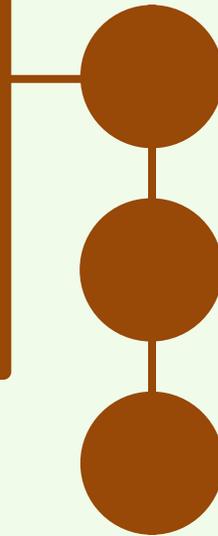


Scientific Teaching in Practice Webinar



SUMMER INSTITUTES
on Scientific Teaching

Learning Objectives for Webinar

After this webinar, participants will be able to ...

- **distinguish “backward design” from traditional methods of teaching preparation**
- **contrast a learning goal from a learning objective**
- **describe a general framework for determining if a question requires low or high cognitive-level thinking**

Why do we assess any kind of learning?



Common answers:

- **Grades or pass/fail**
- **Allow the learner to gauge their learning**
- **Motivate learning**
- **Evaluate and improve our teaching**



Terminology

- **Summative assessments**
 - Typically occur at the end
 - Usually high stakes
- **Formative assessments**
 - Occur during the teaching event
 - Provide regular feedback to both the facilitator and the participants during the learning process

Common Lecture Planning

Choose a Topic



Research & Write/Revise Notes



Prepare PowerPoint or Lecture and activities



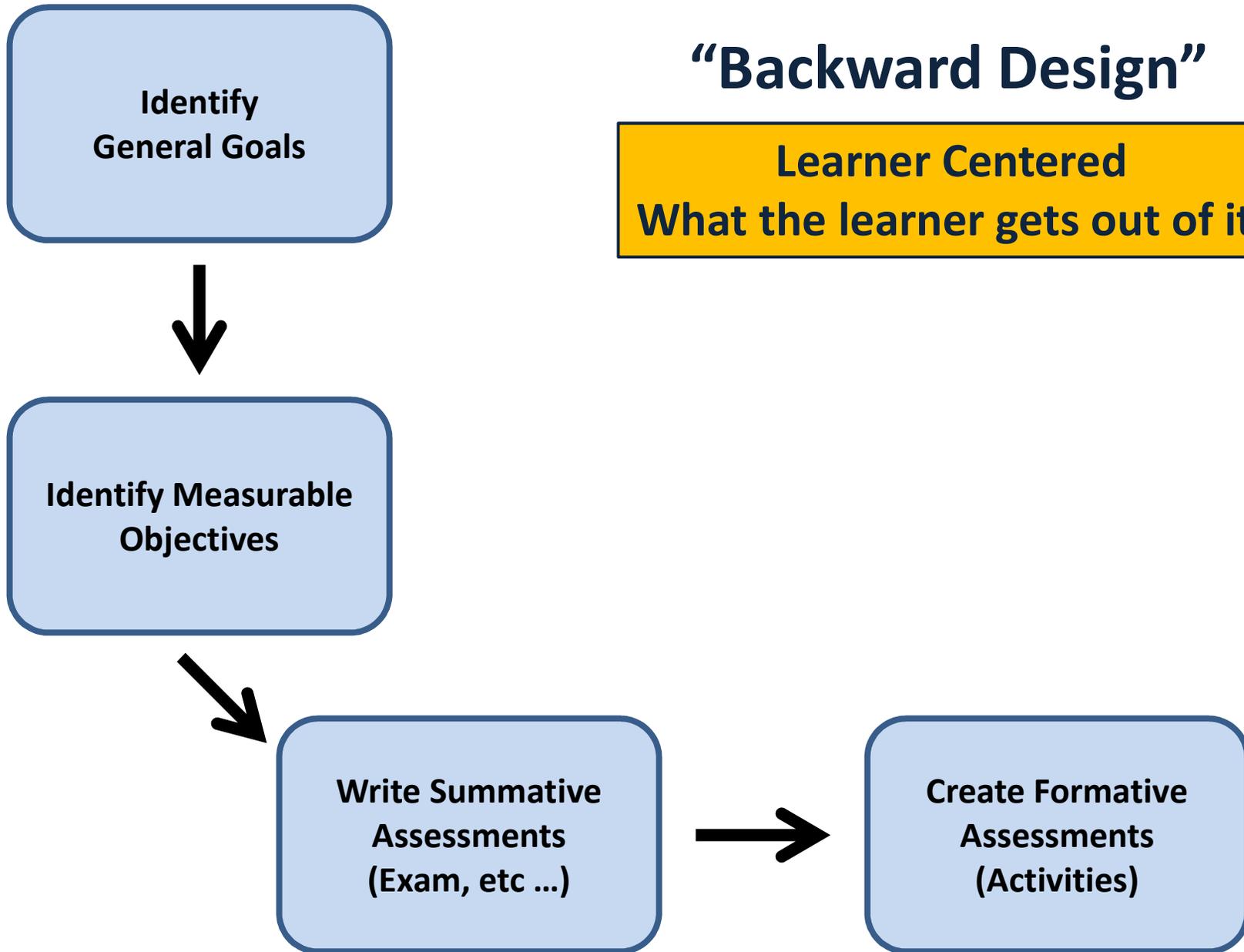
Write Exam

Instructor Centered =

What the instructor is going to do to the learner.

