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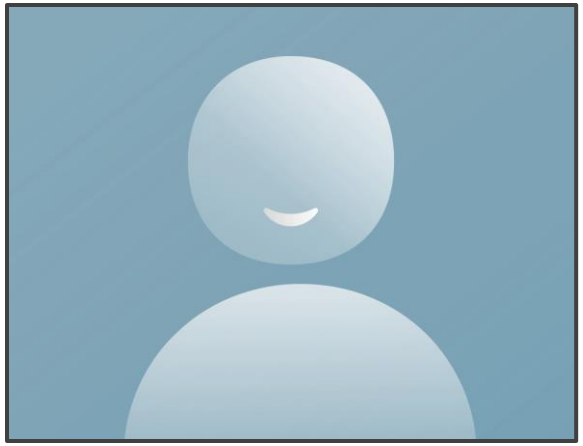
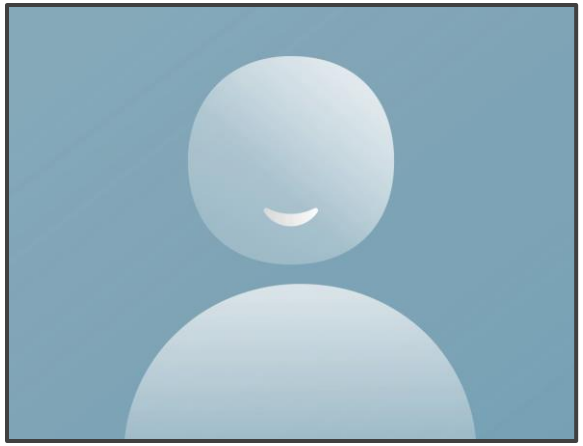
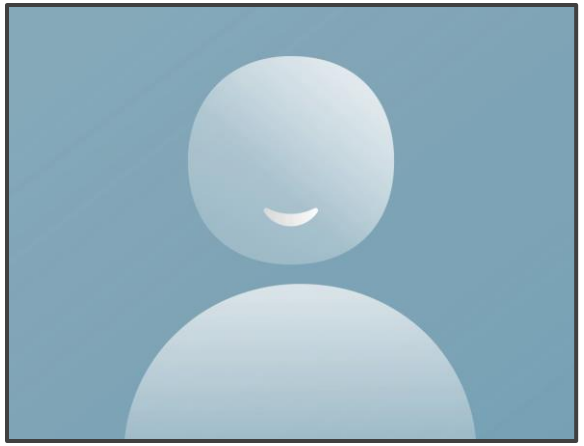


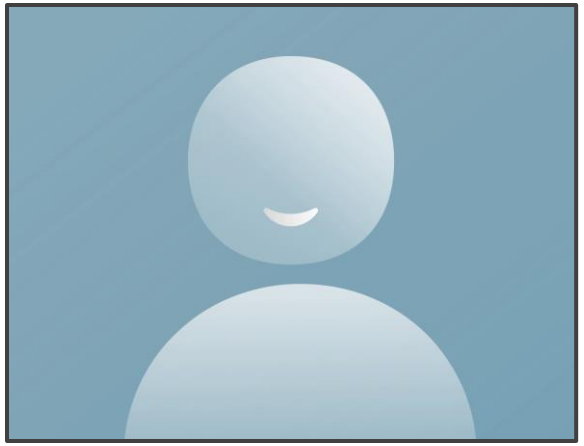
- 1. Some fruit bats eat up to twice their body weight in sugary mangoes, bananas, or figs every day to not only survive, but thrive. Unlike humans, these flying mammals can have an essentially permanent sweet tooth and do not develop some of the negative health consequences such as diabetes. A study published January 9 in the journal Nature Communications found that genetic adaptations have helped keep their sugary diets from becoming harmful.



- 2. The study could have future implications for treating diabetes, which affects an estimated 38 million Americans, according to the Centers for Disease Control and Prevention (CDC). It is the eighth leading cause of death in the United States and the leading cause of kidney failure, lower-limb amputations, and adult blindness

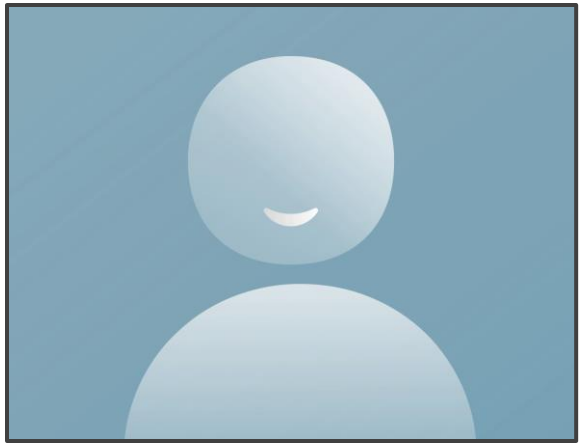


- 3. “With diabetes, the human body can’t produce or **detect insulin,** leading to problems controlling blood sugar,” study co-author and University of California, San Francisco geneticist Nadav Ahituv said in a statement. “But fruit bats have a genetic system that controls blood sugar without fail. We’d like to learn from that system to make better insulin- or sugar-sensing therapies for people.

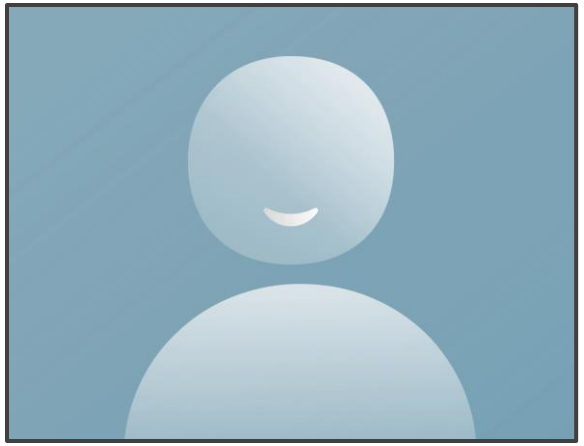


Insulin is a peptide hormone. Explain how cell detect insulin ? (3)

- Insulin binds to a specific receptor on the cell surface membrane (1)
- Receptors are complementary to insulin (1)
- Insulin cannot enter the cell because it is a peptide hormone (1)
- Binding triggers changes inside the cell via secondary messengers or enzyme activation (1)

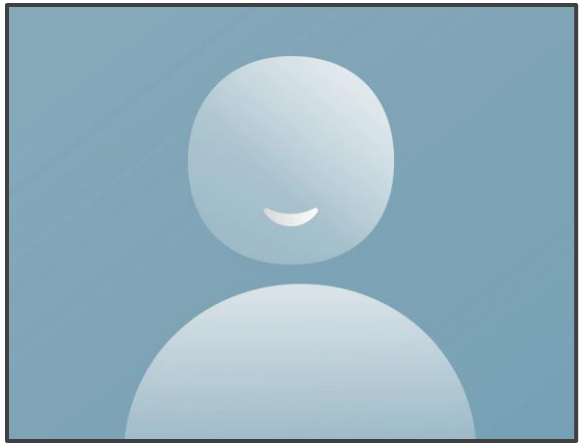


- Fruit bats vs. insect bats 4. Every day, fruit bats wake up after about 20 hours of sleep and feast on fruit before returning back to their caves, trees, or human-built structures to roost. To figure out how they can eat so much sugar and thrive, the team in this study focused on how the bat pancreas and **kidneys evolved**. The pancreas is an abdominal organ that controls blood sugar.

