

Does 21st Century Lecture Technology Improve Learning?

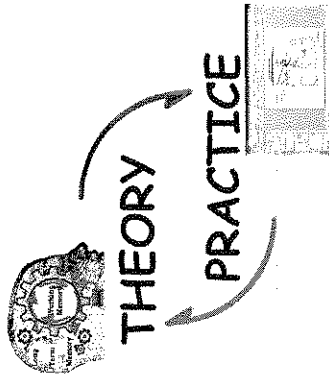


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Cognitive load theory can be used to inform best practices in the design of visuals that accompany lectures



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2. Extraneous cognitive load

- Incidental mental processing that does not contribute to learning the content
- Demands on working memory that are not related to the content = distractions
 - Added sounds unrelated to content;
 - Fast pace
- OR some can even be connected to the content = confusion
 - Mental searching like when information is not clear or not yet automated
 - Images that are busier/more detailed than necessary;
- Bigger interference when the intrinsic load is high
- Under the control of the instructional designer and learner (e.g. Device use)

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“...foreshortening of evidence and thought, low spatial resolution, a deeply hierarchical single-path structure as the model for organizing every type of content, breaking up narrative and data into slides and minimal fragments, rapid temporal sequencing of thin information rather than focused spatial analysis, conspicuous decoration and Phruff, a preoccupation with format not content, an attitude of commercialism that turns everything into a sales pitch.”

The Cognitive Style of PowerPoint by Edward Tufte

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Cognitive load theory posits that the brain has a limited capacity for processing incoming information

- Speed of the processor is limited
- Can only hold a limited amount of information in working memory at one time
- Pulls schema (i.e. knowledge) from long term memory as needed into working memory
 - Automation of schema with increased use reduces the load on working memory

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3. Germane (effective/essential) cognitive load

- The required essential mental processing of the information necessary for learning to occur
- Constitutes an intentional increase in effort that is focused on the content
 - Enhances learning by devoting memory resources to schema development and their automation
 - Under the control of the learner with improved study habits
 - Facilitated by the instructional designer, e.g.
 - Prompt elaboration or analogy development
 - Reinforcement and feedback
 - Provide more and varied examples
 - Create assignments

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Objectives

1. Evaluate effective use of teaching visuals based on evidence from the literature
2. Revise teaching visuals to improve teaching effectiveness
3. Apply principles of effective use of visuals to development of teaching materials

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Three types of cognitive load must be managed to promote learning

1. Intrinsic cognitive load
 - Intrinsic or inherent to the content
 - Usually has multiple interacting elements that contribute to the load
 - It is the mental representation of the information that inherently ties up working memory
 - Cannot be altered by instructional delivery unless you actually change it by simplification or segmenting

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The intrinsic, extraneous, and germane loads add up

- Together, they cannot exceed the capacity of working memory if learning is to occur = ~3 pieces of information

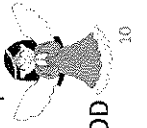
9

Remember the types of cognitive load

- **INTRINSIC** cognitive load = what it takes to represent the information in working memory (representational holding)
- **EXTRANEIOUS** cognitive load = **INCIDENTAL** processing uses up working memory
- **GERMANE** cognitive load = **ESSENTIAL** processing in working memory that is required for learning

Extraneous = **EVIL**

Germane = **GOOD**



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There are 5 ways to overload working memory

They are combinations of overloading across the visual and auditory channels with essential or incidental processing

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Using visual images or text with audio/narration enlarges the capacity of working memory

- Most inputs for lecture-type learning are either visual (text and images) or auditory (lecture).
- The two systems have separate working memory capacities.
- Using them simultaneously enlarges the available working memory

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Since intrinsic load is immutable, reducing extraneous load can allow for increased application of germane load = improved learning

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	Auditory channel		Visual channel
1	Essential processing overloaded	OR	Essential processing overloaded
2	Essential processing overloaded	AND	Essential processing overloaded
3	Incidental processing overload UNrelated to content (distractions)	OR/ AND	Incidental processing overload UNrelated to content (distractions)
4	Incidental processing overload related to content (e.g. confusion)	OR	Incidental processing overload related to content (e.g. confusion)
5	Essential processing plus representational holding	OR/ AND	Essential processing plus representational holding

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Let's see how you are doing with the concept of cognitive overload and its causes

Practice predicting the outcome of a research study

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What would you predict – based on cognitive load theory? Mark with an “X”.

