

THE OCTOPUS — THE SMARTEST ALIEN ON EARTH

Bloom's Level: Analyze

Standard:

NGSS MS-LS1-3 — Develop Models of Organisms

NGSS MS-LS4-2 — Analyze Evidence of Evolution

TEKS §112.18(b)(11)(A) — Biodiversity and Ecosystem Sustainability

STUDENT EDITION



An octopus changes its skin color and texture in milliseconds using specialized cells called chromatophores, iridophores, and papillae — all without a centralized command.

The Octopus — The Smartest Alien on Earth

What If Intelligence Looked Nothing Like Ours?

Imagine an animal that can unscrew a jar from the inside, recognize the face of a specific human researcher, and change the color and texture of its skin in less than a second — all while having no bones, no centralized brain as we know it, and blood that runs blue. This is not science fiction. This is the octopus, and scientists semi-seriously describe it as the closest thing to alien intelligence ever discovered on Earth.

To understand why, we need to break down what makes an octopus so radically different — and what that difference reveals about the very nature of intelligence itself.

A Body Built Unlike Anything Else

Three Hearts, Blue Blood, and Nine Brains

Start with the basics: octopus biology is extraordinary. An octopus has **three hearts**. Two pump blood to the gills; one pumps it to the rest of the body. When an octopus swims, that third heart actually stops beating — which is why octopuses prefer crawling. They literally get winded from swimming.

Their blood is blue because it uses **hemocyanin** (a copper-based molecule) to carry oxygen, instead of the iron-based hemoglobin that makes our blood red. Copper works better in cold, low-oxygen environments like the deep ocean — a clear example of how structure supports function.



An octopus changes its skin color and texture in milliseconds using specialized cells called chromatophores, iridophores, and papillae — all without a centralized command.

Now for the most mind-bending part: the octopus nervous system. An octopus has approximately **500 million neurons** — roughly the same as a dog. But here's what makes it alien: only about one-third of those neurons are in the central brain. The other **two-thirds are distributed across its eight arms**. Each arm contains its own cluster of neurons, called a **ganglion**, that can process information and direct movement independently of the central brain.

This is called a **distributed nervous system**. The table below contrasts it directly with the human nervous system:

Feature	Human Nervous System	Octopus Nervous System
Neuron location	Nearly all in brain/spinal cord	1/3 brain, 2/3 in arms
Control style	Centralized	Distributed
Arm/limb autonomy	None — limbs follow brain commands	Each arm processes and reacts independently
Total neurons	~86 billion	~500 million

This means each arm can taste, touch, and react to its environment on its own almost like eight semi-independent agents working under one commander. The difference between these two systems is fundamental, and examining it helps us understand why octopus behavior can seem so surprisingly flexible.

What the Arms Can Do Alone

Semi-Independent Processing in Action

Researchers have discovered that if an octopus arm is severed (which can happen in the wild), it will continue reaching, grasping, and responding to stimuli for up to an hour. It is important to be precise here: the arm is not thinking or conscious — it does not have feelings, intentions, or awareness. What it is doing is processing sensory input and executing motor responses through its local ganglion, without any instruction from the brain.

This distinction matters. When a central brain sends a general command — "reach for that crab" — the arm figures out how to do it on its own, bending around obstacles and adjusting grip strength without waiting for further instructions.

Scientists compare this to the way your gut has its own nervous system (the enteric nervous system), but in the octopus, this distributed control is far more sophisticated.

Problem-Solving and Cognition: What Research Reveals

Examining the Evidence of Intelligence

Scientists have run controlled experiments to examine octopus cognition. In one well-known study, octopuses were placed in tanks with sealed jars containing food. Not only did they learn to unscrew the lids — they did so faster with each trial, demonstrating **learning and memory**. Some individuals figured out the task in under five minutes.

In another experiment, octopuses at a Seattle aquarium were shown to consistently squirt water at a specific light bulb that annoyed them — targeting the same bulb, repeatedly, even when staff changed. This suggests not just reaction, but **recognition and intentional behavior**.

Perhaps most striking: octopuses at a research facility in Naples, Italy, were shown to recognize individual human faces and behave differently toward people they liked versus those who had treated them unpleasantly. They were differentiating between individuals — a cognitive skill once thought to require a much larger, more centralized brain.

Camouflage at the Cellular Level

How Skin Becomes a Screen

Octopus camouflage is not just color change — it is a full-body display system controlled at the level of individual skin cells. Three types of cells work together:

- **Chromatophores** — pigment-filled sacs that expand or contract to show or hide color
- **Iridophores** — cells that reflect light and create iridescent shimmer
- **Papillae** — tiny muscle-controlled bumps that change skin texture, mimicking rocks, coral, or sand

The entire display can shift in **under 200 milliseconds** — faster than a human blink. And here's the twist: octopuses are colorblind. Scientists are still debating exactly how they match colors so precisely. One hypothesis involves light-sensing proteins in the skin itself, meaning the skin may "see" independently of the eyes.

