The Science of Pixar
At the Oregon Museum of Science and Industry (OMSI)
Parabolas as grass
A blade of grass is a small thin curve that can be represented by a parabola.

Computer-generated variety
Real blades of grass don't all look alike. Pixar writes programs that vary the color, height, width, and curve of the virtual blades of grass.

The way something looks tells a story. What is it made of? Is it new or old? Well taken care of or neglected? After a virtual 3D model is created, a surface artist constructs its appearance with computer programs called shaders. Shaders determine the way light scatters off the surface so it looks shiny, transparent, and smooth (like glass) or dull and rough (like rust).

Shaders
Shaders are programs that tell a computer how to display all aspects of an object's surface appearance.
The Rendering Equation

\[ L(x, \omega_o) = \int_\Omega f(x, \omega_\iota, \omega_o) L(x, \omega_\iota) \cos(\theta) \, d\Omega \]

In plain language, this is a simultaneous-equation energy balance:

“The light shining from the point P is the reflection of the incoming light directed to the point P from all of the other points in the scene.”
The virtual scene is set—the characters are loaded and posed, the lights and camera are in position, and the simulations are ready to run. But no one knows what it looks like until the rendering process turns all that data and programming into an image we can see. Pixar generates low-resolution renders fast, then in progress and high resolution renders for the final film.

The virtual 3D scene This visualization of the data that defines the scene.

The rendered 2D image Rendering calculates the color of every pixel in an image.

Moving with math
Computer animators position digital models into key poses. Then the computer fills in the transitions based on mathematical functions called splines.

Acting from pose to pose
Mr. Incredible is posed to run, but the transition to the next pose will tell if he is bounding along or tiring out.
While animators focus on acting, simulation programmers create motion that makes scenes feel alive and believable. Some simulations—hair, fur, and clothing—respond to the way a character moves. Other simulations recreate natural phenomena, such as fire or water. Programmers start with the underlying physics, but they balance believability with the artistic needs and the time it takes to run the simulation.

A frame from above before the simulated elements were included.

The same frame with the simulations added.

Automated oceans

All the water in *Finding Nemo* is simulated using computer programs, not animated by hand.
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