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THE WINTER ISSUE

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HOW IS SNOW MADE?

Lucia Mastroianni

In the months of December, January, and February, the air gets colder and the precipitation that falls on us from the clouds is not rain, but small delicate crystals that combine to make the fluffy snow that brightens our winters. Snow is defined as atmospheric water vapor frozen into ice crystals and falling in light white flakes. But how does the water suddenly create these beautiful snowflakes, each with a unique pattern?

Snow originates from water vapor within clouds when their temperature is below freezing (32 degrees F). Clouds play a major role in the creation of snow, and the type of cloud is significant. cumulonimbus and nimbostratus clouds contributing most to snowfall. Cumulonimbus clouds are dense, towering storm clouds with strong updrafts. They carry water vapor high up to colder atmospheric temperatures making the forming of ice crystals easy. They also produce heavy precipitation, producing heavy snowfalls. Nimbostratus clouds are thick, dark gray clouds that cover the sky and produce continuous, steady precipitation over a wide area. Unlike cumulonimbus clouds, they are ideal for accumulating significant snowfall rather than short snowstorms because of their depth, moisture, and prolonged, consistent output

Snowflakes begin to form when tiny water droplets held within clouds freeze onto pollen or dust particles. As this primary crystal falls towards the ground, water vapor attaches to the existing crystal and freezes; this is how the branches on a snowflake normally form. The water droplets instantly freeze when they come in contact with these particles in the atmosphere because the water is supercooled. Supercooled water is liquid water that's cooled below its normal freezing point but hasn't frozen because it lacks "nucleation sites" (dust, particles) for ice crystals to form on, allowing it to remain liquid until disturbed, which triggers

rapid freezing.

The reason snowflakes are symmetrical is due to the underlying chemistry of a water molecule. Water molecules naturally arrange into a hexagonal (six-sided) crystal lattice due to hydrogen bonding. A water molecule (H_2O) has a bent shape, with hydrogen atoms on one side and an oxygen atom on the other. These molecules form strong hydrogen bonds with neighbors, creating stable, ordered arrangements. The most stable and common way for water molecules to bond is in a hexagonal structure with 120-degree angles between molecules. Therefore, as water molecules begin to freeze over dust particles and water vapor attaches, this hexagonal structure stays.

The temperature at which these crystals form is also incredibly important to their making. This temperature determines the basic shape of the snowflake. We see long needle-like crystals at 23 degrees F and very flat plate-like crystals at 5 degrees F. The shape of the arms of the snowflakes are also dependent on atmospheric conditions as the ice crystal falls. A crystal may begin to grow arms in one manner, and then minutes or even seconds later, slight changes in the surrounding temperature or

humidity causes the crystal to grow in another way.

This creates extreme variability that causes no two snowflakes to be exactly alike. Individual snowflakes all follow slightly different paths from the sky to the ground and encounter slightly different atmospheric conditions along the way.

Snow is such a natural phenomenon that many do not realize the incredible underlying chemistry and variability of snowflakes and snowfall.

Next time you see it snow, try to catch a few snowflakes on your jacket and admire the patterns made up of water vapor and dust particles from the atmosphere.

Sources:

https://www.noaa.gov/stories/how-do-snowflakes-form-science-behind-snow
https://www.americanscientist.org/article/the-formation-of-snow-crystals
https://www.weather.gov/arx/clouds#:~:text=These%20clouds%20appear%20frequently%20in,as%20cumulus%20or%20flat%20cumulus.&text=A%20cumulus%20cloud%20that%20exhibits,Other%20interesting%20clouds:

WHY COLD AIR MAKES THE NOSE RUN

Cristina Ellis

Once again, winter is upon us. As temperatures plummet, plants and animals across the world are reacting in their own ways, and humans are no exception. Our body reacts to the cold in a myriad of ways, including shivering, goosebumps, and even runny noses. Yes, you read that right, runny noses.

The runny nose you get because of cold air is a bodily defense mechanism. The nose protects the respiratory system in two ways: it warms air before it reaches the lungs, and it filters out harmful particles and bacteria to prevent them from penetrating deeper into the respiratory tract. To function optimally, our respiratory system needs warm, moist air.

