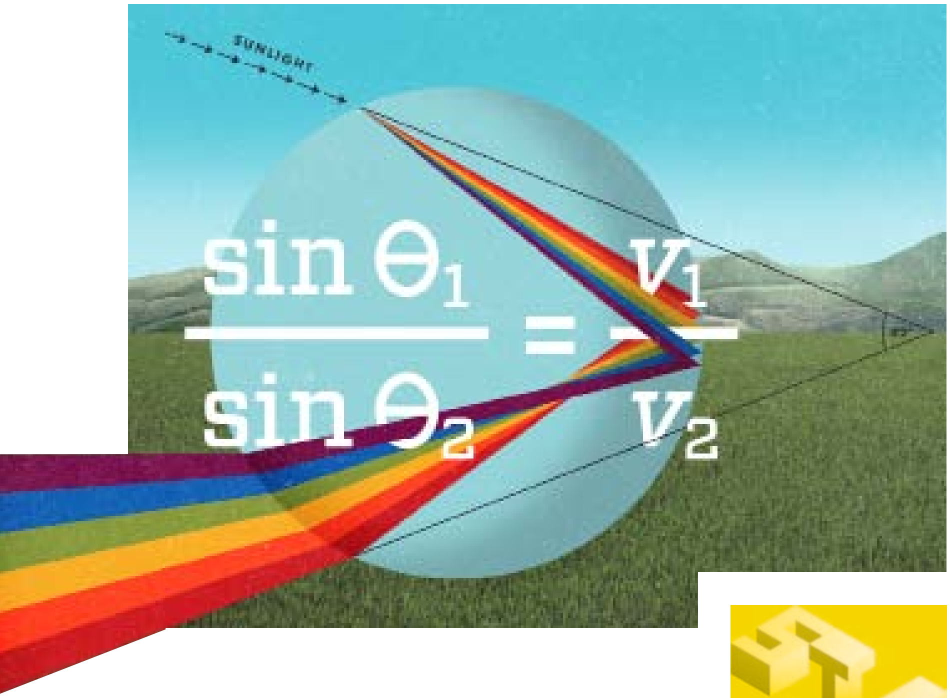
EQUATION

The Law of Rainbows

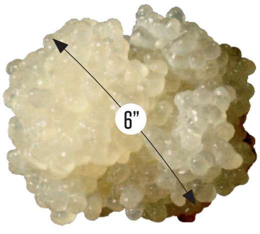


$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2}$$

When sunlight hits a raindrop, some photons glance off the surface. But others penetrate, reflect off the opposite side of the droplet, and shoot back out the front. That *internally* reflected light is what makes rainbows—which is why you see them only when the sun is at your back. And the colors? Well, light moves slower in water, and the sudden deceleration alters its direction of travel. Short wavelengths like violet bend more than long ones like red, causing that beam of white sunlight to fan out into a spectrum of colors—which then hit the other side of the raindrop at different spots and bounce back out at divergent angles. Now picture a sky full of raindrops. Each one reflects the full spectrum, but because of the varying angles, we see different colors from drops at different heights. Look up at a 42.4-degree angle from the ground and you'll see red light—the top band of the rainbow. At 40.7 degrees, you'll see violet, the bottom band. Once you've calculated the angle at which the sunlight hits the drop, the equation for Snell's Law helps us determine the distribution of those color bands. —JULIE REHMEYER

Decoding Snell's law (above):

$\sin\theta_1$	$\sin\theta_2$	v_1	v_2
A measure of the angle of incidence—the angle at which a ray of sunlight strikes a raindrop.	A measure of the angle of refraction—the ray's angle of travel inside the drop. The difference between the two angles is the amount the light bends.	The velocity of light through air. This is very close to **c**, the speed of light in a vacuum, and is almost identical for all colors.	The velocity of light through water—about 25 percent slower than $\mathbf{v_1}$. In water, violet light travels about 1 percent slower than red light.



Hemoglobin Gets Its Own Action Figure

Casey Steffen loves hemoglobin. "It's such a wonderful, elegant transporter of oxygen," says Steffen, who owns a company that produces animated 3-D stories about science.

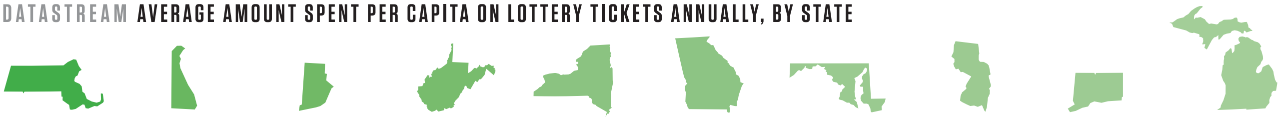
A chance introduction to Michael Gulen, who makes action figures as prototype development director at McFarlane Toys, led to a discussion of hemoglobin's merits. Charmed by Steffen's enthusiasm, Gulen agreed to mock up a hemoglobin toy. Of course, Steffen didn't want to throw a cape on an amorphous blob, he wanted a true-to-form hemoglobin molecule big enough to hold. That meant taking a digital model of hemoglobin—all 4,659 atoms—and blowing it up 7.3 million times with perfect fidelity.

Though Gulen was used to 3-D-printing toys at McFarlane, hemoglobin wasn't easy. "When we broke this molecule down into 16 parts, most looked exactly the same," Gulen says. And worse, there was no indication that those parts would hold together.

But it worked, and there is now outside interest in the protein model: a Swiss pharmaceutical company ordered 100 of the hemoglobins, and a VC firm thinks Steffen's brainchild could be the next big children's toy. Innocent plaything by day, bioresearch hero at night? Maybe Steffen's hemoglobin needs a cape after all. —RACHEL SWABY

STEFFEN VFX

DATASTREAM **AVERAGE AMOUNT SPENT PER CAPITA ON LOTTERY TICKETS ANNUALLY, BY STATE**



MA: $627.69

DE: $482.02

RI: $467.74

WV: $438.20

NY: $348.40

GA: $318.74

MD: $274.73

NJ: $270.68

CT: $265.25

MI: $239.39

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