What Does "Intelligence" Even Mean?

Reexamining a Human-Centered Idea

When we compare octopus cognition to human or mammal intelligence, we're forced to examine our assumptions. Intelligence is often defined by traits like problem-solving, memory, and social recognition — and octopuses check every box, using a completely different biological architecture.

Octopuses and vertebrates (like us) last shared a common ancestor over **500 million years ago** — before complex brains even existed. That means complex intelligence evolved twice, independently, along completely separate paths. This is called **convergent evolution**, and it's powerful evidence that intelligence may be a solution the universe keeps arriving at — just wearing very different shapes.

It is also worth noting that octopuses face serious threats in the wild, including habitat loss, ocean warming, and overfishing. Understanding how remarkable these animals are is one reason marine biologists argue strongly for their conservation — and why many countries now include octopuses in animal welfare protections for research.

Summary

The octopus challenges us to break apart everything we think we know about minds, bodies, and intelligence. Its distributed nervous system, semi-independent (but not conscious) arms, rapid camouflage, and proven problem-solving abilities are not just fascinating facts — they are evidence of a radically different evolutionary path to complex cognition. By examining how octopus structures function and comparing them to our own, we gain a clearer picture of what life — and intelligence — can look like across the tree of life.

LESSON OBJECTIVE

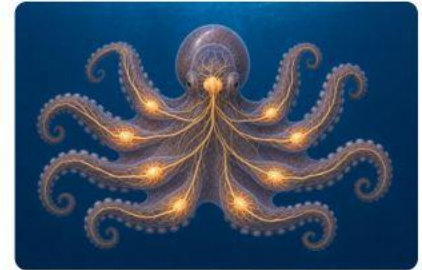
In this lesson, you will analyze how the octopus's unique body structures — including its distributed nervous system, three hearts, and specialized skin cells — work together to support its life functions and behaviors. You will compare the octopus nervous system to the human nervous system and examine scientific evidence to explain how complex intelligence can evolve along completely different biological paths. By the end, you will be able to break down how structure and function are connected in a radically different organism and draw conclusions about what that reveals about the nature of intelligence itself.

Standard: NGSS MS-LS1-3; NGSS MS-LS4-2; TEKS §112.18(b)(11)(A)

Bloom's Level: Analyze

Bloom's Goal: Students will analyze how the octopus's distributed nervous system and specialized structures provide evidence for convergent evolution and challenge human-centered definitions of intelligence.

Explanation: Analyzing requires students to break down complex information into parts and examine how those parts relate to each other and to broader concepts. Here, students will compare biological systems, interpret experimental evidence, and draw reasoned conclusions about structure, function, and evolutionary patterns — going beyond simply recalling facts to building a deeper understanding of why these differences matter.



Unlike humans, an octopus keeps two-thirds of its neurons in its arms — each arm can sense, react, and move semi-independently of the central brain, though the arms themselves are not conscious or self-aware.

APPLICATION QUESTIONS

Read each question carefully, use evidence from the article to support your thinking, and write your answer in complete sentences.

1. An octopus arm that has been severed can still reach, grasp, and respond to stimuli for up to an hour. How does this behavior demonstrate the difference between a distributed nervous system and a centralized nervous system? What does this tell you about how the octopus's body structure supports its function?

Think about: Think about where the neurons in an octopus are located compared to where human neurons are located. What does it mean for an arm to process information on its own, and how is that different from what a human arm can do?

2. The article states that octopuses and vertebrates last shared a common ancestor over 500 million years ago, yet both groups evolved complex intelligence. What does this pattern of convergent evolution suggest about the relationship between intelligence and survival? Use specific evidence from the article to support your analysis.

Think about: Think about what convergent evolution means — two separate lineages arriving at similar solutions. Why might intelligence keep evolving independently? What problems does it help organisms solve?

3. Octopuses are colorblind, yet they can match colors and textures with remarkable precision in under 200 milliseconds. Analyze how the three types of skin cells — chromatophores, iridophores, and papillae — work together as a system, and explain why the hypothesis about light-sensing proteins in the skin is significant to our understanding of how octopus structures function.

Think about: Think about what each type of skin cell does on its own, and then think about what they accomplish together. If the skin can sense light independently of the eyes, what does that suggest about how the octopus's body is organized?

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DATA TABLE & ANALYSIS

Study the data table below, which compares key structural and functional features of the human and octopus nervous systems and bodies. Use the data to answer the three analysis questions that follow. Support your answers with specific evidence from the table.

Experiment: Scientists have compared the nervous systems and biological structures of humans and octopuses to understand how different body plans can support complex behavior and intelligence. The data below is drawn from research findings described in the lesson article on octopus biology and cognition. Use this information to analyze how structure relates to function in two very different organisms.

