

Rapunzel's Hair

In the Brothers Grimm story, an enchantress took Rapunzel from her parents at birth because the infant's father had stolen a kind of lettuce, rapunzel, for his wife from the witch's garden.

Rapunzel by the Brothers Grimm

Rapunzel grew into the most beautiful child under the sun. When she was twelve years old, the enchantress shut her into a tower in the middle of a forest. The tower had neither stairs nor door, but near the top was a little window. When the enchantress wanted to go in, she placed herself beneath it and cried:

'Rapunzel, Rapunzel,
Let down your hair to me.'

Rapunzel had magnificent long hair, fine as spun gold, and when she heard the voice of the enchantress, she unfastened her braided tresses, wound them round one of the hooks of the window above, and then the hair fell twenty ells down, and the enchantress climbed up by it.

On November 24, 2010, Disney's animation of Rapunzel, *Tangled*, opened in theatres. To create a life-like animation of Rapunzel's hair, Disney animators had to study the physics of hair motion.

This week on NPR radio there was a short story about the computer animation used to create realistic hair for Rapunzel. On the Science Friday part of their website, you can see a marvelous, short movie about the animation.

<http://www.sciencefriday.com/videos/untangling-the-hairy-physics-of-rapunzel-4/>

Hair on the scalp grows about 6 inches per year. Rapunzel's hair is 70 feet long.

1. At this rate, how old must Rapunzel be during this movie?

To achieve realistic hair motion for Rapunzel, animators had to create lots of groupings of hair and consider how they move with regard to

- her head movement
- the direction and strength of the wind
- the springiness of her hairs
- the interactions of light and shadows
- and all of the collision between hairs, scalp, and other objects

They used a lot of physics to achieve the lovely motion of Rapunzel's hair.

When a baby is born, it has all of the hair follicles that will last for its whole lifetime. A baby is born with 100,000 hair follicles on its scalp.

Instead of considering 100,000 individual hairs, the animators modeled Rapunzel's hair motion on 173 hairs.

2. What percent of actual hairs did the animators use in their modeling?

Kelly Ward, the senior software engineer for Walt Disney Animation Studios, says that Rapunzel's 70 feet of hair would weigh between 60 and 80 pounds if her hair was real.

3. Measure the length of an average lock of your own hair. Give its length and calculate how much it must weigh.

My good friend Karen has really long hair that reaches down to the bottom of her back. It must be 2 and $\frac{1}{2}$ feet long.

4. How much do you calculate that Karen's hair weighs?

Actually there is a limit to how long hair will grow. The current world record holder for long hair, Xie Qiuping, boasts tresses more than 5.6 meters long.

5. How long is Xie Qiuping's hair in feet? (1 meter = 3.2808399 feet)

6. How much might Xie Qiuping's hair weigh?

Sources:

<http://www1.i2r.a-star.edu.sg/~zyhuang/review/research/others/egcas00.pdf>

<http://www.webmd.com/skin-problems-and-treatments/hair-loss/science-hair>