	Overloads	Basic PPT	Enhanced PPT
What mode did students like the best?			
From which mode did students believe they learned the most?			
From which mode did the students perform the best on the quizzes?			
Which mode took faculty the most time to prepare?			
Which mode allowed the faculty to make more points in the 50 minute class period?			

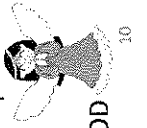
18

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Bartsch and Cobern, 2003

- **Method**
 - 39 students in a Social Psychology class
 - Class met 3X/wk for 50 min for 15 weeks – 2 hours lecture/wk
 - Three modes of lecture delivery were used
 - Lecture accompanied by overhead transparencies
 - Lecture with basic PowerPoint with text only
 - Lecture with expanded PowerPoint including graphs, tables, pictures, sounds – not necessarily related to content
 - Each mode was used for 4 times during the semester for a week each time = two lectures
 - The order of modes was mixed up

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- **Study data collection**
 - Student ratings of how much they enjoyed each lecture (scale 1-9)
 - Student ratings of how much they learned/lecture (scale 1-9)
 - 10 question student quiz for each unit of instruction (some units had multiple lectures)
 - Faculty preparation time for each lecture
 - Number of important content points/lecture

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There are three valuable conclusions from this study

- Students did poorest when the PowerPoint was busiest, likely leading to cognitive overload.
- It also took more faculty time to create a poorer instructional lesson.
- Just because students like it, does not mean it contributes most to their learning.

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1. When the auditory OR visual channel is overloaded with ESSENTIAL processing, off-load from that channel

- Usually due to attention splitting of the overloaded channel
 - E.g. Image with text caption; busy images
- Solution: Off-load from the overloaded channel
 - Either simplify or eliminate whatever is causing the attention splitting
 - Move some information to the other channel

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Off-load by eliminating unneeded text explanations

If the text does not add to a self-explanatory image, delete the text to avoid split attention



From Clark, pg. 86

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Mayer and Moreno (2003) provide a primer on cognitive load reduction for the 5 overload situations

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Off-load by simplifying as much as possible

- Use images as simple as possible for the goal of learning – realism can be confusing
- Even when realism is the ultimate need, ease into it

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Off-load from the overloaded channel to the other channel

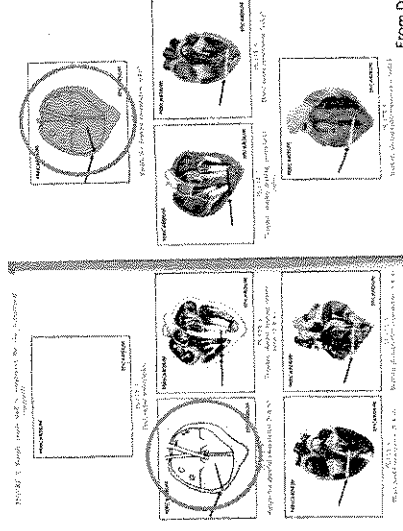
- For an image that is not self-explanatory, delete the text caption and provide explanation with narration

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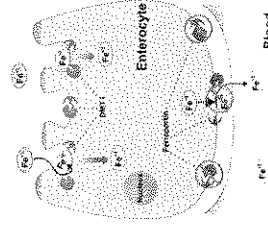
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Which one(s) were most effective in accompanying a lecture?



From Dwyer

Hepcidin will block the absorption of iron from the enterocyte into the blood by causing the degradation of ferroportin



Once the level of body iron begins to decline again, hepcidin production will decline and ferroportin will be active again

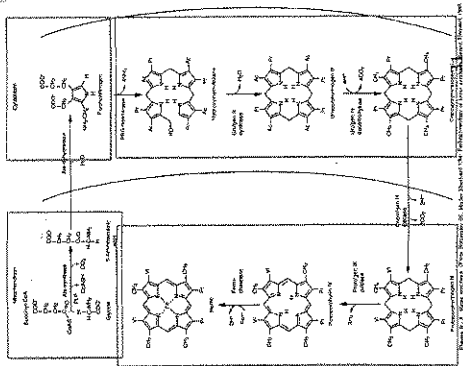
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Review - Use off-loading when one of the channels is overloaded

