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Lab issue/rev. date: 6/24/98

Title:

Fetal Development

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**Appropriate
Level:**

Life Science, Biology, Honors, AP, and Tech prep.

Abstract:

Students will measure pictures of developing cow embryos to generate data for size. Then they will interpret data from graphs to determine age as well as mass. Students will then compare changes of mass during fetal development with changes in size. Finally, students will contrast developmental trends in cows with that of humans. If the dissection of the pregnant bovine uterus was done, the fetal measurements from that lab may also be included.

Time Required:

Two 45-minute class periods: one to complete data collection and graph data and a second one to analyze the graphs.

Additional Teacher Information

Information with Which Students Should Be Familiar

- Vocabulary: gestation, embryo, fetus.

Materials

- Laminated photos of developing bovine (Holstein) fetuses
- Laminated photos of human development
- String
- Ruler
- Calculator

Helpful Hints

- The Grolier's CD ROM has a great simulation (animation) of fetal development which can be used to reinforce the lab activity.
- Some photographs of human fetal development are required for this activity. Any of Lennart Nilsson's photos are excellent for this. Materials can be obtained from the office of a local OB/GYN or from any right-to-life organization. For example, there is a great magazine available through obstetricians' offices called "As Your Baby Grows" put out by Gerber Baby Foods that details the developmental stages of the fetus using Lennart Nilsson's photos. In addition, the Nova video "The Miracle of Life" could be used to show human development; also the video entitled "The First Nine Months of Life" might be used to extend the lab. Another resource is the book "A Child is Born" by Lennart Nilsson and Lars Hamberger.
- The CIBT lab "Dissection of the Pregnant Cow Reproductive Tract" can be done as a great introduction to this lab. If done, data on fetus size should be saved for use in this lab.

Answers to Questions

Student answers will vary based on the method they chose to use for measurement. Two important sources of variation in answers can be discussed. **Measurement error:** Students using different methods will obtain different lengths for the pictured fetuses. **Biological variation:** Measurements (no matter how well made) are of individuals. The graphs represent the average of many individual measurements.

calf #	length from picture (cm)	gestational age from graph (days)	weight from graph (Kg)	Trimester *
1	5.2	23	<1	1st
2	9.3	50	1	1st
3	16.5	64	2	1st
4	37.5	100	3.5	early 2nd
5	85	178	7.0	almost 3rd

* Human pregnancies are divided into 3 trimesters (approximately 13 weeks each); therefore, the first trimester is weeks 1-13 (1-91 days), second is weeks 14-26 (92-181 days), and the third is weeks 27-39 (182-280 days). Because the duration of bovine gestation is similar to human gestation, we can use the idea of trimesters to describe the stage of fetal development even though this is not commonly done by animal breeders or veterinarians.

Questions

1. The halfway point in development in a calf is 140 days. At what day does the fetal calf reach half its final length? $\cong 120$ days. At what day does the fetal calf reach half its final weight? $\cong 240$ days.
2. **Using the graph**, determine how long the average calf is at birth (280 days): $\cong 98$ cm. Convert your answers to inches (2.5 cm/in): $\cong 39$ in. The average human baby is about 19.5 inches at birth.
3. **Using the graph**, determine how many grams the average calf weighs at birth (280 days): $\cong 36$ kg. Convert to pounds (2.2 lb/kg): $\cong 79$ lb. The average human baby weighs 7.3 lb at birth.

Answer these questions in complete sentences on your own paper.

1. What changes are occurring to the embryo/fetus during the first trimester of development?
During the first trimester all of the major organs/systems are forming.
2. During the last trimester of development the brain and other important nervous system changes are occurring. What other changes are visible in the photos?
During the last trimester the fetus is gaining weight and increases in size rapidly.