Cold air, which is drier than warm air, can dry out mucus membranes and irritate or damage lung tissue. As a result, when exposed to cold, dry air, the nervous system responds to protect the respiratory system. It does this by causing glands in the nose to produce secretions and mucus to humidify the air before it enters our lungs. The mucus also traps dust particles, bacteria, viruses, and allergens before they reach sensitive tissue deeper in the respiratory system.

Simultaneously, blood vessels in the nasal lining expand, a process called vasodilation, bringing more blood closer to the surface to warm the inhaled air. Together, the increased mucus and blood flow protect the lungs by creating a filter and humidifier. The reaction is so effective that it can flood the nose with excess fluids, producing a runny nose.

There are several ways we can protect our respiratory system from cold, dry air, including wearing a scarf to reduce exposure and trap warmth around the nostrils, using saline spray to keep the nasal passages moist, and using a humidifier to create humid indoor environments and ease nasal irritation. You can also warm your nose when you come inside from the cold by rubbing your hands together and breathing into cupped hands and/or inhaling some steam from a hot drink.

This winter, when you go for

a long walk, you might notice that you develop a runny nose. Have no fear, this is just a normal part of your body's reactions to the cold.

Sources:

Why Does Your Nose Run When It's Cold?

Quick Dose: Why Does the Cold Weather Make My Nose Run? | Northwestern Medicine

Why Does Your Nose Run When It's Cold Outside? | Chilly Nose Secrets

FSB Fun Facts

FSB Team

Winter is finally upon us!

While everyone decks the halls and trims the tree to ring in the snowy season, here at the FSB, we are once again diving into the science of the season with this set of fun facts. Want to know more about icicles and polar bears? Want to properly understand what we mean when we say frost? You've come to the right place!

1. What physical adaptations help polar bears survive in the Arctic?

Polar bears have several physical adaptations that help them survive the harsh winter cold and the long summer days in the Arctic. These adaptations include:

Their paws are adapted to the ice:
Polar bear paws are large, so their weight is distributed over a larger area, which is advantageous when walking on thin ice. Their claws are non-retractable and shorter compared with the claws of other types of bears, and their paw pads have bumps (papillae). Together, these features function like ice cleats, which help polar bears grip the ice.

Their fur and skin have adaptations that insulate them and prevent over heating:
Polar bears have black skin with a blubber layer (2.5-5 inches thick) beneath it that prevents heat loss. Their skin is covered by dense fur consisting of two layers: a thick underfur topped by long, oily guard hair that prevents water from reaching the underfur. Polar bear fur is transparent; each hair has

a hollow core that reflects and scatters visible light, like snow and ice. This prevents overheating under the intense summer light.

They have powerful night vision and can see underwater because their eyes have a high concentration of rod cells.

2. Why does salt melt ice?
Salt melts ice by lowering

the freezing point of water, a phenomenon known as freezing-point depression. When dissolved in water, salt breaks down. For example, a molecule of table salt (sodium chloride, NaCl) dissociates into a sodium ion and a chloride ion. A molecule of calcium chloride($CaCl_2$), a type of salt used on streets, breaks down into one calcium ion and two chloride ions. The ions interfere with the water's ability to form the rigid structure characteristic of ice, thus lowering the freezing point of water.

Salt is used to prevent streets from icing over because it reduces the freezing point of the water on the ground, so it no longer freezes at 32°F. The higher the salt concentration, the lower the freezing point. For freezing-point depression to work, there must be at least a small amount of water on the road to dissolve the salt. This is why roads are pretreated with a brine solution (a mixture of salt and water) when ice and snow are forecast.

3. How does frost form?

Frost forms when water vapor comes into contact with a surface below the freezing point of water (32°F/0°C). At this temperature, the moisture in the air freezes. There are different types of frost, including radiation frost (hoarfrost), advection frost, window frost, and rime.

- Radiation frost (hoarfrost) is a collection of tiny ice crystals. It forms on exposed areas outside and in refrigerators and freezers.
- Advection frost typically forms as small ice spikes. It forms when cold wind blows over surfaces such as tree branches or poles.
- Window frost forms when a window is exposed to cold outdoor air and warm, moist indoor air, resulting in frost on the inside of the window.
- Rime forms quickly when an icy object comes into contact with a wet surface. It often forms on aircraft when they encounter clouds and on ships operating in very cold regions, such as the Arctic Ocean.

