

Base your answers to questions 1 through 6 on the information below and on your knowledge of biology.

Coral Reefs

Coral reefs are important marine ecosystems that support more species per unit area than any other marine environment. Reefs protect coastlines from storms and erosion, provide communities with food and have the potential for new medicines. Tourism, diving, and snorkeling on reefs add hundreds of millions of dollars to local businesses.

A Stable Coral Reef Ecosystem



The majority of coral reefs are under stress due to a number of factors. Since 1980, many major episodes of coral bleaching have occurred. When coral reefs are under stress, the coral appears white (bleached). Bleached coral might recover but if the stressing conditions continue, they can die.

One of the longest and most destructive events occurred from 2014 to 2017 when over 70 percent of the world's coral reefs were damaged. Coral biologists claim that Florida reefs and the Great Barrier Reef in Australia have had 90 percent of their coral affected in recent decades.

The photographs below show the same coral reef before and after exposure to extremely warm ocean water temperatures.

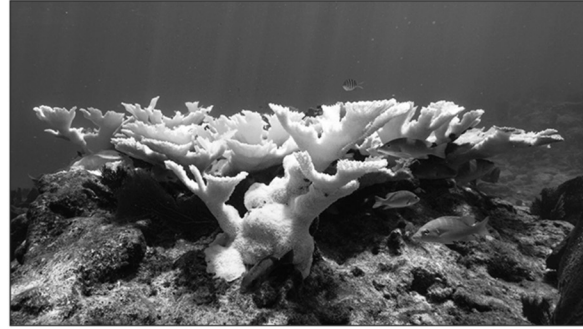
Changes in Pickles Coral Reef, Florida

April 7, 2022



Living coral

September 7, 2023



Bleached coral (dying)

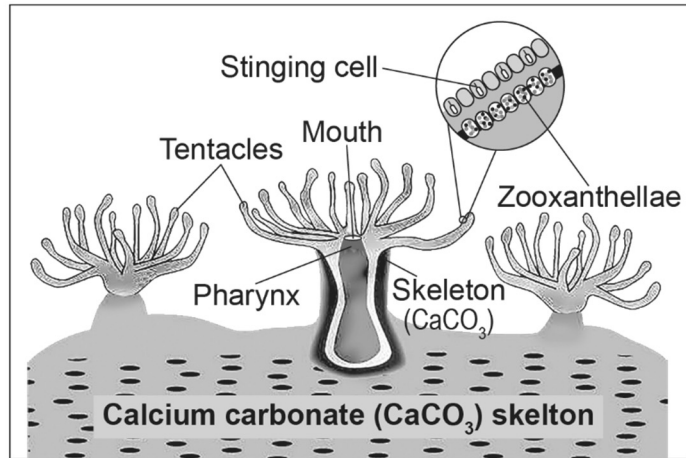
- 1 Which claim best describes the interactions in the coral reef ecosystem since the 1980s and the effect on the biodiversity in those regions?
 - (1) The coral reef ecosystem was stable, so the biodiversity was reduced since reefs can support thousands of species of fish.
 - (2) The reef ecosystem is not stable, so the biodiversity remained relatively constant without altering the variety of corals.
 - (3) The reef ecosystem was stable, so the biodiversity remained relatively constant and it would continue to attract divers and tourists.
 - (4) The coral reef ecosystem was not stable, so the biodiversity was reduced and it may have an impact on the number of tourists visiting the reef.

Coral reefs form over many thousands of years as tiny animals called polyps produce a calcium carbonate (CaCO_3) skeleton. This rock-like skeletal structure adds new layers over time, forming the three-dimensional habitat that makes up the reef. Most polyps depend on a beneficial relationship with a diverse group of photosynthetic algae called zooxanthellae. When coral polyps are under stress, some of the zooxanthellae leave the coral polyps, resulting in bleaching. Without the zooxanthellae algae, the coral takes on a white appearance and will eventually die.

