

## Guided Inquiry • Forensics Lab

## Chapter 14 Lab Using DNA to Identify Human Remains

### Problem

How can pedigrees help scientists identify human remains?

### Introduction

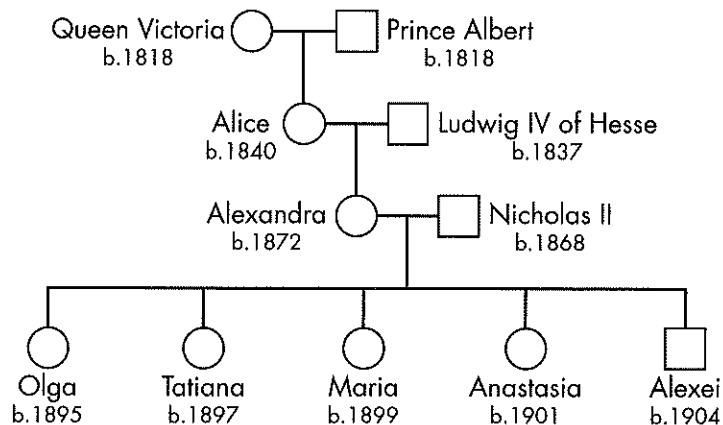
DNA has helped solve countless crimes and some intriguing mysteries—including the fate of the Romanovs. For 300 years the Romanov family ruled Russia. The last Romanov ruler was Tsar Nicholas II. His wife, Tsarina Alexandra, was descended from Queen Victoria of England, as shown in Figure 1.

In 1917, revolution swept through Russia. The royal family was captured and held prisoner until they were killed on July 16, 1918. The official report said that all the bodies were burned and then buried in a single grave. However, some witnesses said that one or two of the children were not buried with the others, and for many years there were rumors that Anastasia had survived.

The new government did not allow any research into the fate of the Romanovs. The house in which they were killed was destroyed, and the burial site was kept secret. In 1991, after the breakup of the Soviet Union, scientists were at last allowed to examine the burial site and remove the bones.

In this lab, you will investigate how the scientists classified the skeletons that they found. You will also figure out how pedigrees helped the scientists find living relatives whose DNA could be compared with DNA extracted from the bones.

**Figure 1** Simplified pedigree for Tsarina Alexandra



## Skills Focus

Analyze Data, Draw Conclusions

### Pre-Lab Questions

- 1. Infer** The tsar and tsarina had five children. Did all seven family members have the same mitochondrial DNA (mtDNA)? Give a reason for your answer.

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- 2. Predict** To confirm that bones belonged to the Romanov children, which living relative would be more useful—a relative of the tsar or a relative of the tsarina? Why?

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- 3. Infer** If two people have the same mtDNA, what can you infer about their biological relationship?

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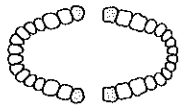
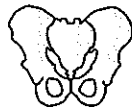
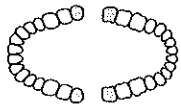

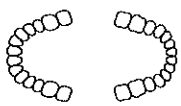

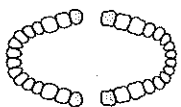

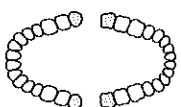

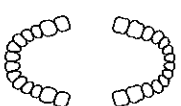

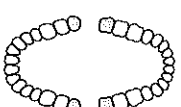

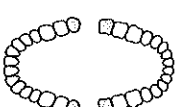



## Procedure

### Part A: Sorting the Bones

The seven members of the Romanov family were not alone when they died. With them were a doctor, a nurse, and two servants, who were also killed. The identification of the bodies was difficult because the bodies in the grave were in a large pile. When scientists sorted the bones, they were able to reconstruct only nine skeletons. To figure out who was missing, the scientists first needed to classify the skeletons by age and sex.

- 1. Relative Age** Scientists can use wisdom teeth to determine the relative age of skeletons. The wisdom teeth are the last teeth to emerge from the gums. This event usually occurs between the ages of 17 and 21. Use the data in Table 1 to classify each skeleton by age. Classify skeletons with wisdom teeth as age 22 or older. Classify skeletons without wisdom teeth as younger than age 22.

