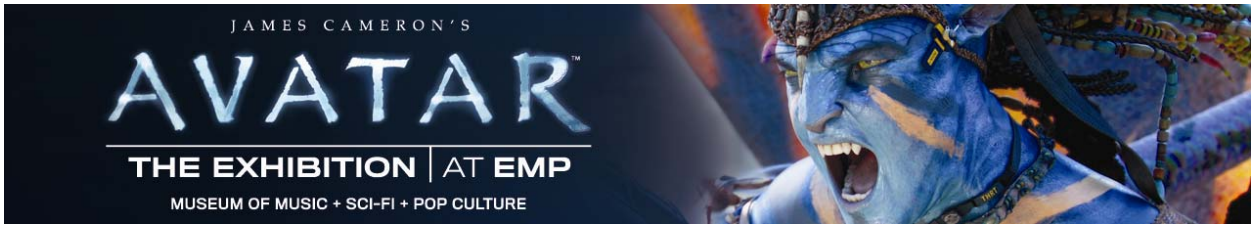


EARTH SCIENCE OF AVATAR

Subject: In James Cameron's "Avatar" scientists travel to a distant planet called Pandora looking for natural resources. After arriving in this strange new world, they realize that they are not alone! Learn about the techniques scientist use to study soil and investigate the complex web of life both on the planet Pandora as well as here on Earth!

Grade Level: 4th and 5th

Learning Standards: WA state EALR 4: Physical Science and Life Science

Big Ideas: Earth Systems, Structures, and Processes, Ecosystems

Core Content: Formation of Earth Materials, Food Webs

Learning Objectives:

4-5 ES2D:
Students will understand that soils are formed by **weathering** and **erosion**, decay of plant matter, transport by rain through streams and rivers, and deposition of **sediments** in valleys, riverbeds, and lakes.

Materials

-Pencils

-Paper

-Magnifying glasses

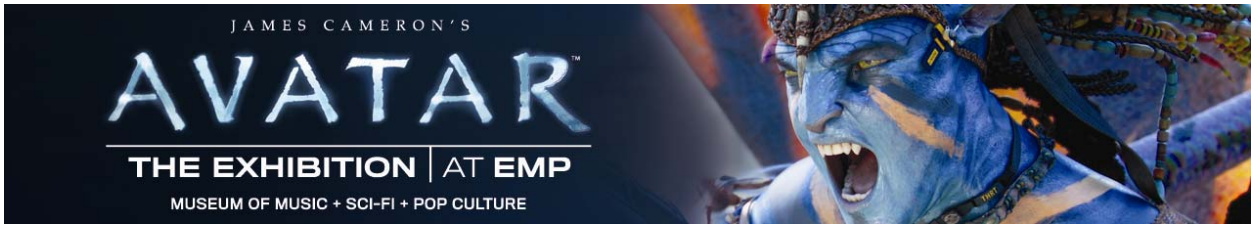
-Soil Samples from various areas around home or school

-University of Washington Soil Texture flowchart: http://www.puyallup.wsu.edu/soilmgmt/Pubs/SoilTextureDiagram_c.pdf

4-5 ES2E:
Students gain an understanding that soils are often found in layers, with each layer having a different chemical composition and different physical *properties*.

4-5 LS2A
Students will understand that an **ecosystem** includes all of the populations of living organisms and nonliving physical factors in a given area. Living organisms depend on one another and the nonliving physical factors in their ecosystem to help them survive. Students will be able to identify the living and nonliving parts of an ecosystem.

4-5 LS2C
Students will gain an understanding that plants and animals are related in food webs with **producers** (plants that make their own food), **consumers** (animals that eat producers and/or other animals), and **decomposers** (primarily bacteria and fungi) that break down wastes and dead organisms, and return nutrients to the soil.



Vocabulary

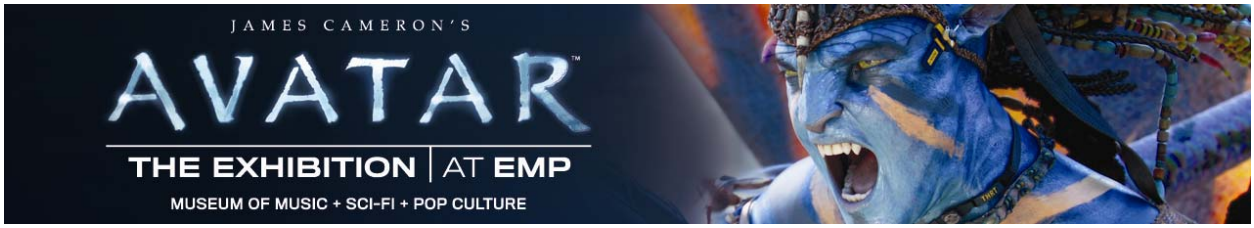
consumer	nutrients
decomposer	organism
ecosystem	producer
elements	sediment
erosion	soil
food web	weathering