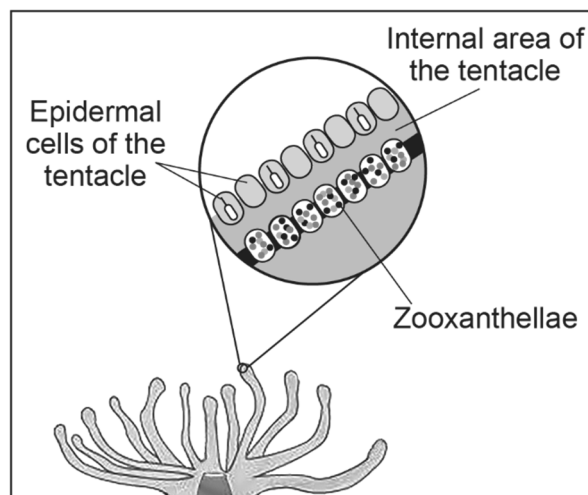
Live Coral Polyps



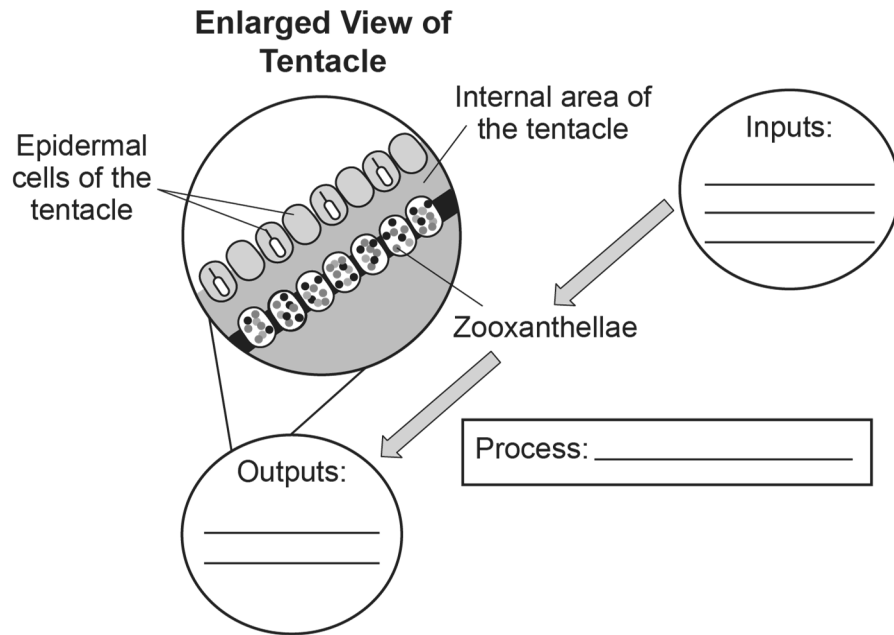
Structure of Coral Polyps



The illustration below provides an enlarged view of a single polyp tentacle that shows the relationship between the zooxanthellae and a healthy coral polyp.



