ScienceNewsLearning

EDUCATOR GUIDE

August 24, 2024

Woolly Mammoth DNA and A New Element

SOCIETY FOR SCIENCE

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About this Guide

Use news articles from the August 24 *Science News* issue to discuss a new possible element and learn how elements get onto the periodic table and practice what happens during transcription and translation while learning about recently analyzed woolly mammoth DNA.

This Guide includes:

Lesson Plan: When atoms collide, new elements arise

> **Learning Overview:** Take note — there could soon be a new element on the block. By smashing atoms together, scientists have been expanding our periodic table of elements beyond what occurs in nature. Learn how scientists create them while answering questions and discussing how such innovations may help us in the future.
>
> **NGSS-DCI:** HS-PS1; MS-PS1.
>
> **Paired Articles:**
> *Science News:* "A new element on the periodic table might be within reach"
> Readability Score: 11.4
>
> *Science News Explores:* "The periodic table might soon have a new element"
> Readability Score: 7.0
>
> **Student Worksheet**: These questions are formatted so it's easy to choose the ones that will work for your students, post them to your LMS or print them off as a worksheet.

Lesson Plan: Turning genes on and off

> **Learning Overview:** Scientists have been able to study genetic activity in an ancient woolly mammoth's DNA, thanks to a new method. Learn about the research study and the preservation of the DNA while thinking through the implications of having certain genes turned on or off.
>
> **NGSS-DCI:** HS-LS3; HS-LS4; MS-LS3.
>
> **Paired Articles:**
> *Science News:* "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'"
> Readability Score: 9.8
>
> *Science News Explores:* "Freeze-drying turned a woolly mammoth's DNA into 'chromoglass'"
> Readability Score: 6.0
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> **Student Worksheet**: These questions are formatted so it's easy to choose the ones that will work for your students, post them to your LMS or print them off as a worksheet.

Lesson Plan: Pairing up to create proteins

Learning Overview: Scientists studied ancient woolly mammoth DNA that had been freeze-dried in place, preserving it and retaining its shape. The researchers adapted a technique for studying the structures of chromosomes within a nucleus to determine which genes were turned on and off in the mammoth genome. In this activity, students will review what happens when genes are turned on by completing exercises that illustrate hypothetical DNA base pairing and simplified examples of transcription and translation.

NGSS-DCI: HS-LS3; HS-LS4; MS-LS3.

Paired Articles:
Science News: "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'"
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Lesson Plan: When atoms collide, new elements arise

Learning Overview: Take note — there could soon be a new element on the block. By smashing atoms together, scientists have been expanding our periodic table of elements beyond what occurs in nature. Learn how scientists create them while answering questions and discussing how such innovations may help us in the future.

NGSS-DCI: HS-PS1; MS-PS1.

Paired Articles:
Science News: "A new element on the periodic table might be within reach"
Readability Score: 11.4

Science News Explores: "The periodic table might soon have a new element"
Readability Score: 7.0

Directions: To engage students before reading the article, have them answer the "Before Reading" questions as a warmup in class. Then, instruct students to read the online *Science News* article "A new element on the periodic table might be within reach" and answer the "During Reading" questions. As an optional extension, instruct students to answer "After Reading" questions as a class discussion or as homework.

This article also appears in the August 24 issue of *Science News*. *Science News Explores* offers another version of the same article written at a middle-school reading level. Post this set of questions without answers for your students using this link.

Here's an additional lesson plan to introduce atoms, ions and isotopes and a collection of lesson plans on the periodic table and its history.

Before Reading

1. First, watch this short video. Then, imagine you are a scientist who is excited because you've just created a new element. You've named this element imaginarium (Im). Write a short letter, as though to a close friend, explaining your accomplishment. Assume that this friend does not have a science background, and briefly explain to them how you created this element.

Answers will vary but should include some description of creating new elements by smashing atoms together.

2. Pick any element from the periodic table and list two ways it is useful to people. What problem might we encounter if this element were not available?