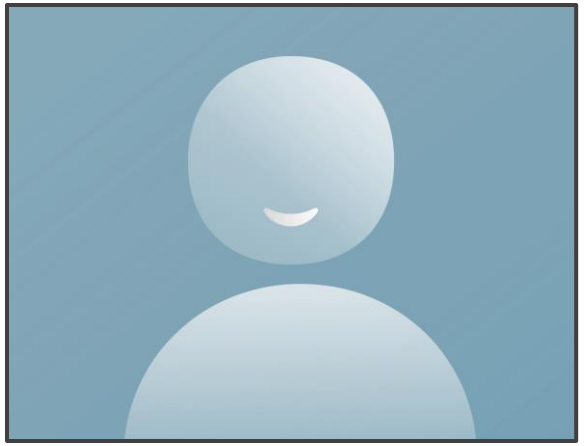


How kidney is involved in glucose regulation? (4)

- **Glucose is filtered** from the blood **at the glomerulus** into the **Bowman's capsule** (1)
- Glucose is **reabsorbed from the proximal convoluted tubule (PCT)** into the blood (1)
- **Reabsorption occurs by active transport and co-transport** with sodium ions (1)
- This ensures that **all (or nearly all) glucose is returned to the blood**, so **no glucose is lost in urine** under normal conditions (1)

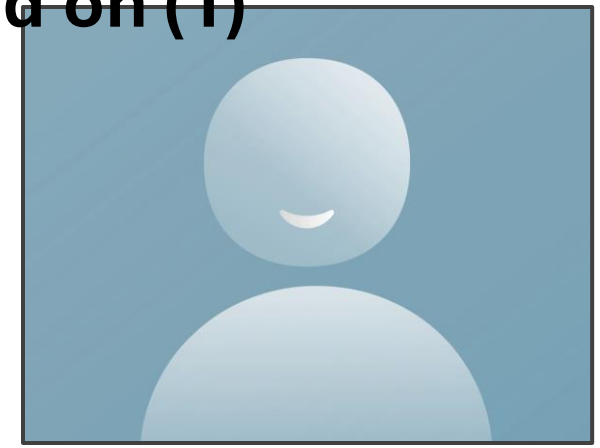


- 5. Researchers compared the Jamaican fruit bat with an insect-eating bat called the big brown bat. They **analyzed the gene expression**–which genes were switched on or off and regulatory DNA that controls gene expression To do this, the team measured both the gene expression and regulatory DNA present in individual cells. These measurements show which types of cells primarily make up the bat's organs and also how these cells regulate the gene expression that manages their diet.

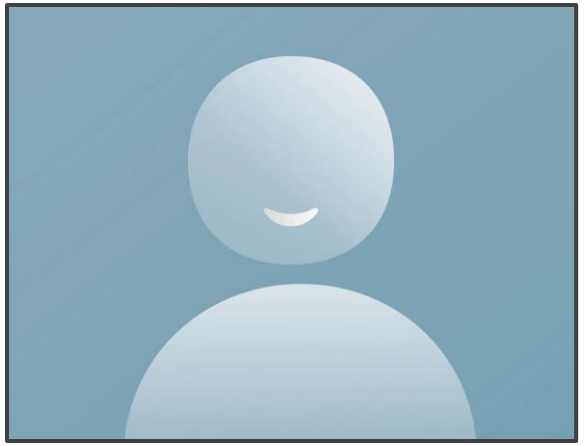


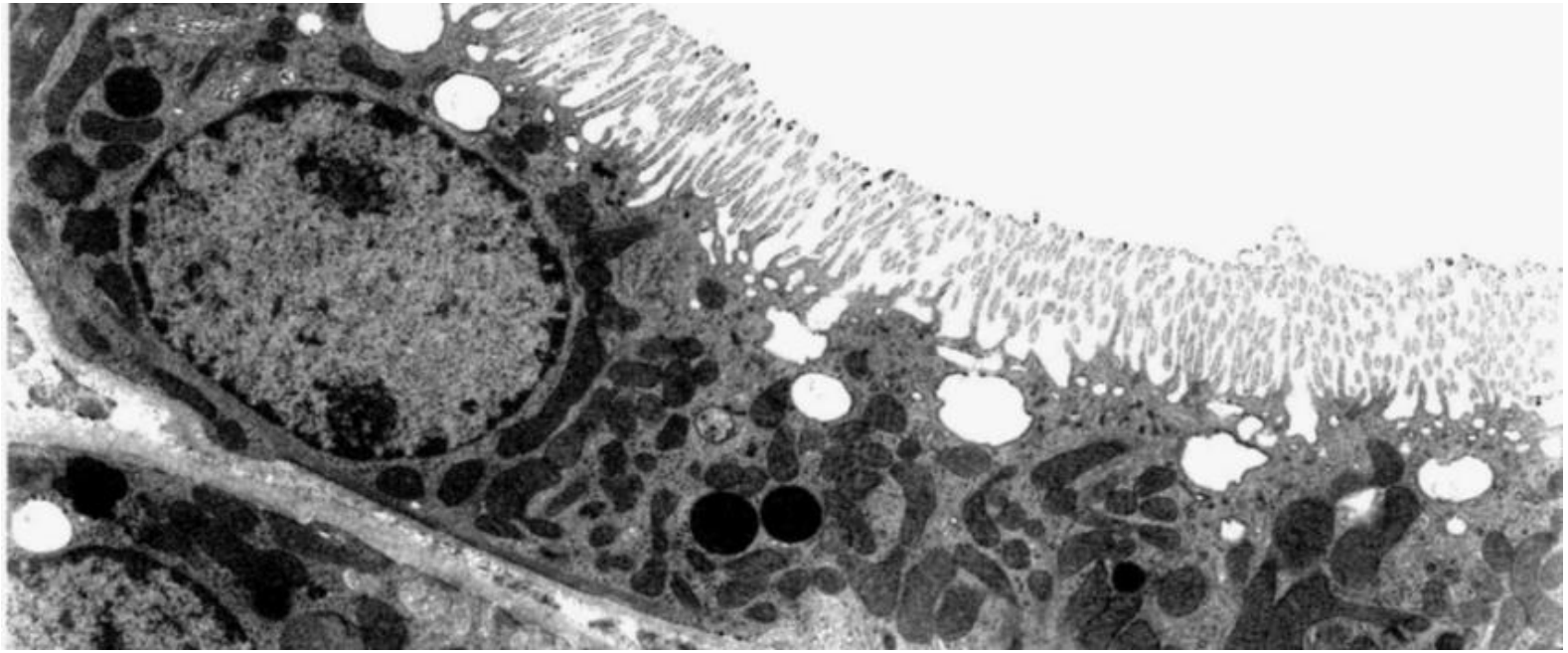
Explain how the analyze the gene expression ?

