Educators are challenged to develop innovative and creative educational materials that enhance and supplement the traditional lecture format. The materials must facilitate active learning, enhance problem-solving skills, and encourage small group discussion. Educational games are a fun way to achieve these goals. Although games do not replace the traditional methods of obtaining theoretical knowledge, games can reinforce data acquisition while promoting process skills (3).

In developing and playing educational games, teachers and students add variety and alternatives to the traditional lecture format. Games increase student involvement, motivation, and interest in the material and allow the instructor to be creative and original when presenting the topics (4, 7). Games also challenge students to apply the information, thus allowing them to evaluate their critical thinking skills (8). Finally, games create a challenging, constructively competitive atmosphere that facilitates interaction among students in a friendly and fun environment.

Our goal was to generate supplemental materials that would complement and enhance the information presented in the traditional lecture. With this goal in mind, we developed four educationally sound and fun games: 1) crossword puzzles, 2) hidden messages, 3) word scrambles, and 4) word searches. The time required to complete each puzzle depends on the level of difficulty of the game. The educational materials are easy to develop and can be adapted to any curriculum. Although the principles of these materials can be adapted to many scientific disciplines, these specific games provide an unique opportunity to integrate and analyze basic concepts of gastrointestinal (GI) physiology.
MATERIALS AND METHODS

The games were developed for the GI section of the medical physiology course at our medical school. The syllabus for the GI component is divided into five sections: basic concepts, movement of food, GI secretions, and digestion and absorption. The final section is an overall review of the entire GI course. For each general section, a specific puzzle (crossword, hidden message, word scramble, or word search) was developed and presented to the students. The Appendix presents the puzzles for the basic concepts section of the GI syllabus. Puzzles for the remaining four sections of the GI syllabus can be obtained by contacting the authors.1 The crossword puzzles contain 35–50 questions, whereas the hidden message, word scramble, and word search puzzles contain 10 questions. The goal was to develop a fun and active way to review GI physiology.

The crossword puzzles were developed using the Crossword Construction Kit (2). The hidden messages, word scrambles, and word searches were developed using The New Puzzle Factory program created by Michael X. Watman (11).

GAMES

Crossword

Objective. The object of the crossword puzzle is for the students to complete the puzzle by answering questions related to GI physiology.

For the crossword puzzle, the students are presented with two columns of questions related to GI physiology (down and across). Each question is specifically numbered and corresponds to the number found in the puzzle. If the student cannot answer the clue, letters from previously answered questions may aid the student in correctly identifying the concept. Figure 1 presents an example of the crossword puzzle.

Additional Option. The students are encouraged to develop their own crossword puzzle using terms from the lecture material that were not included within the original puzzle. Students may vote for the most creative crossword puzzle.

Hidden Message

Objective. The object of the hidden message puzzle is for the students to decipher a hidden message. This is achieved by first answering specific questions. Subsequently, students place specific letters from the answers into the hidden message puzzle. By completing the hidden message puzzle, students learn concepts of GI physiology.

For the hidden message puzzle, students are presented with a question and a number of spaces that allow for the proper spelling of the unknown answer. For example, if the correct answer is liver, five spaces are provided at the end of the question. Most spaces are assigned a number that represents specific letters.

1 To request an electronic copy, send a Macintosh-formatted disk to the authors at Wayne State University School of Medicine, Scott Hall, 540 E. Canfield Ave., Detroit MI, 48201 or FAX at (313) 577–5494.
that will be used at the end of the puzzle to determine the final hidden message. Specifically, once a question has been correctly answered, the numbered letters from the answer are placed into the corresponding numbers found in the hidden message. The hidden message also contains a number of spaces that do not contain numbers (these spaces already contain letters). The hidden message can be solved once all of the questions have been correctly answered. Figure 2 demonstrates the concept of the hidden message puzzle.

Additional option. The students are encouraged to develop their own message. Once the hidden message is completed, the student may use the letters from the hidden message to create his or her own statement about the lecture material. Each letter from the hidden message may be used only once, and additional letters that were not included in the original message may not be used. The students are challenged to use as many letters as possible from the hidden message. A prize may be awarded to the student who uses the most letters from the hidden message to create a new statement.

Word Scramble

Objective. The object of the word scramble puzzle is for the students to complete the question by unscrambling the letters in the answer.

Question:
Galstones form when ______ precipitates from solution.

Answer:
Galstones form when ______ precipitates from solution.

