

**Teacher’s Guide**

**Could Future Vaccines Be Pain-Free?**

***February 2022***

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Activate students’ prior knowledge and engage them before they read the article.

[Reading Comprehension Questions](#_Student_Reading_Comprehension) 3

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[Graphic Organizer 5](#_Graphic_Organizer_1)

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

[Answers 6](#_Answers_to_Reading)

Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

[Additional Resources 8](#_Additional_Resources_1)

Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

[Chemistry Concepts, Standards, and Teaching Strategies 9](#_Chemistry_Concepts,_Standards,)

# Anticipation Guide

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Hypodermic needles and syringes were first used to deliver medicine in the early 20th century.
 |
|  |  | 1. Vaccines introduce material that trains a body’s immune system to produce antibodies to destroy the target virus or bacteria.
 |
|  |  | 1. Antigens interact with antibodies through noncovalent forces such as hydrogen bonding.
 |
|  |  | 1. Vaccines injected into your arm also protect your nose.
 |
|  |  | 1. Vaccines developed for arm injections would also work in intranasal vaccines.
 |
|  |  | 1. There are more immune cells in your muscle than in your skin.
 |
|  |  | 1. One type of microneedle technology uses warm water to dissolve the separator layer above the microneedles.
 |
|  |  | 1. Dissolvable microneedles using sugar and polymer molecules are now undergoing clinical trials in West Africa.
 |
|  |  | 1. Vaccines in microneedle patches can be stored at room temperature.
 |
|  |  | 1. People have been inoculated through the nose and skin for centuries.
 |

# Student ReadingComprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: Use the article to answer the questions below.

1. State some other options for delivering vaccines to the body.

2. What are vaccines composed of that help our bodies fight infections?

3. Briefly explain how antibodies stop viruses.

4. State the 2 types of immunity cells found in our skin.

5. What are some reasons that allow us to believe that skin patches are better than traditional needles for delivering vaccines?

6. State some benefits from microneedles versus regular needles.

7. Explain why arm injections are not very effective for respiratory viruses? What would be more effective?

8. Explain the difference between a covalent force and a non-covalent force.

9. Give at least one example of a chemical that exhibits the following non-covalent forces: Electrostatic force (Hint: ionic), hydrogen bonding, London dispersion force.

10. What is the reason for cells or other substances to exhibit hydrophobic properties?

11. What should medical researchers consider when making and using patches and microneedles in medicine, with regards to health and safety?

12. Why was Pascal’s discovery of liquid pressure useful for the application of syringes and vaccines?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. What are some other uses for patches and microneedles that could help people?

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to compare different types of vaccine delivery methods. Try to find at least two advantages and two disadvantages for each.

|  |  |  |
| --- | --- | --- |
| **Vaccine Delivery Method** | **Advantages** | **Disadvantages** |
| **Needle and Syringe** |  |  |
| **Intranasal** |  |  |
| **Microneedles** |  |  |

**Summary:** On the back of this sheet, write three new things you learned about vaccines.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. Besides using needles, vaccines can be introduced into the body using intanasal sprays and skin patches.

2. To fight infections, vaccines contain weakened or inactive parts of the disease, or genetic instructions to make parts of the disease.

3. Antibodies stop viruses lock onto the viruses and destroy them. They hook on using *noncovalent* forces.

4. The two types of immunity cells in our skin are called dendritic cells and Langerhans cells.

5. Some reasons that we believe skin patches are better are that skin cells contain a lot more immune cells, and that the patches are less painful than needles.

6. Microneedles are better than regular needles because they can keep the vaccine more stable, thus lasting longer. Also, the microneedles are more efficient in delivery, so much less vaccine is needed.

7. Arm injections are not good for respiratory viruses because many times, the virus will replicate in the nose, before it reaches the specific antibodies. Introducing antibodies through the nose will activate the antibodies there, which will attack the virus much quicker.

8. Covalent means sharing of electrons. This is when 2 atoms share electrons between each other (when the electron orbitals of each atom overlap) and create a covalent (chemical) bond. A non- covalent force is an attraction between 2 substances that do not involve sharing of electrons. Typically the attractions tend to occur between opposite charges on the substances.

9. Electrostatic force: Sodium chloride (NaCl)

 Hydrogen bonding: Water

 London dispersion forces: Carbon dioxide

 (answers will vary)

10. Cells need to have hydrophobic properties in order to contain the proteins and other components inside without dissolving in water.

11. (Answers may vary). Many people may have specific skin allergies that could create an adverse reaction to the skin patches and microneedles. Everybody’s skin is different, so the effects may be different for different people. Scientists also need to make sure the dissolving needles do not contain substances that could harm people.

12. Pascal discovered that when pressure was applied on one section of a liquid, the pressure is distributed throughout the liquid. This is because liquid is incompressible. This property of liquids allows vaccine to be “pushed” through a needle to get into the body quickly.

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

# Additional Resources

**Labs and demos**

Under pressure: Hands on activity

<https://www.teachengineering.org/activities/view/cub_dams_lesson03_activity1>

**Simulations and Videos**

Syringe simulation

<https://demonstrations.wolfram.com/PascalsSyringe/>

Intermolecular Forces

<https://teachchemistry.org/classroom-resources/intermolecular-forces-2020>

Pascal’s Pressure with syringes

<https://youtu.be/cAz-YEN2S9Q>

**Projects and extension activities**

Make a Cartesian Diver

<https://sciencebob.com/make-a-cartesian-diver/>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Physical properties
* Intermolecular forces

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

|  |
| --- |
| **HS-PS1-3.** Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.**HS-ETS1-3.** Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. |

**Disciplinary Core Ideas:**

* PS1.A: Structure and properties of matter
* PS2.B: Types of interactions
* ETS1.C: Optimizing the design solution

**Crosscutting Concepts:**

* Stability and change
* Cause and effect
* Systems and system models

**Science and Engineering Practices:**

* Planning and carrying out investigations
* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific knowledge is based on empirical evidence.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students why they think vaccines are usually administered through intramuscular injection. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
	+ As they read, students can find information to confirm or refute their original ideas.

After they read, ask students what they learned about vaccine delivery systems.