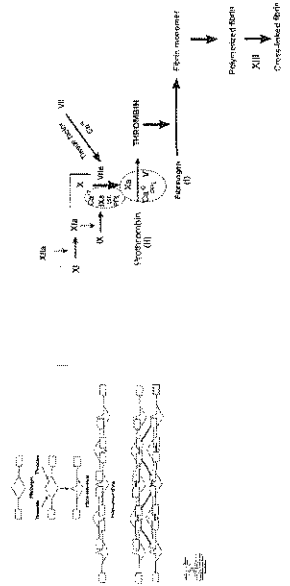
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Segment

- Take the content apart, with pauses between the pieces as they are taught sequentially
 - Allows it to "sink in"
- Self-pacing of computerized modules allows students to do their own segmenting



- Teach parts of the process separately and then put them together



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- When both channels are overloaded with **ESSENTIAL** processing segment or pre-train.
 - When the content is rich and especially if the pace is fast, learners have to choose to which channel they will attend and they can't attend to both

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Use a road map as a variation on segmenting at a higher level

- Use a "road map" of a course or a lesson or set of lessons
 - Return to it periodically, letting students know where they are in the lesson/course
- Hemoglobin
 - Iron
 - Protoporphyrin
 - Globin
 - Molecular structure
 - Function

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Take the lesson apart and PRE-TRAIN the pieces then put them together

- Insure students have pre-requisite knowledge
- List and describe the components of a system before describing the operations/sequence of events
 - E.g. Don't just launch into how a spectrophotometer works; name, locate on a diagram, and state the function of the parts; THEN describe how it works
- Orient students to tables, images before describing the concepts they depict – "On the X axis we have..." "What we are looking at is..."

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- When one or both perception channels are overloaded with incidental processing **UNRELATED** to the content (i.e. Distraction), either eliminate it or signal away from it

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Eliminate distractions whenever possible

- Eliminate use of music in the background of a narrated presentation
- Eliminate content provided “for interest” if it does not directly support the instructional objectives

37

What constitutes “for interest” information?

- From Harp and Mayer, 1998: Lesson on lightning formation; Interest item on a football player who was hit by lightning
- “...students who read expository passages with seductive details (i.e. Interesting but irrelevant adjuncts) recalled significantly fewer main ideas and generated significantly fewer problem-solving transfer solutions than those who read passages without seductive details....”

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But Kathy, I love my “for interest” examples! I don’t want to give them up.

- There is a difference between “for interest” items for emotional interest (e.g. entertainment or motivation) and cognitive interest

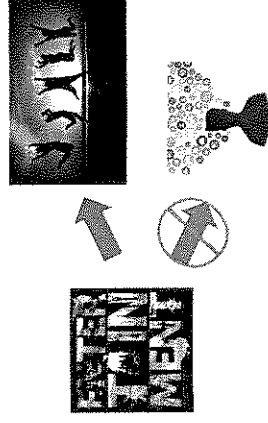
41

Eliminate distractions whenever possible

- Eliminate use of music in the background of a narrated presentation
- Eliminate content provided “for interest” if it does not directly support the instructional objectives
 - If you decide to keep content “for interest”, then present it after the lesson (Harp, Mayer 1998)

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Harp and Mayer 1997 showed that entertaining add-ons may contribute to student enjoyment but do not contribute to scientific understanding



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But add-ons that contribute to clarity and understanding, and thereby better learning, will contribute to student enjoyment



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When distractions cannot be eliminated, Signal what is important

- Signal to students what is essential so you reduce the distraction of the incidental content
- Signals = verbal emphasis, arrows, pointing

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So insure that “for interest” items are pertinent to the content of the lesson

- If the example illustrates the application of the content (e.g. Most case studies), that is not just “for interest”
- If the example is an analogy that activates familiar schema and thereby reduces cognitive load, that is not just “for interest”

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Bottomline – when there are real distractions – eliminate them or draw attention away from them and to the important content with signals

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Avoid using lecture, on-screen text and images all at the same time