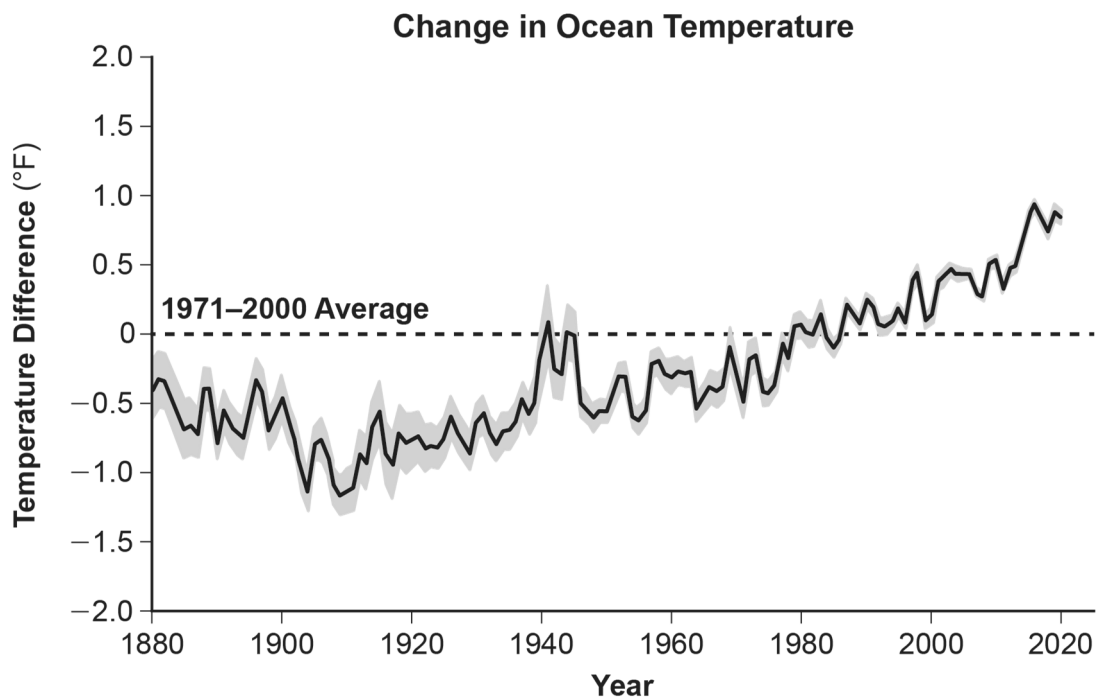
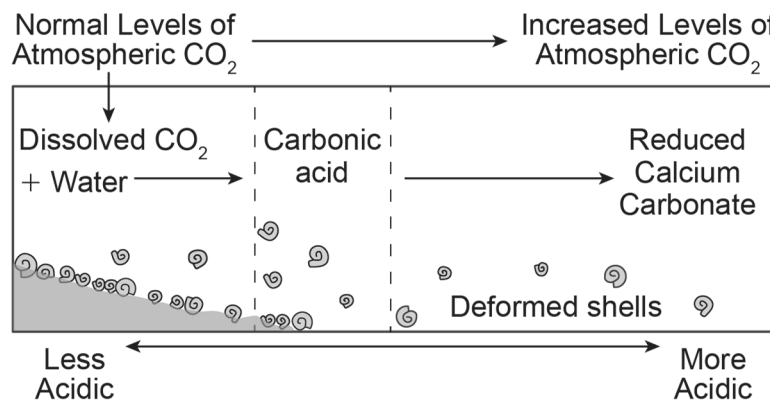
- 2 Complete the model below to illustrate the process occurring in the zooxanthellae located in the cells of the coral polyp. Your model should include all inputs of both matter and energy and identify the process involved. [1]



One potential source of stress on coral reefs is atmospheric carbon dioxide, which dissolves in the seawater forming carbonic acid. When excess carbon dioxide is present, it changes the acidity of ocean water and the availability of calcium carbonate for organisms to build and maintain their shells, skeletons, and other calcium carbonate-based structures.

Research shows that another stressor is the current trend of the large-scale temperature change in oceans. This causes the zooxanthellae to either leave or be ejected from the coral polyps. The graphs below show changes in ocean conditions over the past century.

Changes in Ocean Conditions that Affect Coral Reefs



- 3 Which claim best explains how continued changes in ocean acidity would affect the stability of the coral reef ecosystem?
- (1) Decreasing dissolved carbon dioxide will decrease the acidity of oceans and cause ocean water to warm.
 - (2) As the acidity of the oceans increases, the coral polyps will not have enough calcium carbonate to form their skeletons.
 - (3) Ocean acidification will reverse the effects of ocean warming and contribute to stabilizing the coral reef ecosystem.
 - (4) The coral polyps will need to adapt to the decreasing acidity and find a different substance to form their skeleton.
- 4 Use evidence from the information provided to support an explanation of how biotic *and* abiotic factors affect the carrying capacity of shell-building organisms, such as corals, in a reef ecosystem. [1]

Some species of zooxanthellae and coral have traits that make them more tolerant of changes to the temperature of the water in which they live. Scientists are experimenting with selective breeding of these species of coral and zooxanthellae to produce a coral that would be more likely to survive changing ocean temperatures.

