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# Understanding Viruses Through 3D Modeling & AR Visualization

BIOS4YOU
AR 2.0

BIO-INSPIRED STEM TOPICS FOR ENGAGING YOUNG GENERATIONS
THANKS TO THE USE OF AUGMENTED REALITY

Project Number: KA220-BW-23-30-126516

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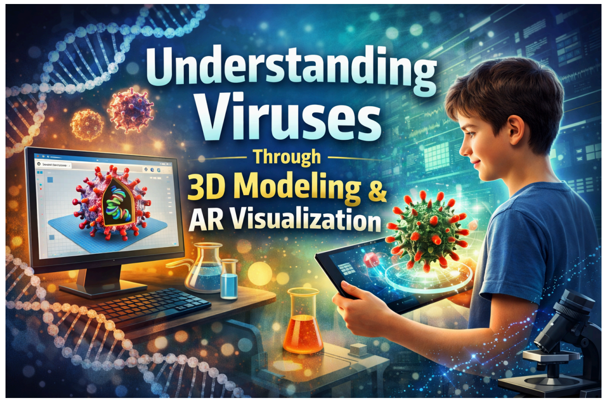


*(Image source: generated with AI tools)*

| | |
|---|---|
| **General topic of the learning path** | Bio-Technology. Human Genome Project and Genomic Medicine |
| **Specific name of the learning unit** | **Understanding Viruses Through 3D Modeling & AR Visualization** |
| **Age of the target users** | 14-18 years |
| **Requirements for the learner** | Basic knowledge of cell biology; ability to use a smartphone, tablet, or PC; basic digital literacy skills |
| **Description of the learning unit** | This learning unit introduces students to viruses within the context of biotechnology and genomic medicine. Learners explore virus structure, genetic material, and classification, and examine how viruses interact with host cells. Through inquiry-based learning, students design virus models using 3D digital tools and visualize them using Augmented Reality (AR). The unit connects biological knowledge with bio-inspired design, digital modeling, and STEM skills, supporting understanding of viruses as both biological agents and biotechnological tools. |
| **Subject: Parties involved** | Biology, Biotechnology, Computer Science, Health Sciences, Genomic Medicine, STEM Education |
| **Keywords** | Viruses, viral genome, biotechnology, genomic medicine, bio-inspiration, 3D modeling, Augmented Reality, STEM learning |

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| **Key qualifications, skills and knowledge that can be acquired** | • Understanding of virus structure, genetic material (DNA/RNA), and basic infection mechanisms<br>• Ability to relate viral structure to biological function<br>• Awareness of the role of viruses in biotechnology and genomic medicine<br>• Bio-inspired and systems thinking<br>• Digital modeling and visualization skills<br>• Spatial reasoning and scientific communication<br>Collaboration and critical thinking |
| **Resources and didactic aids used** | Educational texts and diagrams on virus biology, instructional videos (e.g. Khan Academy), 3D modeling tools (Tinkercad Codeblocks; optional advanced tools such as Blender), AR platforms (Delightex or; alternative AR tools depending on school infrastructure), smartphones, tablets, or computers with internet access. |
| **Assessment criteria and evaluation** | Formative assessment based on student participation, inquiry, collaboration, and progress during modeling activities. Summative assessment based on the accuracy of the 3D virus model, understanding of virus structure and function, clarity of AR-based explanation, presentation quality, and reflective discussion linking virus biology to biotechnology and genomic medicine. |

# Introduction

Viruses are among the smallest biological entities, yet they have a significant impact on human health, ecosystems, and global society. Because viruses are invisible to the naked eye and function at a microscopic level, they are often difficult for students to fully understand using traditional teaching methods. This learning unit introduces viruses through 3D modeling and Augmented Reality (AR), allowing learners to explore virus structures and types in an interactive and visual way. By combining biological knowledge with digital design and AR visualization, students gain a clearer understanding of how virus structure is connected to function, while developing essential STEM and digital skills.

