Supplemental Material

Slominski *et al*.

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In this Supplemental Material, we provide examples of "expected" or "normative" reasoning from our biology and physics experts for the questions within their discipline. These examples are influenced by the responses provided by experts in our initial piloting of the prompt. We emphasize again that we are not necessarily providing "correct" answers, but rather the reasoning and responses that the prompts could elicit. As described in our manuscript and supported by Redish and Cooke (2013), biologists often consider this problem in the context of a larger, dynamic system. As a result, they prioritize and attend to outside structures and emergent properties of that system. Physicists and engineers, however, approach the problem differently, often considering only the system presented in the prompt and focusing explicitly on the boundary conditions given. With these different approaches, it is reasonable that experts in different fields reach different conclusions.

Expected Biologist Responses (Table 1)
These responses were generated to reflect how we might expect an instructor for Introductory Human Anatomy and Physiology to reason about the prompt. These responses make use of the concepts typically included when discussing fluid dynamics in an introductory biology course (e.g. Poiseuille's equation, Mean Arterial Pressure, etc.). The equations and relationships presented below come from a widely used introductory Human Anatomy and Physiology textbook (Martini, Bartholomew & Nath, 2015) and an upper-level Human Physiology textbook (Silverthorn, 2007).

In the context of the circulatory system, an instructor is likely to reason that blood moves faster through a narrow vessel since the speed is equal to the flow rate divided by the cross-sectional area of the vessel. Thus, the flow speed would be largest in the vessel that has the narrowest exit on the right (B), then A, then the vessel with the widest exit (C) for a ranking of BAC.

When asked to rank the fluid flow rate exiting the right end of the blood vessel, we would expect biologists to incorporate resistance into their reasoning since resistance is such a prominent feature in HA&P. Doing so, a biologist would reason that resistance is inversely proportional to the fourth power of the vessel radius, and flow rate is inversely proportional to resistance. Thus, the vessel with the narrowest exit (B) would have the largest resistance and the lowest fluid flow rate, giving a ranking of CAB.

The sub-question asking participants to rank the pressure of the fluid in the right side of the tube was included to satisfy the physicists values of the problem, and as such we are not entirely sure how biologists would reason. Here we present two possible paths. The first is that a constricting vessel increases pressure, so the narrowest tube on the right side (B) would have the largest pressure, resulting in a ranking of BAC. The second possible chain of reasoning would reason that pressure decreases as arteries branch out into smaller vessels. Here, we thought a biologist would rely on the idea of Mean Arterial Pressure, as measuring the pressure in a single vessel is somewhat inauthentic. The narrowest tube on the right side (B) would then have the lowest pressure, resulting in a ranking of CAB.

The reasoning for the fourth question, which asked participants to rank the resistance of the three tubes, is partially reflected in the reasoning for the question on fluid flow rate above. Since all vessels have the same length and the viscosity of the fluid in each is the same, the determining factor in resistance is the radius of the vessels. Thus, the narrowest vessel (B) would have the highest resistance, giving a ranking of BAC.

Expected Physicist/Engineering Responses (Table 2)
These responses were generated to reflect how we might expect an instructor of Physics or Engineering to reason about our prompt. We assumed that engineering instructors would generate responses most similar to physics instructors. These responses make use of the concepts typically included when discussing fluid dynamics in an introductory physics course (e.g. Continuity equation, Bernoulli's equation, Poiseuille's equation, etc.). The equations and relationships presented below come from a widely used algebra-based introductory physics textbook (Knight, Jones, & Field, 2010).

In the context of water in pipes, a physicist is likely to reason that the fluid is incompressible, so the flow rate should be the same at both ends of any tube. The prompt states that the flow rate into the left end of each tube is identical, so the flow rate on the right end of each tube is also identical. The flow speed is equal to the flow rate divided by the cross-sectional area of the tube, so the tube with the narrowest right side (B) would have the fluid with the largest speed, giving a ranking of BAC.

