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Introduction

In addition to summative assessments, which could be in the form of a unit examination or the final examination, teachers might choose to provide meaningful and timely formative assessments for their students. One area that many teachers are exploring is formative assessment combined with peer review.

Specific outcomes in the *Biology 20-30 Program of Studies (2007)* have verbs that indicate the depth of understanding that students completing the course should have. Some of the verbs such as *list, identify, state, or define* are cognitively simple; other verbs such as *explain, evaluate, and assess* are cognitively challenging. Many students experience minimal success with cognitively challenging tasks in summative assessments. One way of increasing their success is to allow them to explore the required depth of cognition in a risk-free situation of formative assessment before a summative assessment experience. What follows is a summary of the cognitive expectation typically associated with certain verbs.

Cognitive Expectations

Different verbs indicate different cognitive levels, as described in Bloom's taxonomy.

Knowledge	Comprehension and Application	Higher Mental Activities (HMA)
<p>In general, verbs such as <i>list, describe, identify, sort, rank, define, etc.</i>, are at a basic cognitive level and are classified as <i>knowledge</i>.</p> <p>As a peer reviewer, you are looking for an answer that addresses basic biological principles.</p>	<p>Verbs such as <i>compare, apply, calculate, determine, etc.</i>, are at a more difficult cognitive level and are classified as <i>comprehension and application</i>.</p> <p>In general, students need to connect ideas to get to this level. As a peer reviewer, you are looking for the student to provide an answer and a link to another principle.</p>	<p>Verbs such as <i>explain, evaluate, justify, analyze, assess, design, etc.</i>, require a very high cognitive engagement and are classified as HMA.</p> <p>As a peer reviewer, you are looking for the response to contain statements followed by <i>because</i> or <i>therefore</i> as evidence that the student has clearly addressed the relationship between ideas.</p>

Description of Items

These materials are based on a modified written-response item previously released to Alberta educators by Alberta Education. The question covers general outcomes B2, B3, C1, and D3. Teachers may choose to modify the item further or to use only certain parts of the item if they wish.

Suggested Use

Day 1 (20 minutes)

Distribute one of the questions and its associated peer feedback form to students at the same time.

Have students read the question and talk about the depth of coverage required by the bolded verbs. Have the students then look at the peer feedback form. In the centre section of the form, there are horizontal bars that provide a graphical representation of the depth of coverage and cognitive level expected.

Individually or in groups, students develop a response to the question. The responses are shared with other students in the class for the purpose of peer feedback: student reviewers complete the peer feedback form and include comments indicating where the response falls short of the expectation or contains errors. This is the vitally important step: both the peer reviewer and the peer responder get to interact about the content of the course without a mark, a score, or a judgment about the responder being made.

Day 2 (20 minutes)

Students receive their feedback forms from their peers and have an opportunity to describe what changes need to be made to the response. This is a critically important step for students, some of whom might have very little experience with the process of using constructive criticism for improvement.

Day 3 (20 minutes, or outside of class time)

After students have had time to respond to the peer feedback, they can submit a final response to be scored, or they can respond to a similar question for individualized assessment that covers similar material.

Group work and peer feedback are excellent activities for practice, improvement, and learning, but not for assigning individual grades; for the purpose of assigning individual grades, the best practice is that teachers score work done by individual students.

In Alberta, the standards for final scores are as follows: a standard of excellence score (80%) requires students to build new connections between ideas; an acceptable standard score (50%) is awarded to a response that contains only exactly what the student was told. Scores between 50% and 80% are awarded to responses that imply connections or build new connections but also contain errors in content. Scores above 80% are awarded to responses that provide new connections and have completely accurate content.

Extensions

Once you and your students are comfortable with the cognitive tasks required by the directing verbs, and once everyone understands the relationship between the cognitive tasks and the horizontal bars, students can build the bars themselves based on the directing verbs when they get the question.

In this manner, any writing task can be converted into formative assessment.

Use the following information to answer the next question.

Polychlorinated biphenyls (PCBs) are manufactured chemicals that were used for many years in materials such as inks and paints, as well as coolants for some electrical equipment. Since 1977, the manufacture and import of PCBs have been banned in Canada, but trace amounts of these persistent chemicals are still found in both our food and our bodies.

PCBs are endocrine disruptors that mimic the effects of estrogen. Exposure to endocrine disruptors can cause reduced fertility in men by decreasing the number of Sertoli cells in the testes. Some scientists believe that exposure to endocrine-disrupting chemicals is decreasing the fertility of the human population. When fertility decreases, the growth of the population is affected.

Exposure to PCBs has been shown to affect prenatal brain development. In addition, exposure to PCBs has also been linked to the development of some forms of cancer. Cancer cells often have an abnormal number of chromosomes, which can be shown in a karyotype.
















Write a response that addresses the points specified below.