Hidden Message (Word): ______ M A ______

Hidden Message (Word): ______ S T O M A C H ______

An example of a word scramble question and answer.

For the word scramble puzzle, the students are presented with a question and the answer to the question (with the letters scrambled). The student is challenged to unscramble the letters to correctly answer the question. Each scrambled answer contains only the letters needed to correctly answer the question, and each letter may be used only once. Figure 3 is an example of a question, a scrambled word, and the answer.

Additional option. Once the word scramble puzzle has been completed, the students are challenged to form their own question and scrambled answer. The students develop the new question by using letters from each unscrambled word in the original puzzle. At least one letter but no more than five letters may be taken from each unscrambled word. The student may not include additional letters (letters not found within the unscrambled words) for the question. The number of additional questions and answers required from the students are variable depending on the size of the original puzzle.

Word Search

Objective. The objective of the word search puzzle is for the student to answer a question by finding the correct answer within the puzzle.

The students are presented with a puzzle that contains answers to questions about the lecture material. The student has two options to complete the puzzle. First, the student may answer the questions and then find the correct answers within the puzzle. Alternately, the student may find the answer within the puzzle before reading the question. This option allows the student to match the found answer with one of the questions. Answers within the word search puzzle are found horizontally, vertically, diagonally, or backwards. An example of a word search puzzle is presented in Fig. 4.

Additional option. The students are challenged to develop questions for the words found within the
The crossword puzzles provide students an unique, innovative, and fun opportunity to evaluate their own level of learning by identifying concepts that have not been mastered. The student’s inability to answer a question identifies areas of concern or weakness that can be corrected by targeted studying.

The word scramble game provides the student with all of the information required to complete the puzzle. This game is an excellent way to present and identify definitions that may be unfamiliar to the student. By being presented with the question and the correct answer (scrambled) the student does not have to look up an unknown answer; rather, he or she has to unscramble the answer. In doing this, the student is using problem-solving skills and analytical thinking to complete the puzzle.

The hidden message game challenges the student to find a hidden phrase or message that correctly identifies a concept from the lecture material. The student must fill in the correct letters missing from the words. By filling in the correct letters, the student will then be able to complete the hidden message. This game is greatly appreciated by students, who are required to use correct spelling of words to receive full credit on the test.

The word search game challenges the student to answer questions related to the lecture material. The students receive immediate feedback because the correct answer is found within the puzzle. This allows the students to evaluate their level of knowledge.

All four games provide an excellent immediate review of material that has been presented in class by challenging the student to recall and apply lecture material. The teacher may choose to use the games during class, thus encouraging small group discussions, or the teacher may wish to provide the games as homework. By assigning the games as homework, the teacher receives an evaluation of the effectiveness of the class presentation. By identifying the areas of student weakness, the teacher can alter his or her

puzzle. The instructor provides only the words. The students are challenged to develop questions or definitions for each of the words found within the puzzle.

FIG. 4.
An example of a word search puzzle.
teaching methods by focusing on the areas of weakness. Through these puzzles, the teacher and student both can receive feedback on topics that need to be reviewed more extensively.

The additional options presented at the end of the puzzles promote an opportunity for students to use critical thinking and problem-solving skills. In each instance, the students are required to develop additional questions and answers based on the original puzzle. The challenge of developing the final questions and answers encourages the students to be creative and innovative.

Many educators seek materials that complement and enhance lecture material without compromising class time. These supplemental materials do not require the instructor to remain in the classroom, and no additional class time is required. All four games reinforce concepts that have been presented in class and allow the student to review information in a new, exciting, fun, and challenging format.

APPENDIX

Basic Concepts
Crossword Puzzle
Crossword Puzzle (answers)
Hidden Message Puzzle
Hidden Message Puzzle (answers)
Word Scramble
Word Scramble (answers)
Word Search
Word Search (answers)