2. **Sex** Scientists can use the shape of the pelvis to determine the sex of a skeleton. The pelvis is a ringlike structure of bones located at the base of the spine. The pelvis of a female is wider and has a wider opening than the pelvis of a male. Use the data in Table 1 to determine each skeleton's sex.

Table 1				
Skeleton	Teeth	Pelvis	Age	Sex
1				
2				
3				
4				
5				
6				
7				
8				
9				

**Part B: Finding Living Relatives of the Tsarina and Tsar**

After examining the skeletons, the scientists knew which skeletons were adult males and which were adult females. However, they did not know which of the adults were the tsarina and the tsar. For this task the scientists needed to use DNA.

Recall that the bodies had been burned before they were buried. The remains had also been repeatedly frozen and thawed as the seasons changed over 75 years. Yet the scientists were still able to extract mitochondrial DNA (mtDNA) from the bones. Now they needed samples of DNA from living relatives for a comparison.

3. Tsarina Alexandra was a descendant of Queen Victoria. Both Queen Elizabeth II and her husband Prince Philip are living descendants of Queen Victoria. Use the pedigree in Figure 2 to trace the descent of Queen Elizabeth II. List the descendants in the space below.

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4. Use the pedigree in Figure 2 to trace the descent of Prince Philip. List the descendants in the space below.

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5. Based on your findings in Steps 3 and 4, whose mitochondrial DNA did scientists use to try to identify the tsarina's bones—Elizabeth or Philip? Explain your choice.

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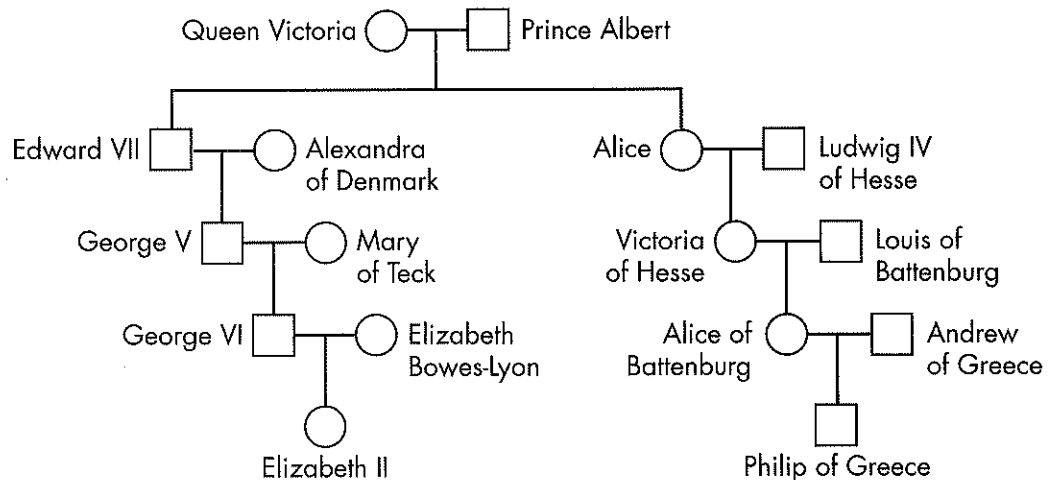


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**Figure 2** Simplified pedigree for Queen Elizabeth and Prince Philip



6. Scientists also needed to find living relatives of Tsar Nicholas II, who was descended from Louise of Hess-Cassel. Use the pedigree in Figure 3 to trace the tsar's descent.

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7. Scientists identified two living descendants of Louise of Hess-Cassel who might be candidates for a DNA comparison—James Carnegie and Countess Xenia. Use Figure 3 to trace the descent of James Carnegie from Louise of Hess-Cassel.

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8. Use Figure 3 to trace the descent of Countess Xenia from Louise of Hess-Cassel.

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9. Based on your findings in Steps 5–7, what is the relationship between James Carnegie and Tsar Nicholas II? What is the relationship between Countess Xenia and Tsar Nicholas II?