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# Explore

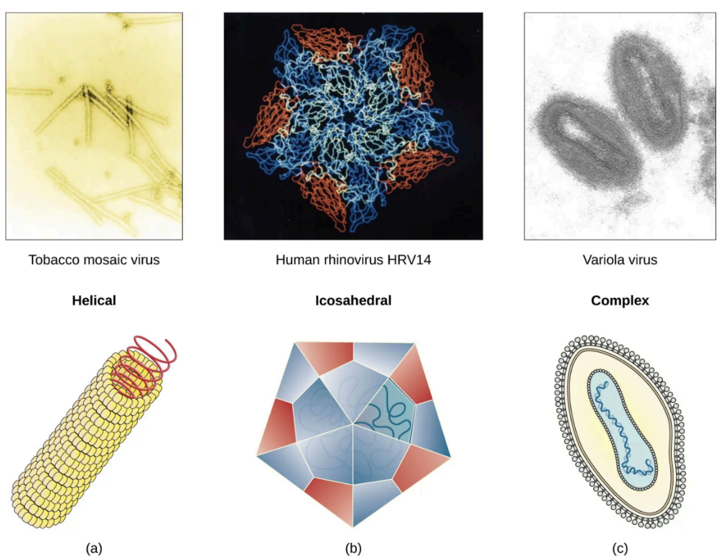
# 1. Foundations of Viruses, Their Parts and Types

In this section, students build the scientific foundation needed to understand what viruses are and why they are unique biological entities. They explore how viral structure relates to function, how viruses replicate using host cells, and how viruses can be classified into different types. This Explore phase prepares learners for the next stages of the unit, where they will model viruses using 3D tools and visualize them in Augmented Reality (AR), transforming invisible biology into interactive learning objects.

### 1.1 What is a Virus?

A virus is a microscopic infectious agent that cannot reproduce independently. Unlike living cells, viruses do not have the full machinery needed to produce energy, grow, or divide. Instead, they must enter a host cell and "use" the host's internal systems to create new virus particles.

Viruses can infect many types of organisms, including animals, plants, fungi, and bacteria. Although simple in structure, viruses can spread efficiently and evolve quickly, which is why they are important in biology, biotechnology, and public health.




1 image.Viruses example. Source:
https://openstax.org/books/biology-2e/pages/21-1-viral-evolution-morphology-and-classification

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**Example:** The influenza virus cannot make proteins on its own. Only after it enters a human cell can it use the cell's machinery to produce new virus particles. This dependency explains why viruses are inactive outside a host.

### 1.2 Virus vs. Cell: Key Differences

To understand viruses, it is helpful to compare them with cells:

- **Cells** are living systems. They have a cell membrane, cytoplasm, and internal structures (organelles in eukaryotic cells). Cells can produce energy and reproduce on their own.
- **Viruses** are not complete living systems. They do not have cytoplasm, organelles, or metabolism. Outside a host cell, a virus is inactive.

This difference explains why viruses are often described as being on the border between living and non-living: they show life-like behavior only *inside* a host cell.

**Example:** A bacterium can live independently in many environments, while a virus infecting that bacterium (a bacteriophage) remains inactive until it finds the correct host.

### 1.3 The Main Parts of a Virus (Structure)

Even though viruses vary widely, many share core structural components:

- **Genetic material (genome):** The "instruction code" of the virus. It can be DNA or RNA. Example Influenza – ssRNA (+): https://microbenotes.com/classification-of-virus/
- **Capsid:** A protective protein shell that surrounds and protects the genome. Capsids often have geometric shapes that help stability and packaging. Example: Adenovirus – icosahedral capsid: https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/General_Biology_2e_(OpenStax)/05:_Unit_V-_Biological_Diversity/5.01:_Viruses/5.1.02:_Viral_Evolution_Morphology_and_Classification
- **Envelope (in some viruses):** A lipid outer layer taken from the host cell membrane. Example: HIV – enveloped with gp120 spikes https://en.wikipedia.org/wiki/Viral_envelope
- **Spikes / surface proteins (in many viruses):** These help the virus recognize and attach to the host cell. Example: SARS-CoV-2 spike protein: https://morgridge.org/community/teaching-learning/virology-immunology/factsheets/virus-structure/

Key idea for students: **Virus structure is not random — each part supports a function** (protection, attachment, entry, replication).

