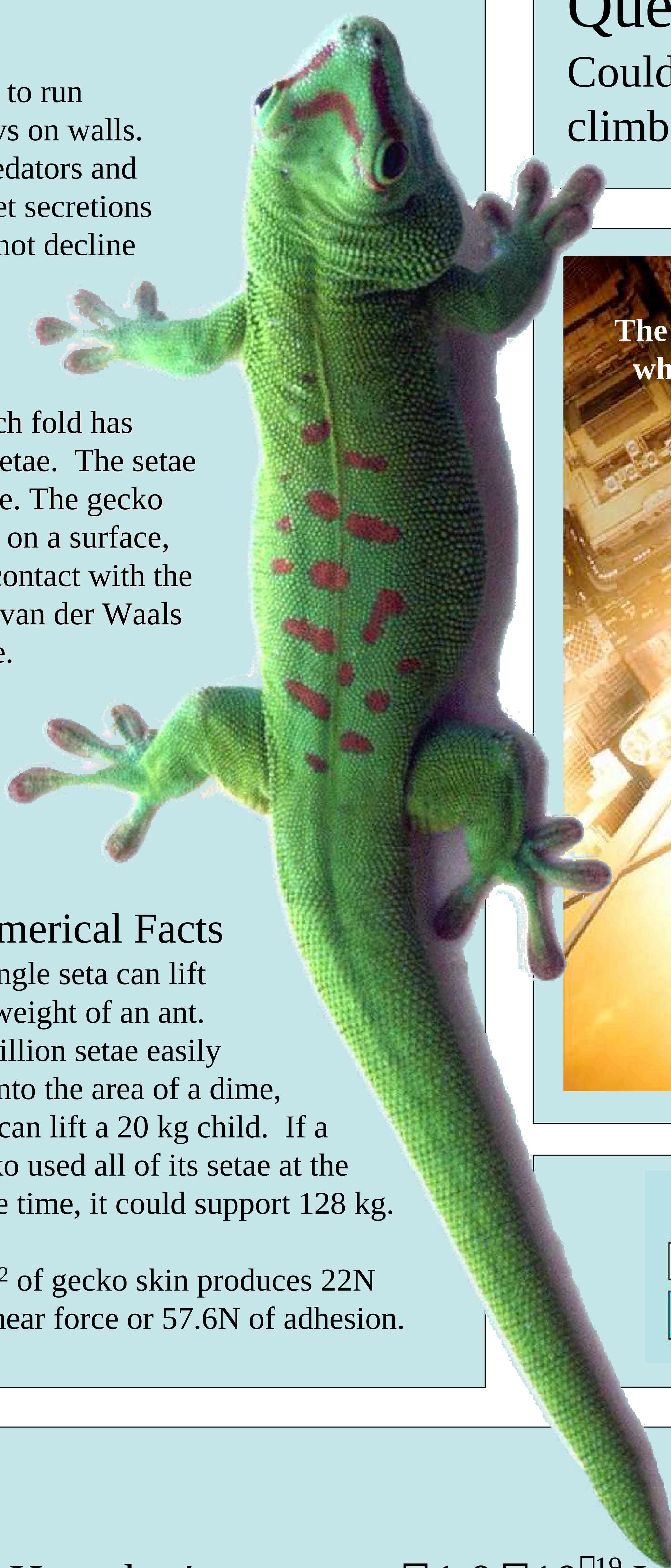
How a Gecko Sticks to a Wall

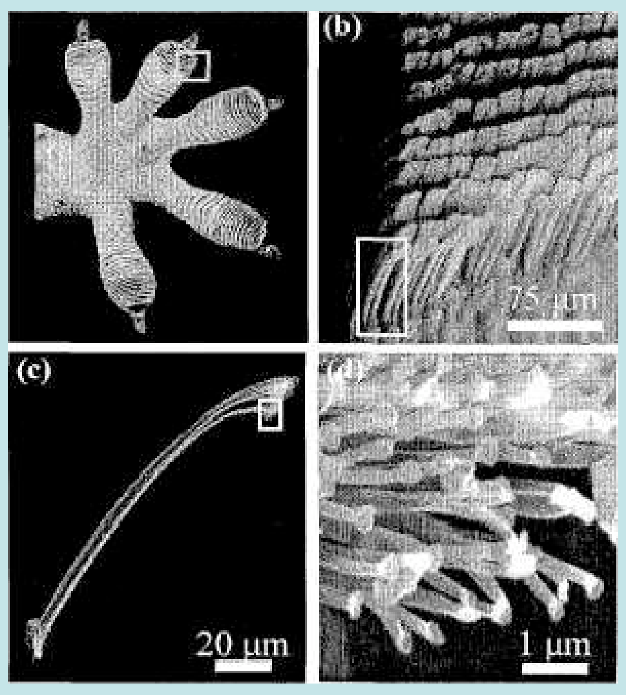
Background Info

Geckoes are well known for their ability to run upside down across ceilings and sideways on walls. This ability lets geckoes escape from predators and find food such as flying insects and sweet secretions found in tree bark. The efficiency does not decline because the feet are self-cleaning.



What causes the feet to stick?

A gecko's foot has surface folds, and each fold has millions of specialized hairs, known as setae. The setae are each tipped with 400 to 1000 spatulae. The gecko uncurls its toes and pushes its foot down on a surface, causing the spatulae to come into close contact with the surface. The close contact produces the van der Waals force that bonds the foot onto the surface.



To break the adhesive bond, the gecko bends its foot forward so the angle between the setae and surface exceeds 30°, causing spatulae to detach.