- 5 Identify the explanation that best describes how the coral and zooxanthellae populations would be expected to change if the current trend in water temperatures were to continue over several generations within the coral reef.
- (1) The proportion of coral and zooxanthellae that can tolerate higher water temperatures will increase because they will survive at a higher rate than those that are sensitive to temperature changes.
 - (2) The coral will eject zooxanthellae that are sensitive to cold water temperatures so that less sensitive algae may take their place.
 - (3) The proportion of coral and zooxanthellae that are cold water tolerant will increase because they will have greater access to calcium carbonate to build stronger outer skeletons.
 - (4) The coral will take in zooxanthellae that are sensitive to high water temperatures so that there is less of a chance that they will develop deformed outer shells.

If they are successful in producing a type of coral that can thrive in changing water conditions, the scientists claim that transplanting these selectively bred corals will restore bleached and dying reefs.

- 6 Evaluate transplanting the selectively bred corals as a solution to coral reef bleaching by providing *one* benefit and *one* possible drawback. [1]

| | |
|----------|-------|
| Benefit | <hr/> |
| Drawback | <hr/> |

Base your answers to questions 1 through 5 on the information below and on your knowledge of biology.

Dinosaurs: Some Live and Some Die

Avian (bird-like) and non-avian dinosaurs in the northern hemisphere lived in extreme heat. The average summer temperature could range from 81° to 104°F. Winters were mild and wet, averaging around 59°F. There was no polar ice at this time. Most non-avian dinosaurs had a mass of about 7700 pounds. Most avian dinosaurs weighed significantly less and most mammals that coexisted with the dinosaurs weighed less than a pound.

Diversity of Life Pre-asteroid Impact



A giant asteroid struck just off the coast of Mexico 66 million years ago. The asteroid impact event is referred to as the K-T extinction. Enormous amounts of dust, sulfur, and carbon dioxide entered the atmosphere. It caused Earth's average surface air temperatures to drop by as much as 47° F. Dust from the impact blocked the Sun's radiation for an extended amount of time, and photosynthesis was drastically reduced.

Many dinosaurs were immediately killed while others managed to survive for a period of time. All of the non-avian dinosaurs went extinct. The mammals that survived the impact increased in number. They continued to survive and evolve.

- 1 A possible explanation for why some organisms survived and others did not is that some were
 - (1) herbivores that had a large variety of plants to eat
 - (2) able to evolve quickly into better adapted non-avian species
 - (3) better able to compete successfully after the asteroid impact
 - (4) faster and stronger than others and were able to outrun the blast of the impact

- 2 Explain how the evidence provided supports the claim that non-avian dinosaurs went extinct after the impact because of the traits present in their populations. [1]

When scientists analyzed leaf fossils formed after the asteroid impact, they discovered that the number and types of plants changed over time. They grouped the fossils found in the New Mexico and Colorado rock layers into “phases” of changing diversity. During this time, the environment was gradually warming.

Table 1: Leaf Fossils as Indicators of Diversity in New Mexico and Colorado Rock Layers

| Raton Basin Formation | | Phase | Number of Species |
|-----------------------|---------|-------|-------------------|
| | Phase 5 | 5 | 35 |
| | Phase 4 | 4 | 25 |
| | Phase 3 | 3 | 8 |
| | Phase 2 | 2 | 2 |
| | Phase 1 | 1 | 47 |

- 3 Which statement provides evidence that could be used to support the claim that the evolution of plants is the result of changes that occurred in the environment?
- (1) The diversity of plants in Phase 1 remained constant after the K-T extinction event changed environmental conditions on Earth.
 - (2) The number of plant species decreased during the 1.5 million years before the K-T extinction event due to stable environmental conditions on Earth.
 - (3) The diversity of plant species increased during the 1.5 million years after the K-T extinction event changed environmental conditions on Earth.
 - (4) The number of plant species remained stable from Phase 3 to Phase 5 as the environment on Earth recovered from the K-T extinction event.