Answers will vary.

During Reading

1. How would creating element 120 change the way the periodic table looks?

Element 120 would start a new row on the periodic table.

2. Regarding element 120, what does the number in its name refer to?

The number 120 refers to the number of protons in its nucleus.

3. What is the name of element 116?

Element 116 is called livermorium.

4. How many atoms of element 116 did scientists create after 22 days of "searching"?

Scientists created two atoms of element 116.

5. As of the publication of this article, how many elements make up the periodic table?

There are currently 118 elements that make up the periodic table.

6. How many neutrons does Calcium-48 contain in its nucleus? Why was this calcium isotope named in the article.

Calcium-48 contains 28 neutrons. Scientists used it in a lab to produce five of the heaviest elements.

7. As scientists aim to create elements further along the periodic table, what element have they used to replace calcium-48 in experiments? Why did they make this replacement?

Scientists have begun using titanium-50 in place of calcium-48. They're using titanium-50 because it has more protons, which allows scientists to use targets (some other element) for making element 120 that will not be radioactive.

After Reading

1. Refer to your answer to question 2 in Before Reading, where you listed a few ways a particular element helps us. With that in mind, what might we have to gain by the creation of new elements? Briefly explain why a person might care about the creation of new elements.

Answers will vary.

2. After reading this article, describe one of the challenges scientists encounter when creating new elements in the lab. How big a limit do you believe this is to creating many more novel elements? Briefly explain your answer.

Answers will vary. Regarding challenges scientists encounter, students may refer to the stability of the nucleus or the energy required to make such elements.

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Student Worksheet: When atoms collide, new elements arise

Directions: Answer the first set of questions as instructed by your teacher before reading the article. Then, read the online *Science News* article "A new element on the periodic table might be within reach" and answer the remaining questions as directed by your teacher.

Before Reading

1. First, watch this short video. Then, imagine you are a scientist who is excited because you've just created a new element. You've named this element imaginarium (Im). Write a short letter, as though to a close friend, explaining your accomplishment. Assume that this friend does not have a science background, and briefly explain to them how you created this element.

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During Reading

1. How would creating element 120 change the way the periodic table looks?

2. Regarding element 120, what does the number in its name refer to?

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After Reading

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Lesson Plan: Turning genes on and off

Learning Overview: Scientists have been able to study genetic activity in an ancient woolly mammoth's DNA, thanks to a new method. Learn about the research study and the preservation of the DNA while thinking through the implications of having certain genes turned on or off.

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Paired Articles:
Science News: "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'"
Readability Score: 9.8

Science News Explores: "Freeze-drying turned a woolly mammoth's DNA into 'chromoglass'"
Readability Score: 6.0

Directions: To engage students before reading the article, have them answer the "Before Reading" question as a warmup in class. Then, instruct students to read the online *Science News* article "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'." Afterward, have them answer the "During Reading" questions.

As an optional extension, instruct students to answer the "After Reading" questions as a class discussion or as homework. Review DNA, genes, and other basics of genetics using the first section of "The genetics puzzle" lesson plan titled "Genetics basics."

This article also appears in the August 24 issue of *Science News. Science News Explores* offers another version of the same article written at a middle-school reading level.

Before Reading
1. DNA is crucial for living things. Briefly explain what you think DNA does for us. What problem would we encounter if our cells did not contain DNA?

DNA is crucial because it carries information that tells the cells in our body how to build and maintain life. Without DNA, our bodies wouldn't make proteins that help our bodies function. Our cells wouldn't reproduce, and we would stop growing.

During Reading
1. How old is the mammoth DNA discussed in this story?

The mammoth sample and DNA is 52,000 years old.

2. What can scientists learn about DNA using the Hi-C technique? What has prevented scientists from using this technique to examine ancient DNA before?

The Hi-C technique looks at the 3D structure of DNA, allowing scientists to see the shape of the chromosomes. The Hi-C technique had failed on ancient DNA in the past, since the 3D structure of DNA tends to disintegrate over time.

