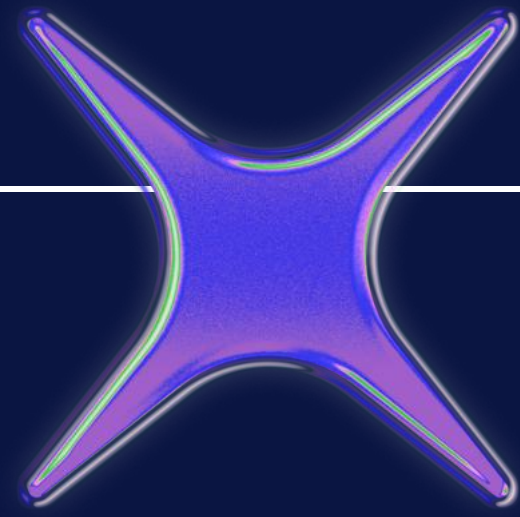
ADJUST FOR EACH RENDER



Lens Distortion adds a realistic stretch of real lenses to the image, while dispersion refracts light towards the borders. This node adds more realism on too perfect renders. Keep the values low to have it subtle. You don't want the effect to dominate your result.

Film Grain can add different cinema filter effects that would happen due to chemical reactions of old analogue film rolls. 70mm cinema is a nice 2000s film grain effect that's not overdoing it.





HAVE FUN
CREATING