Table 2: Mammal Evolution

| Mammal | When Appeared After K-T Extinction (years) | Body Mass (Kg) | Feeding Niche | Comparative Size |
|---------------|---------------------------------------------------|-----------------------|----------------------------------------------|-------------------------|
| L | 300,000 | 4-6 | Ate only insects, and had small, sharp teeth | Raccoon size |
| M | 450,000 | 50 | Herbivore, with canine teeth | Chimpanzee size |
| N | 680,000 | 44-77 | Omnivore, with canine teeth and massive jaws | Wolf size |
| O | 720,000 | 34-56 | Herbivore, with 2-3 rows of molar teeth | Sheep size |

- 4 Which statement provides evidence that changes in an environment may cause changes in mammal species?
- (1) Mammals got larger in body size as plant diversity decreased.
 - (2) As the type of plants changed, the tooth and jaw structure of mammals changed.
 - (3) Where the animals lived changed as the number of plant species increased.
 - (4) The mammals listed in the chart were adapted to feeding on the same species of plants.

- 5 Evaluate all the information given and complete the table by providing evidence that supports the claim that changes in environmental conditions may result in: [1]

| | |
|--------------------------------------------------|-------------------|
| increased numbers of individuals of some species | <hr/> <hr/> <hr/> |
| the emergence of new species | <hr/> <hr/> <hr/> |
| the extinction of other species | <hr/> <hr/> <hr/> |

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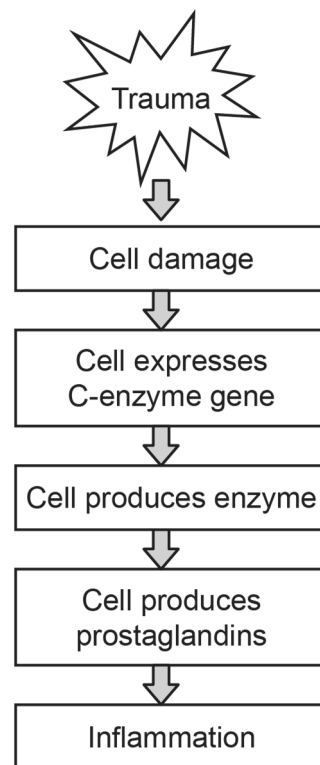
Prostaglandins: One of the Most Important Molecules You Never Heard of

When cells experience trauma and are damaged, they quickly communicate this damage to nearby cells. One way this is accomplished is by the release of chemical messengers known as prostaglandins. Prostaglandins signal cells to respond with inflammation and pain (the inflammatory response). This, in turn, tells the organism that something is wrong.

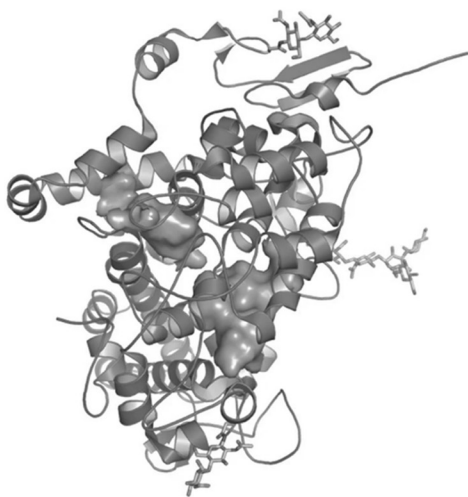
Prostaglandins are produced by human cells present in multiple body systems. These include white blood cells, cells of blood vessels, and cells of the digestive tract. These cells produce C-enzymes. These enzymes signal the cells to produce prostaglandins. The model to the right illustrates this process.

C-enzymes are present in cells in different forms, including C-1 and C-2. Both forms are expressed in different tissues at different levels.

