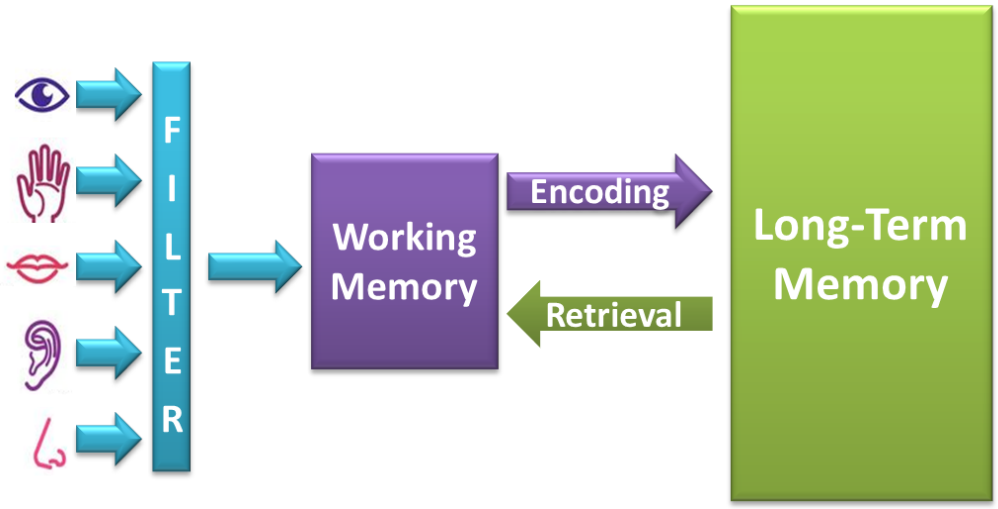
Summary of the *Science of Memory*: **ANSWER** (attention, novelty, spacing, "why", emotions, retrieval)

<u>ATTENTION</u>: Focused attention is necessary, but not sufficient, for long-term memory

- Intentional learning requires focused attention and clear learning goals
  - Create and share clear learning outcomes
- Attention is limited and decreases over time
  - Take breaks, include activities to reset attention during class
- Multitasking is a myth; task switching yields errors
  - Consider policies to restrict cell phone and laptop use
- Primacy-recency effect
  - Use first and last minutes of class for most important concepts and summaries



<u>NOVELTY</u>: The brain seeks novel stimuli and has built-in curiosity

- Novelty increases motivation and interest; motivation can increase time spent attending and processing
  - Mix up the order and type of activities; include engaging images or videos
- Mystery drives interest, promotes retention and the desire to learn the answer
  - Ask students to predict or guess before giving a demonstration
  - Ask questions before providing answers; use driving questions
  - Avoid giving PowerPoint notes in advance
- Practice should be varied
  - Use a variety of interactive teaching techniques and different types of practice

<u>SPACING</u>: Distributed practice (spacing) yields best long-term retention

- Working memory is limited; long-term memory is unlimited
- Massed practice (cramming) doesn't work well for long-term memory
  - Encourage spaced practice by giving frequent (weekly) assessments
- Mixed practice (interleaving) has demonstrated benefits
  - Consider making assessments cumulative; encourage students to mix practice
  - Return to prior content, make explicit connections with current content

- Practice makes processes automatic, automaticity frees up working memory
- Spacing gaps should include sleep, which helps memory formation and learning
    - Tell students to review notes just before bed

<u>WHY</u>: Meaning and context help retention

- We understand new things in the context of what we already know
    - Provide concrete, relatable examples to help understand abstract concepts
    - Put knowledge into the larger context/big picture; why it matters
- Help students put knowledge into larger context, connect items, see relevance
    - Use mind maps/concept maps, flow charts
    - Encourage elaboration—expanding on ideas with additional details and explanation
    - Connect to current events or real-life examples to make it relevant
- We solve new problems better when we understand the underlying principles
    - Encourage students to identify or summarize underlying principles
- Chunking: creates pattern, increases functional capacity of working memory
- Rote memorization: mnemonics (acronyms, pegging, loci, visual link, songs)
- Metamemory (teaching students about memory) improves learning

<u>EMOTIONS</u>: Memory formation involves the limbic system, also associated with emotions

- "Affective filter" can impact perception of teacher AND subject matter
    - Share your enthusiasm for the subject matter
    - Get to know your students' interests and career goals, try to include them
    - Present yourself as a real, approachable person by sharing appropriate, humanizing information
    - Tell relevant stories to make big ideas personal
    - Come to class 5 minutes early and stay 5 minutes late to chat
- Cortisol (stress) is bad for the hippocampus's optimal functioning
    - Set realistic, clear expectations for assignments and exams to minimize anxiety
- The brain uses up to 25% of the body's energy: nutrition, hydration, sleep matter
    - Set reasonable deadlines that recognize the need for appropriate sleep

<u>RETRIEVAL</u>: Retrieval practice and appropriate application strengthens long-term memory

- Retrieval practice or practice testing is highly effective
    - Make practice tests available
    - Encourage self-quizzing, flash cards
    - Reward additional practice with extra credit
- What you think about is what you remember—the practice must be appropriate to the eventual assessment
    - Use orienting tasks such as prediction, reflection, questions/prompts to guide study
    - Ask students "what are you thinking about when you study?"
- Learning is effortful; there are no shortcuts
    - Tell students that how they study is important; not just how much
    - Rereading, highlighting are common, ineffective practices

References and Additional Resources

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. John Wiley & Sons.

Brown, PC, HL Roediger III, MA McDaniel. (2014). *Make It Stick: The Science of Successful Learning.* Harvard University Press.

Dunlosky, J, KA Rawson, EJ Marsh, MJ Nathan, (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest*, 14, 4-58.

Karpicke, JD and HL Roediger. (2008). The critical importance of retrieval for learning. *Science*, 319, 966-968.

McDaniel, M. A. (2012). Put the SPRINT in knowledge training: Training with SPacing, Retrieval, and INTerleaving. In A. F. Healy, & L. E. Bourne, Jr. (Eds.), *Training Cognition: Optimizing Efficiency, Durability, and Generalizability.* Psychology Press.

Sousa, DA. (2011). *How the Brain Learns.* Corwin Press.

Willingham, DT. (2009). *Why Don't Students Like School? A Cognitive Scientist Answers Questions About How the Mind Works and What It Means for the Classroom.* John Wiley & Sons.

Websites

How to Get the Most Out of Studying (a five part video series)
https://www.youtube.com/watch?v=RH95h36NChI&list=PL85708E6EA236E3DB

The Learning Scientists: Six Strategies for Effective Learning (slides and handouts)
http://www.learningscientists.org/downloadable-materials/

Handouts

1. Student study skills: http://bit.ly/Yee-Study-Skills
2. Interactive Techniques: http://bit.ly/FCTL-CATS