<table>
<thead>
<tr>
<th>ACROSS</th>
<th>DOWN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. barrier to absorption (three words)</td>
<td>also known as Meissner’s plexus (two words)</td>
</tr>
<tr>
<td>11. stimulates bicarbonate secretion from the pancreas</td>
<td>contraction of circular muscle with intermittent relaxation (seen at sphincters) (two words)</td>
</tr>
<tr>
<td>13. electrical activity in the gut consisting of slow waves</td>
<td>contraction and relaxation of circular muscle used to mix nutrients with secretions (two words)</td>
</tr>
<tr>
<td>14. responds to dietary fat to stimulate gallbladder contraction and pancreatic enzyme secretion</td>
<td>secretes enzymes and bicarbonate</td>
</tr>
<tr>
<td>15. major artery supplying the stomach, liver, and spleen (two words)</td>
<td>venous drainage from the digestive tract (two words)</td>
</tr>
<tr>
<td>16. absorbs water and concentrates fecal material (two words)</td>
<td>the mechanical and chemical breakdown of food into nutrients that can be absorbed</td>
</tr>
<tr>
<td>22. the only indespensable secretion in the stomach (two words)</td>
<td>major propulsive movement</td>
</tr>
<tr>
<td>23. produces bile salts</td>
<td>innervates the stomach, pancreas, and small intestine (two words)</td>
</tr>
<tr>
<td>25. outer layer of GI wall</td>
<td>baseline level of smooth muscle contraction</td>
</tr>
<tr>
<td>29. located between longitudinal and circular muscle layers (two words)</td>
<td>calcium produces _____ on top of the slow waves</td>
</tr>
<tr>
<td>30. mesenteric artery supplies the large intestine</td>
<td>also known as submucosal plexus (two words)</td>
</tr>
<tr>
<td>34. storage and preliminary digestion of food</td>
<td>principle substance absorbed in the colon</td>
</tr>
<tr>
<td>35. sympathetic postganglionic neurotransmitter</td>
<td>____ system enhances GI function</td>
</tr>
<tr>
<td>37. released into extracellular fluid to act on nearby cells</td>
<td>secreted by G cells</td>
</tr>
<tr>
<td>38. organ involved in digestion and absorption (two words)</td>
<td>parasympathetic preganglionic neurotransmitter</td>
</tr>
<tr>
<td>39. distal division of the stomach</td>
<td>GI tract has an ______ nervous system</td>
</tr>
<tr>
<td>40. __________ glands contain intrinsic factor, HCl, pepsinogen, and mucus</td>
<td>produces pepsinogen (two words)</td>
</tr>
<tr>
<td></td>
<td>system diminishes GI function</td>
</tr>
<tr>
<td></td>
<td>tube for passage of food from mouth to stomach</td>
</tr>
<tr>
<td></td>
<td>may mediate the “housekeeper” function of the GI tract during the interdigestive period</td>
</tr>
<tr>
<td></td>
<td>secretes HCl and intrinsic factor (two words)</td>
</tr>
<tr>
<td></td>
<td>decreases motor and secretory activity of the stomach</td>
</tr>
<tr>
<td></td>
<td>phospholipid bilayer, unstirred water layer, and tight junctions are ________ to absorption</td>
</tr>
<tr>
<td></td>
<td>antagonize the release of acetylcholine in the wall of the GI tract</td>
</tr>
</tbody>
</table>
Basic Concepts Crossword Puzzle

1 2 3 4 5 6 7
8 9 10 11 12 13
14
15
16
17 18 19
20
21
22
23 24
25
26
27
28
29
30
31
32 33 34
35 36
37
38
39
40
Basic Concepts Crossword Puzzle
(answers)
Basic Concepts Hidden Message Questions

1) This organ functions to synthesize and recycle bile salts
   2  11 104 27 26

2) ______ nervous system generally enhances gastrointestinal activity
   89 18 75 28 10 22 42 149 41 20 53 30 46 14 17

3) Venous drainage from the stomach, pancreas, and intestines empties into the
   149 3 88 51 44 7 117 43 16 13

4) The majority of digestion and absorption occurs in this organ
   29 48 58 21 34 23 19 52 49 31 66 38 24 50

5) Hormone released in response to dietary fat
   114 95 4 35 54 74 71 61 70 8 67 39 69 59

6) Plexus in the GI wall located between the submucosa and mucosal layers
   57 56 78 72 86 80 73 107 101 149 45 76 147 111

7) Contraction of circular muscle which moves aborally-propulsive
   89 96 112 91 127 77 81 68 10 98 29

8) Glands that secrete acid, intrinsic factor, pepsinogen, and mucus
   12 84 31 90 124 103 25 40 122 109 82 5 61

9) Barrier between adjacent cells to prevent absorption
   94 116 99 120 102 150 93 132 119 134 33 110 72

10) Sympathetic postganglionic neurotransmitter
   136 36 130 100 89 143 13 105 149 53 141 11 19 113
Basic Concepts Hidden Message