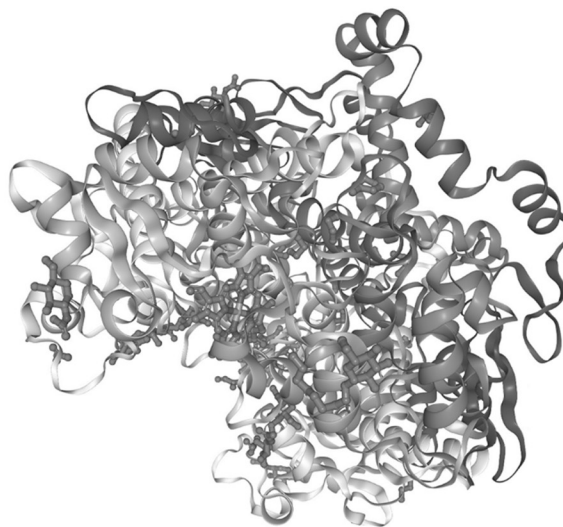
Ribbon models are often used to illustrate the physical structure of molecules. The ribbon models below represent the two different forms of the C-enzyme that produce prostaglandins.



C-1 Form



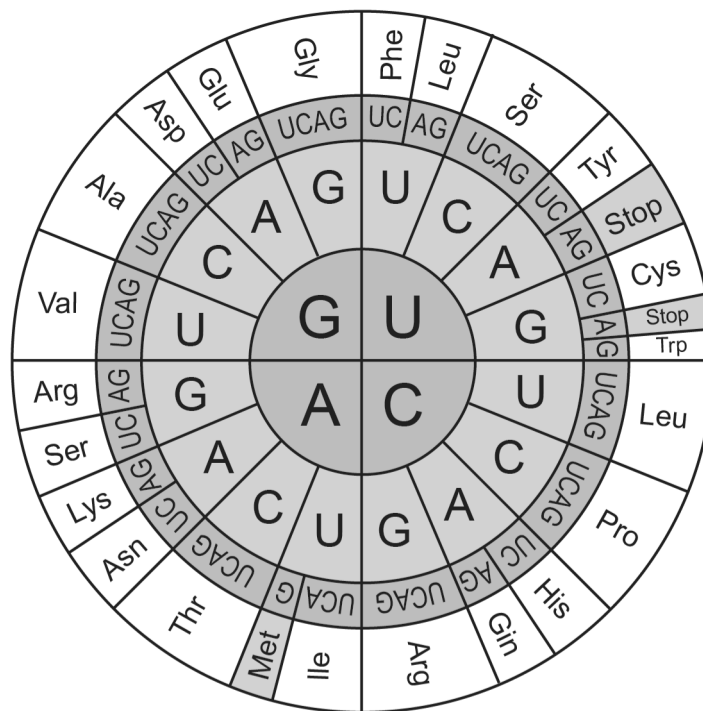
C-2 Form



- 1 Based on the models, which statement best supports the claim that the two enzymes function differently in tissues due to the amino acid sequence present in the C-1 and C-2 forms of the enzyme?
- (1) The two forms of the C-enzyme result in different DNA sequences that have different shapes.
 - (2) The DNA codes for the production of prostaglandin in molecules that control the production of both C-1 and C-2.
 - (3) The amino acid sequences of both molecules are the same because both are examples of C-enzymes.
 - (4) Each form of the C-enzyme gene produces a different amino acid sequence that results in proteins with different shapes and functions.

In order for a gene to be expressed, such as the gene that codes for the C-enzymes, the cell must follow specific steps. The codon chart below can be used to simulate one step in the process used by the cell when producing the C-enzyme.

Codon Chart

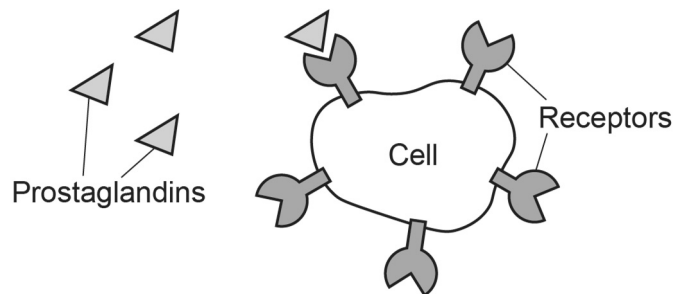


- 2 Use the highlighted portion of the table to construct an explanation that summarizes how the DNA sequence is expressed by cells to produce C-enzymes that control the production of prostaglandin molecules. [1]