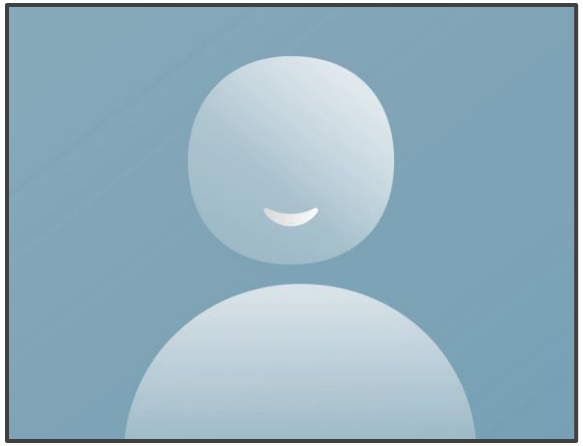
- use microarray (1)
- Extract mRNA and make cDNA (1)
- Label cDNA and apply to microarray (1)
- cDNA binds to complementary DNA probes (1)
- Fluorescence shows which genes are switched on (1)



- 6. They found that the compositions of the pancreas and kidneys in fruit bats evolved to accommodate their sugary diet. The pancreas had more cells to produce insulin, an essential hormone that tells the body to lower blood sugar. It also had more cells that produce another sugar-regulating hormone called glucagon. **The fruit bat kidneys had more cells to trap scarce salts and electrolytes as they filter blood.** Changes in DNA 7. Taking a closer look at the genetics behind this, the team saw that the regulatory







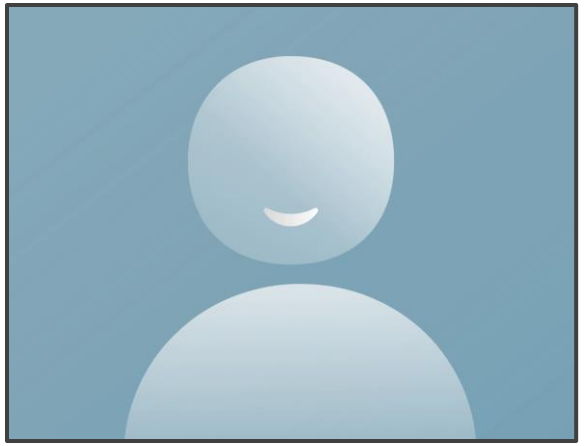
how more cells can take ions back into the body from kidney?

More mitochondria (1)
→ provide more **ATP** for **active transport**.

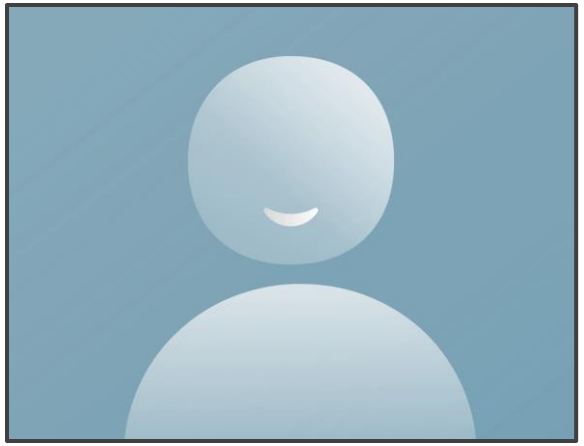
More carrier proteins / ion pumps in the membrane (1)
→ allow **more ions** (e.g. Na^+) to be transported.

Increased surface area (microvilli / folded membrane) (1)
→ allows **more transport proteins** and greater **exchange surface**.

Thicker capillary network / good blood supply (1)
→ maintains **concentration gradient** for diffusion.



- Changes in DNA 7. Taking a closer look at the genetics behind this, the team saw that the regulatory **DNA in those cells had evolved to switch the appropriate genes for fruit metabolism on or off**. The insect-eating big brown bats had more cells **that break down protein and conserve water** and the gene expression in these cells was calibrated to handle a diet of bugs



How DNA in those cells had evolved to switch the appropriate genes for fruit metabolism on or off ?

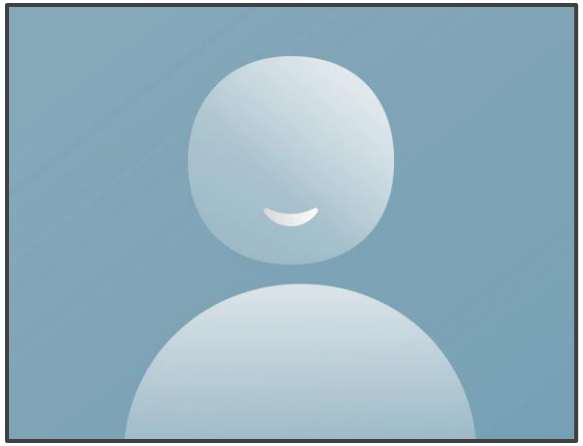
Chemical stimulation can trigger changes in cells (1)

Epigenetic modifications (e.g., methylation, acetylation) affect gene expression without changing the DNA sequence (1)

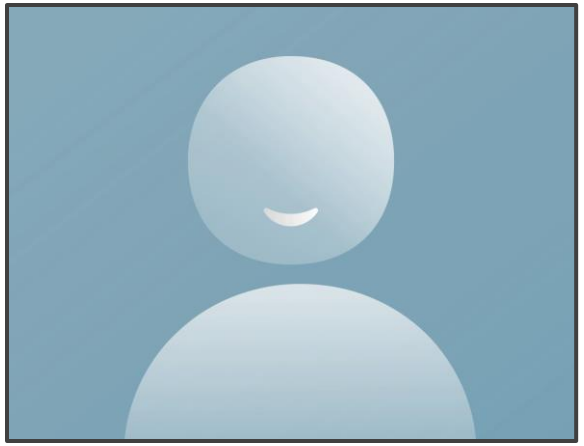
These changes can **alter transcription factor binding**, thereby **switching genes on or off** (1)

Proteins produced as a result can cause **permanent changes in the cell's function** (1)

Over time, **DNA evolves** under selective pressures to **switch genes on or off in response to the environment** (1)



- The breakdown of proteins leads to nitrogen waste such as urea. Animals living in dry environments **convert this waste into forms** that require **less water for excretion**, thus **helping conserve water**.