“Backward Design”

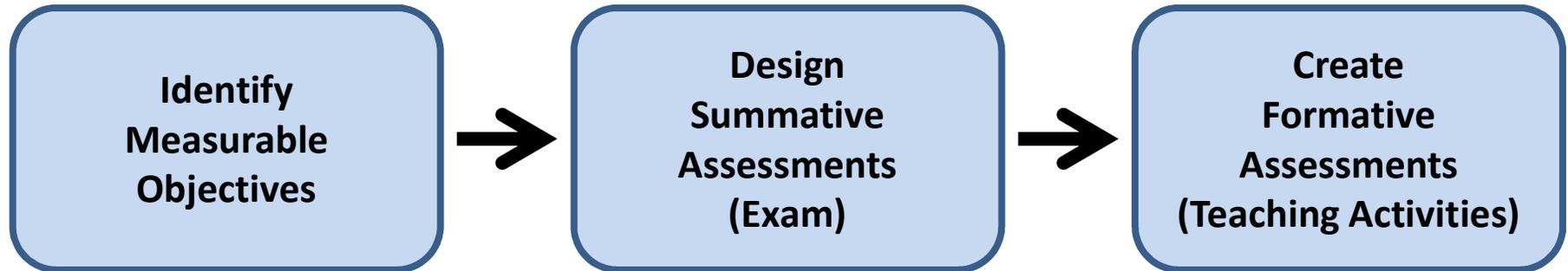
Learner Centered
What the learner gets out of it.



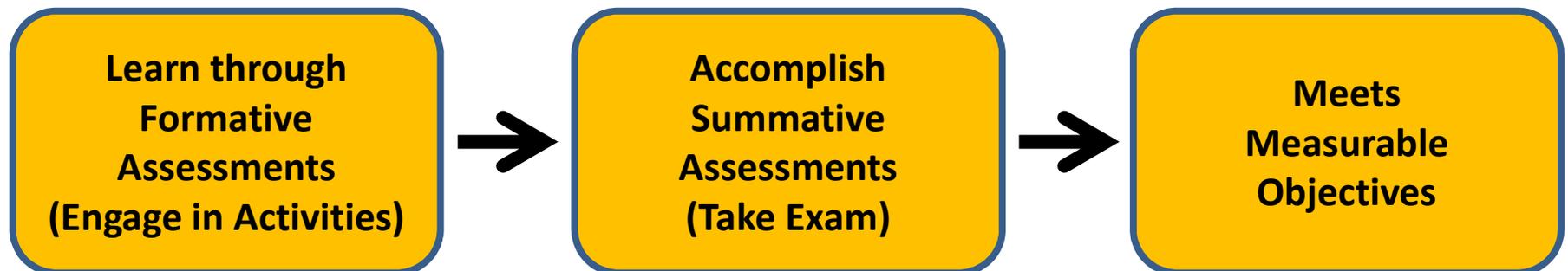
Adapted from Wiggins and McTighe (1998)

Backward Design

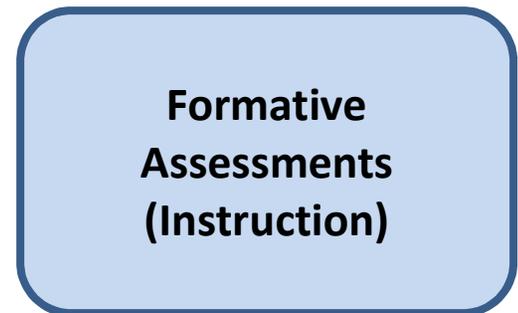
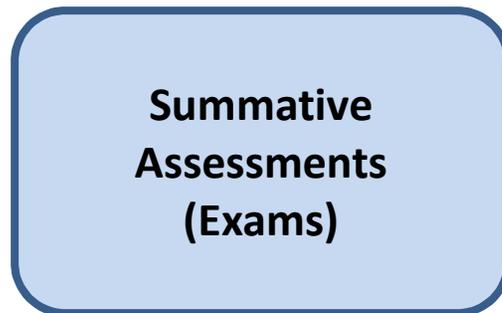
Instructor vs Learner Views



What the instructor does.