Expression of C-Enzyme Gene Segment

| | | | | | |
|---------------------|------------|------------|------------|------------|------------|
| Gene DNA Sequence | TCG | AAA | TGC | AAT | TAT |
| mRNA Sequence | AGC | UUU | ACG | UUA | AUA |
| Amino Acid Sequence | Ser | Phe | Thr | Leu | Ile |

Prostaglandins cause inflammation by attaching to protein receptors on the surface of some cells, as shown in the model below.

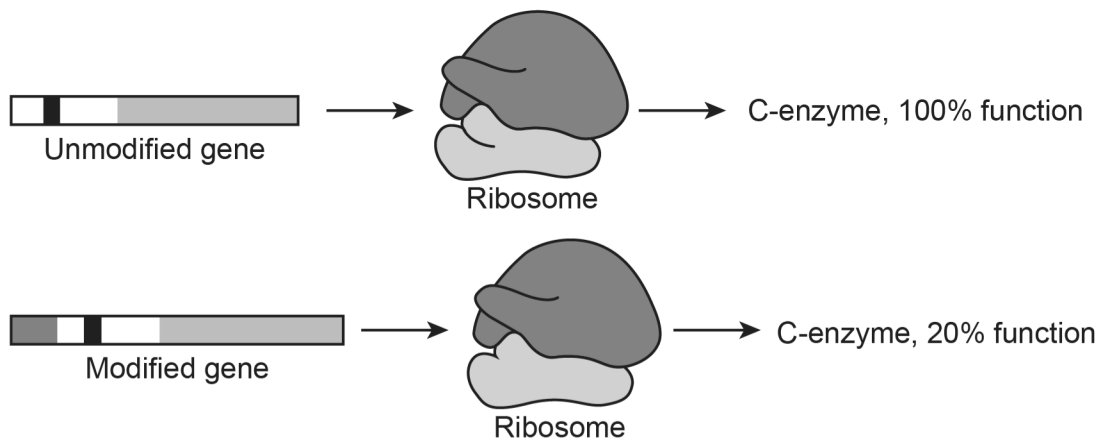


- 3 Which claim could be used to describe a possible cause of the new variation in the gene that codes for the production of the prostaglandin receptor?
- (1) The changed receptor will produce a new DNA sequence with different functions that change the inflammatory response.
 - (2) Events during reproduction or exposure to some environmental factors could result in a new inheritable variation in the DNA that codes for the production of prostaglandin receptors.
 - (3) The protein will no longer be able to produce the gene that codes for prostaglandins, resulting in a weaker inflammatory response.
 - (4) The changed DNA will be passed on through reproduction and result in a different order of simple sugar subunits that make up the C-enzyme protein.

- 4 An individual inherited a new variation in the gene that codes for the production of the prostaglandin receptor. Which question could be asked to clarify how the variation was passed on to the individual?
- (1) Were the father's white blood cells able to produce gametes with the variation?
 - (2) Did the receptor lose function due to a lack of prostaglandin molecules?
 - (3) Was the variation caused by a change in a gene sequence in the mother's gametes?
 - (4) Was the prostaglandin receptor with the variation the same size as the original receptor?

Inflammation has been linked to an increased risk for some cancers. Researchers are examining the role of C-enzymes and their production of prostaglandins, which have been linked to the development of these cancers.

Experiments using animal models, such as mice, have tested the effect of a modified version of the C-enzyme gene on the occurrence of some cancers. The modified gene has an extra DNA segment added to one end. Animals with the modified gene had a decreased incidence of intestinal cancers. The diagram below represents the expression of the unmodified and the modified genes.



- 5 Construct an explanation, based on the evidence provided, that would account for the decrease in cancer that was observed in the animals with the modified gene. [1]

- 6 Describe a qualitative or quantitative constraint that these researchers took into account when using animal models in the design of their experiment. [1]
