Create a DNA protocol

What elements are necessary to remove DNA from a cell and in what quantities? What skills are necessary to be a successful group member?

Most Life Science/Biology classes ask students to extract DNA. In this lesson, students create their own protocol, using substances that are provided and described, to extract DNA. However, the framing of this lesson will put students in a job interview simulation where several people will be hired as laboratory technicians, based on how well they perform in a group situation in which their group is tasked with creating a protocol for extracting DNA.

In this lesson, students will be put into groups of 3–4 and create a protocol to extract DNA. They will then present their protocol to the larger group and get feedback about their process and results. Success in DNA extraction is not the only goal, but communication, collaboration and interpersonal skills must be displayed. If the group struggles with these skills, it is doubtful that they would be hired.

Ohio standards

- 8.LS.3: The characteristics of an organism are a result of inherited traits received from parent(s) (and DNA).
- Traits are determined by instructions encoded in deoxyribonucleic acid (DNA), which forms genes.

Biology

- B.C.1: Cell structure and function
- Structure, function and interrelatedness of cell organelles
- B.H.2: Structure and function of DNA in cells

Chemistry

- C.PM.6: Intermolecular forces of attraction

Human Anatomy and Physiology

- AP.LO.1: Hierarchy of organization

Student prior knowledge

Students need to have a grasp of cell membranes and membrane-bound organelles and what substances make up those membranes. They should also know where DNA is located and the structure of DNA within the nucleus.

Suggested timeline

Two 45- to 50-minute class periods

Materials

- DNA extraction cards
- Small quantities of substances described on the DNA extraction cards: vinegar, sugar, pineapple juice, dishwashing liquid, water, salt, oil, baking soda, meat tenderizer, ethanol or isopropyl alcohol
- Filter paper or cheese cloth
- Test tubes or centrifuge tubes
- Test tube rack
- Small cups
- Plant-based food (strawberries, kiwi, or similar)
- Sealable plastic bag
- Funnels
- Wooden splints/tweezers

Teacher preparation

1. Gather all materials.
2. Make copies of student handout and descriptive cards of materials.
3. *Optional:* Create a cell model. Depending on the students' prior knowledge, you may want to review the cell organelles and cell membranes. One way to do this is to create a model of the cell using a box and several materials to show the various structures that will need to be broken down to reach the DNA.
4. Sample materials for a cell model may include:
    - Plastic bag = cell membrane
    - Shredded paper = cytoplasm
    - Smaller sealed plastic bag = nuclear membrane
    - Yarn (tangled) = DNA bundled around histones within the nuclear membrane.

Procedure

1. Prepare students for the activity by discussing interviewing skills. Ask students, have they ever interviewed for a job? What skills might they need in order to have a successful interview? Begin by having them discuss with a partner, then their table group, then open to the entire class to share information from their groups. Be sure they include communication, active listening, collaboration, creativity, flexibility, leadership, and initiative.
2. Invite students to an interview situation in a biotech lab where they will be creating and performing a DNA extraction protocol. Students may need a definition of a protocol:

    Protocols are procedures that are established and adopted by a lab or group of labs in order to produce quality results that can be replicated by others. These procedures include detailed step-by-step instructions to ensure that scientists are doing all the actions necessary to get accurate results. Different labs testing for the same disease may use different protocols based on the equipment and resources available. Protocols are constantly updated based on new technology and/or scientific discoveries.
3. Pass out the materials cards that describe what materials they may use. Give each group 10 minutes to discuss what materials they would like to use. Observe communication patterns within the groups, as perhaps a team of interviewers would.
4. Allow the rest of the period for students to create their protocol. Remind them of the critical elements of a protocol:
    - Recording substances used and quantities of each
    - Recording who completed each step
    - Recording results
    - Recording any redesign
5. At the end of day 1, ask students to fill out an exit ticket to determine how well the group is functioning. Potential questions could be rated on a 3-point Likert scale with 1 = no, 2 = sometimes, 3 = yes, and may include:
    - Everyone had a chance to participate equally in our discussion.
    - Everyone is listening to contributions.
    - Someone in the group is taking over.
    - I am "keeping up" and understanding what our group is doing and why.
    - We have divided the work fairly.
    - I would rate our collaboration as non-existent, OK or Very Good.
    - One improvement I would suggest to improve communication and collaboration is:
6. The following day is for presentation and discussion of each group's protocol. Review ground rules for listening to presentations: each group will present their protocol and results. The other groups will listen attentively with no interruptions until the presentation is complete, then offer feedback.

7. Reminder: success in DNA extraction is not the only goal: communication, collaboration, and interpersonal skills must be displayed. If the group struggled with these skills, it is doubtful that they would be hired.
8. The teacher or other groups are encouraged to give feedback about the protocol process and their results in a supportive and civil manner. Skepticism is allowed and encouraged. Asking why the group chose to use a particular material or method should show critical thinking on the group's part.
9. Once each group has shared their protocol, the goal is to discuss the most successful protocols in order to create a single protocol that the "lab" would adopt to use as its standard operating procedure (SOP).
10. Post-assessment: Ask students to give self-reflective feedback about their experience.
    What do you know now that you didn't know before about how to get DNA out of a cell?
    On a scale of 1–10. 1 is very low, 10 is very high:
    - Rate your current ability to communicate using evidence when talking in your lab group.
    - Rate your current ability to communicate using evidence when talking in large class "lab meeting."
    - What is one way in which you grew in your ability to participate in a class discussion? Be specific. Give an example from the lab group work or meeting if possible.

Suggested wrap-up

Ask students to identify the combination of skills/ characteristics that helped them to successfully navigate the task of extracting DNA while working in a group.

This activity allows students to practice both hard and soft skills that are often needed for successful interviews. Interviewers are looking for specific measurable abilities or knowledge (hard skills) needed for daily lab routines. For example, knowing the function of chemicals and order in the extraction as well as basic cell knowledge helps to minimize mistakes at the lab bench. Interviewers are also looking for the interpersonal skills (soft skills) of the interviewee. Biotech jobs tend to be highly collaborative so employers want to evaluate whether interviewees can effectively communicate with coworkers as well as build positive relationships in the workplace.

Differentiation

This activity is framed as an interview and therefore a competition. Students with differing abilities should be included in the various groupings. Additional support can be provided by giving students the task the night before to help them prepare, reminding them to review the concepts in advance, providing audio/video instructions, etc.

Extensions

An extension of this activity might include collecting the resulting DNA and attempting to use gel electrophoresis to visualize the DNA using DNase, RNase and electrophoresis. The article cited describes the process.

Kosaka, N & Kumano, Y (2022). DNA Extraction: Comparing DNA Using DNase, RNase & Electrophoresis, *The American Biology Teacher,* 84 (8): 467–471. ***doi.org/10.1525/abt.2022.84.8.467***

Support information

- DNA is stored in the nucleus and is bundled around proteins called histones.
- The nucleus is surrounded by a membrane.
- The cell membrane is made of a phospholipids bi-layer.
- DNA can be extracted using a combination of materials that will break down the membranes and precipitate the DNA in solution.

Career connections

- **Biomanufacturing technician:** Analyzes data, use aseptic technique, works in clean rooms to test the purity or quality of products, and more.
- **Laboratory assistant, technician:** Performs lab testing and supplies labs with needed materials.
- **Process development associate or product development associate:** Analyzes process or products in biomanufacturing to make improvements in efficiencies.
- **Quality assurance, Quality control:** Tests products for safety and uniformity.