Human Prenatal Development
Investigation 3

Teacher Guide

Tips for Success

- Login to your account on the Human Prenatal Development Student Portal, then leave the page open so you can access the Introduction & Fun Facts, Concept Slides, and other pages.

- A Chromebook/laptop with an Internet connection is required in the lab for each lab group to digitally enter information into this Student Guide. **Alternatively**, the PDF may be photocopied and data can be entered directly on the printed paper version.

Identify your work:

You will work with a collaborative team of scientists for Phases 1 and 2. Doing so will increase the reliability of your results. You will complete the Conclusions and Discussion questions independently. Doing so will enable you to reflect on your personal development and process as a whole.

Your Name:

Group or Lab Partner(s):

Baseline Observation:

Briefly explain what you currently understand about meiosis, gamete (sperm and ova) formation, and human chromosomes. Doing so will allow you to evaluate your work over time.

Student answers will vary.

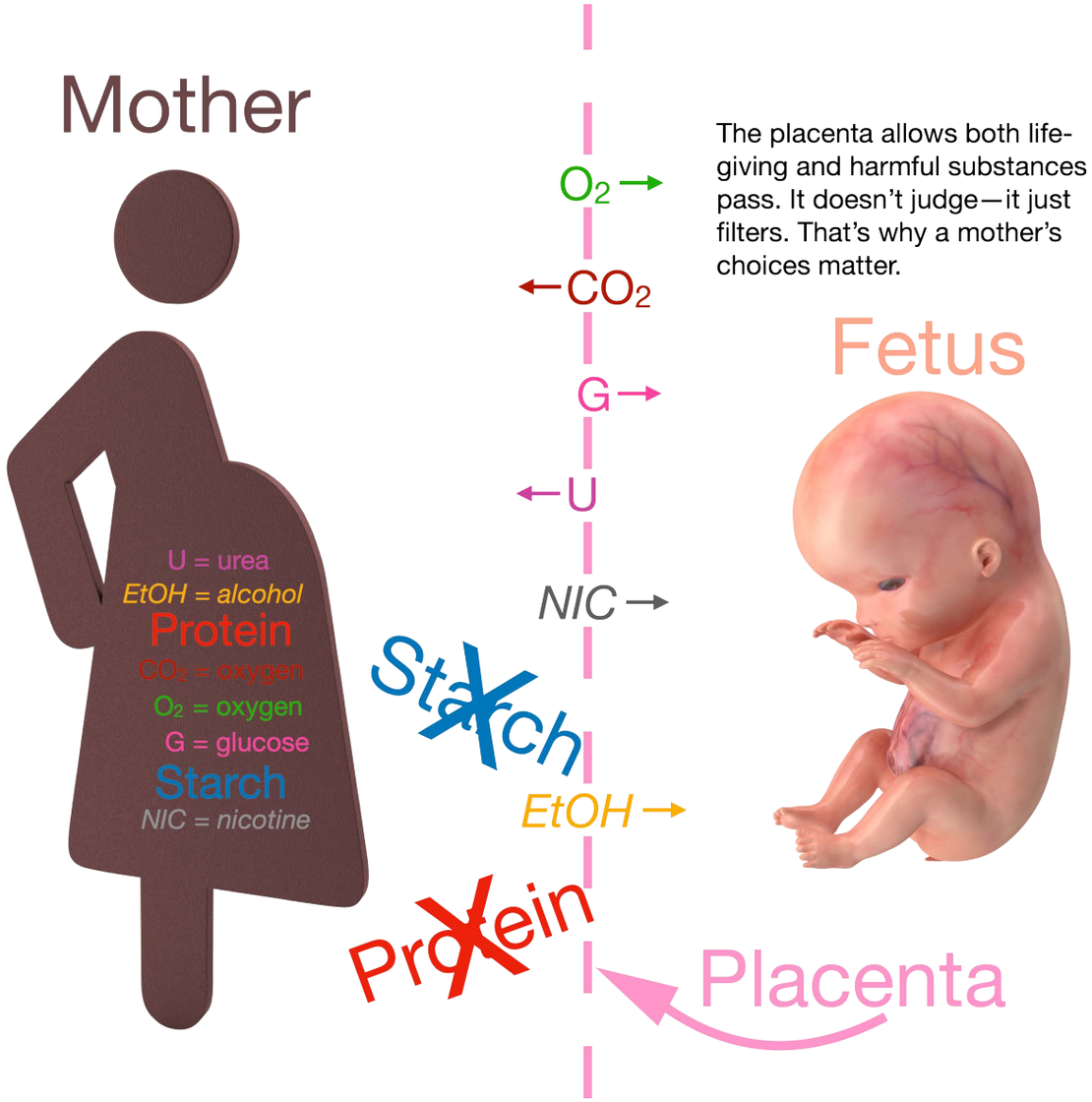
Background Research:

Open the *Introduction* and *Concept Slides* via the *Student Portal*. As you read through the information, think critically, asking questions and evaluating the claims - not simply accepting what you read. Take note of any information that will help you answer the *Phase 2.2* questions. After reading the research, complete the *Student Guide* through and including *Phase 2.2*, and prepare to share your thoughts during the class presentation of the information.