3. What was the new technique that "had to be invented" by researchers and what did scientist Marcela Sandoval-Velasco say about the research process?

A team of researchers invented the PaleoHi-C technique to use on ancient samples. Marcela Sandoval-Velasco said that the invention proved that science is slow, iterative, full of failures and collaborative.

4. What was unique about the woolly mammoth skin sample that made it possible for scientists analyze its DNA?

The woolly mammoth skin had been freeze-dried and preserved in permafrost, which resulted in the chromosomes within the DNA being frozen in place.

5. How many pairs of chromosomes did wooly mammoths have?

Woolly mammoths had 28 pairs of chromosomes.

6. Use the analogy of dancers on a dance floor from the article to explain what it means for a gene to be "turned off." How could scientists tell that certain genes were turned on or off?

A turned off gene means it's not active in the chromosomes, and therefore isn't producing protein. The turned-off genes aren't participating in the gene activity "dance," whereas the turned-on genes are on the dance floor. Scientists can tell that genes are turned off because they're in a different subcellular compartment than the genes that are turned on.

7. How many genes did scientists find "turned on" in mammoths but not elephants?

Scientists found 425 genes that were active in mammoths but not in elephants.

8. What does the gene known as *Egfr* control?

The Egfr gene controls skin and hair growth.

9. The article refers to some unconventional experiments undertaken by the scientists in the study. Describe some of these unconventional methods and explain how they helped contribute to the findings.

Some of the unconventional methods scientists used were testing the Hi-C technique on turkey bones, roadkill, leather and samples of beef jerky after they had been microwaved, run over with a car, hit with a baseball and shot with a shotgun. These methods helped researchers learn the limits of the Hi-C technique and the stability of DNA with a chromoglass structure.

After Reading

1. This story discusses how genes can be turned off and on by comparing the genes in elephants and mammoths. Now think about how different cells in one organism's body might use different genes. Consider this, for instance: A human nerve cell and a white blood cell both contain the same DNA. Yet, these cells have very different jobs in the body. How could two cells with the same DNA function so differently?

Cells behave differently within the same DNA because the genes that are turned on result in different proteins being produced.

2. Christina Warinner says that the research highlighted in the article "opens up a lot of new doors" in the study of ancient DNA. What new options might be available to researchers now — using this technique — that they lacked before? Give one scientific question that you think PaleoHi-C might one day help to answer.

Using the research highlighted in the article, scientists can study ancient DNA samples taken from a variety of species that will help them learn more about those species and their modern counterparts. What are the differences in genetic activity between a megalodon and a modern great white shark?

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Student Worksheet: Turning genes on and off

Directions: Read the *Science News* article "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'" and complete the comprehension questions as directed by your teacher.

Before Reading

1. DNA is crucial for living things. Briefly explain what you think DNA does for us. What problem would we encounter if our cells did not contain DNA?

During Reading

1. How old is the mammoth DNA discussed in this story?

2. What can scientists learn about DNA using the Hi-C technique? What has prevented scientists from using this technique to examine ancient DNA before?

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Lesson Plan: Pairing up to create proteins

Learning Overview: Scientists studied ancient woolly mammoth DNA that had been freeze-dried in place, preserving it and retaining its shape. The researchers adapted a technique for studying the structures of chromosomes within a nucleus to determine which genes were turned on and off in the mammoth genome. In this activity, students will review what happens when genes are turned on by completing exercises that illustrate hypothetical DNA base pairing and simplified examples of transcription and translation.

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Readability Score: 9.8

Science News Explores: "Freeze-drying turned a woolly mammoth's DNA into 'chromoglass'"
Readability Score: 6.0

Directions: Ask students to read the *Science News* article "Freeze-drying turned a woolly mammoth's DNA into 3-D 'chromoglass'" and complete the comprehension questions for homework. Discuss answers with your class before starting this activity.