3. How does the rate at which the fetus changes in length compare to the changes in weight?
The fetus grows in length much quicker than it increases in mass. Most of the increase in fetal mass occurs during the third trimester.
4. Many women don't realize that they are pregnant until they are eight weeks along. Why is it **especially** dangerous to the embryo for a woman to take drugs early in pregnancy?
A woman might not know she is pregnant and take drugs during those first 8 weeks when all the organs and systems are developing.
5. Most women do not begin to "show" until the fourth or fifth month; in addition, they do not experience "quickening" (feeling the fetus kick or move) until this time. **Use the lab information** to explain this.
Up until the fourth or fifth month the fetus is not large enough to be felt when it kicks.
6. Twins are typically born smaller than singles. Explain this.
With twins, two babies need to split the nutrients of one. Maternal blood volume is greatly increased resulting in a strain on her circulatory system. Anemia often results because of increased demands for iron by the fetuses. In some cases there may be shunting of blood from one placenta to another known as a twin-to-twin transfusion. This results in the recipient twin being larger.

What are two other potential causes for limits on fetal size?
Other factors which influence fetal size include: maternal age, parity (number of previous pregnancies), nutritional level, drugs, alcohol or tobacco use, and the amount of placental development.
7. Think about newborn mice, gerbils, horses, guinea pigs and humans. Are all placental mammals at the same developmental stage when born? Include some specific animals in your answer.
Birth takes place at various stages of development in placental mammals. Guinea pigs are born fully covered with hair, they have teeth and begin to eat immediately. Rats and mice are born relatively undeveloped and humans are in-between.

References

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- Nine Month Miracle* (1995) [CD ROM]. Atlanta, GA: A.D.A.M. Software Inc.
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- Sorenson, A. M. (1979) *Animal Reproduction*. McGraw-Hill, New York.
- Swett, W. W., Matthews, C. A. and M. H. Fohrman (1948) *Development of the fetus in the dairy cow*. Technical bulletin/United States Department of Agriculture, no. 964.

Fetal Development

Development in humans lasts about 280 days or 40 (± 2) weeks, from fertilization until birth. During that time the change from a single-celled zygote to a baby occurs. Fertilization of the egg occurs in the fallopian tube, forming a zygote that divides rapidly by cleavage as it travels to the uterus. The zygote enters the uterus 3 days after fertilization. In humans, the embryo stage extends from fertilization until the embryo measures approximately 3 cm (crown to rump). This requires about 54-56 days or 8 weeks of development. This period of embryonic development is characterized by rapid cell division and is the most critical time in the development of an individual. The embryos of placental mammals appear very similar to each other and the patterns of development are similar. During this early embryo stage all organ systems are being developed and are highly vulnerable to damage by environmental agents such as viruses, drugs, radiation or infection. Agents producing developmental defects are referred to as **teratogens**. They may cause embryo malformations based on premature cell death or they may destroy cell function by interrupting biochemical reactions. Many of the important events in early embryonic development occur before a woman even knows that she is pregnant.

After about 12 weeks of development the embryo is considered a fetus. At this point it has the characteristics which establish it as unquestionably human. The fetus is less susceptible to teratogens; however, these noxious agents may interrupt the normal functional development of organs, especially the central nervous system throughout pregnancy. A fetus at less than 24 weeks is unable to live outside the womb. At 26 weeks it may be sustained alive in an incubator, but the brain is not yet sufficiently developed and the respiratory and temperature-regulating centers do not function well enough to support life independently. A fetus born at this time is in danger of respiratory failure, poor temperature control, or both. The last trimester is characterized by a sharp increase in mass due to subcutaneous fat deposition after week 32. The final tissues to be completely developed are those of the respiratory system (especially the lungs) and the nervous system (especially the brain). The important message of this lab is that a woman must take care of herself from the moment of conception (and even before conception) on to ensure having a healthy baby.

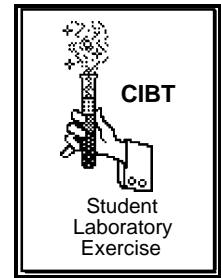
Human Developmental Milestones

Age (wks)	CR length (mm)	Foot (mm)	Fetal Wt (grams)	External Characteristics
9	50	7	8	Eyes closing or closed. External genitalia not distinguishable as male or female.
10	61	9	14	Intestines in abdomen. Early fingernail development.
12	87	14	45	Sex distinguishable. Well-defined neck.
14	120	20	110	Head erect. Early toenail development.
16	140	27	200	External ears stand out from head.
18	160	33	320	Quickening (movement) felt by mother.
20	190	39	460	Head and body hair visible.
22	210	45	630	Skin wrinkled.
24	230	50	820	Fingernails present.
26	250	55	1000	Eyes partially open. Eyelashes present.
28	270	59	1300	Eyes wide open.
30	280	63	1700	Toenails present. Body filling out. Testes descending.
32	300	68	2100	Fingernails reach finger tips.
36	340	79	2900	Body plump. Toenails reach toe tips. Flexed limbs; firm grasp.