B______F______W
2 3 4 5 7 8

__F__
10 11 12 13 14 15 16 17 18 19 20 21 22

23 24 25 26 27 28 29 30 31

41 42 43 44 45 46

48 49 50 51

52 53 54

D______D______O______O_________,
56 57 58 59 61

66 67 68 69 70 71

72 73 74 75 76 77 103 80

81 82

B______O______O_________,
84 86 88 89 90 91 93

94 95 96

D______
98 99 100 101 102

104 105

107 109 110 111

______E______E______E______A______G______E______
112 113 114 116 117

119 120

122 124 127

F______A______T______O______O______C______A______D______A______C
130 132 134 136

141 143

O______T___
147 149 150
Basic Concepts Hidden Message Questions (answers)

1) This organ functions to synthesize and recycle bile salts
   \[ L \ I \ V \ E \ R \]
   2 11 104 27 26

2) ______ nervous system generally enhances gastrointestinal activity
   \[ P \ A \ R \ A \ S \ Y \ M \ P \ A \ T \ H \ E \ T \ I \ C \]
   89 18 75 28 10 22 42 149 41 20 53 30 46 14 17

3) Venous drainage from the stomach, pancreas, and intestines empties into the
   \[ P \ O \ R \ T \ A \ L \ V \ E \ I \ N \]
   149 3 88 51 44 7 117 43 16 13

4) The majority of digestion and absorption occurs in this organ
   \[ S \ M \ A \ L \ L \ I \ N \ T \ E \ S \ T \ I \ N \ E \]
   29 48 58 21 34 23 19 52 49 31 66 38 24 50

5) Hormone released in response to dietary fat
   \[ C \ H \ O \ L \ E \ G \ Y \ S \ T \ O \ K \ I \ N \ I \ N \]
   114 95 4 35 54 74 71 61 70 8 87 39 69 59

6) Plexus in the GI wall located between the submucosa and mucosal layers
   \[ M \ E \ I \ S \ S \ N \ E \ R \ S \ P \ L \ E \ X \ U \ S \]
   57 56 78 72 86 80 73 107 101 149 45 76 147 111

7) Contraction of circular muscle which moves aborally-propulsive
   \[ P \ E \ R \ I \ S \ T \ A \ L \ S \ I \ S \]
   89 96 112 91 127 77 81 68 10 98 29

8) Glands that secrete acid, intrinsic factor, pepsinogen, and mucus
   \[ G \ A \ S \ T \ R \ I \ C \ G \ L \ A \ N \ D \ S \]
   12 84 31 90 124 103 25 40 122 109 82 5 61

9) Barrier between adjacent cells to prevent absorption
   \[ T \ I \ G \ H \ T \ J \ U \ N \ C \ T \ I \ O \ N \ S \]
   94 116 99 120 102 150 93 132 119 134 33 110 72

10) Sympathetic postganglionic neurotransmitter
    \[ N \ O \ R \ E \ P \ I \ N \ E \ P \ H \ R \ I \ N \ E \]
    136 36 130 100 89 143 13 105 149 53 141 11 19 113
Basic Concepts Hidden Message
(answers)

B L O O D F L O W
2 3 4 5 7 8

S I G N I F I C A N T L Y
10 11 12 13 14 16 17 18 19 20 21 22

I N C R E A S E S F O L L O W I N G
23 24 25 26 27 28 29 30 31 33 34 35 36 38 39 40

A M E A L T O M E E T T H E
41 42 43 44 45 46 48 49 50 51 53 54

D E M A N D S O F M O T I L I T Y,
56 57 58 59 61 66 67 68 69 70 71

S E C R E T I O N, A N D
72 73 74 75 76 77 79 80 81 82

A B S O R P T I O N, T H E
84 86 88 89 90 91 93 94 95 96

D I G E S T I V E O R G A N S
98 99 100 101 102 78 104 105 107 109 110 111

R E C E I V E T H E L A R G E S T
112 113 114 116 117 119 120 122 124 127

F R A C T I O N O F C A R D I A C
130 132 134 136 141 143

O U T P U T.
147 149 150
Basic Concepts Word Scramble

1) Organ that secretes enzymes and bicarbonate
   NCASPREA
   _______________________

2) Responsible for the “housekeeping” activity of the stomach
   ITLIMNO
   _______________________

3) _______ bilayer is a barrier to absorption
   PILDI
   _______________________

4) Hormone that stimulates bicarbonate secretion from the pancreas
   NSITCREE
   _______________________