- **Hypothesize** how exposure to PCBs can cause reduced fertility in men. **Predict** how PCBs could affect fertility in women. **Justify** your prediction.
- **Sketch** a hypothetical graph of human population growth as a function of time showing the effect of decreased fertility. On the graph, **label** the time at which reduced fertility begins. **Explain** why you placed the label where you did.
- **Identify** one technology that could be used to assist a man with reduced fertility in fathering a child. **Describe** the technology, and **describe** how the technology increases fertility.
- **Explain** how PCBs are able to pass from a woman to her embryo or fetus. **Identify** the stage of pregnancy during which exposure to PCBs would have the greatest effect on prenatal brain development. **Explain** why the effect would be greatest at the time identified.
- **Hypothesize** how PCBs could play a role in the development of cancer. **Explain** which stage of mitosis is the best for showing the number of chromosomes in a cancer cell.

Student's Name _____

Peer Feedback—PCB

Reviewer's Name _____

<p>Program Links to Tasks in this Question</p>	<p>The horizontal bar indicates the scope required in the response. Place an "x" on the bar to indicate the level demonstrated in the response.</p>	<p>Looking Back</p>
<p>Hypothesize how exposure to PCBs can cause reduced fertility in men. Predict how PCBs could affect fertility in women. Justify your prediction.</p>	<p>Knowledge  Comprehension/Application  Higher Mental Activities </p> <p>Hypothesize Predict Justify</p> <p>Peer Feedback: I've placed an "x" on the bar to indicate the level of your response. I set the level there because I noticed that...</p>	<p>Changes that I am going to make to my response...</p>
<p>Sketch a hypothetical graph of human population growth as a function of time showing the effect of decreased fertility. On the graph, label the time at which reduced fertility begins. Explain why you placed the label where you did.</p>	<p>Knowledge  Comprehension/Application  Higher Mental Activities </p> <p>Sketch Label Explain</p> <p>Peer Feedback: I've placed an "x" on the bar to indicate the level of your response. I set the level there because I noticed that...</p>	<p>Changes that I am going to make to my response...</p>
<p>Identify one technology that could be used to assist a man with reduced fertility in fathering a child. Describe how the technology works, and describe how the technology increases fertility.</p>	<p>Knowledge  Comprehension/Application  Higher Mental Activities </p> <p>Identify Describe Describe</p> <p>Peer Feedback: I've placed an "x" on the bar to indicate the level of your response. I set the level there because I noticed that...</p>	<p>Changes that I am going to make to my response...</p>
<p>Explain how PCBs are able to pass from a woman to her embryo or fetus. Identify the stage of pregnancy during which exposure to PCBs would have the greatest effect on prenatal brain development. Explain why the effect would be greatest at the time identified.</p>	<p>Knowledge  Comprehension/Application  Higher Mental Activities </p> <p>Explain Identify Explain</p> <p>Peer Feedback: I've placed an "x" on the bar to indicate the level of your response. I set the level there because I noticed that...</p>	<p>Changes that I am going to make to my response...</p>
<p>Hypothesize how PCBs could play a role in the development of cancer. Explain which stage of mitosis is the best for showing the number of chromosomes in a cell.</p>	<p>Knowledge  Comprehension/Application  Higher Mental Activities </p> <p>Hypothesize Explain</p> <p>Peer Feedback: I've placed an "x" on the bar to indicate the level of your response. I set the level there because I noticed that...</p>	<p>Changes that I am going to make to my response...</p>

Sample Responses

- **Hypothesize** how exposure to PCBs can cause reduced fertility in men. **Predict** how PCBs could affect fertility in women. **Justify** your prediction.

Hypothesize:

If PCBs decrease the number of Sertoli cells, then exposure to PCBs will cause a decreased number of sperm, because Sertoli cells support and nourish developing spermatids. A decreased number of sperm decreases fertility.

or

If PCBs mimic the effects of estrogen, then spermatogenesis will decrease and fertility will decrease because exposure to PCBs will suppress FSH secretion in a man.

Predict:

Exposure to PCBs will decrease fertility in women.

Justify:

PCBs mimic the effects of estrogen, which has a negative feedback effect on the pituitary gland and therefore suppresses the secretion of FSH. Decreased secretion of FSH results in decreased development of follicles and therefore decreased fertility.

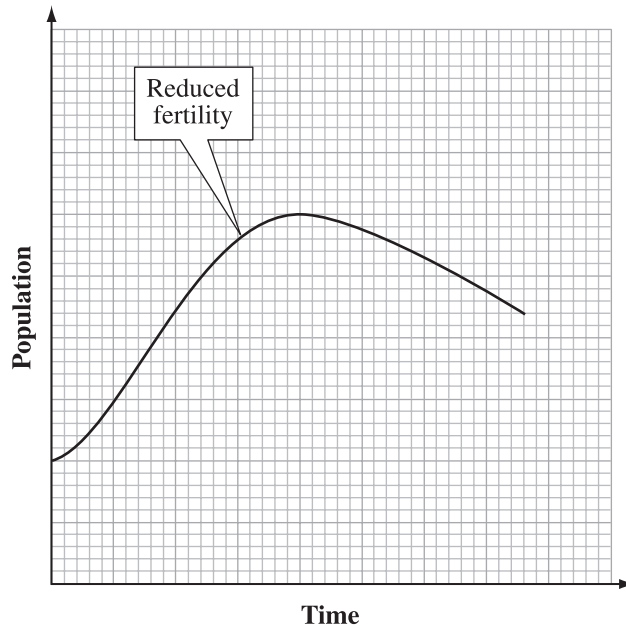
or

PCBs mimic the effects of estrogen, which has a negative feedback effect on the pituitary gland and therefore suppresses the secretion of LH. Decreased secretion of LH results in decreased ovulation and therefore decreased fertility.

