Science Fair Logbook

How do geckos walk upside-down?

By Amelia Leung and Hazel Chau

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Section 1: Acknowledgement & Sources

We want to acknowledge our parents for organising meetups for us to work on the project, supplying resources, and encouraging us to do Science Fair. We would also like to thank Heather Lai for hosting Science Club and for giving us this experience. We would also like to acknowledge the websites we used: Arizonawicca (Reddit), BYJUS, Edge of Existence, Louise Gentle (The Conversation), Markus Heim (Research Gate), Katie Moskvitch (PhysicsWorld), National Geographic Kids, National Science Foundation, Open

Access Government, PetHelpful, Rainforest Alliance, R.O. Brinkhurst (The Canadian Encyclopedia), Alan J Rocke (Britannica), H. Shaw, M. Follows, M, T. Cox (New Scientist), Ben Shouse (Science), Emily Sohn (ScienceNews Explores), Sustainable Nano, University of California, Berkeley (Science Daily), University of Massachusetts at Amherst (PHYS.ORG), and Wikipedia for the information on this project. Lastly, we would like to thank Peter Forbes and W.W. Norton Company (The Gecko's Foot - Bio-inspirations : Engineered From Nature), Melissa Gish and The Creative Company (Geckos), Rebecca Johnson and New York: Windmill Book (Gorgeous Geckos), and Wil Mara and Cherry Lake Publishing (From Gecko Feet to Adhesive Tape) for writing the books we used! Thank you!

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Section 2: Timeline

Wednesday, October 25
No research, Topic chosen:
How do Geckos Walk Upside-Down?
Wednesday, November 1
Branch questions chosen
Wednesday, November 8
Logbook creation
Wednesday, November 22
Started researching about topic
Wednesday, November 29
Half-way done research
Wednesday, December 6
Done research, Started slideshow: template, photos, etc
Wednesday, December 13
Working on logbook
Sunday, December 31
Working on slideshow, finishing research, starting slideshow
Tuesday, January 2
Working on slideshow
Thursday, January 4
Finished slideshow, started trifold
Wednesday, January 10
Working on trifold, CYSF forms (basic)
Wednesday, January 17
Working on trifold, CYSF forms (declarations)
Thursday, January 18
CYSF forms (risk)
Sunday, January 21
Working on trifold, CYSF forms (risk)
Wednesday, January 24
Working on trifold, fixing slideshow, CYSF forms (citations, risk)
Saturday, January 27
Working on trifold
Sunday, January 28

Working on trifold and logbook
Tuesday, January 30
Working on trifold, logbook, and finishing touches on the slides
Wednesday, January 31
Working on logbook, and slides
Friday, February 2
Working on slides, logbook, and finishing touches
Saturday, February 3
Finishing touches on slides and logbook.
Sunday, February 4
Finishing citations in logbook and trifold
Monday, February 5
Done logbook, finishing slides and working on Cue cards
Tuesday, February 6
Finishing CYSF forms
Wednesday, February 7
Finished trifold
Thursday, February 8
Prepare for fair

Section 3: Problem & Method

We wanted to find out why geckos could walk on walls because we were fascinated when we saw some in Hawaii. We decided to investigate this topic and try to expand on the possibilities of us doing the same thing.

We looked at books, websites, and a live gecko to find out the way they walked on walls.

Section 4: Research & Data

Geckos-What are they:

Geckos are a type of lizard that lives everywhere besides Antarctica. They are nocturnal, unlike lizards. They range in size from 1.5 cm to 60cm. There are 1, 500 species of geckos. The difference between geckos and lizards is that geckos lay eggs in pairs instead of clusters unlike lizards. They can also make chirps and barking noises. They can be green, orange, yellow, blue, and brown.