To support visual and conceptual understanding of virus structure, students are encouraged to watch a short educational video explaining the basic biology of viruses. The video clearly

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presents the main parts of a virus, including genetic material, capsid, envelope, and surface proteins, and explains how these components work together during infection. This resource helps learners connect written descriptions with dynamic visual explanations, making complex microscopic structures easier to understand before moving on to 3D modeling and AR activities.

**Recommended video resource:** Khan Academy – *Viruses*
https://www.khanacademy.org/science/biology/biology-of-viruses/virus-biology/v/viruses

## 1.4 How Viruses Infect Cells (Viral Life Cycle – Basics)

A simplified viral life cycle includes these stages:

1. **Attachment:** The virus binds to specific receptors on the host cell surface using spikes or surface proteins.
2. **Entry:** The virus (or its genome) enters the host cell. Enveloped viruses often fuse with membranes; others may enter through endocytosis.
3. **Replication & protein production:** The host cell produces viral genetic copies and viral proteins.
4. **Assembly:** New virus particles are assembled from newly made parts.
5. **Release:** New viruses leave the cell, either by bursting the cell (lysis) or by budding (common in enveloped viruses).

This life cycle explains why viruses depend on hosts and why they can cause damage: viral replication can disrupt normal cell function.

## 1.5 Virus Types: How Can We Classify Viruses?

Viruses can be grouped in different ways. For this unit, students focus on classifications that connect clearly to modeling and AR visualization:

- **By genome type**: DNA viruses (herpesvirus, etc.) vs. RNA viruses (influenza, etc.). (More: https://pmc.ncbi.nlm.nih.gov/articles/PMC7150055/)
- **By envelope**: Enveloped (HIV, influenza, etc.) vs. non-enveloped (poliovirus, norovirus, etc.). More: https://virologyresearchservices.com/2022/05/22/enveloped-vs-non-enveloped-viruses/
- **By shape:** Helical (tobacco mosaic virus – for plants, etc.), icosahedral (adenovirus, etc.), complex (bacteriophage, etc.). More: https://bio.libretexts.org/Bookshelves/Introductory_and_General_Biology/General_Biology_2e_(OpenStax)/05:_Unit_V-_Biological_Diversity/5.01:_Viruses/5.1.02:_Viral_Evolution_Morphology_and_Classification; https://microbenotes.com/classification-of-virus/)

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- **By host:** Animal viruses (HIV, etc.), plant viruses (TMV, etc.), bacteriophages (T4 phage, etc.). More: https://microbenotes.com/classification-of-virus/

These categories are useful because they connect directly to what students will create in 3D: **different shapes, different outer layers, different "surface features."**

## 1.6 Why Do Viruses Matter in Biotechnology and Society?

Viruses are often associated with disease, but their importance extends far beyond causing infections. In modern science and biotechnology, viruses are also used as tools to study biology, develop medical solutions, and understand natural systems.

One important application of viruses is in **vaccines and immune science**. Scientists study viral surface proteins to understand how the immune system recognizes a virus. For example, research on influenza viruses has shown that small changes in viral surface proteins can affect how well vaccines work each year. Similarly, understanding the structure of viral proteins has helped scientists design vaccines that train the immune system to respond more effectively to infection. These examples show why knowing virus structure is essential for protecting human health.

> **Connection to 3D modeling:** When students design spikes or surface proteins on their virus models, they are representing the same structures scientists study when developing vaccines. The size, position, and number of spikes in a 3D model help explain how a virus recognizes and attaches to host cells.

Viruses are also used in **gene therapy and biological research**. In laboratories, modified viruses are commonly used as vectors to deliver genetic material into cells. For instance, harmless versions of viruses are used to introduce new genes into cells so scientists can study how those genes function. In some medical applications, viral vectors are used to deliver therapeutic genes to specific cells, demonstrating how viruses can be redesigned for beneficial purposes.

> **Connection to 3D modeling:** By creating a capsid around the viral genome in a 3D model, students visualize how genetic material is packaged and protected. Modeling the capsid as a geometric structure helps learners understand why shape and symmetry are important for stability and function.

Beyond medicine, viruses play a key role in **evolution and ecosystems**. In marine ecosystems, viruses infect microorganisms such as bacteria and algae, controlling their population sizes. This process helps regulate nutrient cycles in oceans, which are important for global climate balance. Viruses can also transfer genetic material between organisms, contributing to genetic diversity and long-term evolution.

