PEEBEDU

CFTR Channel Simulation

AP Biology

Name: _____ **Period:** _____ **Date:** _____

> Open **peebedu.com** and navigate to **CFTR Channel Simulation**. Click the **Introduction** button (*i*) to read about the CFTR protein, the central dogma, the deltaF508 mutation, membrane transport, and the cholera connection. Then close the introduction and familiarize yourself with the Genotype Selection panel on the left.

Free Response Questions

Question 1 — Conceptual Analysis

> **Simulation Task:** *Set the Maternal Copy to* **Wild-type** *and the Paternal Copy to* **Wild-type***. Click* **Run Simulation** *and observe the central dogma display showing the DNA, mRNA, and protein sequences for each allele. Note the number of functional CFTR channels in the membrane animation and the movement of chloride ions. Then change both copies to* **deltaF508***, click* **Run Simulation***, and compare the protein outcome and the membrane animation.*

(A) (1 pt) **Describe** the processes by which information encoded in a gene is used to produce a functional protein.

(B) (1 pt) **Explain** why cells homozygous for the deltaF508 mutation do not have functional chloride channels in their cell membrane even though they contain the CFTR gene.

(C) (1 pt) **Predict** the effect on chloride ion transport across the cell membrane of a cell heterozygous for the deltaF508 mutation compared to a cell homozygous for the wild-type allele.

(D) (1 pt) **Explain** how variation in the number of functional CFTR channels among individuals in a population could lead to differences in survival when exposed to a pathogen that causes excessive chloride and water loss from intestinal cells.

EK 6.3.A.1, 6.4.A.1, 1.7.A.4, 7.2.A.3

Question 2 — Analyze Data

Medical researchers studied the effects of cholera treatments on samples of isolated intestinal cells. The mechanism by which cholera toxin affects intestinal cells is shown in Figure 1. Doxycycline (an antibiotic commonly used against *V. cholerae*) and oral rehydration salts (ORS), which cause sodium ions to be absorbed by cells, were used as treatments. Treatment combinations of doxycycline and ORS were added to samples that had been infected with cholera toxin or not. Scientists then measured the amount of cAMP produced and the amount of water lost by the cells in each sample and recorded the results in Table 1.

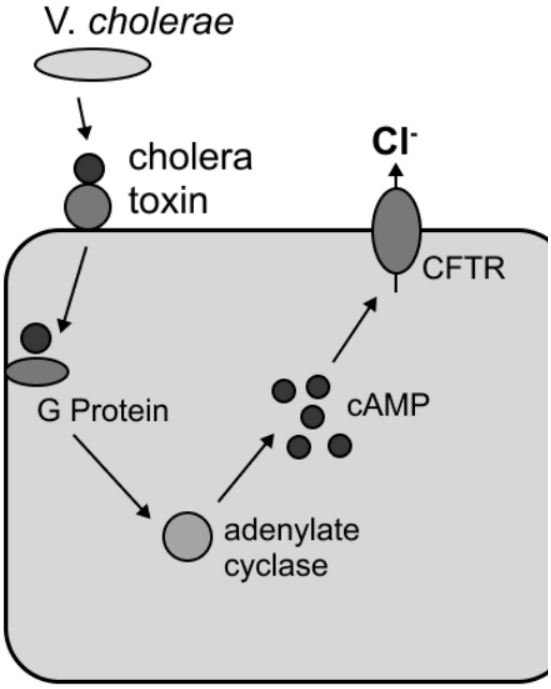

Figure 1. Mechanism of cholera toxin action on CFTR channels in intestinal cells.

Sample	Cholera Toxin	Doxycycline	ORS	cAMP Produced (a.u.)	Water Loss by Cell (%)
I	+	+	–	58	42
II	+	–	+	96	54
III	+	+	+	57	24
IV	+	–	–	98	88
V	–	–	–	12	11
VI	–	+	–	11	10
VII	–	–	+	12	4

Table 1. Effects of cholera toxin and treatments on cAMP production and water loss in intestinal cells.

(A) (1 pt) **Describe** one characteristic of a cell membrane that requires a channel protein to be present for chloride ions to passively cross the membrane.

(B) (1 pt) **Explain** why the movement of chloride ions out of intestinal cells leads to water loss.

(C) (1 pt) **Identify** an independent variable in the experiment.

(D) (1 pt) **Identify** a negative control in the experiment.

(E) (1 pt) **Justify** why the scientists included Sample IV as a treatment in the experiment.

(F) (1 pt) Based on the data, **describe** the effect of cholera toxin on the synthesis of cAMP.

(G) (1 pt) A drug is designed to bind to cholera toxin and prevent it from interacting with the cell membrane. Scientists mix the drug with cholera toxin and then add this mixture to a sample of intestinal cells. **Predict** the amount of cAMP that would be produced if the drug binds to all of the cholera toxin.

(H) (1 pt) In a separate experiment, scientists engineer a mutant adenylyl cyclase that cannot be activated by the G protein. The scientists claim that cholera toxin will not cause excessive water loss from intestinal cells that contain the mutant adenylyl cyclase. **Justify** this claim.

EK 2.4.A.1, 2.5.A.1, 4.2.A.1