Secrets of a Mass Grave

Using the techniques of forensic anthropology to gather and analyze evidence

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Developing expertise in forensic anthropology takes years, yet even an introduction to the field can give students a valuable chance to examine and interpret complex evidence. Forensic investigators often must draw conclusions in less than ideal circumstances based on collected evidence that is incomplete. A forensics unit can help students understand that the same evidence may lead to multiple plausible interpretations.

In this unit, students examine skeletons and draw conclusions from the evidence they find in a simulated mass grave. The activity involves the foundation of forensic anthropology—interpreting the structure of skeletal remains to determine sex, age, height, and possible cause of death.

Working through a series of lessons, students gather, interpret, and draw conclusions from evidence in the same way scientists do. These skills reflect the nature of science and are an essential part of science instruction (DeBoer 2006). As the unit progresses, students engage in scientific discourse by constructing explanations and arguing from their analysis of evidence (Windschitl and Calabrese Barton 2016).

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Engage

Forensic anthropology encompasses investigations of both ancient and modern grave sites, so a thorough explanation of the subject should address both historical and current applications. To see what a mass grave looks like and how bone specialists work, students watch a documentary on medieval graveyards and the evidence the anthropologists used to draw conclusions about the lives, deaths, and burials of the individuals (see "On the web"). Students then read a news article about a modern mass grave in Mexico (Miroff and Booth 2011) that explains how the techniques used to investigate historical sites are used to solve modern crimes and identify individuals.

Students also read a forensic anthropologist's account of her first crime scene and the emotional toll this field can take (Hopping 2005). Together, these three resources help students determine which aspects of forensic anthropology most interest them: studying evidence of the historical past, evaluating modern crime scenes, or focusing on the scientific processes that inform all forensic anthropologists' efforts.

Explore

Introduced to the techniques of studying bones, students learn about the evidence forensic anthropologists use to piece together an *osteobiography*, or "biography of bones." Students study how bone development takes place and how the skeleton remodels itself according to the lifestyle of the individual. Looking at skull and pelvis structure reveals the sex of the individual; skull suture lines help estimate age; measurements of long bones (i.e., humerus, femur, and tibia) help students estimate an individual's height, using the same standard equations forensic anthropologists use. Students practice using all the available evidence (i.e., gender differences, age, and height) by creating their own case studies and challenging each other to determine a plausible osteobiography that would fit the evidence (examples, Figure 1).

To create the case studies, students provide information about the skeletons that can be used by other students to make determinations regarding that skeleton's identity. This data can include, for example, information about jaw angle, skull sutures, and the length of a femur.

Before progressing in the unit, students must demonstrate mastery of:

- differentiating between male and female skeletons,
- estimating an individual's age,
- estimating height from long-bone measurements, and
- identifying some aspects of bone remodeling.

In our unit, current, local case studies—such as crime reports found by scanning the local news media in the weeks before the unit—heightened student interest and offered context for why investigators study bones to identify individuals and not just DNA evidence, as some students suppose.

A sidebar discussion on the unreliability of some DNA evidence can be included if students insist that DNA is the only option for identifying a person. (For example, contamination can occur during collection or DNA evidence, and older samples can degrade. Also, DNA evidence cannot be used if there is no original source to which to compare the samples.)

When introducing the bones, we found it useful to discuss the structure and function of particular bones, such as suggesting that students struggling to remember the differences between the male and female pelvis imagine a fetus fitting through the opening.

FIGURE 1

Examples of student osteobiographies.