Pre-Visit

1. Explore how the formation of soils is related to the following processes: weathering of rock; decay of plant matter; transport by rain, streams, and rivers; deposition of sediments in rivers and lakes.
2. Wearing proper eye protection, experiment breaking rocks and observing remains with a magnifying glass.
3. Soil Texture activity. Break the class into separate groups, distribute various soil samples. Have students take notes and describe the qualities of their soil sample. Students will use the flow chart to determine the composition of their sample. Discuss the natural process the result in deposits of silt, sand, and clay in soil.
4. Discuss ecosystems. Identify the living and nonliving parts. Give students examples to show how the plants and animals depend on one another for survival (e.g., worms decompose waste and return nutrients to the soil, which helps plants grow). Describe how the plants and animals in an ecosystem depend on nonliving resources.

EMP Museum Visit

1. **James Cameron's Avatar: The Exhibition:** Explore the exhibit with particular attention on the scientific study of the planet Pandora. Keep an eye out for artifacts from the movie such as Grace's (Sigourney Weaver) Field Notebook, Soil Sample Kit, and Pandoran Animal Sketches. Learn how the filmmakers worked for years to make the ecosystem of Pandora as realistic as possible.



2. **Curriculum Connection Activity:** Experience the role of an earth scientist as you use lab equipment to test soil samples for important nutrients, chart the food web of Pandora, and design your own fantastic creatures that might live on distant planets.

Post-Visit

1. Sample soil from around your school, your home, or a local farm.
2. Create your own worm compost bin to better understand how waste is reclaimed into valuable fertilizer for plants.
3. Test the potential of your compost fertilized soil versus a control group by planting seeds and charting their growth.
4. Use your worm colony as a biological observation station. Create and test theories about the behaviors of worms.

Resources

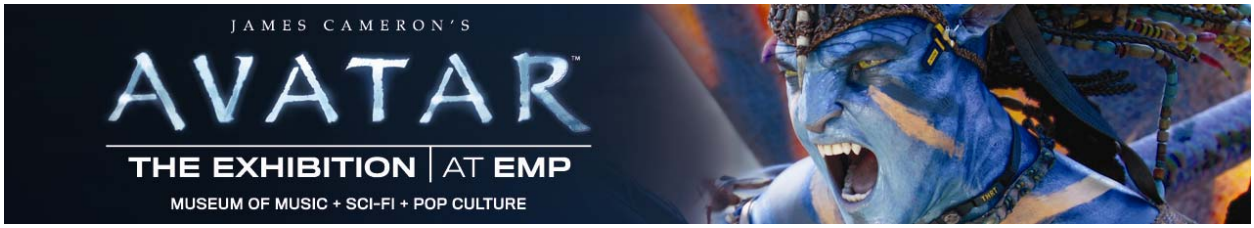
1. "The Making of AVATAR" Jody Duncan and Lisa Fitzpatrick, (2010) Hardcover. Abrams Books.

2. "Avatar Survival Guide: A Confidential Report on the Biological and Social History of Pandora" by Maria Wilhelm & Dirk Mathison. (2009) Paperback. It Books

3. "Super Squirmin's Guide to Underground Secrets"
http://hspnaturetoys.com/~hspnatur/images/stories/Downloads/worm-vue.booklet.pdf

4. The Wormvue Wonder Kit, by HSP Nature Toys:
http://hspnaturetoys.com/~hspnatur/index.php?option=com_content&view=article&id=54&Itemid=65

5. "The Dirt on Soil", Lesson plans by Discovery Channel:
http://school.discoveryeducation.com/schooladventures/soil/index.html



UW-Avatar Exhibition Support Group: Educator Resources

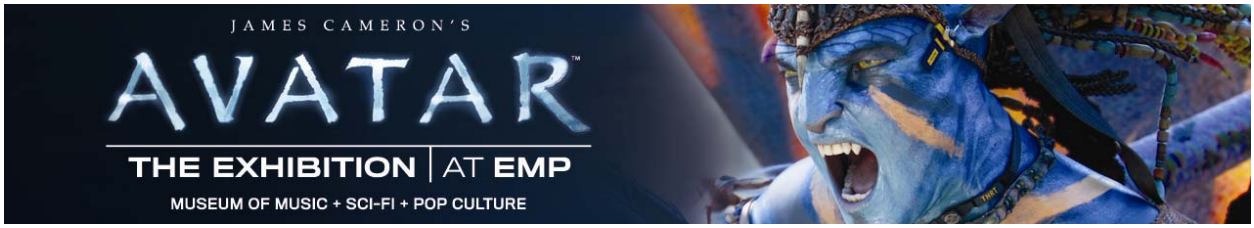
Neurobiology/communication:

- Communication occurs through different mechanisms and at various levels
    - Discuss pheromones and even flower smells as examples of communication between similar/completely different organisms
    - Video of squid/octopus changing color to communicate
- If you could connect your nervous system to other living beings, how would your perception of the world change?
    - More generally, what kinds of perception are important for your lifestyle?
    - Place an object under visible light, then expose the light to a UV or IR filter, how does it look similar or different?
        - All sorts of animals perceive the world in very different ways (UV/IR/polarized light vision, more sensitive sense of smell, etc.)
- There are more than five senses:
    - For example: sense of limb position, balance, temperature, etc.
- Potential classroom activities:
    - The black box test: place an object in a box, use different senses to try to determine what it is
        - Teaching the scientific method: important to emphasize the formulation and testing of hypotheses and observations when trying to determine what is in the box
        - Continue changing object in the box to show how different senses are better suited to detect different objects/signals
    - Play telephone to see how the signal changes as it passes from person to person versus constructing paper telephones
        - How does the speed and accuracy of the signal change? Which one is potentially easier to build?

For a good video for an introduction into how neurobiology and the brain play inform an animal about its environment, watch UW professor Michael Dickinson's recent talk at the Allen Brain Institute on YouTube: http://www.youtube.com/watch?v=7I2dnjEfGBw

Other potentially helpful online resources: the first chapter of Dr. Ralph Greenspan's book *An Introduction to Nervous Systems* (Cold Spring Harbor Press, 2007)

For more on chemical communication, these videos by Dr. Bonnie Bassler of Princeton on bacterial communication are also useful (Part 1 is most relevant for the first link): http://www.ibioseminars.org/lectures/chemicalbiologybiophysics/besslar.html



http://www.ted.com/talks/bonnie_bassler_on_how_bacteria_communicate.html

UW's Dr. Eric Chudler also has an entire website on the nervous system for elementary through high school students: http://faculty.washington.edu/chudler/books.html

Brain Machine Interfaces/Brain Computer Interfaces:

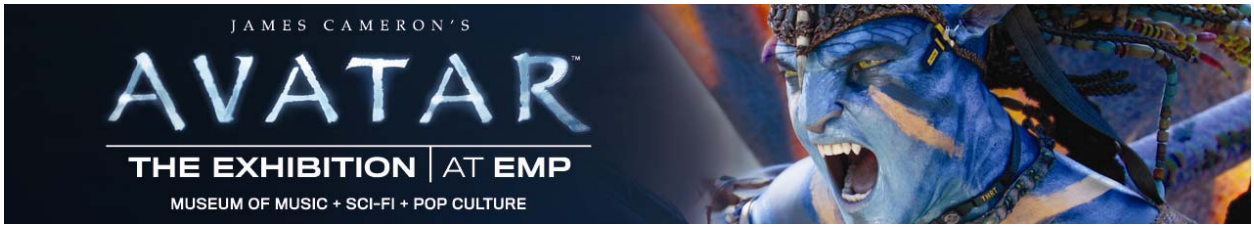
For both the neurobiology and brain-machine interface components, please encourage people to visit the website of the newly funded Center for Sensorimotor Neural Engineering, of which UW is the lead university: http://depts.washington.edu/sensmot/Main/HomePage

Designing exoskeletons that integrate with the wearer and provide the ability to carry very large loads (200 lbs) or restore loss of function to paralyzed individuals.

- Berkeley Robotics and Human Engineering Laboratory
    - http://bleex.me.berkeley.edu/research/exoskeleton/bleex/
    - http://bleex.me.berkeley.edu/research/exoskeleton/elegs%E2%84%A2/
        - The video on this page even has the word "avatar" in it.
- Spin-off company from the same research group
    - Berkeley Bionics: http://berkeleybionics.com/
- News article about a UC, Berkeley student walking at graduation with the aid of an exoskeleton: http://abcnews.go.com/Health/paralyzed-student-walks-uc-berkeley-graduation/story?id=13608789
- The following link is to the website of a lab using electrical signals from muscles (electromyography) to enable amputees to control prosthetic arms. The site has a number of YouTube videos of patients using bionic arms and explains some of the techniques they use to enable the user control the arm effectively: http://www.ric.org/research/centers/cbm/index.aspx

Controlling computers and machines directly with brain activity.