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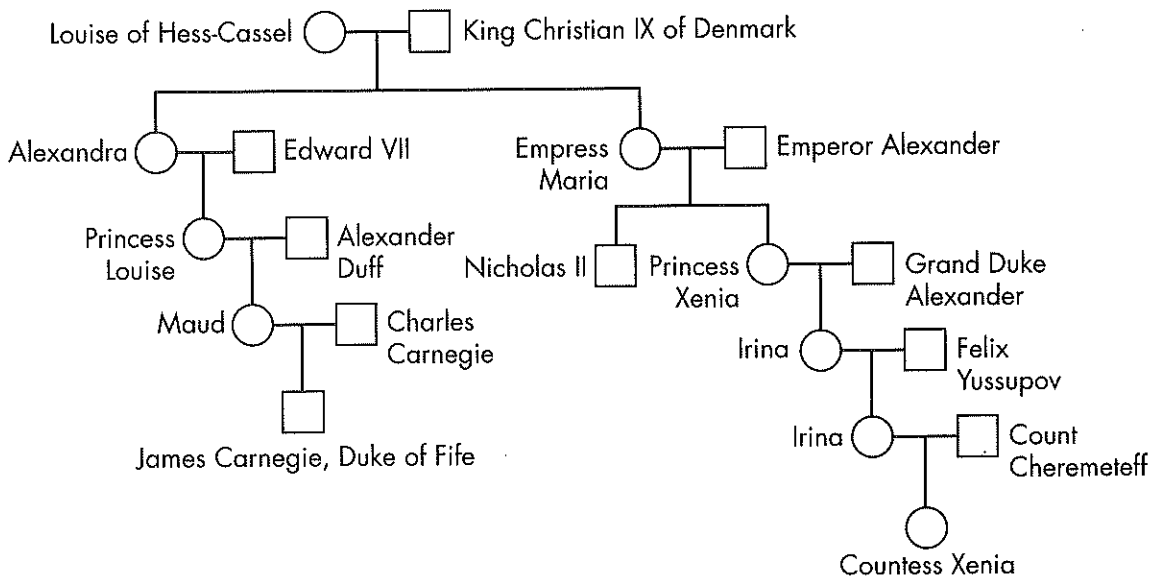


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**Figure 3** Some descendants of Louise of Hess-Cassel



## Analyze and Conclude

**1. Analyze Data** Table 2 lists the age and sex of each Romanov family member and their servants at the time of their deaths. The exact ages of the servants are not known. Compare the data in Table 2 with the data in Table 1. Who are the possible candidates for the two missing skeletons, and why?

Table 2			
Female	Age	Male	Age
Tsarina	46	Tsar	50
Olga	22	Alexei	14
Tatiana	21	Doctor	Adult
Maria	19	Servant	Adult
Anastasia	17	Servant	Adult
Nurse	Adult		

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**2. Draw Conclusions** Could the mitochondrial DNA of either James Carnegie or Countess Xenia be used to try to identify the skeleton of Tsar Nicholas? Explain your answer.

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**3. Apply Concepts** Forensic scientists think they know the identity of a skeleton. What rule should they use to select a relative whose DNA could be used to try to confirm the identity?

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**4. Infer** When mitochondrial DNA from living relatives was compared with mitochondrial DNA from the skeletons, scientists determined that skeletons 3, 4, 5, 6, and 7 were members of the Romanov family. Which of these skeletons can be identified by name based on the evidence you have? Explain your answer.

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**5. Predict** Queen Elizabeth and Prince Philip have four children. Would these offspring have been a useful source of DNA for identifying the Romanov skeletons? Why or why not?

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### Extend Your Inquiry

In 1920, before the discovery of DNA, a factory worker named Anna Anderson claimed to be Anastasia Romanov. Do research to find out what evidence Anna Anderson used to back up her claim. After Anna's death, how did scientists investigate her claim?





## Chapter 13 Lab **From DNA to Protein Synthesis**

### Problem

What are the steps involved in making a protein?

### Introduction

Before a protein can be built, the biochemical blueprints for its construction must be packaged and transferred out of the DNA “library.” First, the specific sequence of DNA that codes for the protein is transcribed into a complementary strand of mRNA. In eukaryotic cells, the mRNA then leaves the nucleus and enters the cytoplasm. In all cells, the mRNA molecule attaches to a ribosome, where tRNA anticodons translate the mRNA into amino acids. The completed amino acid chain, or polypeptide, then folds into its final shape as a protein.

In this lab, you will model transcription of DNA and translation of mRNA while you decode secret messages.