Geckos - Van Der Waals forces:

Geckos use Van Der Waals forces to walk on sideways or upside-down surfaces. This is because of sticky hairs on their toes, called setae, that attach to surfaces like glue, but much stronger. If their bodies are close to the wall, it makes it very easy for them to scale it. The atoms and the surfaces either attract or repel each other. The distance also matters in this. The setae generate these forces. Geckos and lizards can change the angle of these hairs, so they can peel their feet away from the surface they are sticking to. The same charges repel, while the opposites attract. The walls and feet are not polarised, and the geckos can still stick, which is why it is proof that Van Der Waals are at work.

Scientists measured how powerful their grip is. The front 2 feet of the largest gecko can carry 2 kilograms.

Lipids molecules and Setae:

Geckos have these lipids molecules that repel water, which helps so geckos can climb wet surfaces. Scientists say that they push the water away from beneath the setae, so the geckos can have closer contact with the surface.

Setae are made of a type of keratin, similar to what your hair and fingernails are made of. They are extremely delicate. The keratin is aligned in the direction of the setae, possibly to stop them from wearing down. Scientists studied the setae and found that they are coated in a ultra thin film made of lipids molecules, that repel water. Studies found that geckos can stick underwater, and their feet stay completely dry. The film is only one nanometre thick. The setae are flexible allowing them to stick to the surface.

Scientists tested to see if geckos would stick if they put some sort of substance on the setae and within a few steps the substance was cleared out. This means the setae can self-clean.

Smaller things at the ends of the setae are called spatulae. They come so close in contact that the electrons in both the surface and the spatulae interact, creating an attraction called the Van der Waals forces. For a gecko to take its next step, it changes the angle of its setae, interrupting the Van der Waals forces.

Geckos - Why is it that they use Van Der Waals forces instead of other ways?

Scientists ruled out other possibilities of hooks and suction cups for geckos to stick onto walls. Biologist Keller Autumn figured out which it was between the last two possibilities: Sticking via a film of water, or Van Der Waals forces. There was a big difference which would help determine which it was. Water was polar, but Van Der Waals forces were not. Polar means that the molecules are unevenly distributed, and nonpolar ones are. In order to test this, they used silicone dioxide, which was polar, and gallium arsenide, which was not. The gecko stuck nicely on both surfaces, eliminating the thin film of water and confirming Van Der Waals forces in work.

Van der Waals forces:

Van Der Waals forces are named after Johannes Diderik Van Der Waals, a dutch theoretical physicist in 1873, who discovered the Van Der Waals.

They are the force that makes geckos stick to the ceiling. Using molecules that have poles, kind of like a magnet, or like the Earth's axis.

A gecko's foot needs to be close to the wall for the molecules to stick.

The fluctuations in charge distributions between atoms, which don't need to be polar, naturally fall in sync and create an attractive force.

Simple ways to describe it:

- An attractive force between atoms
- Works between many types of materials.
- Can stick no matter the type (n+n, p+p, n+p, p+n)
- Atoms need to be close together to work
- Different types of the force. Negative- positive or positive- negative
- Van Der Waals shape our protein cells into different shapes

Other Animals relations:

Most other animals, including humans, can't stick to walls because they don't have hairs on their feet. Research also shows that geckos are the biggest sized animals that can stick to walls. If they are any bigger, they won't be able to stick because of their body weight and their distance from the wall.

Humans - Can we do the same?:

By using very strong magnets - We use magnetic boots to walk around spacecrafts, or cabins of spacecrafts
Why not - We don't have sticky hairs
If we did- We would be too heavy. Geckos are the biggest thing that can walk upside down

Inventions:

- Magnetic boots - We use magnetic boots to walk around spacecrafts, or cabins of spacecrafts. They attach to the iron floors and ceilings of spacecrafts, which enables astronauts to walk around during weightlessness. They are not yet seen in spacecrafts. Right now astronauts use straps to strap themselves in place.
- Scientists studied how geckos climb walls and created a device called Geckskin that can hold 317 kilograms
- Scientists invented an adhesive tape that has little setae.