Feature (N/A)	Human (N/A)	Octopus (N/A)	Functional Significance (N/A)
Total neurons	~86 billion	~500 million	Reflects overall nervous system complexity
Neuron distribution	Nearly all in brain and spinal cord	1/3 in central brain; 2/3 in arms	Determines whether control is centralized or distributed
Control style	Centralized	Distributed	Affects how quickly and independently body parts can respond
Limb autonomy	None — limbs follow brain commands	Each arm processes and reacts independently	Allows arms to react to stimuli without waiting for brain instructions
Number of hearts	1	3	Two pump blood to gills; one pumps to the rest of the body
Oxygen-carrying molecule in blood	Hemoglobin (iron-based)	Hemocyanin (copper-based)	Copper works better in cold, low-oxygen deep-ocean environments

Feature (N/A)	Human (N/A)	Octopus (N/A)	Functional Significance (N/A)
Skin color-change speed	N/A	Under 200 milliseconds	Faster than a human blink; used for camouflage and communication
Last common ancestor with humans	N/A	Over 500 million years ago	Indicates intelligence evolved independently along separate evolutionary paths

1. Compare the neuron distribution in humans and octopuses. How does the octopus's distributed nervous system give its arms a functional advantage that a centralized system like the human nervous system cannot provide?

2. The octopus uses hemocyanin instead of hemoglobin to carry oxygen. Based on the data table and the lesson, explain how this structural difference is an example of structure supporting function in a specific environment.

3. The octopus and humans last shared a common ancestor over 500 million years ago, yet both show complex problem-solving and cognition. What does this tell you about the relationship between brain structure and intelligence? Use evidence from the table to support your reasoning.

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HYPOTHESIS BUILDER

Read the context below carefully. Then complete each component to build a scientific hypothesis about octopus intelligence and nervous system structure. Use evidence from what you have learned to support your reasoning.

Scientists have observed that octopuses with a distributed nervous system — where two-thirds of their neurons are located in their eight arms rather than in a central brain — are able to solve problems like unscrewing jar lids, recognize individual human faces, and react to their environment quickly. Researchers want to investigate whether the number of neurons located in an animal's arms (rather than in a central brain) affects how independently and efficiently the animal can respond to physical obstacles without waiting for instructions from the brain. They plan to compare response times and success rates when octopus arms navigate a maze-like obstacle course with and without a direct signal pathway to the central brain.

Independent Variable

What is the one factor the researchers are changing or comparing in this experiment? Think about what is different between the two test conditions involving the nervous system.

Dependent Variable

What will the researchers measure or observe to determine the outcome of the experiment? Consider what data they would collect to compare the two conditions.

If

Write the 'If' part of your hypothesis by stating the condition being tested. Begin with 'If the number of neurons distributed in the octopus arms...' and describe what is being manipulated.

Then

Write the 'Then' part of your hypothesis by predicting what will happen to the dependent variable. What do you expect the researchers will observe or measure as a result?

Because

Explain the scientific reasoning behind your prediction. Use what you know about distributed nervous systems, ganglia in octopus arms, and how arm neurons process information independently to justify your 'Then' statement.

CLAIM-EVIDENCE-REASONING (CER)

Read the phenomenon below carefully. Then complete each component of the Claim-Evidence-Reasoning (CER) framework by responding to the guiding prompt. Your responses should be grounded in scientific knowledge from the lesson.

Phenomenon: Scientists studying octopuses have observed that a severed octopus arm will continue to reach, grasp, and respond to stimuli for up to an hour after being separated from the body. Additionally, octopuses have demonstrated the ability to unscrew jar lids, recognize individual human faces, and change skin color and texture in under 200 milliseconds — all using a nervous system where two-thirds of the neurons are located in the arms rather than the central brain.

Claim

Based on the phenomenon described above, make a claim: How does the octopus's distributed nervous system support its ability to survive and respond to its environment? Write a clear, testable statement that answers this question.

Evidence

Identify at least two specific pieces of scientific evidence from the lesson that support your claim. Describe what was observed or measured in each example, and explain how each piece of evidence connects to the structure of the octopus nervous system.

Reasoning

Using your knowledge of how structure relates to function in living organisms, explain WHY the distributed nervous system allows the octopus to behave the way it does. How does having neuron clusters (ganglia) in each arm — rather than relying entirely on a central brain — give the octopus a functional advantage? Connect your reasoning to the concept of convergent evolution if applicable.

CLOSE READING PASSAGE

Read the passage carefully. Then answer the five questions that follow. Use evidence from the text to support your responses. Pay attention to how the author organizes information and chooses specific words and examples.