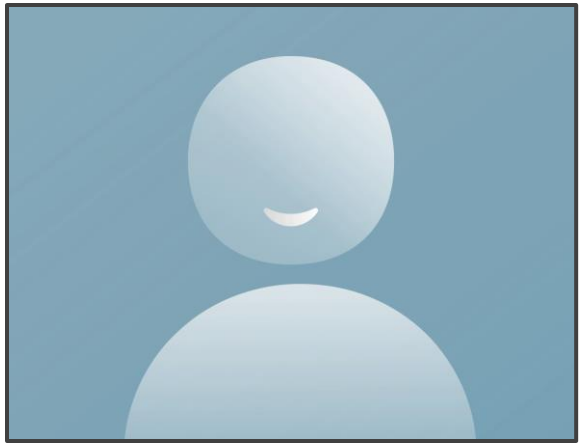


How animals in dry habitats transform this waste into forms that need less water for elimination, thereby aiding in water conservation.

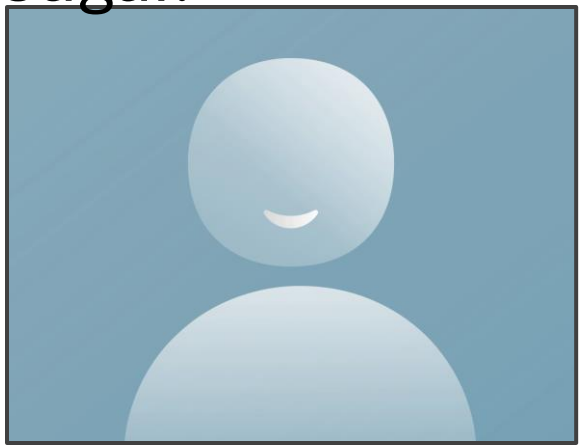
Proteins and amino acids are broken down to produce **ammonia**, which is **toxic** (1)

In animals living in **dry habitats (desert animals)**, ammonia is **converted into less toxic forms** that **require less water for excretion** (1)

They **convert ammonia → urea or uric acid** (1)



- 8. “The organization of the DNA around the insulin and **glucagon genes was very clearly different between the two bat species**,” study co-author and Menlo College biologist Wei Gordon said in a statement. “The DNA around genes used to be considered ‘junk,’ but our data shows that this regulatory DNA likely helps fruit bats react to sudden increases or decreases in blood sugar.



How scientists differentiated between two genes (4)

- DNA is cut into fragments using restriction enzymes (1)
- DNA fragments are placed in wells in a gel (e.g. agarose gel) (1)
- The gel is covered with a buffer solution and an electric current is applied (1)
- DNA fragments are negatively charged (due to phosphate groups) and move towards the positive electrode (anode) (1)
- Smaller fragments move faster / further through the gel pores than larger fragments (1)
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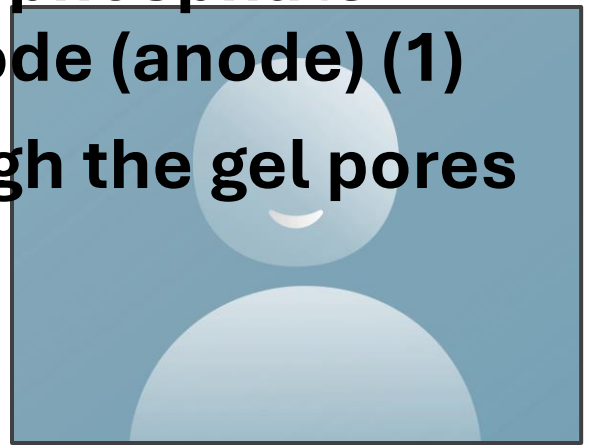
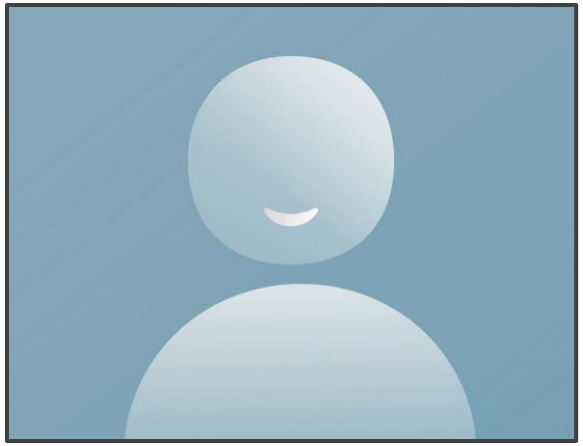
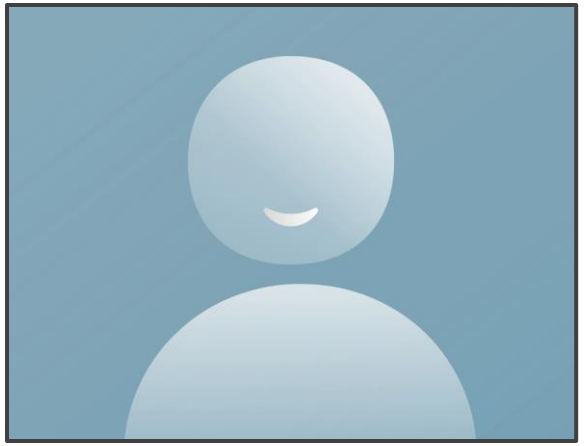


- 9. While some of the fruit bat’s biology resembled what is found in humans with diabetes, **the bats are not known to have the same health effects**