### Skills Focus

Use Models, Sequence

### Pre-Lab Questions

1. **Sequence** Describe briefly the process you will use to decode the messages.

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2. **Compare and Contrast** What role do stop codons play in protein synthesis? What are they used for in the coded messages?

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3. **Predict** Which six letters will not appear in the coded messages? Give a reason for your answer.

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## Procedure

### Part A: How to Decode Messages

- Write the complementary mRNA strand for the DNA sequence given below by finding the mRNA codon that matches each DNA triplet, base for base. The mRNA strand has been started for you. Finish the transcription.

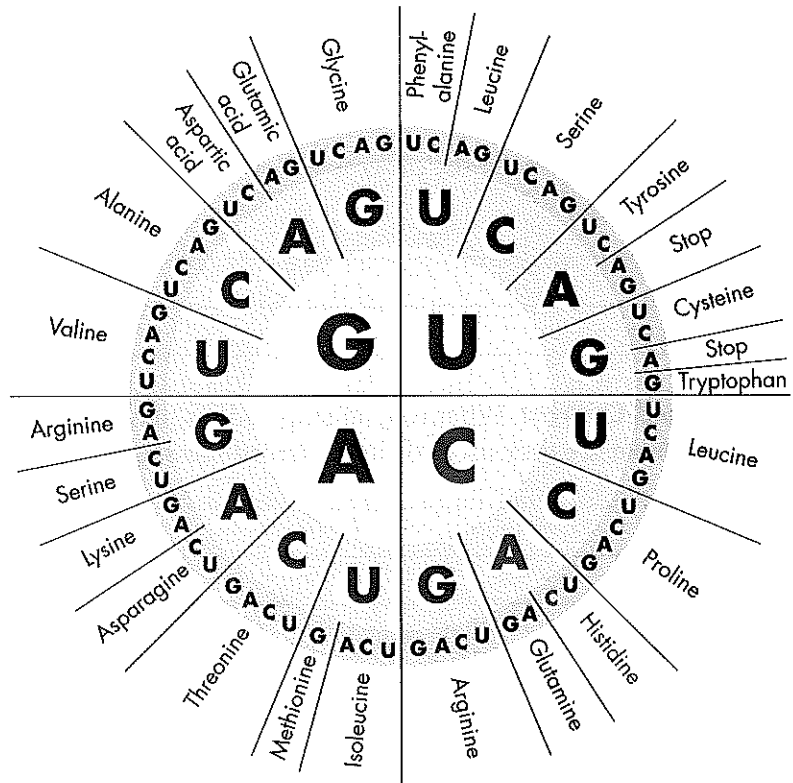
DNA: TAC CGT TTT CTT ATT TAC ATA ACT CTG CGA ATG

mRNA: AUG GCA AAA GAA UAA

- Use Figure 1 to match each mRNA codon from Step 1 with its corresponding amino acid. When the codon is a “stop” codon, include “stop” in the sequence. The amino acid sequence has been started for you. Finish the translation.

methionine, alanine, lysine, glutamic acid, stop,

**Figure 1** Map of mRNA codons to amino acids



3. Use the table to find the single-letter symbol for each amino acid in the sequence from Step 2. The symbols will spell out a sentence or a familiar saying. The first word has been done for you.

MAKE \_\_\_\_\_

Single-Letter Symbols for Amino Acids			
Amino Acid	Symbol	Amino Acid	Symbol
Alanine	A	Leucine	L
Arginine	R	Lysine	K
Asparagine	N	Methionine	M
Aspartic Acid	D	Phenylalanine	F
Cysteine	C	Proline	P
Glutamic Acid	E	Serine	S
Glutamine	Q	Threonine	T
Glycine	G	Tryptophan	W
Histadine	H	Tyrosine	Y
Isoleucine	I	Valine	V

**Part B: Decoding Messages**

4. Use the procedure from Part A to decode the following messages. Remember to transcribe the DNA messages into mRNA codons and then translate the codons into amino acids.

a. TGA CGA TTT CTC ACT ACA CGC GCG CTT

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b. GTA CTT ATT TAA AGC ATC CGT ATT AGT GGC ATA

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c. TAC CTC CTT TGA ATT TAC CTT ACT CGT TGT ATT AAA  
TAT CAG CTC

\_\_\_\_\_

d. TGT GTA CTT ACT GGG GAT CGC TTG ATT GTA CGG  
AGC ATC ACG GTG CGA TTG CCC CTT CTG

\_\_\_\_\_

e. TGT GTG CTC ACT AGA GTA TAG GGA ATT AGG CGG  
TAT GAC AGC ATC CGA TGC ACT CTG CGC ACC TTA

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## Analyze and Conclude

**1. Apply Concepts** How did you know which bases to use when you transcribed the DNA sequence to mRNA codons?

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**2. Predict** Suppose the DNA sequence for the first message in Part B began with TGT CGA instead of TGA CGA. Would the message change? Why or why not?

