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An Activity Aimed at Improving Student Explanations of Biological Mechanisms

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[*Note to instructors: Edit bracketed sections*]
Modified by [*Your name, your institute, and the date*]

Read

Individually, read the biological explanation provided.
[*Approx. 5-10 minutes. Instructors may prefer to assign the reading for outside of class. Instructors may provide readings about any topic with an explanation about a biological mechanism or encourage students to find one of their own choice. Previously we have used topics of cystic fibrosis transmembrane conductance regulator, vesicle trafficking, aquaporin and ion channels functions. We modified readings such as the following to create one-page handouts:*

Skwarecki, B. (2014). Cystic Fibrosis Might Be 2 Diseases. *Scientific America.* http://www.scientificamerican.com/article/cystic-fibrosis-might-be-2-diseases/
Trivedi, B. P. (2013). Doorway to a Cure for Cystic Fibrosis. *Discover. http://discovermagazine.com/2013/september/14-doorway-to-a-cure*
von Heijne, G. (2003). Advanced information on the Nobel Prize in Chemistry. *Nobelprize.org*. http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2003/advanced-chemistryprize2003.pdf.]
Zierath, J. R. & Lendahl, U. (2013). Machinery Regulating Vesicle Traffic, A Major Transport System in our Cells. *Nobelprize.org* http://www.nobelprize.org/nobel_prizes/medicine/laureates/2013/advanced-medicineprize2013.pdf]

Think

What components does the author integrate into their explanation? Analyze and mark the text with the respective shapes as follows:

- Science research methods (■);
- Models, figures, graphs, or analogies including anthropomorphic stories (▲);
- Biological and/or social contexts (★);
- How the phenomenon works through physical causes (●); and
- Places where the above components blend and interweave (✓).

Be prepared to share with a partner your thoughts about how the author integrates these components into a coherent explanation.
[*Approx. 5 minutes. Examples from the text are shown on next page for instructors.*]

Pair

With a partner, come to consensus about what components the author did and did not include in the explanation. Share what you noted about the passage. Be sure to discuss any missing items from the above list and address how well the author blended the components in the explanation.
[*Approx. 5 minutes.]*

Share

Report the ideas you discussed with your partner to the class.
[*Approx. 5 minutes.]*

Learn

Learn from your classmates and the summary by the instructor.
[After the activity, we distribute the tetrahedral MACH model and teach students to use the MACH model. The tetrahedral MACH model can be found at the Purdue International Biology Education Research Group (PIBERG) ePubs collection (https://www.bio.purdue.edu/piberg/).]

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Examples of the MACH components found in the assigned text.

Component	Examples from Skwareck (2014) on the topic of cystic fibrosis transmembrane conductance regulator (CFTR).	Analysis of example
M	"Whitcomb's team screened a group of nearly 1,000 patients with pancreatitis and found nine abnormal but supposedly harmless versions of the CFTR gene."	References how scientists sampled patients for data.
	"The techniques the researchers used to figure out the details of how each mutation changes the protein are 'extremely challenging' and 'kind of an art form,' "	Reports about the research methods.
	"Different diseases that all look the same on CAT scans."	References to tools and data collected.
	"Computer simulations confirmed..."	Uses modeling software of investigate.
A	Figure: [http://discovermagazine.com/~/media/Images/Issues/2013/September/gene-mutations-in-CF.jpg?mw=900]	Displays a cartoon model of a protein.
	"Seemingly benign mutations break the switch that turns CFTR from a chloride portal to a channel for bicarbonate."	Uses of a switch as an analogy.
	"CFTR leads a double life."	Anthropomorphizes the entity.
C	"The hereditary disease affects 30,000 Americans, and patients die unless they receive treatment to clear their lungs."	Includes a social context; the disease affects the lives of many people.
	"They can suffer from painful pancreatitis, as well as sinusitis and, in men, infertility."	Includes a biological context; many organ systems are affected.
H	"Cystic fibrosis results from mutations in a gene that produces a tube-shaped protein known as CFTR, essential to the balance of electrolytes in the body. Specifically, this protein allows chloride ions to pass in and out of cells."	Includes specific entities (proteins and ions) interact with spatial and temporal organization.
	"Whitcomb's eventual goal is to disentangle the distinct causes of what, until recently, appeared to be a single disease."	Focuses on the causes of the disease(s).

Examples of the MACH components found in the assigned text (Cont'd).

Component	Examples from Trivedi (2013) on the topic of cystic fibrosis transmembrane conductance regulator (CFTR).	Analysis of example
M	"Tsui had read about a technique for locating a desired gene through DNA markers present in sick people but absent in healthy ones." *	References the research methods.
	"They added a chemical called genistein, a known door-opening drug that, unfortunately, was so weak it worked only in the test tube. Finally, a robotic eye scanned each mixture. If cells were unaffected, the dye caused them to glow orange."	Includes a technique used in drug discovery to visualize channel activity.
A	Figure: [http://discovermagazine.com/~/media/Images/Issues/2013/September/gene-mutations-in-CF.jpg?mw=900]	Includes diagrams of disease and non-disease states.
	"The protein was shaped like a tube and wedged in the outer surface of the cells, resembling the kind of biological valve that would move chloride in and out."	Uses shapes, wedges, and valves as analogies.
	"Instead, the defective protein remains stuck inside the cell, like a Cheerio trapped in a balloon."	Uses macroscopic objects as analogies.
C	"Laura and Cate are among thousands of Americans who have cystic fibrosis"	Includes social context; CF affects personal lives.
	"Affecting one in every 3,900 births in the U.S., CF is one of the most common genetic disorders known."	Includes social context, the disease.
H	"A CFTR protein with this mutation cannot fold properly and cannot navigate its way to the surface of the cell where it would normally reside, providing a channel for chloride to flow in and out."	Explains disease state by the properties of the protein and its spatial organization.
	"Riordan was an expert on proteins called ABC transporters, molecular elevators that shuttle things like fats, drugs and other molecules back and forth across cell membranes."	Addresses spatial organization and activity of the transporter.
	"A mutated gene that produced a broken protein involved in chloride flow could cause a salt imbalance and all the devastation observed."	References how physical entities prevent the activity of chloride channels.