The Placenta – Life's Lifeline

The placenta is one of the most important and fascinating organs in the human body—and it exists for only nine months! It connects the developing baby (the fetus) to the mother, allowing the baby to receive nutrients and oxygen while getting rid of waste. Even though it seems like the baby is "inside" the mother, the two don't actually share blood. Instead, the placenta acts as a barrier and bridge—materials from the mother's blood move through the placenta into the baby's blood without the two ever mixing.

That's important, because the baby might have a completely different blood type than the mother. If their blood mixed directly, it could trigger the mother's immune system to attack the baby's cells. Thankfully, the placenta keeps their blood in separate networks of vessels, with exchange happening across very thin membranes by diffusion, similar to how nutrients are absorbed in the mother's digestive system.



The placenta allows both life-giving and harmful substances to pass. It doesn't judge—it just filters. That's why a mother's choices matter.

Background Research (continued):

The placenta is selective, but not perfect. It lets small, helpful molecules like glucose (sugar), amino acids, oxygen, and water pass from mother to baby. At the same time, it helps carry away carbon dioxide and urea from the baby to the mother, where they can be eliminated. But because it's not a solid wall, some harmful substances can also pass through—and that's where things can go wrong.

Here are a few examples of dangerous substances that can cross the placenta:

Nicotine (from cigarettes or vaping): reduces oxygen to the baby, can cause low birth weight and premature delivery

Alcohol: can lead to fetal alcohol syndrome, which includes learning problems, facial differences, and poor growth

Drugs like cocaine or opioids: can cause miscarriage, withdrawal symptoms in the newborn, or developmental delays

Certain viruses and bacteria: some infections (like rubella or Zika) can pass through and harm the baby's brain or heart

Environmental toxins: like lead or mercury from contaminated water or food

Even some medications: —that's why pregnant women are told to be very careful about what they take

These examples show that while the placenta is a protective gatekeeper, it's not a perfect filter. It can't always tell the difference between something helpful and something harmful—especially if the harmful substance is small and sneaky.

Understanding how the placenta works helps us appreciate the incredible design of pregnancy, and why it's so important to care for both the mother's environment and choices while the baby is developing.

Response to Your Research: Answer the question(s) then list **three new facts** you learned from your research.

1. **Why is it so important that the mother's and baby's blood never mix during pregnancy? What could happen if they did?**

It's important because the mother and baby might have different blood types, and if their blood mixes, the mother's immune system could recognize the baby's blood as "foreign" and start attacking it. This could lead to serious problems, including the destruction of the baby's red blood cells. The placenta is designed to prevent this by keeping the two blood supplies completely separate, while still allowing small molecules like nutrients and oxygen to pass between them. It's like having two highways next to each other with tiny bridges for goods to be exchanged, but without letting the cars merge. This separation helps keep both mother and baby safe during pregnancy.

2. **The placenta is selective, but not perfect. What are some real-world consequences of harmful substances crossing the placenta, and why is it important for pregnant women to be careful about what they eat, drink, or take as medicine?**

Even though the placenta acts like a filter, it doesn't block everything. Small harmful substances like alcohol, nicotine, and certain drugs can pass through and reach the baby. This can cause serious health problems like fetal alcohol syndrome, where babies are born with physical and learning difficulties, or withdrawal symptoms if the mother used addictive drugs. It can even lead to miscarriage or early birth. That's why doctors tell pregnant women to avoid smoking, drinking alcohol, and taking medications unless they're known to be safe during pregnancy. Protecting the baby means being careful about what goes into the mother's body, because the placenta can't always tell what's good or bad.