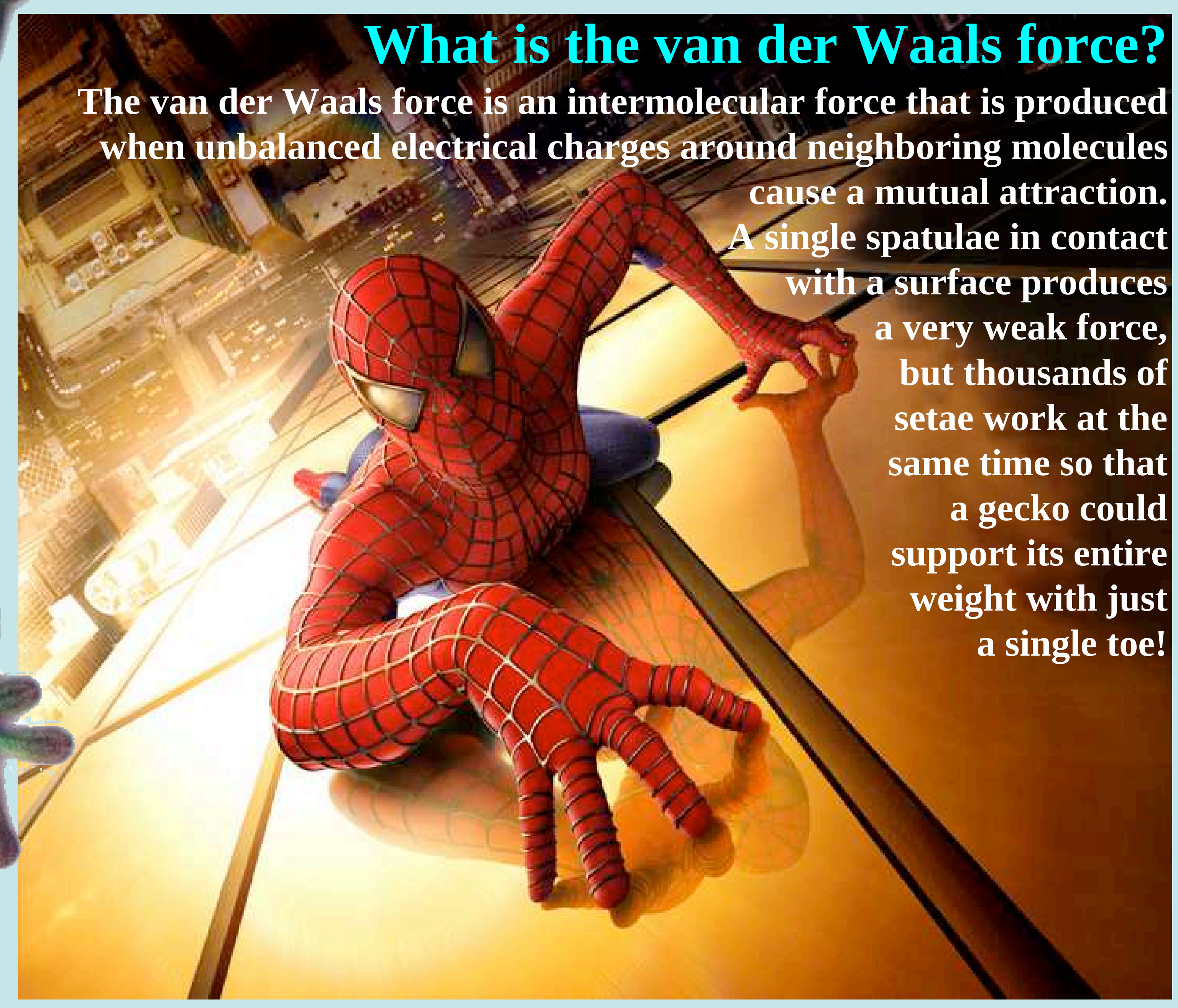
Numerical Facts

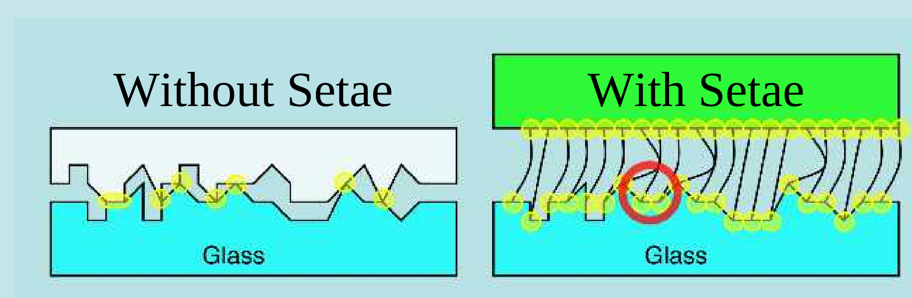
A single seta can lift the weight of an ant. A million setae easily fit onto the area of a dime, and can lift a 20 kg child. If a gecko used all of its setae at the same time, it could support 128 kg.

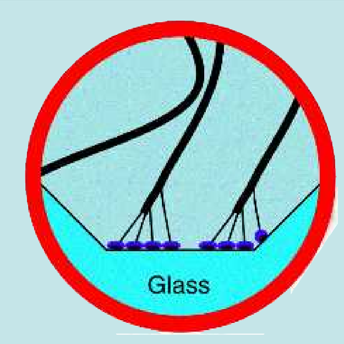
1cm^2 of gecko skin produces 22N of shear force or 57.6N of adhesion.

Question

Could Spiderman use Gecko-like gloves and shoes to climb a skyscraper?







Formulas

$$F_{\text{van der Waals}} = \frac{H}{6\pi D^3} \qquad H = \text{Hamaker's constant} \approx 1.0 \times 10^{-19}\ \text{J}$$

$$D = \text{Distance separating two planes}$$

Calculations

$$F_{\text{vdW spatulae}} = \frac{1 \times 10^{-19}\ \text{J}}{6\pi\left(3.0 \times 10^{-10}\ \text{m}\right)^3} = 1.9648 \times 10^4\ \text{N/cm}^2$$

$$F_{\text{vdW setae}} = F_{\text{vdW spatulae}} \times 2.5\% = 4.9122 \times 10^2\ \text{N/cm}^2$$

$$F_{\text{vdW skin}} = F_{\text{vdW setae}} \times 4.5\% = 22.1048\ \text{N/cm}^2$$

Comparison

	Gecko	Spiderman
Length	30cm	179cm
Mass	225g	75kg
Speed	1m/s	9.84m/s
(in body lengths)	3.3*	5.5
Contact Area	4cm^2	716cm^2
Adhesion (max)	230N	41,242N
Shear (max)	88N	15,827N
Shock Tolerance	N/A	12,000N

Handy Facts about Surface Area

Tokay gecko:
1cm^2/foot

Spiderman:
122cm^2/hand
236cm^2/foot

Conclusions

Spiderman can run up the skyscraper as fast as he wants!

If Peter Parker runs at full speed up a wall using his feet only, as long as the gecko skin properly contacts the skyscraper, he will not be able to exceed the maximum sheer force of the gecko skin.

His only worry is how he might catch himself in the (unlikely) event of a fall. A human body can withstand 12kN of force for a very brief moment. 716 cm^2 of gecko adhesive has a shearing force of over 15kN - enough to destroy the harness worn by rock climbers.

poster by Sophia Lee and Colin Ng

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