Bovine Developmental Milestones

Age days	External Characteristics
18	Primitive streak present; amnion complete
24	Three primary brain vesicles visible; forelimb bud present
26	Fourth brachial arch and mammary ridge present; hind limb bud forming
30	Eye pits forming; eyes pigmented; hard palate forming
38	Eyelids forming; ear forming as a ridge;
40	Ear partly covers acoustic groove.
50	Eyelids partially cover eyes.
56	Palate fused.
60	Eyelids fused; external genitals differentiated; hooves forming.
76	Tactile hairs appear on face.
100	Hooves becoming firm and opaque.
110	Tooth eruption begins.
150	Lower lip and chin covered with fine hair; eyelashes present; tactile hairs on chin; color markings appear; hooves become hard; teats well formed; descent of testes complete.
196	Eyelid separated
230	Body fully covered with hair
278-290	Birth

Fetal Growth and Development



Objectives

- Observe pictures of both cow and human embryos/fetuses.
- Interpret graphs to determine when most of the changes in size and mass occur during the gestation period.
- Contrast trends in growth and development in the cow to the human.

Introduction

Development in humans lasts about 280 days or 40 (± 2) weeks from fertilization until birth. During that time the change from a single-celled zygote to a baby occurs. Fertilization of the egg occurs in the fallopian tube. The zygote divides rapidly by cleavage as it travels towards the uterus. It enters the uterus 3 days after fertilization. Later, the embryo undergoes rapid developmental changes. All the organ systems of a human embryo begin to develop within 60 days (eight and a half weeks) following fertilization of the egg. The heart begins to beat after 4 weeks. By eight weeks the eyes, ears, nose, mouth and fingers and toes are easily recognizable and male and female reproductive systems have differentiated. At about eight weeks, the developing embryo begins to look distinctly human and is known as a fetus. At 60 days the fetus weighs 2 g. At birth the average baby weighs 3.2 kg.

Gestation in cows is also about 280 days and follows a pattern similar to humans.

Materials

- Laminated photos of developing bovine (Holstein) fetuses
- Laminated photos of human development
- String
- Ruler
- Calculator

Procedure

You have been provided pictures of bovine (Holstein) embryos and fetuses, and graphs of calf length and mass at different developmental ages. Using the measuring standards included in the pictures, determine the crown rump length of each of the embryos and fetuses in the picture set. The crown rump length is the length from the crown (high spot on the head) to the point of attachment of the tail. In some cases you will need to curve around the animal's back. You will need to devise a method to use the measuring standard to determine the crown rump length.

Next, use the **gestational age vs crown rump length** graph to determine the age of the fetus based on its length and use the **fetal weight vs crown rump length** graph to determine the mass of the fetus from the age you determine. Finally, estimate the developmental trimester for the fetuses in each picture. Record your data on the table.

Observations

calf #	length from picture (cm)	gestational age from graph (days)	weight from graph (Kg)	Trimester *
1				
2				
3				
4				
5				

- * Human pregnancies are divided into 3 trimesters (approximately 13 weeks each); therefore, the first trimester is weeks 1-13 (1-91 days), second is weeks 14-26 (92- 181 days), and the third is weeks 27-39 (182 - 280 days). Because the duration of bovine gestation is similar to human gestation, we can use the idea of trimesters to describe the stage of fetal development even though this is not commonly done by animal breeders or veterinarians.