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**3. Use Analogies** Suppose some codons mapped to two different amino acids? What would the effect be on your translation of coded messages? What would the effect be on the production of proteins?

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**4. Sequence** During the actual production of proteins in a cell, what might happen to a strand of RNA before it leaves the nucleus?

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**5. Evaluate and Revise** What step could you add after you transcribe the DNA to make a more complete model of protein synthesis?

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## Extend Your Inquiry

Create your own secret message using DNA triplets. Exchange messages with classmates and try to solve the messages you receive. Remember that there is no triplet for the letters B, J, O, U, X, and Z. You will need to be creative to come up with messages that don't use those letters.

## Open-Ended Inquiry

## Quick Lab 10.1 **Modeling the Relationship Between Surface Area and Volume**

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### Problem

How does cell size affect a cell's ability to function?

### Introduction

In this lab you will construct a set of paper cubes. The cubes will represent cells at different stages of growth. After you construct your cubes, you will calculate the volume, surface area, and ratio of surface area to volume of each cube.

### Skills Focus

Use Models, Calculate, Design an Experiment

### Materials

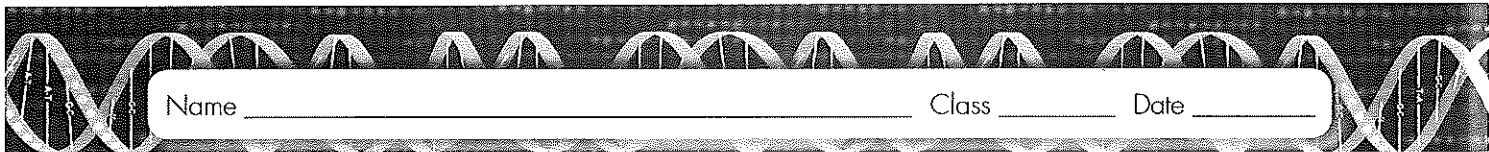
- patterns for 6-cm, 5-cm, 4-cm, and 3-cm cubes
- scissors
- tape or glue

### Safety

Do not direct the points of the scissors toward yourself or others. Use the scissors only as instructed.

### Procedure

1. Cut out the patterns on pages 295, 297, and 299 and fold them along the dashed lines. Use the tabs to tape or glue the sides together. Do not tape down the top side.
2. Calculate the surface area of each cube. Find the area of one side of the cube and multiply that area by the number of sides. Record your results in the data table on the next page.
3. Calculate the volume of each cube. Multiply width times length times height. Record the results in the data table.



Name \_\_\_\_\_

Class \_\_\_\_\_

Date \_\_\_\_\_

4. Divide the surface area by the volume to find the ratio of surface area to volume. Record your results in the data table.

Data Table			
Width of Side	Surface Area (cm <sup>2</sup> )	Volume (cm <sup>3</sup> )	Ratio of Surface Area to Volume
6 cm			
5 cm			
4 cm			
3 cm			

5. Use your data to calculate the number of 3-cm cubes that would fit in the same volume as the 6-cm cube. Also calculate the total surface area for the smaller cubes.

Number of 3-cm cubes: \_\_\_\_\_

Total surface area of smaller cubes: \_\_\_\_\_

### Analyze and Conclude

1. **Review** Describe the function of a cell membrane and its relationship to what happens inside a cell.

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2. **Draw Conclusions** How did the ratio of surface area to volume change as the size of the cubes decreased?

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3. **Relate Cause and Effect** As a cell grows, what happens to the amount of activity in the cell and the need for materials to be exchanged across the cell membrane?

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4. **Draw Conclusions** How could the growth of a cell affect its ability to survive?

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