Future Inventions:

- Grappling hook: extra strong and sticky (possibly to latch on to it)
- Suction cups have been used before to scale buildings, but ceiling climbing?
  If a person is about 90 kilograms it would take two 8”” suction cups

Animals that can walk upside down:
Geckos can't use glue because they leave no residue. Scientists looked at the geckos' feet and they don't have any hooks. Because geckos can stick to things that are not polar it means geckos have to use Van Der Waals forces.
Bugs: by using tiny hairs (that can stick into the walls, because they are so tiny) that make a glue-like substance made from sugars and oils, if you look closely, you might see tiny greasy footprints.

- Some bugs: use Van Der Waals forces and have hairs that increase the surface area so they can stick more. They also have claws on the end of their feet that also help attach, but also help release. They twist them so it comes off so they can walk.
- Tree frogs: they can grip wet or dry surfaces
  Foot is covered in a wet film. Scientists think a tree frog's foot sticks to things as a damp piece of paper sticks to a window, but it doesn't work on wet things
  Studied the foot and found the film is super thin, in some parts there is no film at all
  The foot has little bumps, and because the film is so thin the bumps poke through, helping as traction on slippery surfaces.

The toe pads have fluid flowing through them. On wet surfaces the channels funnel away extra fluid. On dry surfaces they bring more moisture to the pads.

- Small lizards
  Using Van der waals forces

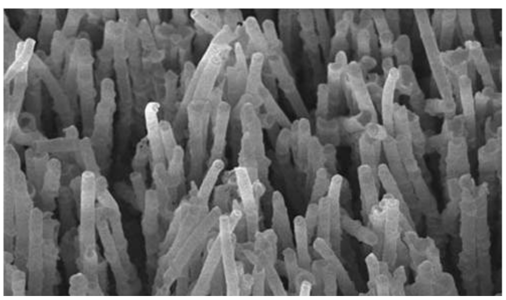
Magnetic Boots:

Magnetic boots have not yet reached outer space yet, although it is certainly being explored in ways by scientists. If it works, they can utilise it in order for astronauts to navigate around the spacecraft easily instead of floating around and bumping into all the equipment.

Geckskin: (Not Using in Slides)

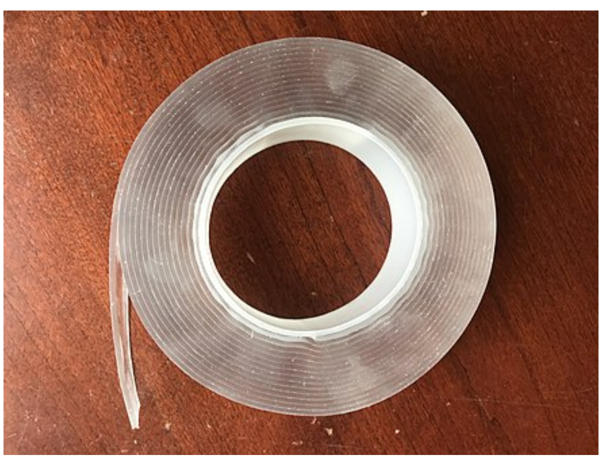
Geckskin, also called synthetic setae, is a powerful sheet made by scientists to hold 700 kilograms of metal with an index sized sheet.

Nano Tape:



Nano tape is used by the military, health care, and sports.
Nano tape, also known as gecko tape, by using carbon nanotubes (Nanotechnology) to create setae structures using chemicals. The setae is 10-20 nm (nanometres: one billionth of a metre). Scientists tested the Nano Tape by using a 40 g Spider Man figure to a glass surface, with a 0.5cm^2, and was able to carry 100 g.

The Nano Tape is used to hang light weight items such as pictures and decorative items, though on smooth surfaces. It leaves no marks and no residue on the surface and can stick in extreme temperatures.



Section 5: Analysis

We analysed our findings and tried to expand off our new knowledge. We figured out that the ability to walk on walls is crucial to a gecko's survival. Our suggestion to this theory is because insects, a gecko's essential food, also climbs on walls. Other lizards do not necessarily need this adaptation because they have other dietary options.