- Eliminate these types of redundancy
 - Text describing images that are being verbally described - creates split attention as students read to reconcile the audio with the visual
 - Captioning of recorded audio lectures that also have images and especially when the visual also includes text
- Narration alone for explanation of images is preferred (no added text)
- GOOD NEWS – text plus narration (i.e. lecture with PPT text) is better than lecture alone (Moreno and Mayer, 2002)

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Integrate words into pictures

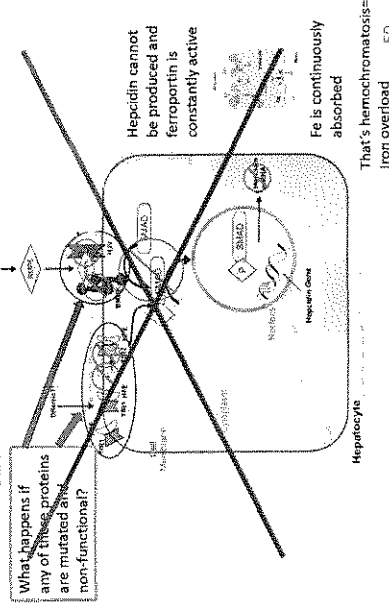
- Integrate text into images rather than captions

See example on next two slides

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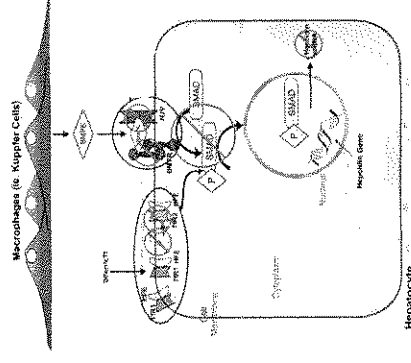
Not like this

1. ... Rest the thumb and forefinger of your non-dominant hand at the edges of the opposite end of the stationary slide. Hold the spreader slide with the thumb and forefinger of your dominant hand.
2. Rest the edge of the spreader slide....

Image from Rodak's Hematology³

- 4. When the ESSENTIAL content delivery introduces incidental processing demands,**
- Eliminate redundancy of content delivery modes in the same channel and/or
 - Use integrated presentation of words and images

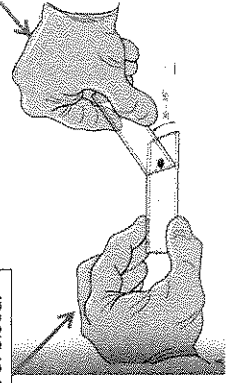
48



51

Like this

1. Rest the thumb and forefinger of your non-dominant hand at the edges of the stationary slide opposite to the drop of blood.
2. Hold the spreader slide with the thumb and forefinger of your dominant hand.



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Integrate words into pictures

- Integrate text into images rather than captions
- Put labels near the items in images
- Be sure to use arrows, lines that connect things
- Design images that move in natural directions for your audience
 - Left to right for English readers – so put text to the left of images
 - Top to bottom – so put text ABOVE images

55

Individualize instruction

- When students can individualize their instruction, they can control factors that otherwise contribute to overload
 - Pace of recorded lectures
 - They can devote more time to viewing images and making sense of them

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What additional evidence-based best practices can be applied to the use of PowerPoint to avoid cognitive overload and thereby facilitate learning?

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5. Synchronize narration(lecture) and pictures in time

- Synchronize visuals and narration to prevent the need for representational holding in short term memory
 - Don't split text and visuals across slides/pages
 - Insure that with animations, the narration is simultaneous and not sequential (narration then video)

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Use sentence-headlines in bold type to state the conclusions to be drawn from the slide (Alley, et al)

This is called assertion-evidence or assertion-conclusion design

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Things I already do	Things I want to do more or begin to do
Off-load to the other channel	
Segment or Roadmap	
Pretrain parts/put it together	
Eliminate extraneous load	
Signal what's important	
Eliminate redundant content delivery	
Insert text into images	
Synchronize in time	
Individualize	

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Microcytic Anemias

- Iron deficiency anemia
- Thalassemia
- Anemia of chronic inflammation
- Sideroblastic anemia

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There are 4 anemias that must be differentiated in a patient with microcytosis