Review DNA, genes, and other basics of genetics using the first section of "The genetics puzzle" lesson plan titled "Genetics basics."

Before students complete the "Pairing up the bases" section, review the structure of DNA with them. Remind students that DNA's structure is a double helix: The two outer strands, composed of the sugar deoxyribose and phosphate, form the sides of the twisted ladder. The rungs are base pairs, and each rung is composed of two nucleotide bases, either A (adenine) and T (thymine) or C (cytosine) and G (guanine). The base A is uniquely attracted to and pairs with T, while C is uniquely attracted to and pairs with G. When the double helix structure is pulled apart into two strands, each strand is a template for the formation of a new complementary strand.

Before students complete the second section, discuss the article, review translation and transcription processes with your students, and have students think about where scientists doing this work might consider translation and transcription. The article discusses the impact of genes being turned on or off by comparing activity of the *Egfr* gene in elephants and woolly mammoths. In elephants, the gene is turned on, and in woolly mammoths, it is off. The *Egfr* gene regulates skin and hair growth. In people, switching the gene off leads to long, thick eyelashes and excessive hair growth. Scientists suspect that mammoths may have long, shaggy coats because *Egfr* is turned off. Scientists found 425 genes that were active in mammoths but not in elephants and, conversely, 395 genes turned on in elephants but not in mammoths.

Review the relationship between genes, transcription, translation and proteins. Genes can contain instructions for proteins. Genes that are turned on undergo active transcription and translation, increasing the amount of the protein encoded by the genes. If a gene has been turned off, the level of the

protein that it encodes does not increase. Transcription is the process by which DNA is copied to messenger RNA, or mRNA. Translation is the process by which mRNA is used to produce proteins. Remind students that mRNA differs from DNA in that it is single stranded, its backbone includes ribose instead of deoxyribose, and it uses U (uracil) nucleotide bases as a complement to A (adenine) instead of T (thymine). mRNA serves as a messenger to transport the genetic code from the nucleus out to the ribosome, in the cytoplasm, for protein production. When mRNA arrives at the ribosome, the organelle needs help translating what the code means. This is where tRNA, or transfer RNA, comes into play — it looks at the codon, a sequence of three nucleotides, and deposits the correct amino acid.

To help further student understanding of the topics, share these HHMI videos on DNA replication, transcription and translation.

Hands-on option: When students finish the first section, have them write their answers on a poster board. Then give them 4 different colored Post-it notes that each represent a different RNA nucleotide base (A, U, C, G). Have them complete the transcription section as a group on their poster board using the sticky notes. Finally, have them use a codon wheel to determine the amino acid that will be produced by each three-base sequence in the RNA and write it on their poster. To use the wheel, start in the center and find the first base pair in the grouping of three, then work outward to find the resulting amino acid. Remind them that the resulting protein forms once translation is complete and the amino acid sequence folds into a protein.

Pairing up the bases

Before beginning this section, review the structure of DNA with your teacher or partners. Remember that the nucleotide base pairs in one strand of DNA complement the nucleotide base pairs in the second strand.

Write the complementary base pair sequence under each original strand of hypothetical woolly mammoth DNA found by scientists.

Strand 1:

Original DNA strand:	ATG-CGC-ATA-CAC-ATT-ACG-ACA-ACC-CTT-TGA
Complementary base pair:	***TAC-GCG-TAT-GTG-TAA-TGC-TGT-TGG-GAA-ACT***

Strand 2:

Original DNA strand:	ATG-CCC-GGC-CGT-ACT-ATC-GTA-TCC-AAA-TGA
Complementary base pair:	***TAC-GGG-CCG-GCA-TGA-TAG-CAT-AGG-TTT-ACT***