Section 6: Applications

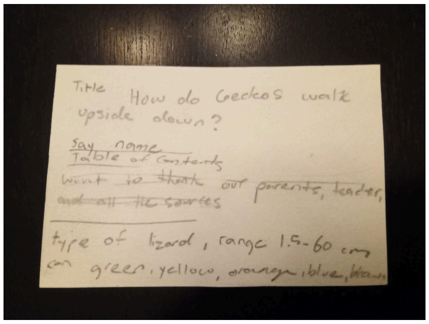
Based on our current understanding of geckos and their adaptations, we expanded on inventions to help humans do the same. We looked at the possibility of velcro that can stick onto walls instead of just being used for shoes and anti-gravity spacecrafts. We also looked at suction cups and grappling hooks to see how they could be used to full potential to help us in our daily lives even more.

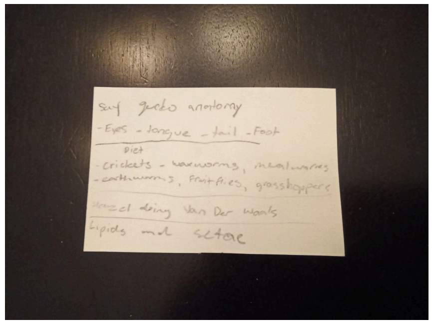
Section 7: Rough Drafts

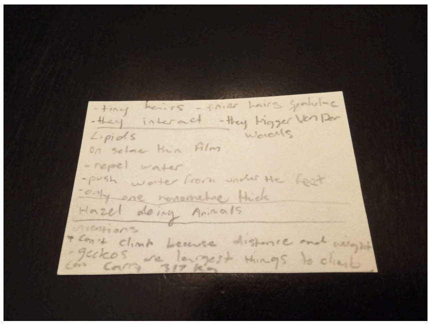
We made a lot of errors in this research project, the biggest one was that we had messed up our trifold. Luckily, we were able to fix the error. We also had to discard a lot of our work since it didn't fit into the criteria of the fair. We did remake our entire slides due to the same reason, but we were improving as we went. Overall we think we fixed all our errors and set the project back on track.

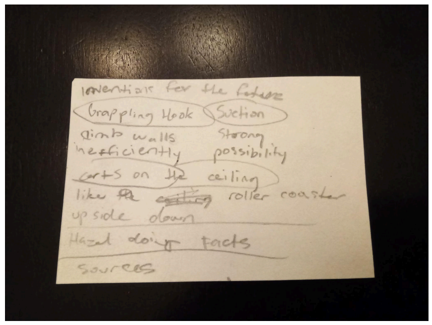
When we were working on our trifold we had to add more things and since we already drew we had to get another trifold. This is our first trifold.

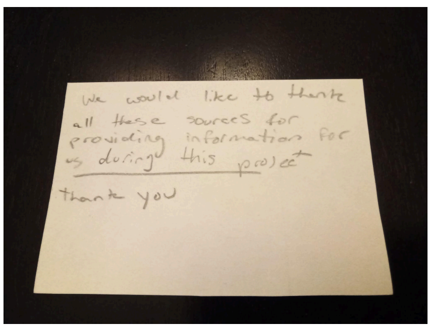
These are our old index cards. We do not need them anymore since we realised we are presenting from the trifold, not the slides.


Title How do Geckos walk upside down?
Say name
Table of Contents
~~Want to thank~~ our parents, teacher,
~~and all the sources~~
type of lizard, range 1.5-60 cm
can green, yellow, orange, blue, brown,


say gecko anatomy
-Eyes -tongue -tail -Foot
Diet
-crickets - waxworms, mealworms
-earthworms, fruit flies, grasshoppers
Hazel doing Van Der Waals
Lipids and setae


-tiny hairs -finier hairs spatulae
-they interact -they trigger Van Der Waals
Lipids
on setae thin film
-repel water
-push water from under the feet
-only one nanometre thick
Hazel doing Animals
inventions
+ Can't climb because distance and weight
-geckos are largest things to climb
can carry 317 kg


inventions for the future
Grappling Hook
Suction
climb walls inefficiently
Strong possibility
carts on the ceiling
like the ~~ceiling~~ roller coaster
up side down
Hazel doing Facts
sources


We would like to thank all these sources for providing information for us during this project
thank you

Section 8: Conclusion

In conclusion, we answered our overall question, by learning that geckos can walk upside down using a special force called Van Der Waals forces that are triggered by tiny hairs on their feet called setae. We also found out that not all animals need to have little hairs to walk upside down, though they can't use the Van Der Waals forces without setae. We did this project because we were interested when we saw a gecko in Hawaii walking upside down.