Questions

Observe the pictures of human fetal development. Compare them with the fetal calf pictures. **Based on your observations of the photos of humans and cows as well as the graphs, answer the following questions:**

1. The halfway point in development in a calf is 140 days. At what day does the fetal calf reach half its final length? _____. At what day does the fetal calf reach half its final weight? _____.
2. **Using the graph**, determine how long the average calf is at birth (280 days): _____ cm. Convert your answers to inches (2.5 cm/in): _____ in. The average human baby is about 19.5 inches.
3. **Using the graph**, determine how many grams the average calf weighs at birth (280 days): _____ kg. Convert to pounds (2.2 lb/kg): _____ lb. The average human baby weighs 7.3 lb.

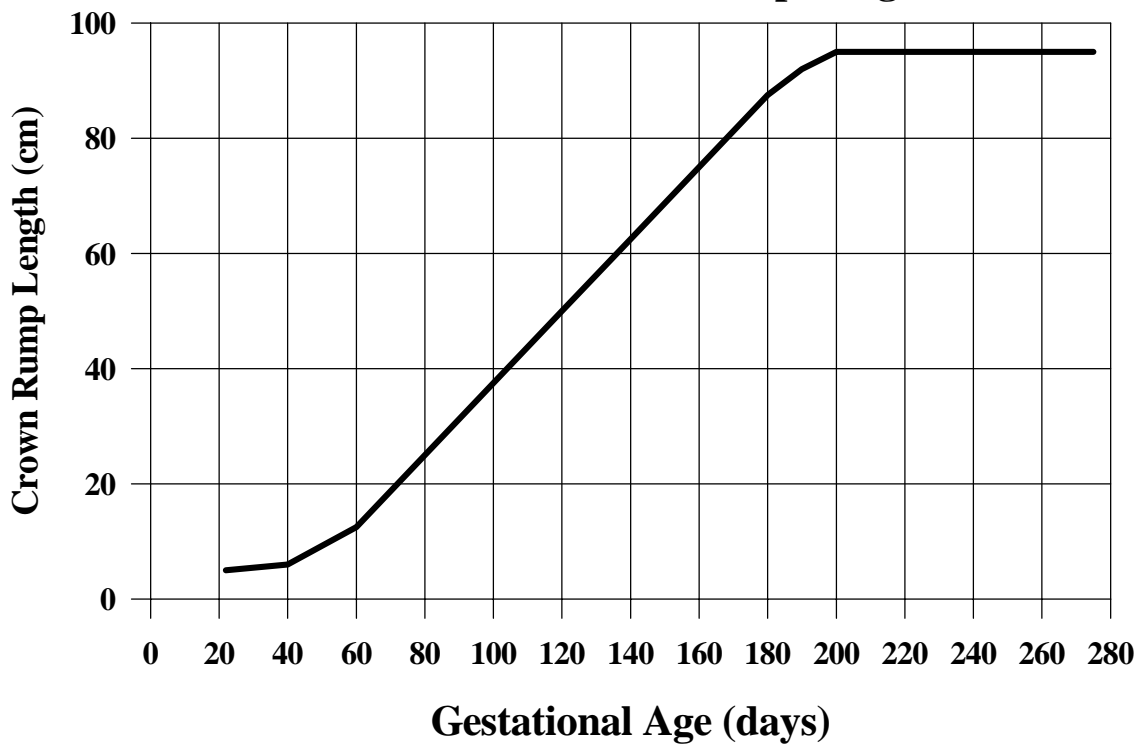
Answer these questions in complete sentences on your own paper.

1. What changes are occurring to the embryo/fetus during the first trimester of development?
2. During the last trimester of development the brain and other important nervous system changes are occurring. What other changes are visible in the photos?
3. How does the rate at which the fetus changes in length compare to the changes in weight?
4. Many women don't realize that they are pregnant until they are eight weeks along. Why is it **especially** dangerous to the embryo for a woman to take drugs early in pregnancy?
5. Most women do not begin to "show" until the fourth or fifth month; in addition, they do not experience "quickenings" (feeling the fetus kick or move) until this time. **Use the lab information** to explain this.
6. Twins are typically born smaller than singles. Explain this.

What are two other potential causes for limits on fetal size?

7. Think about newborn mice, gerbils, horses, guinea pigs and humans. Are all placental mammals at the same developmental stage when born? Include some specific animals in your answer.

Bovine Fetal Crown Rump Length



Bovine Fetal Mass