Student-created example	Student response
A body was found wet and dead near the shore at 2 a.m. There were defensive wounds on the legs. The subpubic angle was found to be 54°, and the femur length was 43.18 cm. The femur head is almost completely fused to the shaft.	The skeleton belongs to a male because the subpubic angle is less than 90°. His height is estimated to be 165.49 cm (43.18*3.01 + 35.52). He is probably 16 to 18 years old because the femur head is fused to the shaft.
A skull and a few bones were found near the walls of an old mine by the exit. They are covered in dirt and small rocks as if a wall collapsed. The left temporal bone is smashed inward, leaving a wide hole, and the right parietal bone is cracked. The lambdoidal suture is closed, but the sagittal suture is not yet fused. There is a prominent protuberance on the occipital bone. The skull has square eye orbits. The teeth are worn down but do not have fillings. The left femur is 45.5 cm.	One of the miners was hit with plausibly one of the mining tools such as a pick or hammer on the side of his head, killing him before he hit the wall and fell down. Seeing as the skull had worn-down teeth and no fillings suggests that he couldn't afford dentistry, meaning he must have been one of the workers. The square eye orbits and protuberance on occipital bone reveals that he was male, and the lambdoidal suture being closed with the sagittal suture not yet being fused indicates his age was 30 or 31. Not knowing what ethnic group the man belongs to, we used the formula of all ethnic groups and both sexes to find his estimated height. According to his femur size, he could have been 169 cm (5.5 ft.) tall. As for how he died, the left temporal bone was smashed in, leaving a wide hole, possibly from a blunt object such as a miner's hammer. The crack in the right parietal bone could have come from a fall against the wall the skull was near.

Other ways to help students master the material included introducing each topic (identifying sex, determining height, determining age) separately with practice worksheets and having students prepare written field guides for identifying bone features.

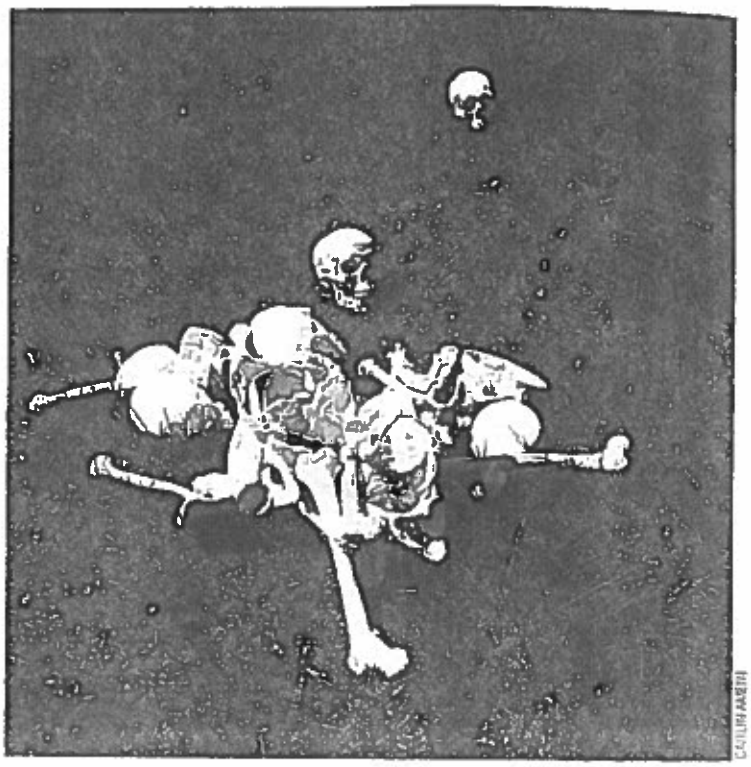
Explain

Students practice using their knowledge of bone features with an online simulation and research activity (see "On the web") involving the graves of the Romanov family in Yekaterinburg, Russia. The Romanovs, rulers of Russia until 1917, were overthrown and executed, their bodies buried in shallow graves. Some of their remains were found in 1991 and the rest in 2007 (Coble et al. 2009). Identifying the individuals from the gravesites in the simulation is excellent practice for students of forensic anthropology.