In the future we will build off of our current knowledge about how geckos walk on the ceiling and try to expand our research on if humans can do the same.

Section 9: Summary

Problem and Method

Problem: How do geckos walk upside-down?

We wanted to find out why geckos could walk on walls because we were fascinated when we saw some in Hawaii. We decided to investigate this topic and try to expand on the possibilities of humans doing the same thing.

We looked at books, websites, articles, and live geckos to find out the way they walked on walls.

Research

Geckos are a type of lizard that lives everywhere besides Antarctica. They are nocturnal, unlike lizards. They range in size from 1.5 cm to 60cm. There are 1, 500 species of geckos.

The difference between geckos and lizards is that geckos lay eggs in pairs instead of clusters unlike lizards. They can also make chirps and barking noises. They can be green, orange, yellow, blue, and brown.

Geckos use Van Der Waals forces to walk on sideways or upside-down surfaces. Van Der Waals forces are named after Johannes Diderik Van Der Waals, a dutch theoretical physicist in 1873, who discovered the Van Der Waals.

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- Can stick no matter the type (n+n, p+p, n+p, p+n)
- Atoms need to be close together to work

Scientists ruled out other possibilities of hooks and suction cups for geckos to stick onto walls, and came up with Van Der Waals. The last two possibilities are: Sticking via a film of water, or Van Der Waals forces. There was a big difference which would help determine which it was. Water was polar, but Van Der Waals forces were not. Polar means that the molecules are unevenly distributed, and nonpolar ones are. The gecko stuck nicely on both surfaces (polar and nonpolar), eliminating the thin film of water and confirming Van Der Waals forces in work.

Geckos have these lipids molecules that repel water, which helps so geckos can climb wet surfaces. Scientists say that they push the water away from beneath the setae, so the geckos can have closer contact with the surface.

Setae are made of a type of keratin, similar to what your hair and fingernails are made of. They are extremely delicate. Scientists studied the setae and found that they are coated in a ultra thin film made of lipids molecules, that repel water. Studies found that geckos can stick underwater, and their feet stay completely dry. The film is only one nanometre thick. The setae are flexible allowing them to stick to the surface.

For a gecko to take its next step, it changes the angle of its setae, interrupting the Van der Waals forces.
Most other animals, including humans, can't stick to walls because they don't have hairs on their feet. Research also shows that geckos are the biggest sized animals that can stick to walls. Any bigger and they can't support it. We're also too far away from the wall.

Some other animals ways to climb on walls are:

- Some bugs: use Van Der Waals forces and have hairs that increase the surface area so they can stick more. They also have claws on the end of their feet that also help attach, but also help release. They twist them so it comes off so they can walk.
- Tree frogs: they can grip wet or dry surfaces
- Small lizards
  Using Van der waals forces

Analysis

We analysed our findings and tried to expand off our new knowledge. We figured out that the ability to walk on walls is crucial to a gecko's survival. Our suggestion to this theory is because insects, a gecko's essential food, also climbs on walls. Other lizards do not necessarily need this adaptation because they have other dietary options.

Based on our current understanding of geckos and their adaptations, we expanded on inventions to help humans do the same. We looked at the possibility of velcro that can stick onto walls instead of just being used for shoes and anti-gravity spacecrafts. We also looked at suction cups and grappling hooks to see how they could be used to full potential to help us in our daily lives even more.