4. What gives icicles their distinct shape?

Icicles form when water drips in subfreezing

temperatures. Once the first drop freezes, another drop follows and freezes, and so on and so on, but what is the science behind their unique shape?

Icicles are covered with a thin film of water. As a new drop of water travels down the icicle and freezes, the molecules release heat, which keeps the film of water covering the icicle from freezing. Heat is also released into the air around the icicle. The combination of the water flowing down and the warm air flowing up produces a long, pointy shape that is thicker at the top and thinner at the bottom. The bumps, or ripples, on the icicle are caused by impurities, such as salt and/or minerals dissolved in the water. According to scientists, icicles made from distilled water, which has no impurities, are smooth. The higher the concentration of contaminants in the water, the fatter the bumps.

Sources:
https://iere.org/how-do-polar-bears-adapt-to-their-environment/
https://www.worldatlas.com/articles/how-is-the-polar-bear-adapted-to-its-environment.
https://www.thoughtco.com/why-does-salt-melt-ice-607896
https://www.britannica.com/story/why-does-salt-melt-ice
https://science.howstuffworks.com/nature/climate-weather/atmospheric/road-salt.htm
https://education.nationalgeographic.org/resource/frost/
https://www.weatherbug.com/news/Frost-What-Causes-This-Phenomenon
https://www.foxweather.com/learn/how-do-icicles-form
https://www.abc27.com/winter-in-central-pa/how-do-icicles-form-and-are-they-dangerous/

THE EXPRESSION OF FOLLISTATIN PARALOGS IN APHID BRAINS REVEALS MECHANISMS OF WING DIMORPHISM

SARAH GALLEN

Abstract:
This study investigates the genetic and environmental mechanisms that regulate wing dimorphism in pea aphids, focusing on the expression of follistatin gene paralogs (FS1, FS2, FS3) in the brains of winged and wingless male and female aphids. Using in-situ hybridization probes, brain scans revealed that FS1 and FS3 are co-expressed in the same neural domains, particularly in neurosecretory cells and glial progenitor regions. This overlap was more pronounced in wingless males. However, in wingless females, the scans revealed that FS1 and FS2 are coexpressed in the same brain region, with a brighter signal due to probes targeting both transcripts. These findings demonstrate the importance of gene expression in shaping adaptive morphological traits in response to environmental pressures.

Intro:
This experiment investigates the genetic and environmental mechanisms that regulate wing dimorphism in pea aphids (Acyrthosiphon pisum), focusing on the expression of the follistatin gene in the brains of male and female winged and wingless aphids. Aphids exhibit two morphs: winged (alate) and wingless (apterous). The winged morphs are adapted for dispersal, possessing full wings and sensory and reproductive adaptations for flight and colonization of new environments. The wingless morphs are optimized for reproduction, exhibiting higher fecundity but limited dispersal capability. This wing dimorphism allows these insects to balance the trade-offs between dispersal and reproduction, enhancing their adaptability to changing environments and resource availability. Gene duplication is believed to have contributed to the complexity of genetic regulation behind wing dimorphisms in aphids.

As the aphids develop, the nervous system processes sensory information and controls behavior. The brain, as the central part of the nervous system, integrates environmental cues and controls physiological responses. The nervous system also coordinates behavior through interactions with the endocrine system. Neurosecretory cells in the brain and other neural tissues play a crucial role by producing hormones that regulate growth, reproduction, and development. These cells act as a bridge between the nervous and endocrine systems, translating environmental cues into hormonal signals that influence physiological changes via gene expression.

Specifically, follistatin is a hormone produced in several forms. These follistatin paralogs–fs-1, fs-2, and fs-3—are critical determinants of wing morphology in male and female aphids. The divergence in the expression of these paralogs suggests that gene duplication has allowed aphids to balance the expression of traits beneficial for either dispersal or reproduction based on environmental cues. These studies indicate that fs genes are all slightly different versions of an original gene, with each paralog evolving to take on specific roles in regulating wing morphology. There is abundant evidence from studies that suggests follistatin genes have evolved through gene duplication, leading to the formation of distinct paralogs.