Experiment-Materials:

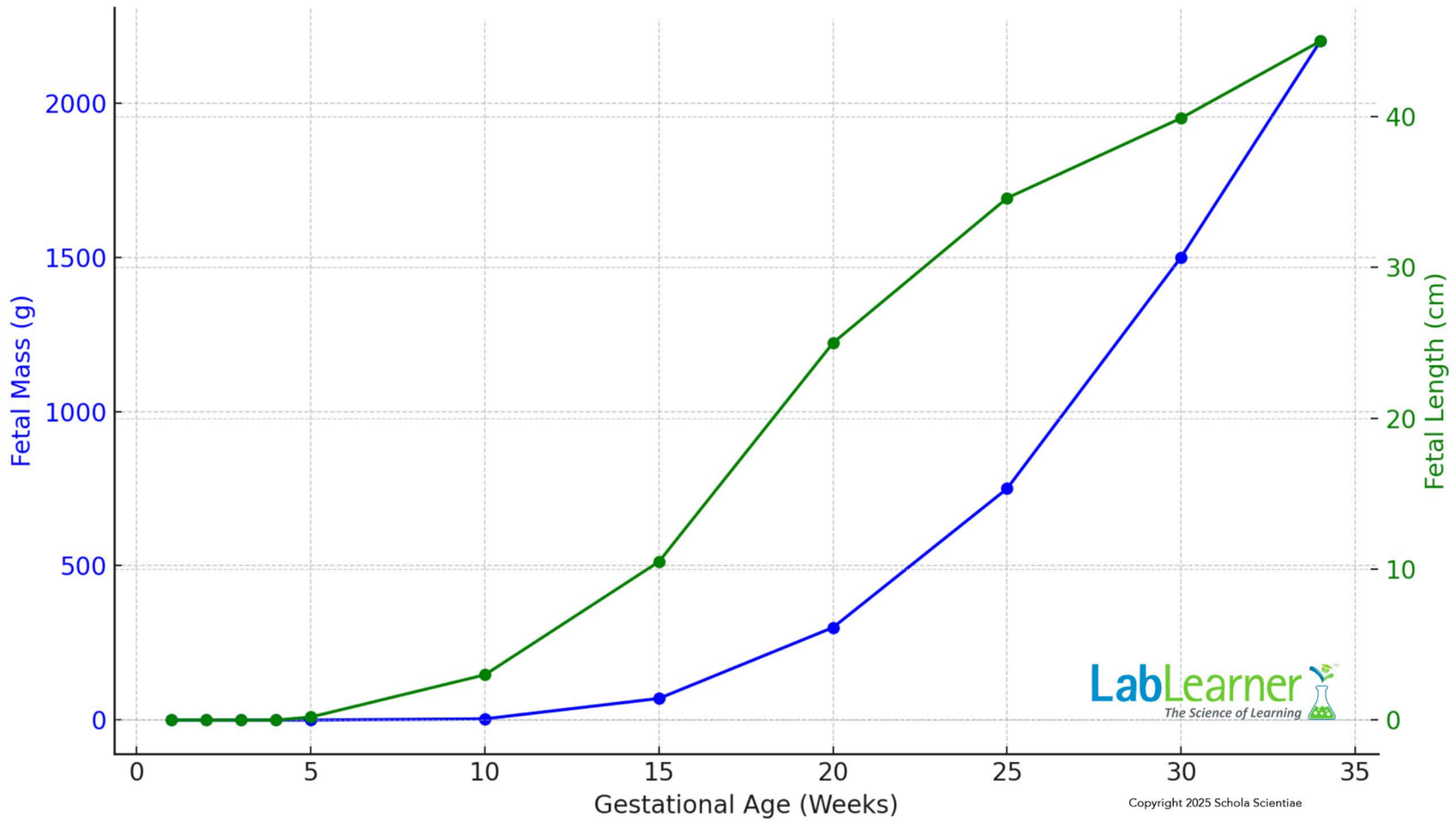
- [ ] Chromebook/Laptop (or SDR)
- [ ] D-Glucose (20 g)
- [ ] Corn starch (4 g)
- [ ] Water (~150 ml total)
- [ ] Acetic Acid (vinegar)
- [ ] 100 ml graduated cylinder
- [ ] 400 ml beaker
- [ ] Filter paper (18.5 cm diameter)
- [ ] Funnel
- [ ] pH paper
- [ ] Glucose test strips
- [ ] Stirring rod
- [ ] 15 ml centrifuge tube
- [ ] Metric ruler or meter stick
- [ ] Modeling clay
- [ ] Triple beam balance (or digital scale)

Experiment-Protocol:

This first activity will span the entire *Human Prenatal Development* CELL. Each week in the lab, you will use the data table and graph below that provides developmental milestones to follow fetal mass and length during prenatal development.