1. Iron deficiency anemia
2. Thalassemia
3. Anemia of chronic inflammation
4. Sideroblastic anemia

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Alley, et al (2006)

Iron ore
is strong and durable

Iron Ore Distribution

Led to 63% recall

Think about what the outline format is communicating for each slide

1. Use numbers when things need to be enumerated
- Use bullets when enumeration is not important
- Remember what indentation means
 - Communicates that this point applies to the one above ONLY

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Find or create images to support the slide headline (Alley 2013)

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Alley, 2013

A common error in the mapping of scientific talks is to show a list that is not memorable

Outline

- 1 Introduction
- 2 Backgrounds
- 3 Maps for Hg Cycling
- 4 Measurements from Station
- 5 Surface Sampling
- 6 Environmental Implications
- 7 Conclusions
- 8 Questions

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ADJUST font and image sizing FOR PROJECTION in different lecture locations.

<http://www.thinkoutsidetheslide.com/selecting-the-correct-font-size/>

71

Iron

- An abundant metal: makes up 5.6% of earth's crust
- Properties:
 - strong, sharp, welded
 - strong, durable
- Accounts for 85% of metals used
- Iron was discovered in 1844 in Michigan's Upper Peninsula
- Soon found other ores in upper Wisconsin and Minnesota

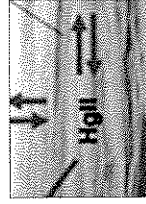


Kessler 1984

Led to 46% recall

Alley, et al (2006)

This talk traces what happens to mercury after it depletes from the atmosphere in arctic regions



Theory for mercury cycling

Measurements from Station



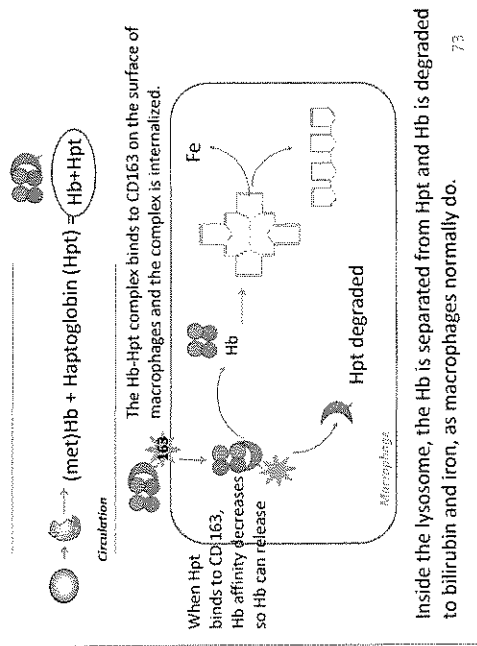
Alley, 2013

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Adjust font and image sizing for readability of handouts