By studying brain scans and the expression of follistatin paralogs, this research aims to uncover how gene expression regulates wing dimorphisms across the sexes. Specifically, it aims to understand how genetic regulation in neural tissues influences aphids, enhancing the understanding of adaptive mechanisms in response to environmental pressures. The experiment hypothesizes that follistatin paralogs show differential expression in the brains of winged versus wingless aphids, depending on the sex, and that these expression patterns contribute to regulating wing morphology.

Materials and Methods:

Total RNA was collected from asexual females or wingless male nymphs using Trizol-chloroform extraction. Next, cDNA was generated from polyA+ RNA using SuperScript IV Reverse Transcriptase with oligo-dT primers, followed by RNaseH digestion. For each follistatin paralog (1-3), cDNA clones were obtained by designing forward primers in the 5' UTR and reverse primers in the 3' UTR of each gene. Whole follistatin coding sequences and partial UTRs were amplified from cDNA with Phusion High-Fidelity 2x PCR Master Mix, cloned into pCR4-TOPO, and verified via Sanger sequencing. Additional primers were designed to amplify sequences from the second and third exons of fs2 or fs3, with the T7 promoter sequence included in the reverse primer to generate probe templates. Probe templates were again amplified with Phusion 2x Master Mix, purified with the Qiagen PCR purification kit. Probe synthesis was carried out using T7 RNA polymerase (Thermo Fisher) and DIG RNA labelling mix (Roche). Probes were then isolated via DNase treatment and Lithium-Chloride precipitation.

Asexual female and sexual male pea aphids were reared and collected as previously described (Saleh Ziabari et al.,2025) ([https://www.pnas.org/doi/10.1073/pnas.2420893122]). First, second, and third instar nymphs were fixed overnight at 4C in 5% DMSO 1X PBS 6% Formaldehyde. Brains were dissected the following day in ice-cold 1X PBS + 0.1% Triton X-100 (0.1% PBT) and then quickly dehydrated in ice-cold 100% methanol. Brains were rehydrated in 1X PBS + 0.1% Tween-20 (0.1% PBTW) and treated with Proteinase K in 1X PBS at 4 degrees Celsius for 1 hr. Following four washes in PBTW, fluorescent in situ hybridization was carried out as previously described (attached references) except that we used SigmaFast Fast Red Tablets (Sigma Aldrich) instead of Thermo Fisher Fast Red substrate. Stained brains were mounted in 70% Glycerol on slides sealed with clear nail polish and imaged on a Leica SP6 scanning laser confocal microscope. Images were rendered in Imaris Viewer

(10.0.0.1) and figures compiled in Adobe Photoshop (24.5.0).

Analysis/Discussion:

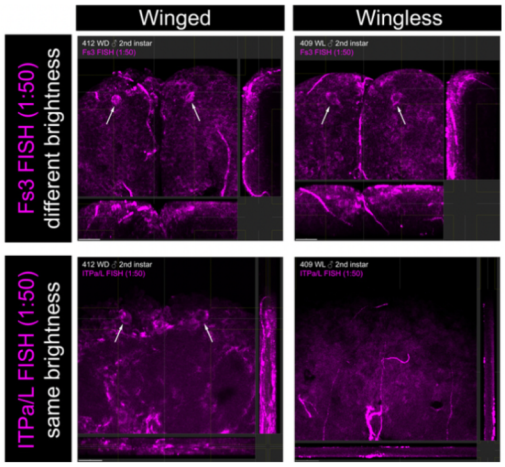

Figure 1: Side-by-side brain scans of winged (412) and wingless (409) males

Neurosecretory cells are specialized neurons that release peptides, functioning as hormones, directly into the bloodstream to circulate throughout the body (definitions go in the intro). Using an in situ hybridization (hybridization happening in the same place where the gene is expressed, as opposed to on the gel) probe specific to FS3 mRNA, cells were labeled and stained to visualize their fluorescence. Interestingly, FS3 probes also stained areas expressing FS1, despite sample 412 showing no FS3 expression. This overlap suggests that FS1 and FS3 are co-expressed within the same brain domains, potentially in neurosecretory cells. Further investigation using the probe to target neuropeptides, such as the ion transport peptide (ITP), highlighted large neurosecretory cells with fluorescence consistent with FS1 and FS3 expression. While this indicates a possible link between ITP and FS1/FS3 expression, it does not serve as definitive proof. Notably, wingless males exhibited no ITP expression, raising intriguing questions about its role and regulation in these cells.