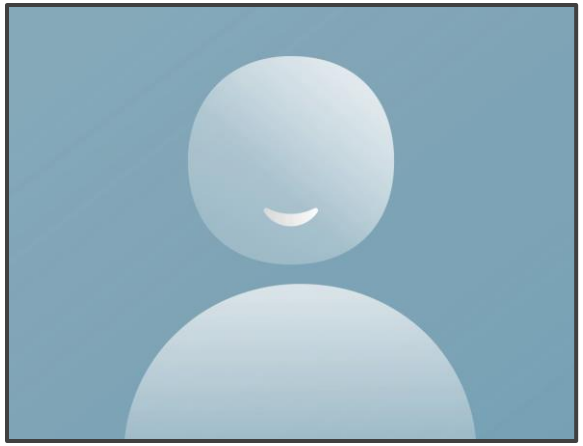


why do certain aspects of the fruit bat's biology mirror those found in humans with diabetes, yet these bats do not experience the same health consequences (2)

- Different enzymes / metabolic pathways for diet (1)
- Different metabolic rates (1)
- Different energy storage strategies (1)
- Tolerance to certain metabolites / toxins (1)
- Blood glucose regulation differs (1)

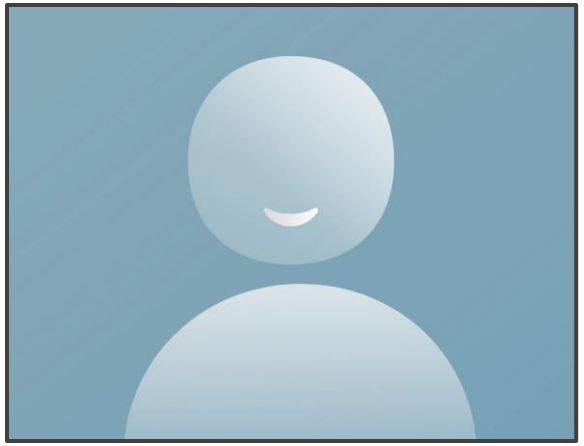


- 10. “Even **small changes, to single letters of DNA**, make this diet viable for fruit bats,” said Gordon. “We need to understand high-sugar metabolism like this to make progress helping the one in three Americans who are prediabetic.

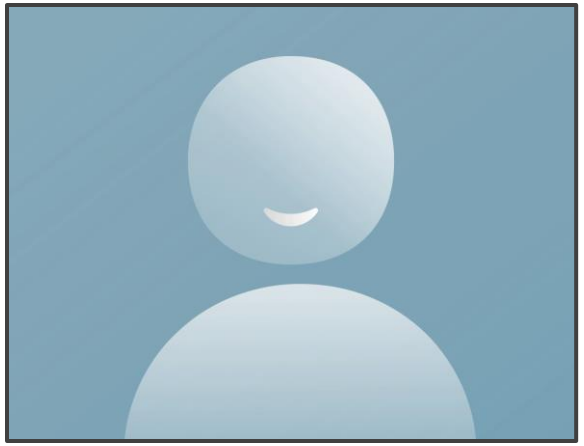


Suggest single change of DNA letters, ensure this diet is feasible for fruit bats (5)

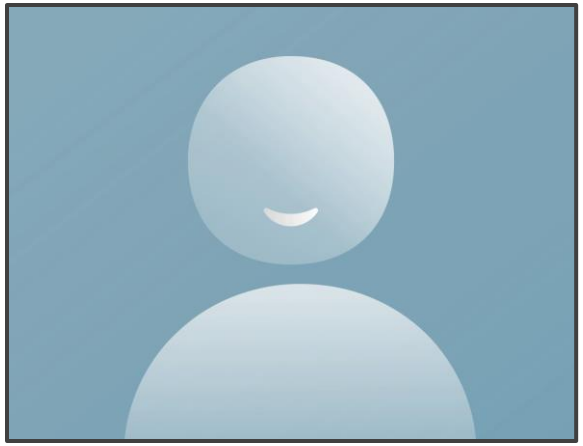
- A **mutation** occurs — a **single base substitution** (1)
- This **changes one DNA base (nucleotide)** in the gene (1)
- The change could **alter one triplet codon**, producing a **different amino acid** in the **enzyme / protein** (1)
- This may cause a **change in the enzyme's active site** so it **binds more effectively** to its substrate (e.g. involved in sugar metabolism) (1)
- Or the mutation could **improve regulation** of insulin / glucose metabolism genes, **allowing tolerance to high sugar intake** (1)
- Hence the **mutation allows fruit bats to process large amounts of sugar** without harmful effects (1)



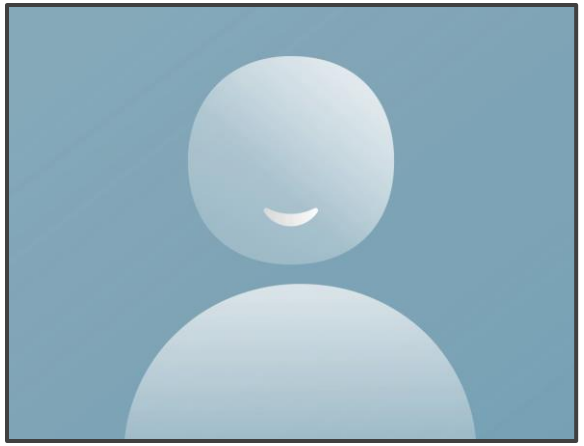
- Studying bats for human health 11. Bats are one of the most diverse families of mammals and everything from their immune systems to very particular diets are considered by some scientists to be examples of evolutionary triumph. This study is one of recent examples of how studying bats could have implications for human health, including in cancer research and virus prevention.



- 12. For this study, Gordon and Ahituv travelled to Belize to participate in an annual Bat a-Thon, where they took a census of wild bats and field samples. One of the Jamaican fruit bats that they captured at the Bat-a-Thon was used to study sugar metabolism.

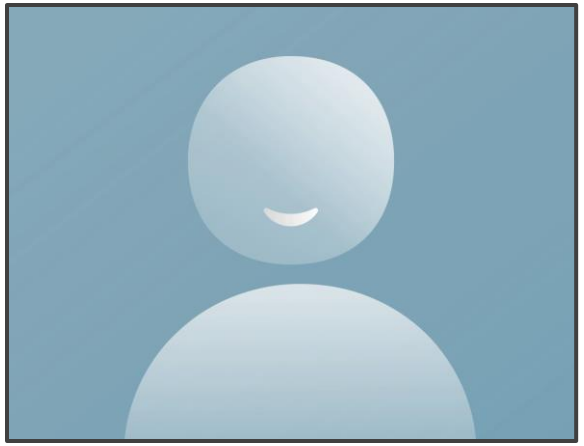


- 13. “For me, bats are like superheroes, each one with an amazing super power, whether it is echolocation, flying, **blood sucking without coagulation**, or eating fruit and not getting diabetes,” Ahituv said. “This kind of work is just the beginning.