> **Connection to 3D modeling:** When students compare different virus types—such as enveloped and non-enveloped viruses—they can model how structural differences affect

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survival in different environments. For example, adding or removing an envelope in a 3D model helps explain why some viruses are more resistant to environmental conditions than others.

In this learning unit, viruses are used as a clear example of how real scientific knowledge can be transformed into simplified digital representations. By designing virus structures using basic geometric shapes and visualizing them through Augmented Reality, students experience how scientists and engineers use models to study complex systems. This approach connects biology with design, technology, and STEM skills, preparing learners to understand how biological structures inspire innovation in the real world.

### 1.7 Questions for Reflection

1. Why are viruses considered different from living cells?
2. How does a capsid protect the viral genome, and why might its shape matter?
3. What is the difference between enveloped and non-enveloped viruses, and how might that affect transmission or stability?
4. How does “structure → function” help explain why viruses infect specific host cells? Which virus feature do you think would be easiest to represent in a 3D model, and which would be hardest? Why?

# Execute

# 2. Bio-Inspired Virus Modeling Through 3D Design

In the **Execute** phase, students explore how the practical abilities of nature—specifically viral structures—can inspire efficient solutions and designs. Viruses demonstrate how minimal structures can achieve highly effective functions, such as protection, attachment, and replication. These natural strategies are examined and translated into digital models through hands-on activities.

## 2.1 Bio-Inspiration: Learning from Virus Structure and Function

Viruses are examples of highly optimized natural systems. With only a few components, they are able to protect genetic material, recognize host cells, and reproduce efficiently. These abilities inspire students to think about how structure, symmetry, and surface design support function.

Students select a virus type and analyze which natural features are essential for its behavior. They then apply this bio-inspired thinking by recreating these features using simplified geometric forms in **Tinkercad Codeblocks**. This mirrors real scientific modeling, where complex natural systems are reduced to essential functional elements.

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## 2.2 How Augmented Reality Supports the Learning Objectives

Augmented Reality applications, such as **Delightex**, support the main objective of the unit by making invisible biological structures visible and interactive. AR allows students to:

- View virus models at different scales
- Rotate and examine structures from all angles
- Attach labels and explanations directly to model components

These AR features help students understand spatial relationships and functional design in ways that are not possible with static images or textbooks.

## 2.3 Practical Activities and Global Learning Examples

During this phase, students engage in practical, hands-on activities inspired by bio-inspiration approaches used in STEM education worldwide. Similar 3D modeling and AR-based exercises are commonly applied in biology and biotechnology education to help learners understand microscopic systems and communicate scientific ideas visually.

Example activities include:

- Designing a virus model that demonstrates how structure enables attachment and protection
- Modifying surface features to explore how changes affect interaction with host cells
- Presenting the virus model in AR as an educational object, explaining its function to peers

These activities reflect real-world scientific practices, where digital models and AR visualizations are used for research, education, and communication.

# Enhance

# 3. Deepening Understanding Through Augmented Reality

In the **Enhance** phase, Augmented Reality (AR) tools are used to deepen understanding, increase engagement, and support more effective knowledge building. AR is especially valuable for learning about viruses, as these biological entities are microscopic and cannot be directly

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observed. By visualizing virus structures in AR, students are able to explore complex biological concepts in a concrete and interactive way.

## 3.1 How AR Improves Understanding of Viruses

AR technology allows abstract and invisible structures to become visible and manipulable. When students view virus models in AR, they can rotate, zoom, and examine individual components such as the capsid, genome, envelope, and surface proteins. This spatial interaction helps learners understand how virus structure relates to function, reinforcing key biological principles discussed in earlier sections.

By presenting virus models at a human scale, AR reduces cognitive load and supports learners who may struggle with purely symbolic or textbook-based explanations. Complex concepts, such as virus attachment to host cells or differences between virus types, become easier to grasp through direct visual interaction.

## 3.2 Increasing Engagement and Active Learning

AR encourages active participation rather than passive observation. Instead of only reading or watching explanations, students interact with virus models they have created themselves. This sense of ownership increases motivation and engagement, as learners see their own work transformed into an immersive AR experience.