What the learner experiences.



**What is the difference?
Does it matter?**

Goals and Objectives

Goals Are Broader and Usually Not Measurable

“Understand”

“Appreciate”

“Learn” and “Think Critically”

Objectives Are Measurable

“Use”

“Graph”

“Design”

Having objectives (the road map) is valuable!

Objectives Should be Aligned with Summative Assessments

Learners demonstrate what they have learned in summative assessments.

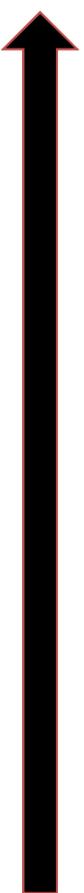
So if you assess them on fact-based knowledge, then that is what they will focus on!

Therefore we need to categorize our exam questions to determine if we are asking the learner to perform lower-order cognitive skills (LOC) or a higher-order cognitive skills (HOC).

See Zoller, U. 1993 in references at the end.

One Method to Categorize Questions: Bloom's Taxonomy

| Cognitive Level | Bloom Level A Simple Phrase to Guide Categorization |
|--|--|
| HOC higher-order cognitive skills | Synthesize "Create something new" |
| | Evaluate "Defend or judge a concept or idea" |
| | Analyze "Distinguish parts and make inferences" |
| LOC/HOC | Apply "Use information or concepts in new ways" |
| LOC lower-order cognitive skills | Comprehend "Explain information or concepts" |
| | Know "Recall information" |



Also, see Lemons, 2013 in references at the end.

Consider How Many LOCs Are Found on Exams

Know

“Recall information”

choose, identify, enumerate,
find, label, list, locate, match,
name, recall, recite, recognize,
report, select, state

Comprehend

“Explain information or concepts”

define, describe, discuss,
explain, express, generalize,
give examples, indicate,
paraphrase, restate,
summarize, translate

**Facts and vocabulary are important!
Objectives should be aligned with assessments.**

See Momsen, J. et al. 2010 in the references.

Key Points

- Objectives are the road map
- Summative assessment drives learning
- Formative assessment is one of the most important strategies for aiding/improving learning
- Alignment between learning objectives, summative assessments and formative assessments is critical

Other Important Points

- Multiple-choice questions can assess higher-order cognitive skills
- Alternative forms of assessment help learning as well



**Thank You
for**

Joining Us!

References

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Momsen, JL, Long TM, Wyse S, Ebert-May D. *Just the facts? Introductory undergraduate biology courses focus on low-level cognitive skills*. *CBE Life Sci Educ* 2010;9:435-440.

Tsai F-J, Suen HK. *A brief report on a comparison of six scoring methods for multiple true-false items*. *Educ Psychol Meas* 1993;53:399-404.

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Multiple-Choice Questions for Assessing Higher-Order Cognitive Skills

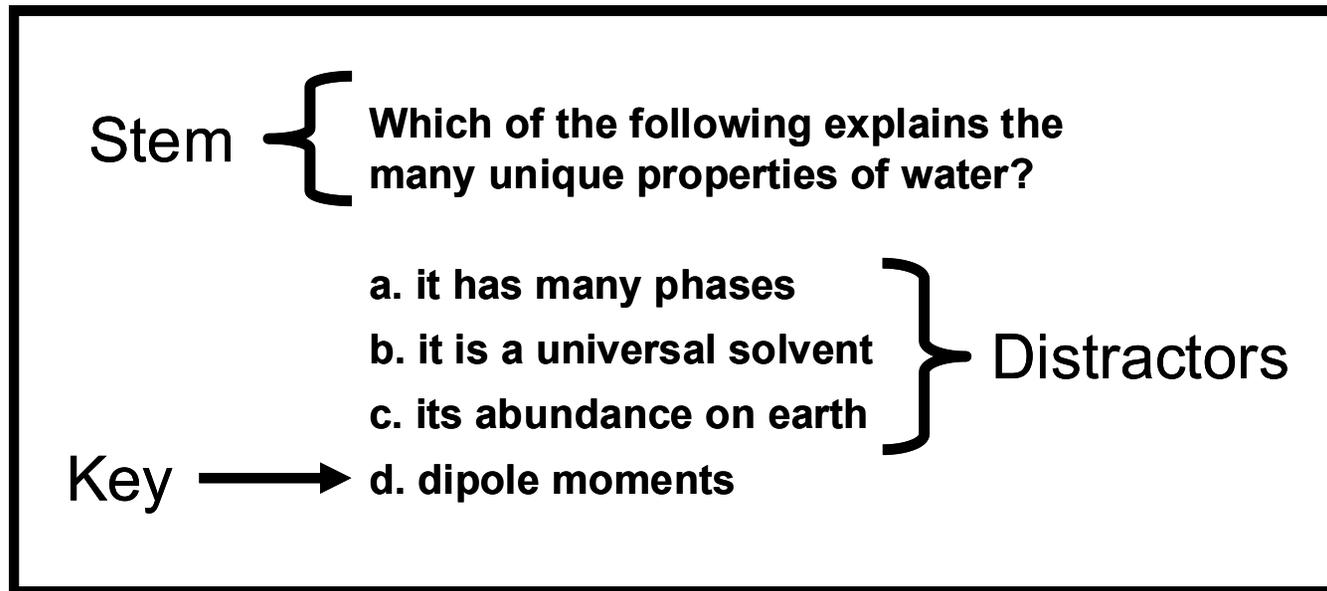
Warning!