The second question asks participants to rank the fluid flow rate at the right end of the tube. Similar to the first question, a physicist is likely to reason that the fluid is largely incompressible, meaning that the fluid flow rate at the left and right ends of any single tube are equal. Since the prompt state that the fluid flow rate into the left end of each tube is equal, the flow rate in the right side of each tube should be equal, giving a ranking of A = B = C, or "=" as shown in our Table 2.

The third question asks about the pressure in the right side of the tube. Here, we expect physicists to employ reasoning with the Bernoulli equation (see Table 2), given both its prominence in introductory physics courses as well as the statement in the prompt that the viscosity of the fluid is very low. For tubes at the same height, Bernoulli's equation states that as the velocity of the fluid increases, the pressure at that location in the fluid decreases. By the reasoning of the previous two questions, the tube with the fastest speed is B, so this tube would have the smallest pressure on the right side, giving a ranking of CAB.

The resistance question was included to satisfy biologists' values in the problem, so we were not sure how a physicist would reason. Below is one line of reasoning that would be reasonable for a physicist to provide. While "resistance" is not used in physics when discussing fluid flow, viscosity is, and physicists are familiar with the Hagen-Poiseuille equation, which states that, for a given viscosity and tube length, the fluid flow rate is proportional to both the pressure difference across the tube and the fourth power of the radius (Table 2). Making an analogy with Ohm's Law from electric circuits, where the current ("flow") is equal to the voltage difference divided by the resistance of the circuit element ($I = \Delta V/R$), the resistance of a tube would be

inversely proportional to the fourth power of the tube radius. Thus, the narrowest tube (B) would have the largest resistance, giving a ranking of BAC.

Comparisons of Expected Reasonings

Our expected reasoning paths should not be construed as predictions. These are informed by the responses in the pilot study, as well as the authors' own lines of reasoning when first encountering these questions. The second question, asking about fluid flow rate, provides the starkest contrast in the results of these possible lines of reasoning, which we now discuss.

In answering the fluid flow rate question, it is reasonable that the physics/engineers and biologists arrive at different answers given their different disciplinary norms. Physicists tend to focus on a given system and what is happening at the boundaries of that system. If the inputs, outputs, and constraints are given, the details of what is causing those inputs and outputs is typically ignored and irrelevant. This is why we expect them to attend closely to the information given in the prompt stating that the fluid flow rate entering all three tubes is equal. Along with the continuity equation, this leads to the conclusion that the fluid flow rate on the right end of each tube is equal.

On the other hand, the systems used in biology are often large and complex, making attending to outside structures and emergent features an important part of a biologists' disciplinary practice. When provided with three vessels that have differing radii, the resistance of each vessel is likely to be the most important factor in determining the blood flow rate. If a biologist does not attend to the statement that the fluid flow rate is equal, different assumptions can be made. Perhaps the pressure difference across all three vessels is the same, so the blood is getting "pushed' identically in all three cases, but vessel B is resisting this more, leading to BAC. Another possibility is that all three vessels have a single vessel feeding them, which would cause the one with the largest resistance to receive the smallest amount of blood, again leading to BAC. Either of these reasoning patterns reflect situations more common in biology than ones where the fluid flow rate into separate vessels is identical.

The differences discussed here reinforce why we did not want to compare the "correctness" of answers across the disciplines, but rather the reasonings. Whether or not an answer is considered correct depends greatly on often hidden assumptions about the nature of the system under study. Different disciplines will gravitate towards different assumptions to different degrees, regardless of how a prompt is presented. This problem is heightened in an interview setting, where participants may feel pressured to "keep talking" rather than taking time to re-read the prompt to tease out the details, particularly with a subject matter they are familiar with.