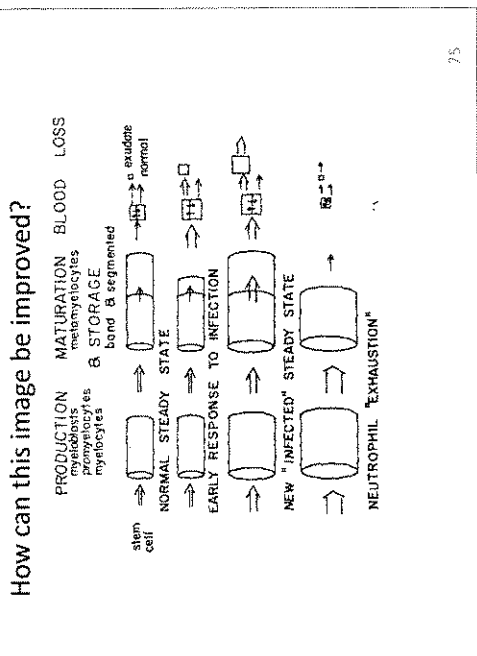
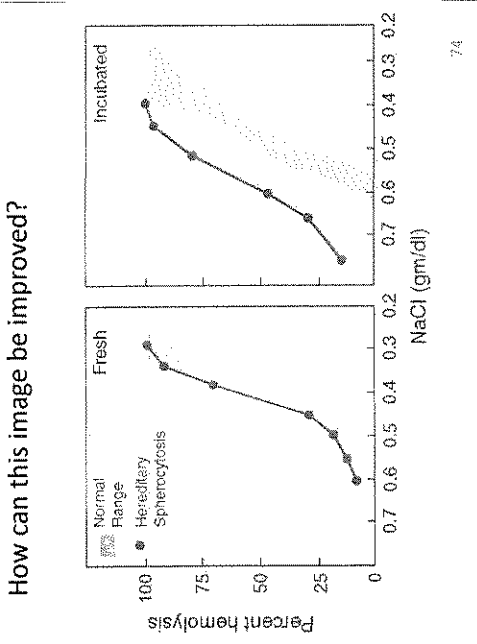
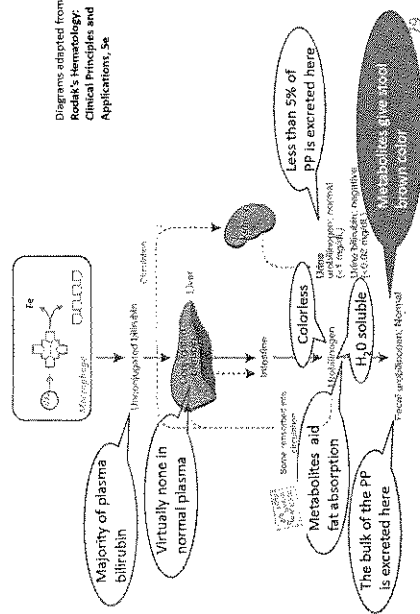
- Print a page and check it out –
- See bonus material on how to get rid of all that extra white space and see Alley 2013 about creating better handouts
- Handouts and presentation slides do not need to be the same!

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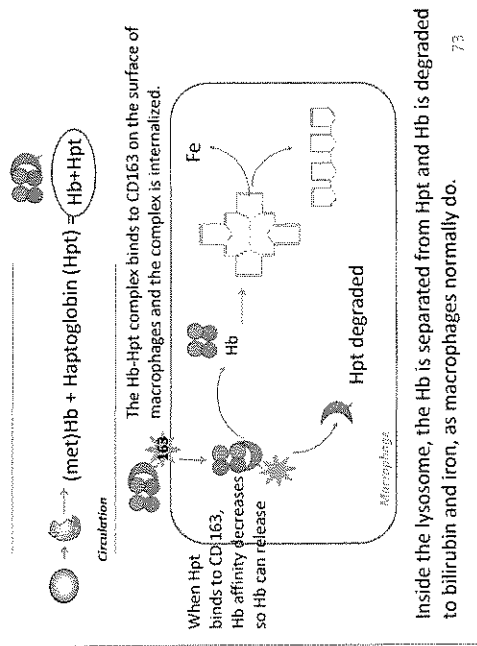
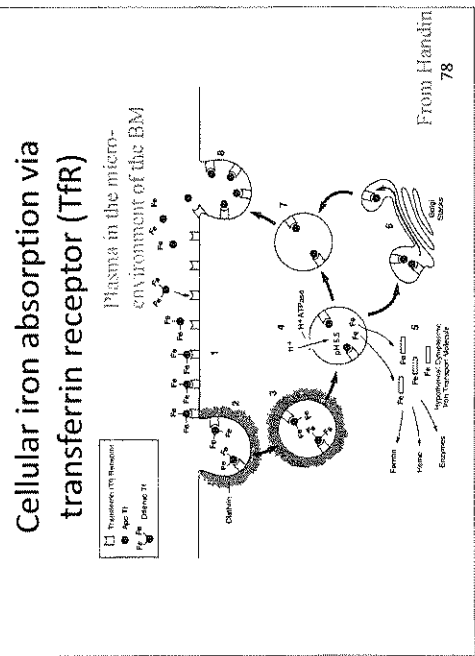
The next two slides are a pair from a presentation. What can be done to improve them?