Interactive AR environments also support collaborative learning. Students can discuss their models, compare virus types, and explain design choices to peers. This social interaction strengthens understanding and helps learners develop communication and scientific explanation skills.

## 3.3 Useful AR Tools and Applications

One effective AR tool for this learning unit is **Delightex**, which allows students to import 3D models, place them in real environments, and add labels or explanatory text. Markerless AR functionality enables flexible use in classrooms or at home, using smartphones, tablets, or computers.

Other AR-based educational approaches used worldwide include:

- AR visualization of molecular and biological structures
- Interactive labeling of 3D scientific models
- AR-supported presentations and digital exhibitions

These tools are commonly applied in STEM education to help learners explore systems that are otherwise inaccessible due to scale or complexity.

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## 3.4 Practical Suggestions for Integrating AR into Learning

To strengthen students' connection to the topic and support effective knowledge building, AR can be integrated in several ways:

- Use AR as a **reflection tool**, where students explain virus structure using their AR model
- Combine AR with **formative assessment**, asking learners to identify parts or explain functions
- Encourage students to **compare different virus models** in AR to highlight structural differences
- Use AR presentations as a **final project showcase**, reinforcing learning outcomes

Through these strategies, AR becomes more than a visual aid—it becomes a tool for reasoning, communication, and deeper understanding.

# Conclusion

This learning unit explored viruses as biological systems by combining scientific knowledge with 3D modeling and Augmented Reality. Through the Explore, Execute, and Enhance phases, students developed an understanding of virus structure, function, and classification while actively applying this knowledge in hands-on digital activities. The use of AR tools supported visualization of microscopic structures, increased engagement, and helped connect bio-inspired principles to real-world scientific and technological challenges, encouraging further exploration of biology through STEM and digital innovation.

| Phase | Description |
|---|---|
| **Explore** | - Research and Discovery: Students explore what viruses are, how they differ from living cells, and why their structure is essential for function. They analyze virus parts (genome, capsid, envelope, surface proteins) and learn how viruses infect host cells. |
| | - Content Development: Learners build foundational knowledge through texts, diagrams, and visual examples, developing an understanding of virus types and classification. |
| | - Needs Analysis: Students identify challenges in understanding microscopic and abstract biological structures, recognizing the need for visual and interactive learning tools. |
| **Execute** | - Curriculum Implementation: Students apply biological knowledge by designing virus models using Tinkercad Codeblocks, translating virus structure into simplified 3D representations. |
| | - Interactive Exercises: Learners create, modify, and compare virus models, focusing on bio-inspired principles such as structure–function relationships, symmetry, and efficiency. They prepare models for AR visualization. |

| | |
|---|---|
| | - Feedback Collection: Students receive peer and teacher feedback through discussion, model presentation, and reflection on design choices and biological accuracy. |
| **Enhance** | - AR Integration: Students import their 3D virus models into Delightex and visualize them using Augmented Reality. AR makes microscopic virus structures visible at a human scale. |
| | - Interactive Learning: Learners interact with AR models by rotating, zooming, labeling, and explaining virus parts, strengthening spatial understanding and conceptual clarity. |
| | **Gamified Content:**<br>● Points and Badges: Awarded for correctly modeled virus structures and clear explanations.<br>● Leaderboards: Optional class-based rankings to encourage motivation.<br>● Quests and Levels: Students progress from basic virus structures to more complex virus types.<br>● Rewards for Exploration: Bonus tasks for discovering additional virus features or comparisons.<br>● Collaborative Gamified Tasks: Group challenges to design and explain different virus types. |
| | **AR-Based Assessments:** Students demonstrate understanding by explaining virus structure and function using their AR models, identifying parts, and reflecting on how structure supports infection and survival. |

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AI-based tools (ChatGPT, Perplexity AI, and NotebookLM) were used to support content drafting, research synthesis, and organization of source materials during the development of this learning unit:


- OpenAI. *ChatGPT* (large language model). https://chat.openai.com
- *Perplexity AI* [AI-powered search and research assistant]. https://www.perplexity.ai
- Google *NotebookLM* [AI-powered research and note-taking tool]. https://notebooklm.google.com

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