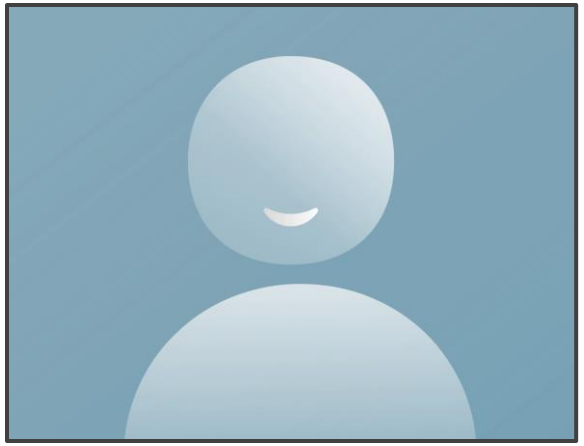


how do insects consume blood without it clotting?

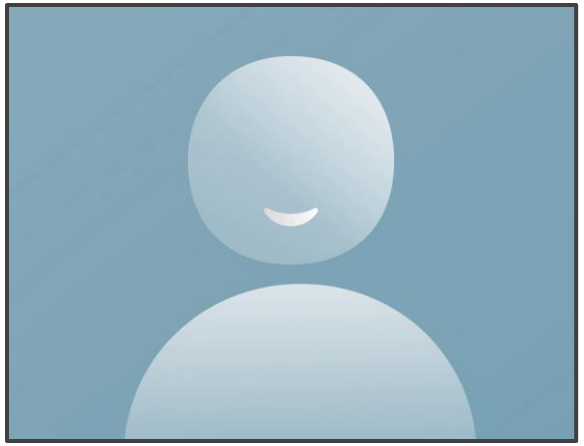
- blood normally clots due to **conversion of fibrinogen to fibrin** by **thrombin** (1)
- **Blood-sucking insects** (e.g. mosquitoes) **prevent clotting** by **injecting saliva containing anticoagulants** (1)
- The **anticoagulants inhibit thrombin / prevent fibrin formation** (1)
- This allows **continuous blood flow** from the host while feeding (1)



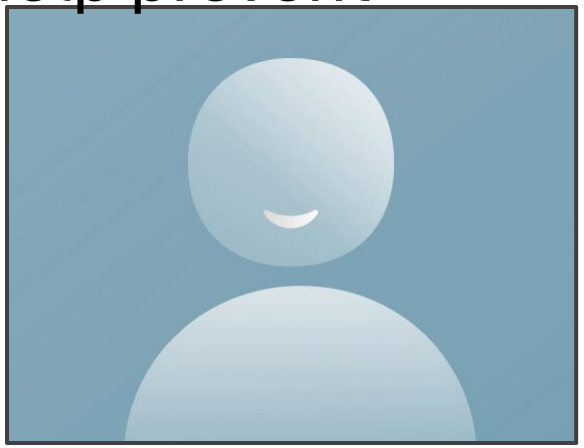
- 14. After getting bit by a bat bug at a recent conference, Armin Scheben had a literal and figurative itch to study bats. The blood-sucking insect is one of many disease-causing parasites that latch themselves onto the flying mammals—yet, bats rarely get sick in the same way humans do



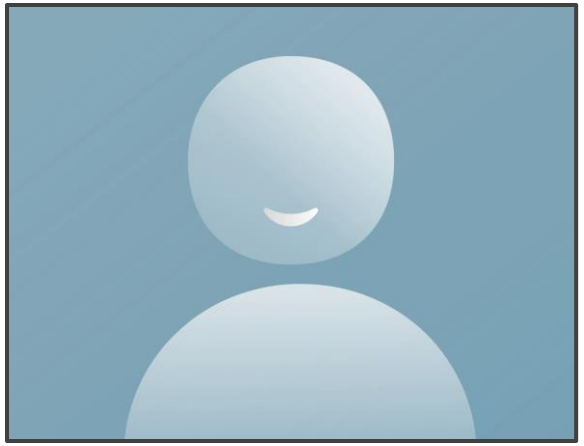
- 15. Mammalian immune systems evolve fast as species are always challenged with new pathogens in their environment. “You need to constantly keep pace with new bad guys that are trying to infect and hurt you,” says Scheben, who is a postdoctoral fellow in population genomics at Cold Spring Harbor Laboratory (and has since recovered from the bite). And while he has studied the genetic adaptations of several mammals, they pale in comparison to the ones that have given bats the ability to fight off infections so effectively



- 16. In a new study published today in the journal Genome Biology and Evolution, Scheben and his team have identified the genes that have contributed to bats' rapidly evolving immune system and their **unique ability to evade deadly viruses and even cancer.** Understanding how bats survive diseases could inspire new immune treatments for humans and potentially help prevent another pandemic.

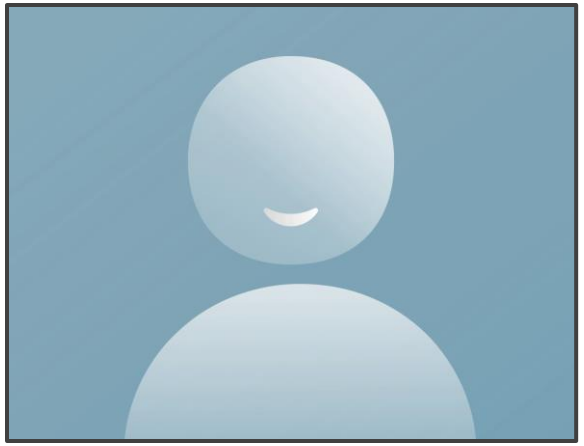


how genes have played a role in bats’ swiftly adapting immune system and their distinctive capability to evade viruses?



Expalin how they gathered information about other species ?