The Octopus — A Distributed Mind

An octopus has approximately 500 million neurons — roughly the same as a dog. But here's what makes it alien: only about one-third of those neurons are in the central brain. The other two-thirds are distributed across its eight arms. Each arm contains its own cluster of neurons, called a ganglion, that can process information and direct movement independently of the central brain. This is called a distributed nervous system. Each arm can taste, touch, and react to its environment on its own — almost like eight semi-independent agents working under one commander. Researchers have discovered that if an octopus arm is severed, it will continue reaching, grasping, and responding to stimuli for up to an hour. The arm is not thinking or conscious — it does not have feelings or awareness. What it is doing is processing sensory input and executing motor responses through its local ganglion, without any instruction from the brain. When a central brain sends a general command — 'reach for that crab' — the arm figures out how to do it on its own, bending around obstacles and adjusting grip strength without waiting for further instructions.

1. According to the passage, what is a ganglion, and what role does it play in an octopus's nervous system? **[Comprehension]**

2. What happens when an octopus arm is severed, and what is the author careful to clarify about this behavior? **[Comprehension]**

3. Based on the passage, why might a distributed nervous system be an advantage for an octopus hunting prey in a complex environment? Use evidence from the text to support your reasoning. **[Inference]**

4. The author compares the octopus's arms to "eight semi-independent agents working under one commander." What does this comparison suggest about the relationship between the octopus's central brain and its arms? **[Inference]**

5. Why does the author include the clarification that a severed octopus arm "is not thinking or conscious" and "does not have feelings or awareness"? How does this choice affect the reader's understanding of the distributed nervous system? [Craft]

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CASE STUDY

Read the scenario below carefully. Then answer all three questions using evidence from the scenario and what you have learned about octopus biology, nervous systems, and evolution.

Scenario: Dr. Reyes is a marine biologist studying octopus behavior at a research aquarium. She places a common octopus, which she has named Ink, in a tank with several sealed jars containing shrimp. Over five days, she records how long it takes Ink to unscrew each jar. On day one, Ink takes 18 minutes. By day five, Ink opens the jar in under three minutes. Dr. Reyes also notices that when she enters the room, Ink swims toward the glass, but when her assistant — who accidentally dropped a net on Ink during week one — enters, Ink retreats to a corner and changes color. During one feeding session, Dr. Reyes watches Ink extend a single arm into a narrow crevice to retrieve a piece of shrimp. The arm bends around two corners without Ink appearing to look at it or adjust its body position. Dr. Reyes notes that the arm seems to navigate the space on its own. She also observes that Ink's skin shifts from smooth to bumpy in less than a second when placed near a piece of textured coral. Dr. Reyes is preparing a report arguing that Ink's behaviors provide strong evidence of both advanced cognition and a uniquely distributed body structure.

1. Analyze the evidence from Ink's jar-opening trials. What do the improving times across five days suggest about Ink's cognitive abilities, and how does this compare to what scientists have found in controlled octopus studies?

2. When Ink's arm navigated the crevice independently, Dr. Reyes suspected this was due to Ink's distributed nervous system. Analyze how the structure of an octopus's nervous system explains this behavior, and explain why this is different from how a human limb works.

3. Ink behaves differently toward Dr. Reyes than toward her assistant, and Ink's skin changes texture near coral. Analyze what these two behaviors together reveal about how octopus body structures support survival, and connect this to the concept of convergent evolution.

MULTIPLE CHOICE

Read each question carefully and select the best answer from the choices provided. Each question has only one correct answer.

1. An octopus arm that has been severed continues to reach and grasp for up to an hour. What does this evidence best support about the octopus nervous system?
 - A. Each arm has its own local ganglion that can process sensory input and direct movement without the central brain.
 - B. The octopus central brain continues to send signals to the arm through the bloodstream after separation.
 - C. The severed arm is conscious and capable of independent thought and decision-making.
 - D. Octopus arms are controlled entirely by reflex arcs located in the spinal cord.
2. Octopuses and vertebrates last shared a common ancestor over 500 million years ago, yet both evolved complex intelligence. What conclusion can best be drawn from this evidence?
 - A. Octopuses must have inherited their intelligence directly from early vertebrate ancestors.
 - B. Complex intelligence can evolve independently along separate evolutionary paths, a process called convergent evolution.
 - C. Intelligence only evolves in animals that have centralized nervous systems like vertebrates.
 - D. The shared ancestor already possessed the same level of intelligence seen in modern octopuses.

3. Compare the human nervous system to the octopus nervous system. Which statement best analyzes a key structural difference and its effect on function?

- A. Humans have fewer total neurons than octopuses, which is why octopuses are more intelligent overall.
- B. Both humans and octopuses use a distributed nervous system, but octopuses have more neurons in their spinal cord.
- C. In humans, nearly all neurons are centralized in the brain and spinal cord, while in octopuses two-thirds of neurons are distributed across the arms, allowing each arm to react independently.
- D. Octopuses rely entirely on their central brain for all movement, just like humans, but their brain is located in their mantle instead of their head.