The overlap in FS1 and FS3 expression in these neurosecretory cells suggests they may work together to influence wing development in male aphids. The absence of ITP in wingless males points to potential differences in genetic regulation tied to wing formation. These findings suggest that certain gene expression in neural tissues plays an important role in shaping adaptive wing traits in response to environmental pressures.

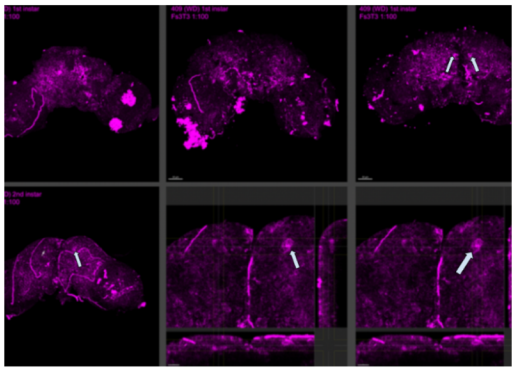

Figure 2: 409 wingless male

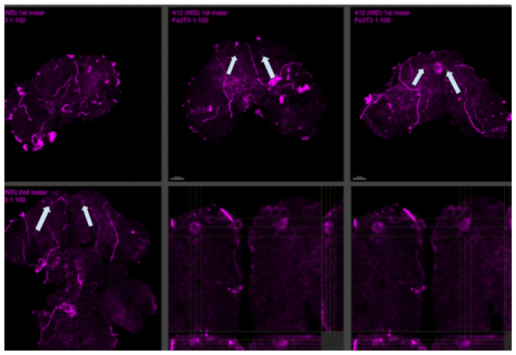

Figure 3: 412 winged male

In multiple brains of 409 wingless samples, staining with the FS3-specific in situ hybridization probe revealed a noticeable difference in brightness compared to winged samples. This increased brightness in wingless brains is likely due to the probe targeting both FS1 and FS3 transcripts, whereas in winged samples, the probe only targets FS1. This dual staining in 409 suggests that FS1 and FS3 are co-expressed within the same brain domain. The expression follows a distinct pattern through the optic lobes, aligning with areas associated with glial progenitors, while the front and top regions correspond to neurosecretory cells. These glial progenitor cells are immature cells in the brain and spinal cord that can develop into different glial cells, which support and protect neurons. These cells play a key role in brain development and repair. The increased probe signal in 409 samples highlights the overlap in FS1 and FS3 expression, resulting in a doubling of transcript detection compared to winged counterparts.

As stated before, in wingless aphids, both FS1 and FS3 genes are active in the same brain regions. This overlapping activity causes a brighter signal in the brain scans of wingless aphids compared to winged ones, where only FS1 is active. This difference in gene activity aligns with specific areas of the brain. For example, FS1 and FS3 activity is found in regions tied to glial progenitor cells and neurosecretory cells. These brain regions are likely where important decisions regarding wing development are happening. Ultimately, the brain's genetic activity influences

whether aphids grow wings, depending on their environment and sex. Our findings align with the findings of a study on Calliphora erythrocephala, which supports this research on aphid wing dimorphism by showing how neurosecretory cells regulate development through hormonal control. These cells influence ovarian growth in flies. Similarly, our study on aphids proposes that FS1 and FS3 expression in brains aligns with neurosecretory regions, suggesting a hormonal or genetic regulatory mechanism affecting wing formation. Both studies highlight the brain's role in controlling key traits through gene expression and endocrine interactions, showing how insects adapt to environmental pressures.