Transcription and translation

When a gene is active, it undergoes the transcription and translation processes to create a protein that aids in a specific cellular function. The presence or lack of this protein can result in certain outward traits (such as the short, thin hair on an elephant or the long, shaggy hair on a woolly mammoth). Remember that RNA differs from DNA in that it is single stranded, its backbone includes ribose instead of deoxyribose, and that it uses the nucleotide base U (uracil) instead of T (thymine). The process of transcription uses a specific type of RNA called messenger RNA, or mRNA. It serves as a messenger to transport the genetic code from the nucleus out to the ribosome, in the cytoplasm, for protein production. When mRNA arrives at the ribosome, the organelle needs help translating the code. This is where transfer RNA, or tRNA, comes into play. tRNA reads a codon, a sequence of three nucleotides, and deposits the amino acid that matches the codon.

For the two strands of DNA that you wrote above, write down the translated mRNA sequence (a result of the transcription process). Then use a codon wheel to determine the amino acid that will be produced by each three-base sequence in the mRNA and write down the amino acid three-letter abbreviation (part of the translation process). To use the wheel, start in the center to find the first base pair in your grouping of three, then work outward to find the resulting amino acid.

Strand 1:

Original DNA strand (*given*):	ATG-CGC-ATA-CAC-ATT-ACG-ACA-ACC-CTT-TGA
Complementary base pair (*student-created*):	TAC-GCG-TAT-GTG-TAA-TGC-TGT-TGG-GAA-ACT
mRNA for created DNA strand:	***AUG-CGC-AUA-CAC-AUU-ACG-ACA-ACC-CUU-UGA***
Amino acid sequence for the student-created mRNA from DNA strand:	***MET (start)-ARG-ILE-HIS-ILE-THR-THR-THR-LEU-stop***

Strand 2:

Original DNA strand (*given*):	ATG-CCC-GGC-CGT-ACT-ATC-GTA-TCC-AAA-TGA
Complementary base pair (*student-created*):	TAC-GGG-CCG-GCA-TGA-TAG-CAT-AGG-TTT-ACT
mRNA for created DNA strand:	***AUG-CCC-GGC-CGU-ACU-AUC-GUA-UCC-AAA-UGA***
Amino acid sequence for the student-created mRNA from DNA strand:	***MET (start)-PRO-GLY-ARG-THR-ILE-VAL-SER-LYS-stop***

Putting it all together
When the woolly mammoth DNA was analyzed, other genes may have been isolated to compare characteristics of the elephant and the mammoth. For this example, use the skills reviewed in the previous activities to fill in the missing pieces and find a genetic difference between elephants and mammoths focusing on two hypothetical genes: *Lgtk*, for "long tusk," and *Shtk*, for "short tusk." Then answer the concluding questions as instructed by your teacher.

Hypothetical mammoth gene: *Lgtk*

Lgtk DNA sequence:	ATG-CAG-CCC-CGA-TTT-CGC-TTA-CGG-GGA-TAA
Complementary strand of DNA:	***TAC-GTC-GGG-GCT-AAA-GCG-AAT-GCC-CCT-ATT***
mRNA sequence:	AUG-CAG-CCC-CGA-UUU-CGC-UUA-CGG-GGA-UAA
Amino acid sequence:	***MET-GLN-PRO-ARG-PHE-ARG-LEU-ARG-GLY-STOP***

Hypothetical elephant gene: *Shtk*

Shtk DNA sequence:	***ATG-CAG-CCC-GCA-AAA-GCG-TTA-CGG-GGA-TAA***
Complementary strand of DNA:	TAC-GAC-GGG-CGT-TTT-CGC-AAT-GCC-CCT-ATT
mRNA sequence:	***AUG-CUG-CCC-GCA-AAA-GCG-UUA-CGG-GGA-UAA***
Amino acid sequence:	MET-LEU-PRO-ALA-LYS-ALA-LEU-ARG-GLY-STOP

Concluding questions
1. How many RNA bases are different between the two hypothetical genes?

9 RNA bases

2. How many amino acids are different between the two genes?

4 amino acids

3. What could you learn by investigating the differences between elephants and woolly mammoth DNA?

Possible student answers: shape of teeth, or ears, feet; length of tails or tusks.