4. Octopuses use hemocyanin instead of hemoglobin to carry oxygen in their blood. Analyzing the relationship between structure and function, why is this an advantage for octopuses?

- A. Hemocyanin carries more oxygen than hemoglobin in warm, oxygen-rich environments near the surface.
- B. Hemocyanin is copper-based and works better in cold, low-oxygen environments like the deep ocean.
- C. Hemocyanin allows octopuses to breathe air directly, reducing their dependence on dissolved oxygen.
- D. Hemocyanin makes octopus blood lighter, which helps them swim faster to escape predators.

5. In experiments, octopuses learned to unscrew jar lids faster with each trial. Which of the following best analyzes what this pattern of behavior demonstrates?

- A. Octopuses have instinctive knowledge of how to open containers because they encounter them in the wild.
- B. The improvement over trials is evidence of learning and memory, not just random trial-and-error behavior.
- C. Octopuses can only solve problems when food is involved, showing that their intelligence is purely instinctual.
- D. The faster unscrewing times prove that octopuses have a larger brain relative to body size than any other invertebrate.

6. Three types of skin cells — chromatophores, iridophores, and papillae — work together in octopus camouflage. How does analyzing the role of each cell type help explain the octopus's ability to blend into its environment?

- A. Chromatophores control texture, iridophores control movement, and papillae control color, together producing a complete disguise.
- B. All three cell types produce pigment, and together they create a wider range of colors than any single cell type could alone.
- C. Chromatophores show or hide color through pigment sacs, iridophores create iridescent shimmer by reflecting light, and papillae change skin texture to mimic surfaces like rock or coral.
- D. Papillae detect light from the environment and send signals to chromatophores and iridophores, which then adjust color automatically.

7. Octopuses at a research facility recognized individual human faces and behaved differently toward people who had treated them unpleasantly. What does this evidence suggest about octopus cognition?

- A. Octopuses have the same type of social brain structure as primates, which explains their ability to recognize faces.
- B. Octopuses can differentiate between individual humans, a cognitive skill that does not require a large, centralized brain.
- C. Face recognition in octopuses is purely instinctual and does not involve any form of memory or learning.
- D. This behavior proves that octopuses are more intelligent than dogs because dogs cannot recognize human faces.

8. An octopus's third heart stops beating when it swims, which is why octopuses prefer crawling. What does this structural detail reveal about the relationship between body structure and behavior?

- A. The third heart is unnecessary for survival, so its stopping during swimming has no effect on the octopus.
- B. The circulatory system's limitation during swimming creates a functional disadvantage that influences the octopus's preferred method of movement.
- C. Octopuses evolved to swim primarily because crawling puts too much strain on all three hearts at once.
- D. The stopping of the third heart during swimming increases oxygen delivery to the muscles, making swimming more efficient.

9. Scientists hypothesize that octopus skin may contain light-sensing proteins that allow it to 'see' color independently of the eyes. If this hypothesis is correct, what would it suggest about how octopuses achieve precise color matching despite being colorblind?

- A.** It would suggest that the eyes send color information directly to the skin cells through a dedicated nerve pathway.
- B.** It would suggest that color matching is controlled entirely by the central brain using information from the environment.
- C.** It would suggest that the skin itself can detect light and color information, allowing camouflage to be coordinated without relying solely on the eyes.
- D.** It would suggest that octopuses are not actually colorblind and that earlier research on their vision was incorrect.

10. Marine biologists argue that understanding how remarkable octopuses are supports the case for their conservation. Which of the following best analyzes the connection between octopus biology and the importance of protecting them?

- A.** Because octopuses are colorblind, they are especially vulnerable to habitat changes caused by ocean warming and need extra protection.
- B.** Octopuses' unique biological structures and demonstrated cognitive abilities make them scientifically valuable, and their loss to threats like habitat destruction and overfishing would eliminate an irreplaceable example of independently evolved intelligence.
- C.** Octopuses should be protected mainly because they are the only invertebrates capable of learning, making them more important than other marine species.
- D.** Conservation efforts for octopuses are important primarily because they are a major food source for humans in many parts of the world.

TRUE / FALSE

Read each statement carefully. Write T if the statement is true or F if the statement is false based on what you have learned about octopus biology, nervous systems, and evolution.

1. An octopus has three hearts, and all three pump blood to the gills.
 True False
2. Approximately two-thirds of an octopus's neurons are located in its eight arms rather than in its central brain.
 True False
3. A severed octopus arm can continue responding to stimuli because it is conscious and capable of independent thought.
 True False
4. Octopus blood appears blue because it uses a copper-based molecule called hemocyanin to carry oxygen instead of iron-based hemoglobin.
 True False
5. The fact that octopuses and vertebrates evolved complex intelligence separately along different evolutionary paths is an example of convergent evolution.
 True False
6. Octopuses can change both the color and texture of their skin, and this entire display can shift in under 200 milliseconds.
 True False

7. Because octopuses are colorblind, scientists have concluded that their skin cells play no role in detecting light or color.