- 17. The authors analyzed the DNA of 15 different bat species to get a clearer picture of how their genes evolved over time. They fully sequenced the genomes of two bat species, the Jamaican fruit bat and the Mesoamerican mustached bat, and gathered the other species from **preexisting datasets**



Explain how they gathered information about other species ? (3)

- **Bioinformatics** involves the **use of computers and databases** to **collect and analyse biological data** such as **DNA, RNA, and protein sequences** (1)
- Scientists **obtain DNA sequences** from different species and **store them in databases** (1)
- They **compare nucleotide or amino acid sequences** between species (1)
- Use **computer algorithms / software** to **identify similarities and differences** (1)
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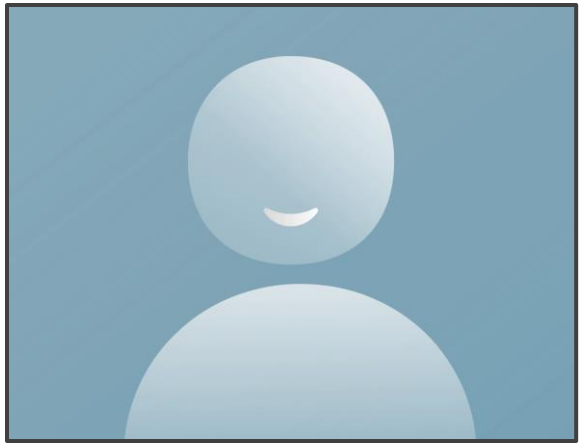
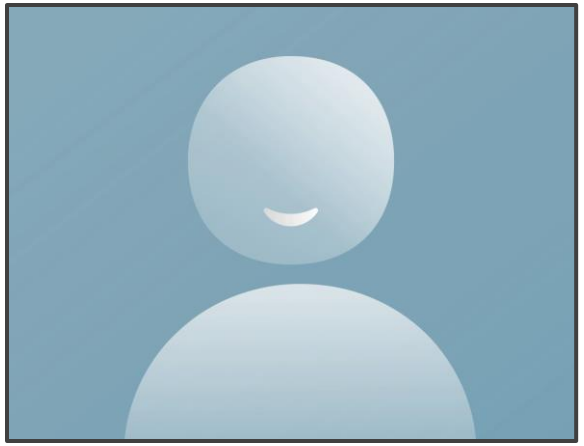
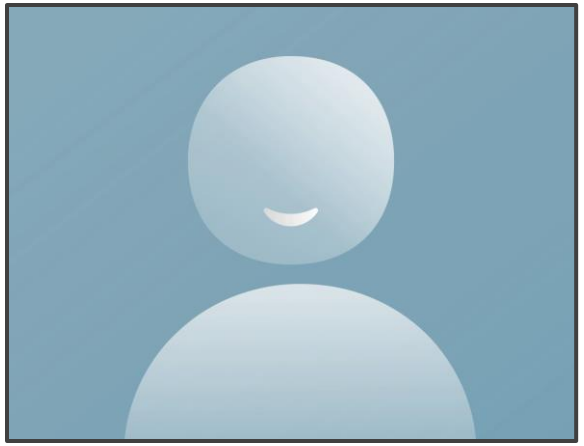


- 18. They then compared the bat genomes to that of humans, mice, and other cancer susceptible mammals, focusing their attention on the sequences that encode proteins responsible for causing or preventing diseases To start, they lined up the homologous genes, or shared genes among different species inherited from a shared evolutionary ancestor. (It’s like comparing apples with apples, explains Scheben.) With each homologous gene, they hypothesized two scenarios: if bats lost it or if it mutated. If the flying mammals completely lost the gene, it suggests that the omission is important in fighting disease. But if it remained with subtle changes in the DNA sequence that are only found in bats, it could show a change in gene function that somehow helps the group stay healthy

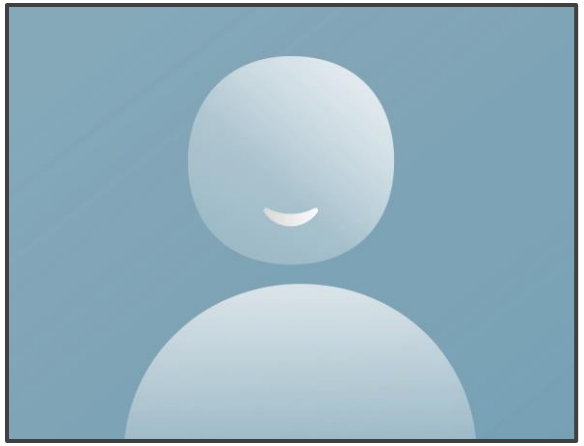


- 19. In the end, the most striking changes the team detected were in type one interferon (IFN) genes, which are important for controlling inflammatory responses to infections. Specifically, they observed a shift in the number of **antiviral IFN-α and IFN-ω genes**. For instance, three bat species seemed to have lost all of their IFN-α while increasing the number of IFN-ω genes

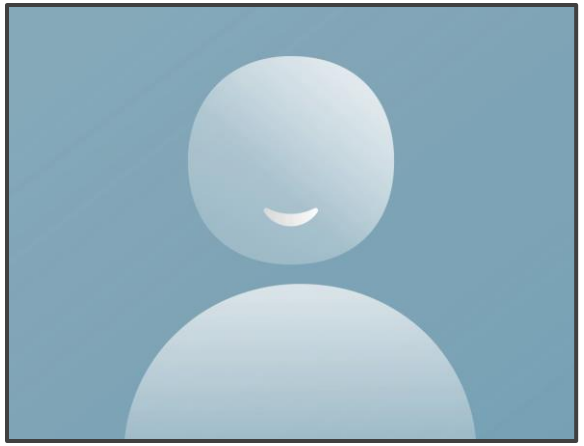


How do the interferon help bats resist viral infections?

- Interferons are proteins produced by cells in response to viral infection (1)
- They bind to receptors on other cells, triggering antiviral gene expression (1)
- This prevents viruses from replicating in uninfected cells (1)
- Inhibit virus life cycle



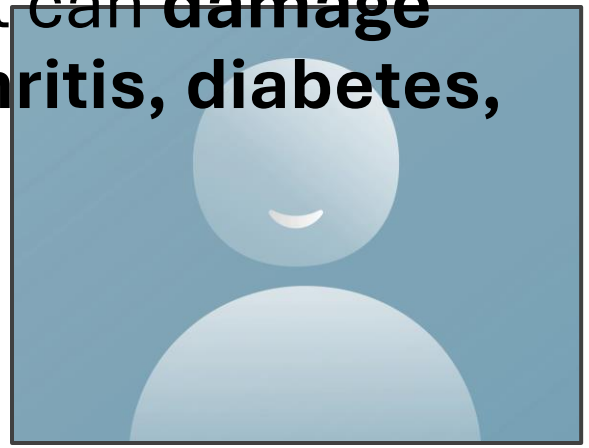
- 20. According to Scheben, the most surprising finding was observing the loss of IFN-α and addition of more IFN-ω genes, “which hadn’t been reported at all before.” The results suggest the new IFN-ω and missing IFN-α genes are important in bats for resisting viral infections while preventing overactive inflammatory responses—a feature that has made inflammation a **double-edged sword in humans**



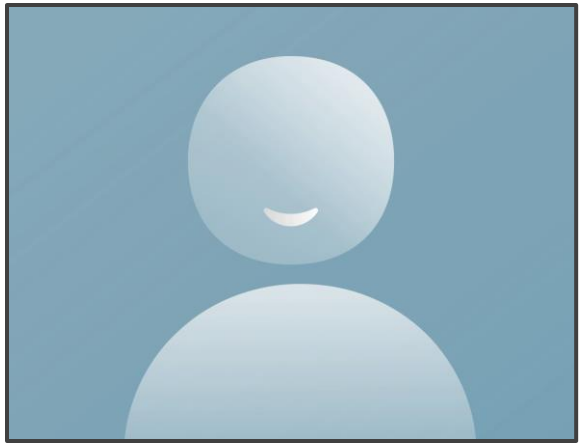
Why is inflammation referred to as a "double-edged sword" in humans?