References
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Table 1. Expected Responses from a Biologist

Question	Ranking	Reasoning
Speed	B, A, C (highest to lowest)	Blood flows through a narrow vessel faster than a wider vessel. $$v = \frac{Q}{A}$$ (v = velocity of flow, Q = flow rate, A = cross-sectional area of the vessel)
Fluid Flow Rate	C, A, B (highest to lowest)	The vessels are all the same length and the viscosity of the blood is the same. The only difference across the three vessels is the radius. The smaller the radius, the greater the resistance to flow. If the resistance increases, the flow rate would decrease. $$Resistance \propto \frac{1}{Radius^4} \qquad Flow \propto \frac{1}{Resistance}$$
	This sub-question was designed to satisfy the physicists' values of the problem. As such, we were not entirely sure how a biologist would answer. Below we offer the two ideas we thought biologists might provide:	
Pressure	B, A, C (highest to lowest)	If a vessel constricts, pressure increases.
	C, A, B (highest to lowest)	As arteries branch out into smaller vessels, the cross-sectional area of the system increases. This results in an overall drop in blood pressure. (*We thought a biologist might rely on the concept of Mean Arterial Pressure when thinking about approximating blood pressure, as it is inauthentic to measure blood pressure on one specific vessel.*)
Resistance	B, A, C (highest to lowest)	The vessels are all the same length and the viscosity of the blood is the same. The only difference across the three vessels is the radius. The smaller the radius, the greater the resistance to flow. $$Resistance \propto \frac{1}{Radius^4}$$

Table 2. Expected Responses from a Physicist or Engineer

Question	Ranking	Reasoning
Speed	B, A, C (highest to lowest)	The prompt states that the volume of fluid entering each vessel on the left per second is the same, so the fluid flow rate (Q) at D, E, and F are identical. The continuity equation $Q_1 = Q_2$ states that the flow rate is the same in all cross-sections of a tube, so Q is the same at locations A, B, and C. Q is related to the speed by: $$V = \frac{Q}{A}$$ (v = velocity of fluid, Q = fluid flow rate, A = cross-sectional area of the tube) So the speed at B is the largest (smallest area), followed by A, and then C.
Fluid Flow Rate	A = B = C	The prompt states that the volume of fluid entering each vessel on the left per second is the same, so the fluid flow rate (Q) at D, E, and F are identical. The continuity equation $Q_1 = Q_2$ states that the flow rate is the same in all cross-sections of a tube, so Q is the same at locations A, B, and C.
Pressure	C, A, B (highest to lowest)	The prompt states that the fluid viscosity is very low, so we can ignore it and use Bernoulli's Equation that relates fluid pressure (P), fluid speed (v), and fluid height (h) at different points along a streamline. $$P_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = P_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$ Points D, E, and F and stated to be at the same pressure, and since the area of the tube and the fluid flow rate (Q) of the fluid is the same at these locations, the speed (v) is also the same. D, E, and F are also all at the same height. So, the left side of the equation is the same for all three tubes. Since X, Y, and Z are also at the same height, the third term on the right also does not change, leaving: $$\text{constant} = P_2 + \frac{1}{2}\rho v_2^2$$ Since the speed (v) is largest at Y, the pressure (P) at Y must be the lowest in order for the two terms on the right-hand side to add to the same constant. Since the speed is smallest at Z, the pressure would be the largest there (corresponding to tube C).

Table 2. Expected Responses from a Physicist or Engineer (Continued)

Question	Ranking	Reasoning
		This sub-question was designed to satisfy the biologists' values of the problem. As such, we were not entirely sure how a physicist or engineer would answer. Below we offer a response we thought a physicist or engineer might provide, if they were to make an analogy with how "Resistance" is used in circuit analysis:
Resistance	B, A, C (highest to lowest)	Now that viscosity is not negligible, we need to use the Hagan-Poiseuille equation for viscous fluid flow: $$Q = \Delta P \frac{\pi r^4}{8\eta L}$$ Here r is the radius of the tube, η is the fluid viscosity, L is the length of the tube. If "resistance" means "resistance to flow", then we can rearrange the equation as: $$\Delta P = Q \frac{8\eta L}{\pi r^4}$$ And identify "resistance" as the terms multiplying Q: $R = \frac{8\eta L}{\pi r^4}$ (for a given pressure difference on the left, Q does down as R goes up) The vessels have the same length and the fluid has the same viscosity, so all that matters is the radius. Since the radius is smallest at Y and largest at Z, the resistance will be largest at Y, followed by X, with the smallest resistance at Z (corresponding to tube C).