This experience will condense the 36-week normal human gestation period into four weeks, with model measurements taken at approximately weeks 7,14, 21, and 28 weeks of development.

Gestational Age (weeks)	Mass (g)	Length (cm)
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0.2
6	0.8	0.8
7	1.6	1.3
8	2.4	1.9
9	3.2	2.4
10	4	3
11	17.2	4.5
12	30.4	6
13	43.6	7.5
14	56.8	9
15	70	10.5
16	116	13.4
17	162	16.3
18	208	19.2
19	254	22.1
20	300	25
21	390	26.9
22	480	28.8
23	570	30.8
24	660	32.7
25	750	34.6
26	900	35.7
27	1050	36.7
28	1200	37.8
29	1350	38.8
30	1500	39.9
31	1675	41.2
32	1850	42.4
33	2025	43.7
34	2200	45



Mass (grams): Based on data from sources like the World Health Organization (WHO), the American College of Obstetricians and Gynecologists (ACOG), and medical texts on fetal development.
Length (cm): Crown-rump length (CRL) in early weeks and crown-heel length in later weeks, commonly sourced from ultrasound or clinical fetal growth studies.

Experiment-Protocol (continued)

Experiment: Development Model at week 21

☐ 1. Use a triple beam balance (or digital scale) to weigh out a piece of modeling clay to the mass indicated at week 21 of the **Data Table** on the previous page. Record the mass of your 21-week model: Mass = 390 g

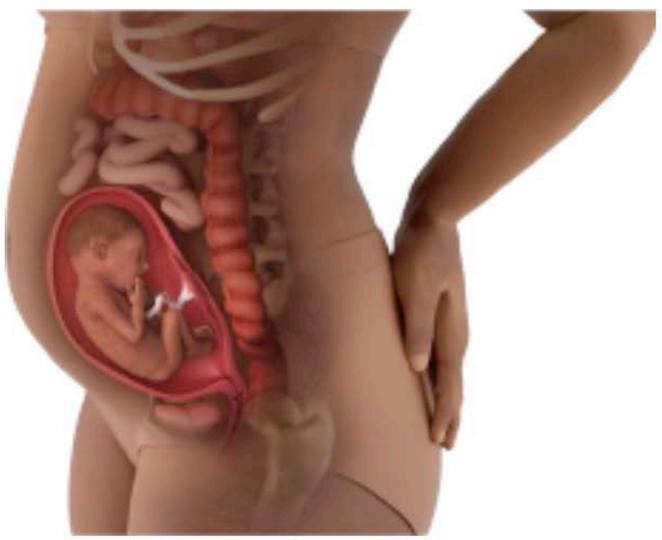
☐ 2. Next consult the **Data Table** once again to find the approximate length of the embryo at this age of gestation (21 weeks).

☐ 3. Using a metric ruler or meter stick, measure your model and form it to be the approximate length listed in the **Data Table**. Record the length of your 21-week model: Length = 26.9 cm

☐ 4. Describe the size and shape of your 21-week fetus model (remember that the baby is referred to as an embryo until the 9th week of gestation, thereafter it is referred to as a **fetus**).

Student answers will vary. Students will likely report that the 21 fetus is much bigger than the 14-week fetus and has more detail.

☐ 5. Depending on your teacher's instructions, either keep the 21-week model fetus to compare your model week to week, or return it to the modeling clay container.



21-week fetus

~390 grams

~27 cm length

Courtesy https://www.babycenter.com/pregnancy/week-by-week/21-weeks-pregnant

Experiment-Protocol:

Experiment: Placenta Function

In this *Investigation*, students use a physical model to represent how the placenta allows some substances to pass while limiting others. This model helps students visualize selective exchange—supporting growth while also showing that the placenta is protective but not perfect.

1. Prepare Solutions:

- [ ] a. Dissolve 20 g of glucose in 100 ml of distilled water to create a 20% glucose solution.
- [ ] b. In a 15 ml centrifuge tube fill to 10 ml marking with acetic acid (vinegar).
- [ ] c. Mix 4 g of corn starch with 100 ml of cold distilled water. Stir thoroughly to make a cloudy suspension. Do not heat.

2. Create the Test Mixture:

a. In a clean beaker, combine:

- [ ] - 40 ml of the 20% glucose solution
- [ ] - 10 ml of acetic acid (vinegar)
- [ ] - 5 ml of the corn starch suspension
- [ ] b. Stir or swirl to ensure the mixture is evenly blended.