Some inventions that we can use in the future are:

- Magnetic boots - We use magnetic boots to walk around spacecrafts, or cabins of spacecrafts. They are not yet seen in spacecrafts. Right now astronauts use straps to strap themselves in place.
- Nano tape: to create setae structures using chemicals. The setae is 10-20 nm (nanometres: one billionth of a metre). Scientists tested the Nano Tape by using a 40 g Spider Man figure to a glass surface, with a 0.5cm^2, and was able to carry 100 g.
- Grappling hook: extra strong and sticky (possibly to latch on to it)
- Suction cups have been used before to scale buildings, but ceiling climbing? If a person is about 90 kilograms it would take two 8”” suction cups

Conclusion and Acknowledgements

In conclusion, we answered our overall question, by learning that geckos can walk upside down using a special force called Van Der Waals forces that are triggered by tiny hairs on their feet called setae. We also found out that not all animals need to have little hairs to walk upside down, though they can’t use the Van Der Waals forces without setae.

We did this project because we were interested when we saw a gecko in Hawaii walking upside down. We wanted to know why they could do this and how. We decided to do this research project on this topic. We also wanted to know if we (humans) could do the same thing as a gecko and walk upside down too.

In the future we will build off of our current knowledge about how geckos walk on the ceiling and try to expand our research on if humans can do the same and find a way for us to do so.

We want to acknowledge our parents for organising meetups for us to work on the project, supplying resources, and encouraging us to do Science Fair. We would also like to thank Heather Lai for hosting Science Club and for giving us this experience.

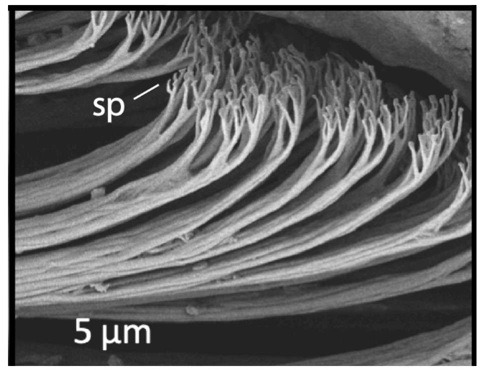
We would also like to acknowledge the websites we used: Arizonawicca (Reddit), BYJUS, Edge of Existence, Louise Gentle (The Conversation), Markus Heim (Research Gate), Katie Moskvitch (PhysicsWorld), National Geographic Kids, National Science Foundation, Open Access Government, PetHelpful, Rainforest Alliance, R.O. Brinkhurst (The Canadian Encyclopedia), Alan J Rocke (Britannica), H. Shaw, M. Follows, M, T. Cox (New Scientist), Ben Shouse (Science), Emily Sohn (ScienceNews Explores), Sustainable Nano, University of California, Berkeley (Science Daily), University of Massachusetts at Amherst (PHYS.ORG), and Wikipedia for the information on this project.

Lastly, we would like to thank Peter Forbes and W.W. Norton Company (The Gecko's Foot - Bio-inspirations : Engineered From Nature), Melissa Gish and The Creative Company (Geckos), Rebecca Johnson and New York: Windmill Book (Gorgeous Geckos), and Wil Mara and Cherry Lake Publishing (From Gecko Feet to Adhesive Tape) for writing the books we used! Thank you!

Section 10: Glossary

Atom - A small piece of matter that makes up everything.
Gallium Arsenide - A dark grey crystal compound containing gallium and arsenic inside it.
Keratin - A protein that makes up your hair and fingernails.
Lipid - Organic compounds that are not soluble in water but soluble in organics.
Nanometre - A really small unit of measurement, one-billionth of a metre.
Nocturnal - Hunts and is active at night.
Polar - Electric or magnetic attraction.
Secrete - To produce a substance.
Setae - Something resembling a hair or a bristle on an animal.
Spatulae - Smaller hairs on the setae.
Species - A group of animals or organisms that have a similarity or share an ancestor.
Silicone Dioxide - An unreactive, hard, compound that consists of sandstone and other minerals.
Synchronicity - Together or in unison.
Van Der Waals - A occuring force between atoms.

Section 11: Images







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