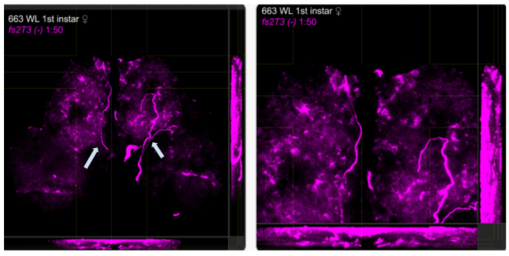

Figure 4: 663 wingless female

The image displays two zoom levels of a first instar wingless female brain, oriented with the anterior (head) at the top and the optic lobes at the bottom. A distinct line of expression runs through the optic lobes, while the neurosecretory cells at the top of the brain exhibit brighter staining. This brighter signal is due to probes targeting both FS1 and FS2 transcripts, indicating their co-expression in these regions. Additionally, the pink fluorescence observed corresponds to expression in the glia, further highlighting the spatial differentiation of transcript expression in the brain's structures. All we can say is that there is staining similar to winged/wingless males, so FS2 may be expressed in the same brain domain in WL females as fs1 in winged males and FS1/FS3 in wingless males.

The cleavage site, a specific point where enzymes divide a protein into segments, serves as a reference point for understanding protein function and evolution.

By aligning protein sequences after the cleavage site, regions of similarity that may indicate function or structural relationships can be identified. In this case, the Fs genes in three aphids show high similarity, suggesting that the change in role from development (fs1) to female environmentally induced winglessness (fs2) to genetically determined winglessness (fs3) is driven more by changes in gene regulation than by alterations in the protein sequences themselves. Highlighted regions in the alignment represent binding sites where neurosecretory cells can trigger intracellular processes. These findings suggest that while variations in protein sequences exist, they likely play a relatively minor role compared to regulatory changes in shaping the functional adaptations of aphids.

Conclusion:

Our research provides valuable insights into the genetic and environmental mechanisms regulating wing dimorphism in aphids, with a specific focus on the expression of follistatin paralogs in the brains of winged and wingless aphids across sexes. The overlap in FS1 and FS3 expression in wingless males and the presence of both FS1 and FS2 in female brains suggest that these paralogs play a critical role in determining wing morphology. These findings align with prior studies on Calliphora erythrocephala, reinforcing the idea that neurosecretory cells contribute to developmental regulation through hormonal control.

However, several limitations should be considered when interpreting these results. One potential source of error lies in measuring the brightness of brain scan fluorescence, which can be subjective and dependent on imaging techniques. Therefore, the extent to which FS1, FS2, and FS3 expression directly impacts wing formation remains somewhat speculative. Future research should prioritize quantifying fluorescence brightness more objectively through digital image analysis tools that minimize human bias. By addressing these questions and refining current methodologies, future studies can build on the foundation established here,

furthering the understanding of how generic regulation and environmental cues shape aphids and other insects.

The findings of a study on Calliphora erythrocephala support this research on aphid wing dimorphism by showing how neurosecretory cells regulate development through hormonal control. These cells influence ovarian growth in flies. Similarly, our study on aphids proposes that FS1 and FS3 expression in brains aligns with neurosecretory regions, suggesting a hormonal or genetic regulatory mechanism affecting wing formation. Both studies highlight the brain's role in controlling key traits through gene expression and endocrine interactions, showing how insects adapt to environmental pressures.

Bibliography:

Biology, ecology, and management strategies for PEA aphid (Hemiptera: Aphididae) in Pulse Crops | Journal of Integrated Pest Management | oxford academic. (n.d.-a). https://academic.oup.com/jipm/arice/11/1/18/5918920

Encyclopædia Britannica, inc. (n.d.). Animals & Nature. Encyclopædia Britannica. https://www.britannica.com/Animals-Nature

Functional significance of the neurosecretory brain cells and the Corpus Cardiacum in the female blow-fly, Calliphora Erythrocephala Meig | Journal of Experimental Biology | the company of Biologists. (n.d.-b). https://journals.biologists.com/jeb/article/29/1/137/12529/Functional-Significance-Of-The-Neurosecretory

Li, B., Bickel, R. D., Parker, B. J., Ziabari, O. S., Liu, F., Vellichirammal, N. N., Simon, J.-C., Stern, D. L., & Brisson, J. A. (2020, March 6). A large genomic insertion containing a duplicated follistatin gene is linked to the pea aphid male wing dimorphism. eLife. https://elifesciences.org/articles/50608

Proceedings of the National Academy of Sciences—its evolution and adaptation | PNAS. (n.d.-c). https://www.pnas.org/doi/10.1073/pnas.1821201116

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