**Faculty often get distracted by the content of a question.
Please focus on the question structure!**

See Dirks, C., et al., 2014 in references at the end.

Structures of Multiple-Choice Questions (MCQs)

Standard MCQ



See Haladyna, T. et al. 2002 in references at the end.

Standard MCQ Examples

LOC (recall)

The site of nitrogen fixation in most of the cyanobacteria is the

- A) akinete.
- B) heterocyst.**
- C) hormogonium.
- D) vegetative cell.

HOC (apply)

In a mixture of the five proteins listed below, which should elute second in size-exclusion (gel-filtration) chromatography?

- | | |
|----------------------------|---------------------|
| A) cytochrome c | Mr = 13,000 |
| B) immunoglobulin G | Mr = 145,000 |
| C) ribonuclease A | Mr = 13,700 |
| D) RNA polymerase | Mr = 450,000 |
| E) serum albumin | Mr = 68,500 |

Structures of Multiple-Choice Questions (MCQs)

| MCQ Format | Advantages | Disadvantages |
|----------------------------|--|---|
| Standard | Can measure HOC skills if strong distractors are used | If not well written the structure can cue a student to the answer |
| Two-Tiered | The second tier surveys students' alternate conceptions; id. distractors | Answer to one tier can cue the answer to the other tier |
| Context Dependent | Can measure HOC skills if strong distractors are used | Not time efficient |
| Multiple True/False | Can measure HOC skills | Less than 5 items has increased errors associated with guessing |
| Matching | Time efficient | Not useful for measuring HOC skills |
| Complex (K-Type) | Requires analytical skills of comparing and contrasting and can measure HOC skills | Not time efficient Tends to be very misleading and results in guessing |

See Kubinger and Gottschall, 2007 in references at the end.

Two-tiered MCQ Examples

Questions 5-6 refer to the following passage:

You have tried different combinations of fertilizers to find the ideal mix with which to grow your favorite strawberries. You set up an experiment to compare your old and new fertilizer mixtures. For each trial, you plant 30 of the same variety of strawberries in the same soil under the following conditions in the table below:

| Variable | treatment 1 | treatment 2 | treatment 3 | treatment 4 |
|-------------------------|-------------|-------------|-------------|-------------|
| fertilizer mix | old | new | old | new |
| sunlight (hours/day) | 8 | 12 | 8 | 8 |
| water (ml/day) | 500 | 300 | 300 | 300 |
| # strawberries produced | 80 | 140 | 100 | 100 |

5. Which treatments should be compared to determine if the new fertilizer produces more strawberries than the old fertilizer?

- a. treatments 1 and 2
- b. treatments 2 and 3
- c. treatments 3 and 4**
- d. treatments 1 and 4

6. Explain your answer to the previous question in the space below.

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- a. treatments 1 and 2
- b. treatments 2 and 3
- c. treatments 3 and 4**
- d. treatments 1 and 4

