BALANCE YOUR LIFE IN MICROGRAVITY

Teacher: Murray Perl Scientist: Dr. Stephen Moore

Standards: A, C, E, F, G

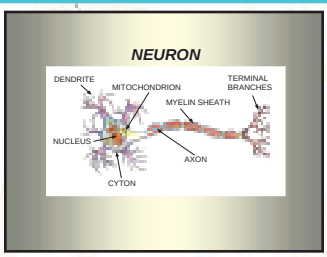
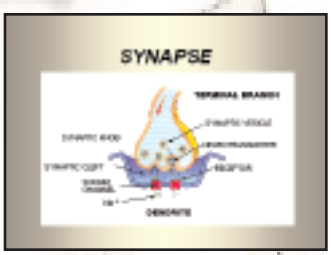
Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Motivation:

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
1 	Ask the class if anyone wants $20. When a volunteer comes forward, stipulate that you will drop a twenty-dollar bill and they must catch it. Further stipulate that the bill must be caught between the thumb and forefinger and their hand must be stationary. After dropping the bill several times students realize it cannot be caught. ***Ask the class to trace the neural pathway involved in catching the bill.***	Students should describe the path from the eyes to the brain to the spinal chord to the muscles in the hand. This should explain why it takes so long for the student to attempt to catch the bill. This will later be contrasted with the speed of reflex. NB: If a student anticipates the drop, they can catch the bill! To prevent this possibility, ask the subject, "Are you ready?" and drop the bill before they respond. This will break the subject's concentration and prevent him/her from anticipating the moment you drop the bill.

Development: How are nerve impulses transmitted?

2  Show NEURON	Ask students how a nerve impulse is transmitted along a neuron.	Nerve impulses are transmitted as a depolarization along the neuron. (Depolarization takes place when Calcium (Ca+) and sodium (Na+) ions enter the cell. If this process is sufficient, an action potential is stimulated, causing potassium (K+) to leave the cell to repolarize the membrane. This depolarization-repolarization continues along the axon until it reaches the presynaptic terminal, where a neurotransmitter is released to communicate the signal to the next neuron.)
	Ask students to describe the synapse.	It is a gap between the terminal branches of a neuron and the dendrites of the next neuron.
3  Show SYNAPSE	Ask students how the nerve message crosses the synapse.	The synaptic vesicle secretes a neurotransmitter across the synaptic cleft. The neurotransmitter fits into a receptor that triggers a depolarization in the next neuron.
	Compare the speed if conduction along the neuron to the speed across the synapse.	The conduction speed of the electrical depolarization is relatively rapid along the neuron. The speed of the neural message must slow down drastically as the neurotransmitter is secreted across the synapse.

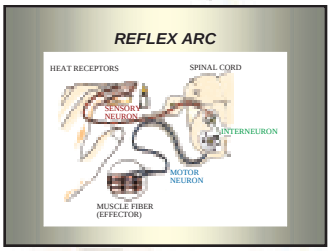
BALANCE YOUR LIFE IN MICROGRAVITY

Teacher: Murray Perl Scientist: Dr Stephen Moore

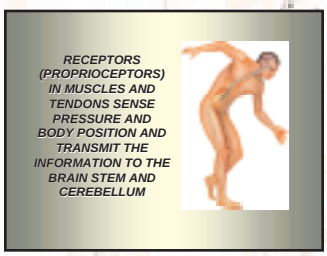
Standards: A, C, E, F, G

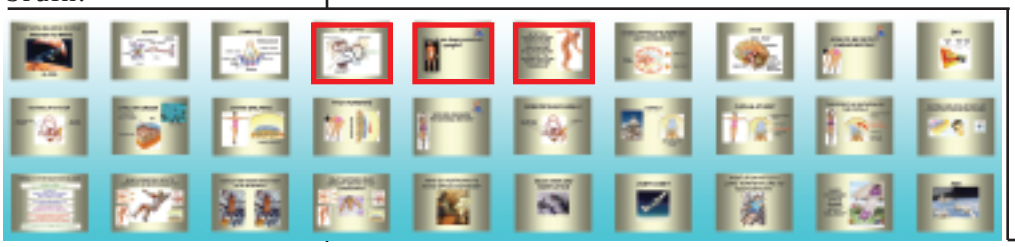
Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
Blast an air horn (Or create another loud noise, i.e. drop a text-book on a flat surface; clap your hands loudly, whistle) near an unsuspecting student.	Note his/her response to the loud noise.	Students should note that the response was nearly instantaneous.
4  **Show REFLEX ARC**	Ask students to compare the neural pathway in a reflex to the voluntary pathway described earlier. Explain why the reflex response is so much more rapid than a voluntary response.	The reflex does not involve transmission to the brain and requires transmission across fewer synapses. A reflex bypasses the brain. Transmission across a synapse is much slower than conduction along the neuron.