- True False

8. Research experiments showing that octopuses learned to unscrew jar lids faster over multiple trials provide evidence of learning and memory.

- True False

9. Octopuses and vertebrates last shared a common ancestor approximately 500 million years ago, before complex brains had evolved.

- True False

10. The distributed nervous system of an octopus functions the same way as the centralized nervous system of a human, because both systems produce intelligent behavior.

- True False

VOCABULARY

Study each term and its definition below. These words are key to understanding the octopus and how its unique structures and behaviors connect to broader ideas about intelligence and evolution. As you read, look for how each term relates to the others.

distributed nervous system

A nervous system in which neurons are spread throughout the body rather than concentrated in one central brain, allowing different body parts to process information independently.

Explain in your own words:

ganglion

A cluster of nerve cells located in each octopus arm that can process sensory information and control movement without instructions from the central brain.

Explain in your own words:

hemocyanin

A copper-based molecule in octopus blood that carries oxygen and gives the blood its blue color, functioning similarly to the iron-based hemoglobin in human blood.

Explain in your own words:

convergent evolution

The process by which two unrelated species independently evolve similar traits or abilities, such as complex intelligence developing separately in octopuses and vertebrates.

Explain in your own words:

chromatophores

Pigment-filled skin cells in octopuses that expand or contract to show or hide color, playing a key role in rapid camouflage.

Explain in your own words:

iridophores

Specialized skin cells in octopuses that reflect light to create an iridescent shimmer, contributing to the animal's complex camouflage display.

Explain in your own words:

papillae

Tiny muscle-controlled bumps on an octopus's skin that can change texture to mimic surfaces like rocks, coral, or sand.

Explain in your own words:

cognition

The mental processes involved in gaining knowledge and understanding, including problem-solving, memory, and recognition, which scientists study in octopuses through controlled experiments.

Explain in your own words:

neurons

Specialized cells that transmit information throughout the nervous system; an octopus has about 500 million, with two-thirds located in its arms rather than its brain.

Explain in your own words:

camouflage

The ability of an octopus to rapidly change both the color and texture of its skin to blend into its surroundings, controlled at the level of individual skin cells.

Explain in your own words:

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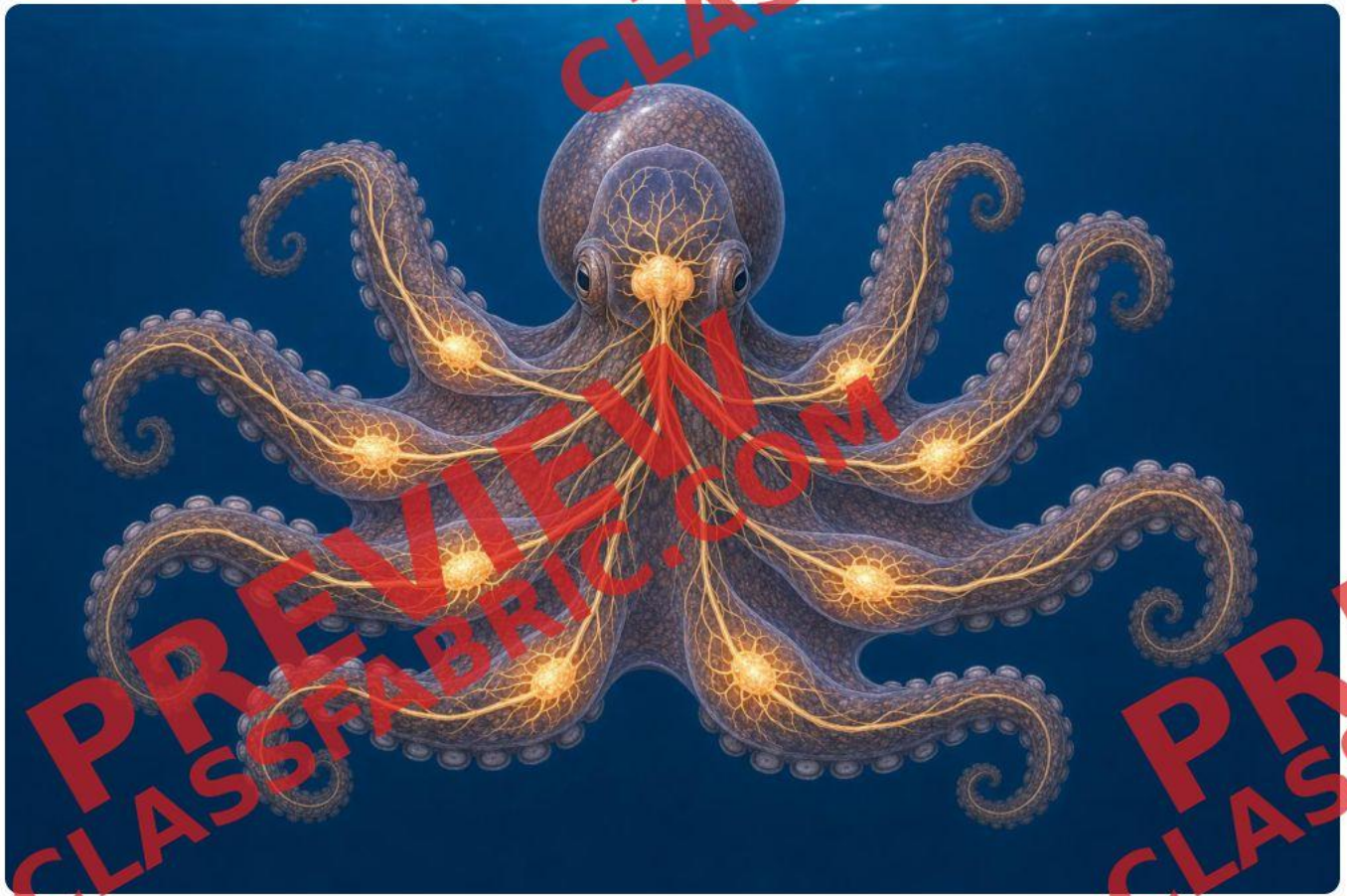
Answer both questions below in 1-2 sentences each. Use evidence from the lesson to support your answers.