or

PCBs mimic the effects of estrogen, which has a negative feedback effect on the hypothalamus and therefore suppresses the secretion of GnRH, which leads to decreased secretion of FSH and LH. Decreased secretion of FSH results in decreased development of follicles and therefore decreased fertility. Decreased secretion of LH results in decreased ovulation and therefore decreased fertility.

- **Sketch** a hypothetical graph of human population growth as a function of time that shows the effect of decreased fertility. On the graph, **label** the time at which reduced fertility begins. **Explain** why you placed the label where you did.



The label is at the point where the population growth rate begins to decrease (i.e. where the line is less steep). The population continues to grow, just more slowly than before.

- **Identify** one technology that could be used to assist a man with reduced fertility in fathering a child. **Describe** how the technology works, and **describe** how the technology would increase fertility.

in vitro fertilization (IVF)

Eggs are extracted from a woman and sperm are collected from a man. The eggs and sperm are mixed in a Petri dish in a laboratory, and a resulting embryo is inserted into the woman's uterus.

IVF increases fertility by facilitating sperm meeting an egg and therefore increasing the chance that fertilization will occur.

or

testicular sperm extraction (TSE)

Sperm are extracted from the seminiferous tubules or epididymis of a man with a low sperm count. The sperm can be used for in vitro fertilization.

TSE increases fertility by extracting and concentrating sperm to increase the chance that fertilization will occur.

or

intracytoplasmic sperm injection (ICSI)

A needle is used to directly inject sperm into a woman's egg. The procedure increases fertility by ensuring that fertilization takes place.

or

hormone therapy

Injections of FSH, LH, or testosterone could increase a man's sperm production. The man might then produce enough sperm for natural fertilization.

- **Explain** how PCBs are able to pass from a woman to her embryo or fetus. **Identify** the stage of pregnancy during which exposure to PCBs would have the greatest effect on prenatal brain development. **Explain** why the effect would be greatest at the time identified.

PCBs cross the placenta from the mother's blood to the fetal blood by diffusion. Diffusion is the movement of chemicals from areas of high concentrations to areas of low concentrations. Although the placental barrier blocks some harmful chemicals, it does not block PCBs.

Exposure to PCBs during the first trimester of development would have the greatest effect on brain development. The effect would be greatest in the first trimester because cells in the embryo are undergoing rapid growth and differentiation during this time. Damage during a period of differentiation affects future development and is permanent and irreversible.

- **Hypothesize** how PCBs could play a role in the development of cancer. **Explain** which stage of mitosis is the best for showing the number of chromosomes in a cancer cell.

Hypothesize:

If PCBs alter genes that control cell division, then the result could be cancer because the rapid division of undifferentiated cells can lead to cancer.

Explain:

Metaphase is the best stage for showing an abnormal number of chromosomes in a cell because the cell's chromosomes have shortened and are easily visible. The chromosomes are arranged at the metaphase plate of the cell and are easier to count than in other stages of mitosis.

Notes: The population graph requires axes to be labelled, a curve that increases and then decreases, and the reduced fertility label to appear where the rate of growth decreases (not at the peak). This is a good opportunity to explore graphical models and what graph shapes mean. It is also an opportunity to explore how a human population growth curve relates to exponential and logistic growth curves.

The students may describe any technology that assists a man in increasing his fertility.

Students must explain how (provide a cause-and-effect response) PCBs cross the placenta barrier in terms of diffusion. It is not sufficient to simply identify the process of diffusion.

Remember, to **explain** is to provide a non-memorized connection between concepts, to **describe** is to provide the characteristics of something or some process. Describing can be done with many statements of fact but without the facts being connected to each other.

Extensions:

1. Students could be asked to explore where PCBs might persist in the environment. They could research how PCBs are being collected and cleaned up. They could research other products that have an effect on hormones. (STS)
2. Students could evaluate the effects of PCBs or other teratogens on embryonic and fetal development at different times of development.
3. Students could explore the relationship of PCBs to cancers and the physiological effects of those cancers. Students could investigate why cancer cells have abnormal numbers of chromosomes; students could build models of aneuploid cancer cells or karyotypes of aneuploid cancer cells.
4. Students could be asked to evaluate the advantages and disadvantages of relying on products like PCBs for reasons related to lifestyle despite the product's potential to cause physiological or ecological harm. (STS)