3. Test your mixture for glucose, acetic acid, and starch before filtration:

- [ ] a. Swirl the test solution and dip a glucose strip into it.
- [ ] b. Time for 3 minutes and then compare the test strip to the glucose concentration color table on the test strip package. Record the glucose concentration here: _____ This is your "Before" glucose concentration.
- [ ] c. Next, dip a strip of pH paper into the test solution and compare it to the pH color table on the pH package.
- [ ] d. Record the pH here _____ This is your "Before" pH.
- [ ] e. Starch is not soluble in water so its presence will cause the test solution to be cloudy. Describe the appearance of your test solution, in terms of cloudiness below:

Experiment-Protocol (Continued)

4. Filter the Mixture:

- [ ] a. Set up a funnel lined with Ahlstrom #601 filter paper over a clean plastic 250 ml beaker.
- [ ] b. Slowly pour the full 50 ml of your mixture into the funnel.
- [ ] c. Allow the filtrate to collect in the beaker below (let the filtration continue for 5 minutes).
- [ ] d. Remove the funnel and filter paper and put aside for later disposal and cleaning.

5. Test the Filtrate:

- [ ] a. Dip a glucose test strip into the filtrate. A color change indicates glucose passed through. Approximate glucose concentration compared to color chart = _____
- [ ] b. Test pH with pH paper. A pH below 7 indicates the solution is acidic, consistent with acetic acid (vinegar). Approximate pH = _____
- [ ] c. Now check the filtrate to see if it is cloudy. A clear solution suggests the starch did not pass through the filter. Describe the clarity of the filtered solution, and compare it to your earlier observations.

Tip: Glucose test strips work best at concentrations of ~10% or more. Be sure to swirl the solution before dipping for consistent results.

Experiment-Protocol (Continued)

☐ 6. Use the data you collected in the steps above to fill out **Table** A, below.

Table A

Component	Before Filtration	After Filtration	Did the component pass through the filter?
Glucose (mg/dL)	300-1000 mg/dL	300-1000 mg/dL	Yes
Acidic Acid (pH)	12	12	Yes
Starch (Cloudiness)	Cloudy	Clear	No

Focus Questions:

1. Why is mitosis essential for human growth and development from a single cell to a multicellular organism?

Human prenatal development depends on a sequence of biological processes that occur in a precise, regulated, and highly coordinated manner. From the moment of fertilization, development proceeds through predictable stages that rely on accurate cell division, controlled gene expression, and regulated cell differentiation. Cells do not divide randomly; they follow internal instructions that determine when to divide, how often to divide, and what type of cell to become.

This orderliness allows complex structures—such as tissues, organs, and body systems—to form in the correct locations and proportions. Even small deviations from these regulated processes can disrupt development, which highlights how tightly controlled prenatal growth must be. The remarkable reliability of human development across billions of individuals underscores that these processes are governed by biological laws rather than chance.

2. Why is a specialized uterine environment, including the placenta, essential for continued prenatal development rather than simple growth of cells alone?

Cell division alone is not enough to support prenatal development. As the embryo grows, it requires a carefully regulated environment that provides nutrients and oxygen, removes wastes, and protects the developing tissues. The uterus and placenta create this specialized environment, allowing growth to continue safely over time.

The placenta acts as an interface between the mother and the developing fetus. It supports growth by allowing selective exchange of materials while also limiting direct mixing of maternal and fetal blood. This balance helps protect the fetus while still meeting its changing needs as development progresses.

3. What is the placenta, and how does it function as a site of exchange between mother and developing child?

The placenta is a temporary organ that forms during pregnancy and connects the developing child to the mother. It allows oxygen, nutrients, and other essential substances to move from the mother’s bloodstream to the developing child, while carbon dioxide and metabolic wastes move in the opposite direction. Importantly, maternal and fetal blood do not normally mix.

Instead, exchange occurs across specialized placental structures that keep the two circulatory systems separate while still supporting growth and development. This arrangement protects both mother and child while ensuring that the developing organism receives what it needs to survive and grow.

Focus Questions (continued):

4. Why is the placenta more accurately described as a selective interface rather than a simple filter?

A simple filter separates materials based mainly on size, allowing smaller particles to pass through while blocking larger ones. While this idea can help model certain aspects of exchange, it does not fully explain how the placenta works. Some large molecules are transported across the placenta, while some smaller substances are blocked or tightly regulated.

The placenta uses specialized biological mechanisms to control what passes through, when it passes through, and in what direction. This selectivity allows the placenta to support life in ways that mechanical filtration alone cannot explain, revealing the limitations of simple models when describing living systems.

5. How did the lab activity help you model how materials move between the mother and the developing fetus through the placenta?

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