* The modified version of the article used during a Fall 2014 course had all excerpts of research methods (M) removed such that students could contrast articles with and without research methods.

Examples of the MACH components found in the assigned text (Cont'd).

Component	**Examples from Zierath and Lendahl (2013) on the topic of vesicle trafficking.**	**Analysis of example**
M	"To test the SNARE hypothesis, Rothman used an *in vitro* reconstitution assay and revealed that SNAREs could indeed fuse membranes."	References specific methods used by scientists.
	"He used temperature-sensitive mutants and screened for genes affecting the intracellular accumulation of secretory enzymes."	Includes screening, a specific technique used in research.
A	Figures [http://www.nobelprize.org/nobel_prizes/medicine/laureates/2013/advanced-medicineprize2013.pdf]	Indicates cartoon models of vesicles.
	"The vesicle fuse at the right location and that cargo molecules are delivered to the correct destination."	Tells a story as if vesicles have an end goal.
C	"…For example, metabolic disorders such as type 2 diabetes are characterized by defects in both insulin secretion from pancreatic beta-cells and insulin-mediated glucose transporter translocation in skeletal muscle and adipose tissue…"	Makes connections to a disease, a social context.
	"This is the case for example for neurotransmitter release in the brain and for insulin secretion from the endocrine pancreas."	Includes a biological context; compares different functions of the mechanism.
H	"…target and vesicle SNAREs (t-SNAREs and v-SNAREs) were critical for vesicle fusion through a set of sequential steps of synaptic docking, activation, and fusion."	References entities like SNAREs, their activities and how they are organized.
	"…rapid exocytosis of synaptic vesicles, which is under tight temporal control and regulated by the changes in the cytoplasmic free calcium concentration…"	Considers exocytosis as an activity and temporal organization.

Examples of the MACH components found in the assigned text (Cont'd).

Component	**Examples from von Heijne (2003) on the topic of aquaporins and ion channels.**	**Analysis of example**
M	"Shortly thereafter, Agre proved this conclusively by demonstrating that expression of CHIP28 in *Xenopus* oocytes made the cells swell rapidly when placed in a hypo-osmotic medium"	References experiment and observation.
	"In 2000 and 2001, the first high-resolution 3D structures of AQP1 and a related glycerol-selective bacterial channel protein (GlpF) were reported"	Includes structural research.
A	Figures [http://www.nobelprize.org/nobel_prizes/chemistry/laureates/2003/advanced-chemistryprize2003.pdf]	Shows models of experiments and channels.
	"Based on these structures, detailed models have been put forward to explain the high permeation rate…"	Indicates models used for explanation.
C	"Aquaporin-like proteins have since been found throughout the living world; in humans alone, there are at least 11 different aquaporin-like proteins, many of which have been linked to various diseases."	Connects to disease, a social context.
	"Plants have an even higher number of aquaporins, with no less than 35 different versions found in the model plant *Arabidopsis thaliana*."	Includes biological context; comparing to other domains.
	"The cloning and overexpression of a bacterial K+ channel with high homology to eukaryotic K+ channels (Schrempf et al., 1995) suggested to some workers that prokaryotic channels might finally provide the missing key to structural studies of ion channels."	Indicates channels of different organisms of varying biological contexts.
H	"The local electrostatic field generated by the protein switches polarity in the middle of the channel, forcing the passing water molecules to rotate in such a way that their dipole moments are oriented in opposite directions in the upper and the lower halves of the channel."	References entities, their interactions and organization.
	"A comparison of the KcsA and MthK structures suggested a general mechanism for channel gating, in which a conformational change in the sensor domain pulls the transmembrane helices apart near the intracellular end of the channel."	Includes entities changed states through conformational changes.
	"Some K+ channels conduct ions in only one direction, serving as 'molecular diodes'. Such inward rectifying channels are blocked by Mg2+ and polyamines that penetrate into the channel from its cytosolic end when the membrane is depolarized."	Addresses the entities, the activity (or lack of activity when 'blocked'), and the state of the membrane.

Work cited:

Skwarecki, B. (2014). Cystic Fibrosis Might Be 2 Diseases. *Scientific America.* http://www.scientificamerican.com/article/cystic-fibrosis-might-be-2-diseases/

Trivedi, B. P. (2013). Doorway to a Cure for Cystic Fibrosis. *Discover*. http://discovermagazine.com/2013/september/14-doorway-to-a-cure

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Zierath, J. R. & Lendahl, U. (2013). Machinery Regulating Vesicle Traffic, A Major Transport System in our Cells. *Nobelprize.org.* http://www.nobelprize.org/nobel_prizes/medicine/laureates/2013/advanced-medicineprize2013.pdf