1. An octopus has two-thirds of its neurons distributed across its eight arms rather than in its central brain. Analyze how this distributed nervous system helps explain why a severed octopus arm can still reach and grasp objects on its own.

2. Octopuses and vertebrates last shared a common ancestor over 500 million years ago, yet both groups evolved complex intelligence. Analyze what this pattern of convergent evolution suggests about intelligence as a biological solution.



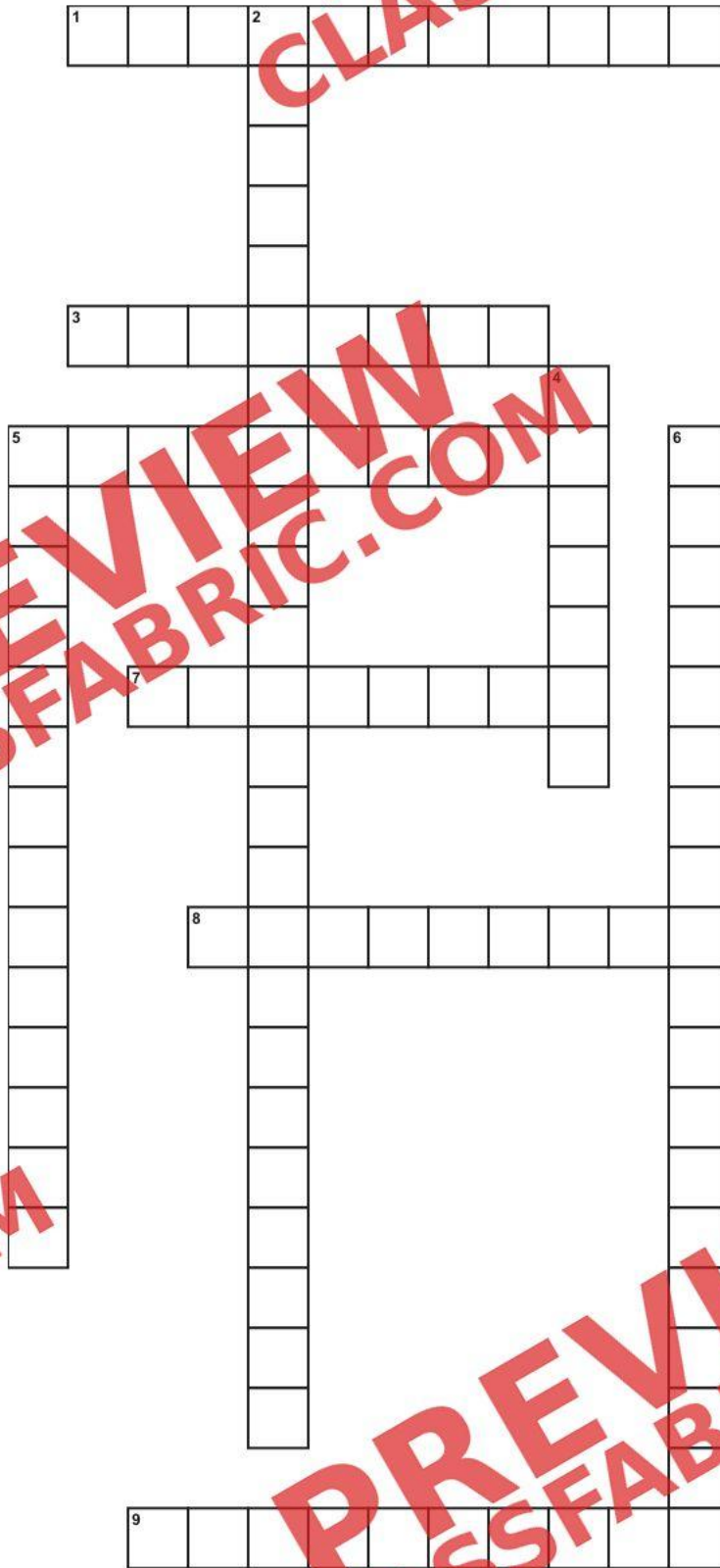
An octopus changes its skin color and texture in milliseconds using specialized cells called chromatophores, iridophores, and papillae — all without a centralized command.