Protoporphyrin (PP) is broken down to bilirubin



Cellular iron absorption via transferrin receptor (Tfr)

- Iron uptake
 - Transferrin delivers iron to cells by binding to transferrin receptor (Tfr) on cell surfaces
 - Transferrin-Receptor complexes cluster
 - Membrane invaginates to form endosome
 - Acidity releases iron from transferrin
 - Endosomal ferrireductase converts to Fe²⁺
 - Iron moves into cytoplasm OR endosome docks with mitochondria to move iron in directly
 - Apotransferrin is returned to the cell surface with receptor, dissociates, and released to plasma



Using strategies to reduce cognitive load can improve student learning

THEORY

PRACTICE

Questions ?

Bonus follows

Procedure for printing handouts that reduces the number of pages and wasted white space

- If you use this procedure it will allow you to:
 - Print more slides/page of the same size as printing out of PowerPoint (e.g. 9 slides/page rather than 6) OR
 - Print the same number of pages with larger slides for easier reading

Continued on next slide

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You really oughta read these

- Clark R, Nguyen F, Sweller J. Efficiency in Learning: Evidence-based guidelines to manage cognitive load. 2006. (San Francisco: J. Wiley and Sons, Inc.) – very practical and easy to read because they practice what they preach!
- Alley M. The Craft of Scientific Presentations: Critical steps to succeed and critical errors to avoid. Ed. 2. 2013. (Springer: New York)
- Mayer RE and Moreno R. 2003. Nine ways to reduce cognitive load in multimedia learning. *Educ Psychol* 38(1): 43-52.

85

References

- Harp SF, Mayer RE. 1998. How seductive details do their damage: A theory of cognitive interesting in science learning. *J of Ed Psych*; 90(3): 414-434
- Moreno R, Mayer RE. 2002. Verbal redundancy in multimedia learning: When reading helps listening. *J of Ed Psych*; 94(1): 156-163.
- Paas F, Renkl A, Sweller J. 2003. Cognitive load theory and instructional design: Recent developments. *Educ Psychol* 38(1): 1-4.
- Tuft E. 2006. *The Cognitive Style of PowerPoint: Pitching out corrupts within*. Ed. 2. (Graphics Press: Cheshire, CT). Pg. 1-2.

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Here's the procedure

1. In Powerpoint, Save As "Pdf"
2. Open the pdf in Adobe Reader. (This may happen automatically upon saving)
3. Click Print icon at upper left or from the File menu

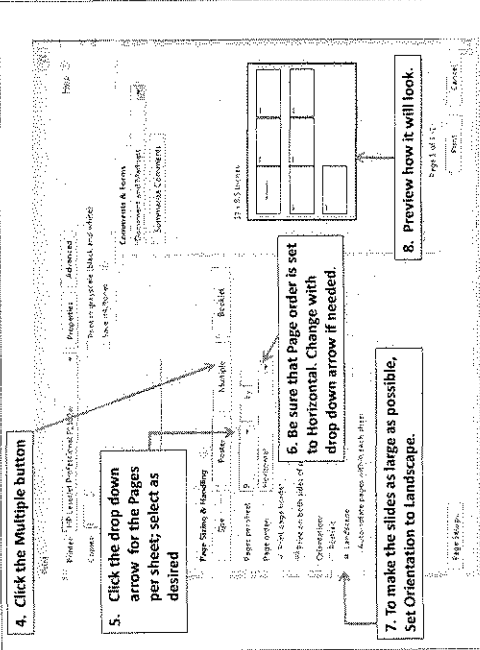
Continued on next slide

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Other good readings

- Fleming M, Levie WH. 1993. *Instructional Message Design: Principles from the behavioral and cognitive sciences*. Ed. 2. (Englewood Cliffs, NJ: Educational Technology Publications)

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References

- Alley M, Schreiber M, Ramsdell K, Muffo J. 2006. How the design of headlines in presentation slides affects audience retention. *Tech Com*; 53(2): 225-234.
- Bartsch RA, Cobern KM. 2003. Effectiveness of PowerPoint presentations in lectures. *Comp & Ed*; 41(1): 77-86.
- Dwyer FM. 1972. *A Guide for Improving Visualized Instruction*. (State College, PA: Learning Services) p. 15-16
- Harp SF, Mayer RE. 1997. The role of interest in learning from scientific text and illustrations: On the distinction between emotional interest and cognitive interest. *J of Ed Psych*; 98(1): 92-102.

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