6. Which of the following best explains your answer to the previous question?

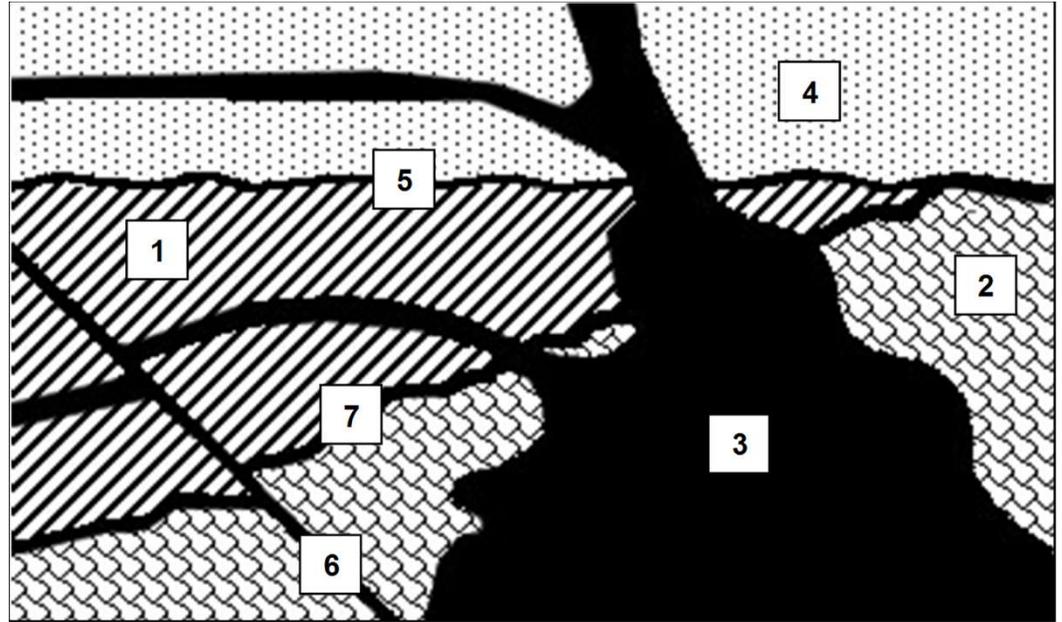
One should compare . . .

- a. treatments that show the new fertilizer yields many more strawberries than the old fertilizer
- b. treatments that show a difference in the number of strawberries yielded
- c. all treatments because conclusions can only be drawn from experiments repeated several times
- d. treatments that only differ in the type of fertilizer used**
- e. treatments that support the hypothesis tested

Context Dependent MCQ Example

1. Using the principles of superposition and cross-cutting relationships, place the sequence of depositional or structural events depicted in the figure from **oldest** to **youngest**.

- a) 2, 1, 7, 5, 4, 6, 3
- b) 7, 2, 1, 6, 3, 5, 4
- c) **2, 7, 1, 5, 4, 3, 6**



2. If transitional fossils were found in layers 1, 2 and 4, which of the following is true of the species represented by fossils?

- a) species in layer 4 evolved from organisms represented by fossils in layer 1
- b) species in layer 2 evolved from organisms represented by fossils in layer 1
- c) species in layers 2 & 4 evolved from organisms represented by fossils in layer 1

Multiple True/False MCQ Example

4. Determine whether the following are true (T) or false (F) about transcription and translation. Five correct responses are required for an overall correct answer.

- F** a. At any given time, a ribosome can be attached to multiple mRNA molecules
- T** b. In bacteria, translation and transcription occur in the same place and time
- T** c. Any ribosome may catalyze the synthesis of more than one kind of polypeptide chain
- T** d. The tRNAs and rRNA, like mRNAs, are transcribed from a DNA template
- F** e. In bacteria, the ribosome binds to the 5' cap and scans for the start codon.

Scoring can be done with the fractional scoring method or the all-or-nothing method. See Gross, 1982 and Tsai and Suen, 1993 in references.

Matching MCQ: Great for assessing definitions and vocabulary (LOC)

Match each genetics term with its appropriate definition or example.

Terms

Definitions and Examples

- | | | |
|----------------|-------|---|
| A. Phenotype | _____ | Both alleles are phenotypically expressed |
| B. Pleiotropy | _____ | The expression of one gene is responsible for more than one phenotype |
| C. Codominance | _____ | Tt would be an example |
| D. Wild type | _____ | Round peas is an example |
| E. Genotype | _____ | Another name for a normal gene |

K-Type MCQ: Can assess HOC but may be problematic.

Stem

- I. option
- II. option
- III. option

- A) I only
- B) II only**
- C) I and II
- D) I, II and III

See Haladyna, T. et al. 2002 in references at the end.

Alternative Summative Assessments That Help Learning and Students Appreciate

Exam Reflections

Grade exams and before returning them to the students, allow students to work in groups to solve the more challenging questions. Allow groups to report out to the entire class.

Group Exams

Students take the exam alone and then they complete it in groups.

Partial Take Home Exams

Send the students home with a subset of questions to complete alone with open book and notes.

See Dirks, C., et al., 2014 in references at the end.