Using the online simulation, students work through the evidence that forensic anthropologists used to identify the skeletons found in the two mass graves of the Romanov family members. Students first learn about the Romanov family pedigree to help them determine any features and genetic markers that could help identify the remains. Then they view pictures of the mass graves. After counting the individual skeletons in the grave site, students analyze the remains to identify which skeleton belongs to which member of the royal family. The simulation includes DNA and mitochondrial DNA analysis. These activities aren't necessary for the forensic anthropology aspect of the activity, although they reinforce the idea that forensic scientists use as much evidence as possible when identifying remains.

FIGURE 2

An example of a mock grave site for students to investigate.



Elaborate

Forensic anthropologists work in the real world without carefully constructed and easily explained mass graves. In the penultimate activity, students are challenged to work together to analyze a simulated mass grave (Figure 2) and create a plausible explanation as to what transpired there.

When creating the mass grave site before the lesson, the teacher should use as many bones and skeletons as possible, placing them to appear in mostly random positions to allow for variance in how students interpret the scene, although the teacher may have a rough story in mind. Ideally, the mass grave should be constructed somewhere outside the classroom to make the simulation more surprising and challenging.

Upon entering the scene, students work as a team to process the mass grave and catalog as much evidence as possible. Students should document the scene thoroughly with pictures and measurements before disturbing any of the bones. Then students split into smaller groups to systematically process the bones for clues as to sex, height, age, and presumed lifestyle.

Students then attempt to reconstruct as many individual skeletons or partial skeletons as possible. When photographing and collecting the bones for evidence, students should be reminded of the standard procedures that crime scene investigators use when bagging and tagging evidence. As they work, students use the evidence they collect to create a plausible explanation as to how the remains came to be in the mass grave. Students are encouraged to consult the osteobiographies and field guides they made earlier in the unit and model their efforts after those guided activities.

Evaluate

Students must demonstrate mastery of basic bone identification skills, including differentiation between male and female skeletons, determination of age ranges, and estimation of height before attempting the mass grave simulations. The Romanov investigation steps students through the process of analyzing a mass grave, identifying the individuals, and determining the sequence of events that led to their burial. Each activity in the unit asks students to build upon their previous knowledge while providing an avenue for the teacher to clarify any misunderstandings the students may have.

As a culminating assignment, students must reflect upon their experience in processing the simulated mass grave site. They are asked to explain the strategies they employed to process the scene and the methods they used to analyze the individual bones and skeletons. They must also provide an osteobiography for at least one of the individuals in the mass grave. Using all the knowledge and evidence obtained throughout the unit, students must create a scenario which explains the simulated mass grave.

Supplies

Ideally, realistic models of bones, available from biological supply companies, should be used to create the simulations because these models replicate the details and landmarks forensic anthropologists use to identify bones. If using such models is unrealistic, plastic or cardboard skeletons purchased from a craft store may be substituted. Likewise, photographs of actual mass graves could be used in the final activity instead of a simulated grave site.

Notes

The emphasis for the activity is for students to collect evidence, make a claim, and provide their reasoning for why their explanation is plausible. When guiding students, teachers should not impose one scripted response but should have students rely on their own interpretations of the evidence. Students may even relate their observations to other case studies they have previously studied. A student explanation justified with evidence obtained from the simulation should be considered correct (see "On the web" for a rubric).

Conclusion

Doing the work of a forensic anthropologist allows students to develop several skills and think deeply about evidence. Although aimed at a forensic science class, the activities presented here could be modified for an evolution unit in a biology class. Not unlike a forensic anthropologist, paleontologists and evolutionary biologists must use the evidence they collect from bones to draw conclusions about the lives of the organisms they are studying.

Forensic anthropology relies on observation and interpretation to make sense of evidence that is often incomplete. By investigating a simulated mass grave, students experience a small part of what it is to be a scientist in the field. ■

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On the web

Online simulation: Recovering the Romanovs from DNA: *www.dnai.org/d/index.html*

Rubric, worksheet: *www.nsta.org/highschoolconnections.aspx*

Video documentary that introduces forensic anthropology: *http://bit.ly/secrets-of-the-dead*

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