- 60 Minutes story on Brain-Machine interfaces showing a paralyzed individual directly controlling a computer cursor and wheelchair using only her brain via an array of implanted electrodes: http://cnettv.cnet.com/60-minutes-braingate-movement-controlled-mind/9742-1_53-50004319.html
    - Link to the website of the group doing this project: http://donoghue.neuro.brown.edu/
- The spin-off company: http://www.cyberkinetics.com/
- NPR and BBC articles on another method of recording brain signals know as electrocorticography (ECoG):
    - http://www.npr.org/2011/05/12/135598390/mind-reading-technology-turns-thought-into-action



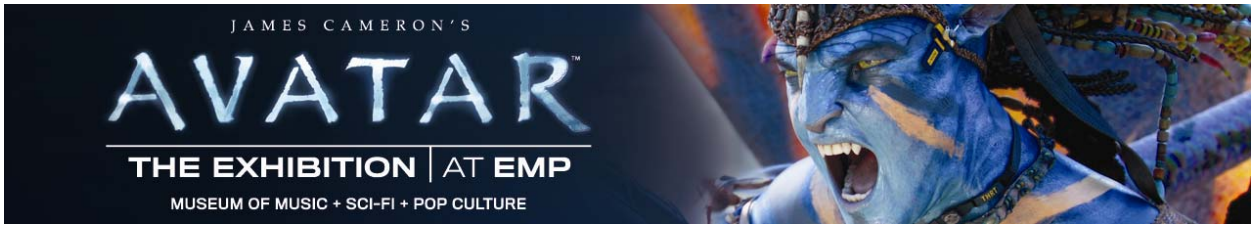
- http://www.bbc.co.uk/news/science-environment-12990211

Cochlear Implants -- artificial implants that directly interface to a person's auditory nerve to restore hearing

- NIH link provides basic overview of how cochlear implants work
  - http://www.nidcd.nih.gov/health/hearing/coch.asp
- The best article on cochlear implants is probably at Wikipedia
  - http://en.wikipedia.org/wiki/Cochlear_implant
- A schematized simulation of how sounds get translated into neural signals by the inner ear also shows the basic strategy that cochlear implants employ at a cruder level than the ear: they decompose complex sounds into their frequency components. Here's the link: http://lab.rockefeller.edu/hudspeth/graphicalSimulations
- Acoustic Simulations of Cochlear Implants (University of California Irvine):
- The following link has some interesting simulations of how cochlear implants of varying channels might sound to a hearing person. A minimum of 3 frequency channels already suffices to understand basic words: http://www.healthaffairs.uci.edu/hesp/simulations/simulationsmain.htm
- There's also a YouTube video with similar information: http://www.youtube.com/watch?v=SpKKYBkJ9Hw

Neurobotics

- Neurobotics is a two-way street connecting brains and robotics. Insights from the study of how nervous systems control movement are used to improve robotic control, and lessons learned from efforts to build robots can teach us about the brain and body.
- ACT Hand: Mimics the human hand as closely as possible:
  - http://neurobotics.cs.washington.edu/projects.html#project8
  - http://www.ri.cmu.edu/projects/project_443.html
- RAT SLAM: Using findings from neuroscience research in the rat (the "place" cells) to achieve robot localization
  - http://en.wikipedia.org/wiki/Place_cell
  - http://itee.uq.edu.au/~milford/Mapping/Mapping.html
  - Rat slam is related to the "embodied" philosophical movement in robotics, which emphasizes interaction with the environment, learning through experience, etc. The scholarpedia entry for neuro robotics leans in this direction: http://www.scholarpedia.org/article/Neurorobotics
  - See also:
    - http://www.eucognition.org/index.php?page=tutorial-on-embodiment
    - http://www.amazon.com/Body-Has-Mind-Its-Own/dp/1400064694



    - http://mitpress.mit.edu/catalog/item/default.asp?ttype=2&tid=11003
- Artificial Retinas and Vision: Visual neuroscience has been studied extensively, and devices that mimic the stages of vision in the retina are beginning to appear. This is similar to the cochlear implant effort, but less far along. Visual neuroscience is teaching us that vision is an *active* process, and not much like a camera at all.
    - http://www.newscientist.com/article/dn10340-silicon-retina-mimics-biology-for-a-clearer-view.html

About the UW-AVATAR Exhibition Support Group: Members of the group came from departments and programs all across the University of Washington. A number of mini workshops, convened in the Department of Biology, discussed the scientific issues underlying AVATAR. The members of the UW-AVATAR Exhibition Support Group are:

Jonathan Dyhr, PhD (Biology)
Armin Hinterwirth, PhD (Biology)
Eric Rombokas (Electrical Engineering)
Dave Williams (Physiology and Biophysics)