Traveling Antibodies

Introduction

Have you ever been around a newborn and been asked to wash your hands before you touch them? Or did you know that a body temperature of just 100.4 is considered serious until you're three months old? Babies are pretty fragile when it comes to getting sick—they can get very sick very fast and very easily. A germ that an older person can easily fight off often lands a newborn in the hospital because their immune systems aren't fully developed to fight germs like an adult. They can't even receive many vaccines until they are 1 year old! As one way to improve the health of young babies and protect them from some diseases, doctors have started to recommend that pregnant people receive vaccines, such as those against coronavirus, the flu, tetanus, diptheria and whooping cough during pregnancy. Antibodies don't stick around forever, but the hope is that by vaccinating the parent, the baby will be protected long enough once they're born to safely reach the minimum age to get the vaccines themselves.

How can a vaccine given to the parent provide immunity to the babies? Because immunity is transferred across the placenta to the fetus during pregnancy! The placenta is a unique organ that develops within the pregnant parent that connects the parent's blood supply to the baby, this is where the umbilical cord sprouts from! See **Figure 1A** for an image of where the placenta is, and **Figure 1B** for a close up look at the placenta. The placenta exists to deliver oxygen and nutrients to the baby while separating the parent's blood supply from the baby's blood supply. It consists of two layers of cells that allow small things across, but prevent big things (like cells) from moving across **(Figure 1C).** Water, nutrients and gasses are small and able to diffuse across the two layers via **passive transport,** meaning that they can pass right through membranes, moving from an area of high concentration to an area of low concentration.

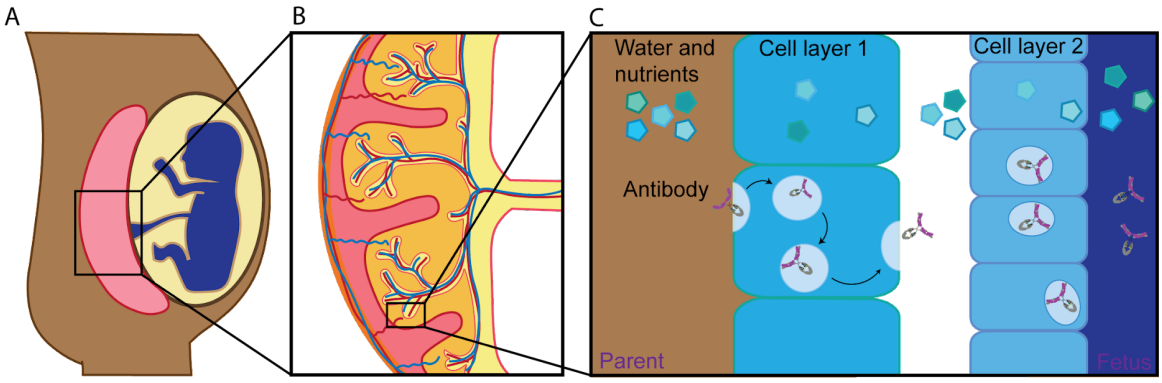

Figure 1. Placental Anatomy. The placenta (pink) attaches to the parent's uterus where the fetus is developing and facilitates nutrient, gas, and antibody transport. Simplistically, the placenta is two cell layers that separate the parent's and the fetus' circulation. Antibodies are actively transported across the placenta (white bubbles represent membrane channels) while water and small nutrients diffuse through by passive transport.
Source: Figure drawn by M. Jennewein.

To send immunity from parent to child, antibodies must also cross the placenta. **Antibodies** are proteins found in the liquid portion of blood that bind specifically to different microbes, preventing the germ from causing damage. Antibodies can also serve as a flashing “come here!” beacon to the rest of the immune system, recruiting white blood cells to attack the pathogen. Because of their larger size, antibodies must be transported via active transport from the parent to the fetus’s circulation.

Active transport works *against* a concentration gradient (so from low concentration to high concentration), requires an input of energy, and requires a transport enzyme. Getting an antibody from the parent’s blood to the fetus’s blood is not simple, and the complexity of the active transport process might explain why infants are born immune to some pathogens but not others. But what determines which antibodies get across the placenta, and which don’t? That’s what Dr. Maddie Jennewein wondered, and what you will investigate in this lesson.

What To Do

Step 1. Explore the Cell Membrane Interactive from PBS.

- Identify the membrane, protein channels, and the box of substances.
- Identify the symbol for oxygen, two blue circles next to each other. Is there more oxygen inside the cell or outside the cell? Predict which way oxygen will move across the membrane, then test your prediction by clicking on oxygen in the box.
- Repeat this exercise for each of the other molecules.
- Antibodies aren’t part of the interactive, but they’d move across the membrane by active transport. Does that mean more like potassium and glucose, or more like oxygen and carbon dioxide?

Step 2. Answer the analysis questions below, reading the Science Bite when instructed.

Analysis Questions

1. Using words or images, explain the following terms**.**

a. Passive transport

b. Active transport

c. Selective permeability

d. Antibody

2. Biological membranes are *selectively permeable*. This means that they control what passes through the membrane.

a. Explain why it is important for cell membranes to be selectively permeable.

b. Refer to **Figure 1**. Explain how passing from parent to fetus is an example of selective permeability.

3. Explain how active and passive transport help an organism maintain homeostasis.

STOP & read Science Bite: What Gets Across?

4. According to the data the researchers collected, some antibodies pass more easily than others. Which types of antibodies were found in the greatest abundance in the cord blood? How does this relate to the types of substances found in blood samples of newborn infants, shown in **Figure 1** of the Science Bite?

5. Is an input of cellular energy needed to move antibodies across the placenta? How do you know?

6. **Connect to the Big Question**. Reflect on the research process in the Science Bite; from Maddy wondering about something they observed to working with a group of researchers discovering something that many people had known about but could not explain.

   a. What might the implications of this discovery be?

   b. What role did curiosity and observation play in this research?