5) Contraction of circular muscle with intermittent relaxation
   TNOIC NCOACTRIONT
   _______________________

6) Outer most layer of the gastrointestinal wall
   ESORAS
   _______________________

7) Hydrochloric acid is secreted by these cells
   AIELAPTR SLCLE
   _______________________

8) A key component of the intrinsic nervous system
   TRNEIMECY XELSUP
   _______________________

9) Parasympathetic preganglionic neurotransmitter
   TLEYOECNCAIH
   _______________________

10) _______ nervous system functions autonomously
    ERCEITN
    _______________________
Basic Concepts Word Scramble
(answers)

1) Organ that secretes enzymes and bicarbonate  
   NCASPREA  
   PANCREAS

2) Responsible for the “housekeeping” activity of the stomach  
   ITLIMNO  
   MOTILIN

3) ___________ bilayer is a barrier to absorption  
   PILDI  
   LIPOD

4) Hormone that stimulates bicarbonate secretion from the pancreas  
   NSITCREE  
   SECRETIN

5) Contraction of circular muscle with intermittent relaxation  
   TNOIC NCOACTRIONT  
   TONIC CONTRACTION

6) Outer most layer of the gastrointestinal wall  
   ESORAS  
   SEROSA

7) Hydrochloric acid is secreted by these cells  
   AIELAPTR SLCLE  
   PARETERAL CELLS

8) A key component of the intrinsic nervous system  
   TNEIMECY XELSUP  
   MYENTERICPLEXUS

9) Parasympathetic preganglionic neurotransmitter  
   TLELYOECNCAIH  
   ACETYLCOLINE

10) __________ nervous system functions autonomously  
    ERCEITN  
    ENTERIC
Basic Concepts Word Search

1) Organ that stores food and begins preliminary digestion
   ______________

2) A major artery supplying the digestive organs
   ______________ (two words)

3) Hormone that stimulates acid secretion from the parietal cells
   ______________

4) The myenteric plexus is also known as
   ______________ (two words)

5) Principle substance absorbed from the colon
   ______________

6) ______ nervous system generally inhibits gastrointestinal activity
   ______________

7) Glands found in the duodenum that secrete mucus
   ______________ (two words)

8) Antagonize the release of acetylcholine to decrease tone and motility
   ______________

9) Stimulates insulin release
   ______________

10) Gastrointestinal electrical activity for motility consists of ___________ and
    slow waves
    ______________
Basic Concepts Word Search
Basic Concepts Word Search (answers)

1) Organ that stores food and begins preliminary digestion
   **STOMACH**

2) A major artery supplying the digestive organs
   **SUPERIOR MESENTERIC**

3) Hormone that stimulates acid secretion from the parietal cells
   **GASTRIN**

4) The myenteric plexus is also known as
   **AUERBACHS PLEXUS**

5) Principle substance absorbed from the colon
   **WATER**

6) ______ nervous system generally inhibits gastrointestinal activity
   **SYMPATHETIC**

7) Glands found in the duodenum that secrete mucus
   **BRUNNERS GLANDS**

8) Antagonize the release of acetylcholine to decrease tone and motility
   **OPIOIDS**

9) Stimulates insulin release
   **GIP**

10) Gastrointestinal electrical activity for motility consists of ________ and slow waves
    **SPIKES**
Basic Concepts Word Search
(answers)

* W * * * * * * * * * * * * * * * * * * *
* * A * * * * * * * * * * * * * * * * * *
C * * T * O P I O I D S * * * * * * * * *
* I R * T E * * * * * * * * * * * * * * *
S * R * * H C A M O T S * * * * * * * * *
E * * X * B R U N N E R S G L A N D S *
T * * S E * * * * * * * * * * * * * * *
N E S * E L * P * * * * * * * * * * * * *
S E K * * P * S * * * * * * * * * * * * *
M E R * S * * * C * * * * * * * * * * *
O R * * * * * P * I * B * * * * * * * * *
E P * * * * * * * * * * * * * * * * * * *
* S Y M P A T H E T I C * * * * * * * *
* S Y M P A T H E T I C * * * * * * * *

AUERBACHS PLEXUS  GASTRIN  OPIOIDS
BRUNNERS GLANDS  GIP  SPIKES
STOMACH  SYMPATHETIC
SUPERIOR MESENTERIC  WATER
Suggested Readings


References


Suggested Web Sites


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