Unlike humans, an octopus keeps two-thirds of its neurons in its arms — each arm can sense, react, and move semi-independently of the central brain, though the arms themselves are not conscious or self-aware.

The Octopus — The Smartest Alien on Earth

CROSSWORD PUZZLE



The Octopus — The Smartest Alien on Earth

CROSSWORD PUZZLE

ACROSS

1. Specialized skin cells in octopuses that reflect light to create an iridescent shimmer, contributing to the animal's complex camouflage display.
3. Tiny muscle-controlled bumps on an octopus's skin that can change texture to mimic surfaces like rocks, coral, or sand.
5. The ability of an octopus to rapidly change both the color and texture of its skin to blend into its surroundings, controlled at the level of individual skin cells.
7. A cluster of nerve cells located in each octopus arm that can process sensory information and control movement without instructions from the central brain.
8. The mental processes involved in gaining knowledge and understanding, including problem-solving, memory, and recognition, which scientists study in octopuses through controlled experiments.
9. A copper-based molecule in octopus blood that carries oxygen and gives the blood its blue color, functioning similarly to the iron-based hemoglobin in human blood.

DOWN

2. A nervous system in which neurons are spread throughout the body rather than concentrated in one central brain, allowing different body parts to process information independently.
4. Specialized cells that transmit information throughout the nervous system; an octopus has about 500 million, with two-thirds located in its arms rather than its brain.
5. Pigment-filled skin cells in octopuses that expand or contract to show or hide color, playing a key role in rapid camouflage.
6. The process by which two unrelated species independently evolve similar traits or abilities, such as complex intelligence developing separately in octopuses and vertebrates.

The Octopus — The Smartest Alien on Earth

WORD SEARCH

D I S T R I B U T E D N E R V O U S S Y S T E M Y
A H F S B V Y I G X W H O X Y B G K P P U A D J Q
K T H P R X T W A Z T T B P U T I N B R J R W I J
M U M R F Y M Y T K O K D T S H J I R A L R G O A
K I N E U R O N S X E J J T K V P E P P W E Y P E
W J D D V A J V S O Z G X Q F V A U E R Y Q Q T K
V T A C H R O M A T O P H O R E S D L N B W X O O
U U B D C W Z M P K Y F S C R R V O O Y X R J Y Z
Q V I F V G D P E P P L K U Y T S Q P U D S D J O
Y W J Z C O N V E R G E N T E V O L U T I O N I C
U Y Y H Q C I R C V U A N A M O S Y M T R H I N G
O O H G Q O H C A M O U F L A G E S Q W X O Q T X
V Q U A K G B Z R I R Y R C C U N Q M Q P O E O U
I B I N C N L W B D V L A Z Y V U N B V A R N L A
R Q E G Z I I Y Z U R Q I W C T W U P Z P H W W R
I K L I R T X F Z V Z T P T F I T E X W I R N N V
D D F I W I G F R M Q D V C A J X I S F L Q J B N
O B C O M O E F M Y T N L X F N U W B J L K M X F
P K N N K N W M R O V K R N V B W W S U A H Q U K
H X C V R C U M G A W E F X M Y F C X V E N B B H
O Q T J X R O K Q G M T E Z P H C I Q Q Z R M P W
R U O N O M K V H E M O C Y A N I N F N J J E G T
E I M R V R F T Y E H S J L L E T H I J Z C C F Z
S X W H R P Z A I G O O D V E Z C R V A R E X H Y
F V J N S L H F G X F O N X Z O R C I C F J N T P

FIND THESE WORDS

ganglion
chromatophores
neurons

convergent evolution
hemocyanin
distributed nervous system

cognition
camouflage

iridophores
papillae