Helpful side:
Inflammation is part of the immune system’s defense. It helps the body **fight infections, heal injuries, and remove harmful substances**.

Harmful side:
If inflammation becomes **overactive or chronic**, it can **damage healthy tissues** and lead to diseases such as **arthritis, diabetes, heart disease, or autoimmune disorders**.

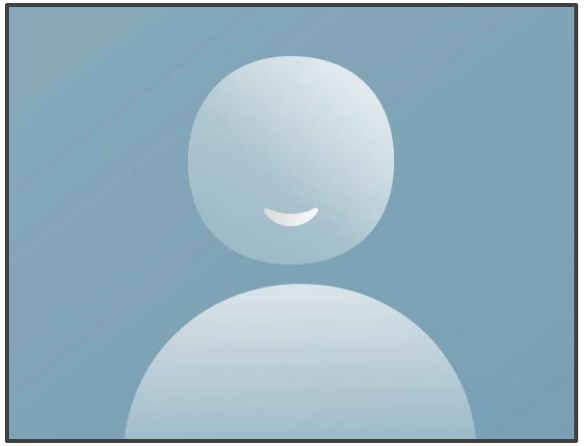


- 21. But while the findings have put geneticists one step closer to understanding how bats evolved their unique ability to resist cancer and viruses, it doesn't paint a complete picture. The study focuses only on the genetics of innate immunity (the immediate immune response to infected cells), says Tony Schountz, a professor at the Center for Vector-Borne Infectious Diseases at Colorado State University, who was not involved in the study. It does not include information about bats' adaptive immunity, which consists of the antibody and T-cell responses that many mammals use to fight diseases. "These are two very different but complementary components of immunity," Schountz explains. **"Nearly all of the focus on bat immunity to date has been on innate immunity, principally because the study of adaptive immunity requires live animals, which few groups have and is much more complicated.**

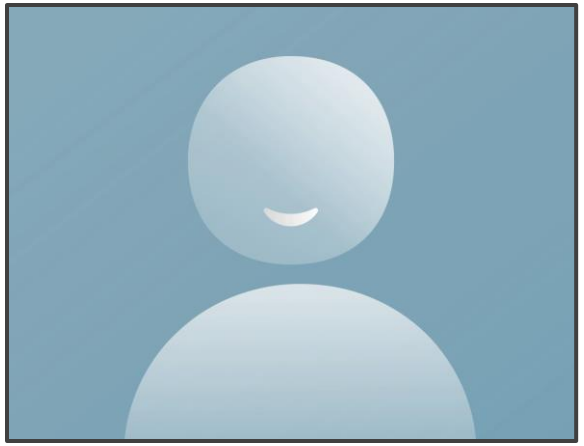


elaborate on the necessity of live animals for researching adaptive immunity?

- **Many specialized cells are involved:** Adaptive immunity uses **B cells and T cells** that work together to fight infections.
- **Develops over time:** Unlike innate immunity, adaptive immunity **takes time to respond** when the body first encounters a pathogen.
- **Memory cells stay in the body:** After an infection or vaccination, **memory B and T cells remain**, allowing the body to **respond faster and stronger** if the same pathogen appears again.

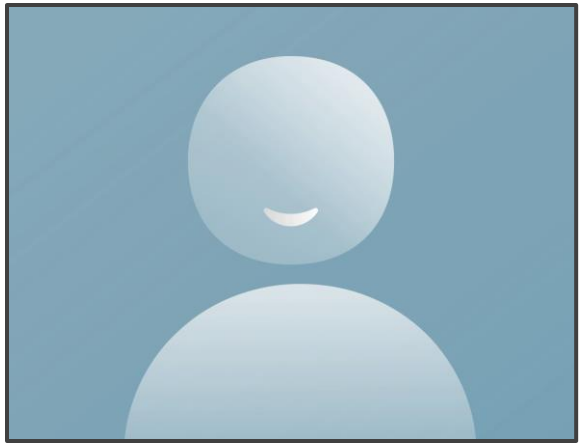


- 22. **Even without a full set of information, understanding the changes in the bats' innate immune system could help scientists develop genetic treatments for humans that decrease susceptibility to certain illnesses.** We can also learn which genes drive bats' 20- to 30-year lifespans, or how their bodies have adapted to process sugar-rich foods without developing the negative consequences seen in people with diabetes

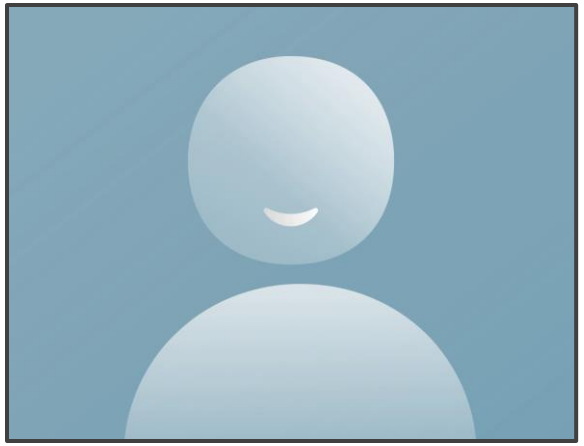


Suggest how scientists can develop treatments only using innate immunity

- Scientists can develop treatments using innate immunity by **stimulating natural defense pathways**, **using chemicals and enhancing phagocytosis activating immune receptors.**



- 23. **And though bats have gained a notorious reputation for their purported role in spreading COVID, Scheben hopes that these new findings could point researchers in the right direction in understanding how the animals host such potent viruses and parasites without getting very sick.** One day, he says, that information could be used to prevent our species from suffering major symptoms when infected. “It’s absolutely not misplaced to believe that studying bats could help us prevent another pandemic.



Why can some pathogens not infect different hosts? (2)

- If another species' cells don't have the right receptors, the pathogen can't attach or enter.

- Each species has a unique body temperature, pH, and biochemistry.