4. How could studying ancient DNA help scientists better understand the evolution of a certain species?

Possible student answer: Scientists could compare how genetically different related species are and investigate which traits are due to genes that are turned off or on. Scientists may be able to link these genetic differences to differences in the animals' environments.

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Student Worksheet: Pairing up to create proteins

Pairing up the bases

Before beginning this section, review the structure of DNA with your teacher or partners. Remember that the nucleotide base pairs in one strand of DNA complement the nucleotide base pairs in the second strand.

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Original DNA strand:	ATG-CGC-ATA-CAC-ATT-ACG-ACA-ACC-CTT-TGA
Complementary base pair:	

Strand 2:

Original DNA strand:	ATG-CCC-GGC-CGT-ACT-ATC-GTA-TCC-AAA-TGA
Complementary base pair:	

Transcription and translation

When a gene is active, it undergoes the transcription and translation processes to create a protein that aids in a specific cellular function. The presence or lack of this protein can result in certain outward traits (such as the short, thin hair on an elephant or the long, shaggy hair on a woolly mammoth). Remember that RNA differs from DNA in that it is single stranded, its backbone includes ribose instead of deoxyribose, and that it uses the nucleotide base U (uracil) instead of T (thymine). The process of transcription uses a specific type of RNA called messenger RNA, or mRNA. It serves as a messenger to transport the genetic code from the nucleus out to the ribosome, in the cytoplasm, for protein production. When mRNA arrives at the ribosome, the organelle needs help translating the code. This is where transfer RNA, or tRNA, comes into play. tRNA reads a codon, a sequence of three nucleotides, and deposits the amino acid that matches the codon.

For the two strands of DNA that you wrote above, write down the translated mRNA sequence (a result of the transcription process). Then use a codon wheel to determine the amino acid that will be produced by each three-base sequence in the mRNA and write down the amino acid three-letter abbreviation (part of the translation process). To use the wheel, start in the center to find the first base pair in your grouping of three, then work outward to find the resulting amino acid.

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Original DNA strand (*given*):	ATG-CGC-ATA-CAC-ATT-ACG-ACA-ACC-CTT-TGA
Complementary base pair:	
mRNA for created DNA strand:	
Amino acid sequence for the student-created mRNA from DNA strand:	

Strand 2:

Original DNA strand (*given*):	ATG-CCC-GGC-CGT-ACT-ATC-GTA-TCC-AAA-TGA
Complementary base pair:	
mRNA for created DNA strand:	
Amino acid sequence for the student-created mRNA from DNA strand:	

Putting it all together

When the woolly mammoth DNA was analyzed, other genes may have been isolated to compare characteristics of the elephant and the mammoth. For this example, use the skills reviewed in the previous activities to fill in the missing pieces and find a genetic difference between elephants and mammoths focusing on two hypothetical genes: *Lgtk*, for "long tusk," and *Shtk*, for "short tusk." Then answer the concluding questions as instructed by your teacher.

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Lgtk DNA sequence:	ATG-CAG-CCC-CGA-TTT-CGC-TTA-CGG-GGA-TAA
Complementary strand of DNA:	
mRNA sequence:	AUG-CAG-CCC-CGA-UUU-CGC-UUA-CGG-GGA-UAA
Amino acid sequence:	

Hypothetical elephant gene: *Shtk*

Shtk DNA sequence:	
Complementary strand of DNA:	TAC-GAC-GGG-CGT-TTT-CGC-AAT-GCC-CCT-ATT
mRNA sequence:	
Amino acid sequence:	MET-LEU-PRO-ALA-LYS-ALA-LEU-ARG-GLY-STOP

Concluding questions

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2. How many amino acids are different between the two genes?

3. What could you learn by investigating the differences between elephants and woolly mammoth DNA?

4. How could studying ancient DNA help scientists better understand the evolution of a certain species?