How do we keep ourselves upright?

5  **Ask students to stand on one leg**	Ask students to note the activity of their body as they attempt to maintain their balance.	The muscles in the legs are contracting and relaxing to maintain equilibrium. Proprioception: the process by which the body can vary muscle contraction in immediate response to incoming information regarding external forces - *The Role of Muscle Spindles in Posture and Movement.* **http://www.umds.ac.uk/physiology/mcal/posture.html**
6  **Show PROPRIOCEPTOR**	Explain that proprioceptors in their muscles and joints are sensing body position and relaying this information to the brain.	The proprioceptors and the muscles interact to adjust muscle tension to maintain balance.



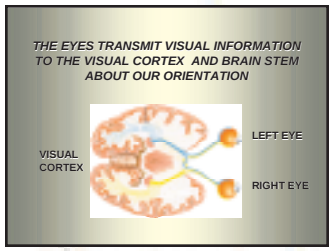
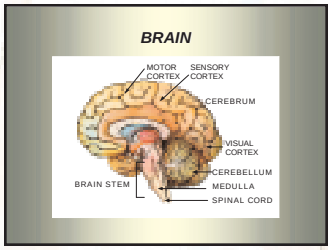
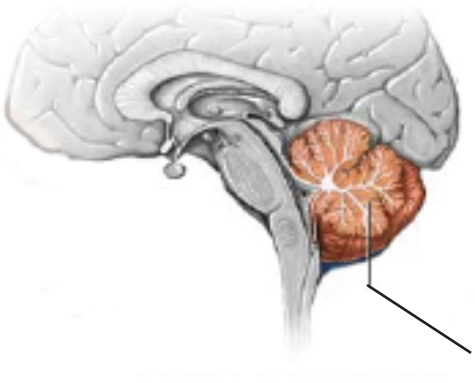
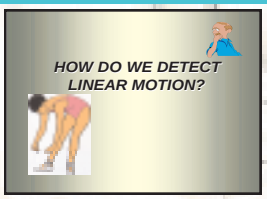
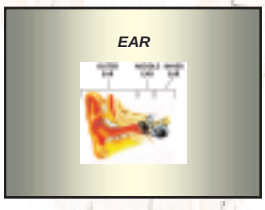
BALANCE YOUR LIFE IN MICROGRAVITY

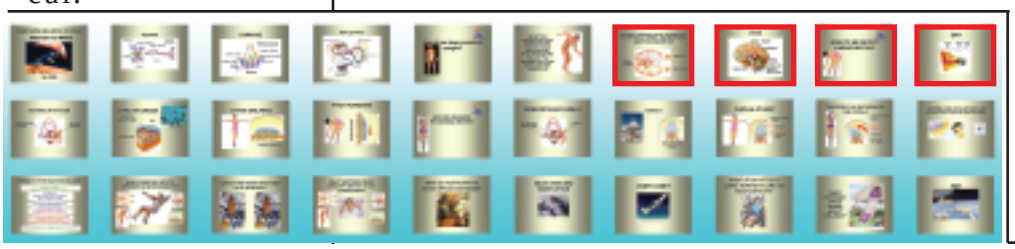
Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
Ask the students to balance one foot with their eyes closed.	Ask them to hypothesize why it is more difficult to maintain balance with their eyes closed	Visual cues are used along with proprioceptors to maintain orientation.
7  **Show VISUAL INFORMATION**	Have students observe that the visual cortex in the brain stem is involved with proprioception.	Sensory information is sent to specific areas in the brain for processing.
8  **Show BRAIN**	Review the function of the cerebellum in coordinating sensory input to maintain balance.	 **Cerebellum** Sensory input from many sources is integrated in the cerebellum to maintain balance and coordination.
How do we detect linear motion?		
9  **Show Linear Motion**	What is linear motion?	Linear motion is motion that occurs in a straight line.
10  **Show EAR**	Describe the structure of the ear.	The ear consists of three components. The outer ear, the middle ear and the inner ear. The inner ear contains components of the vestibular system that are involved with balance and orientation.



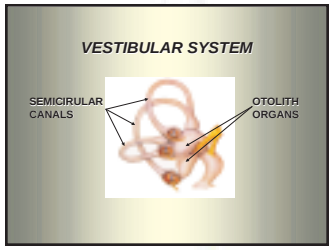
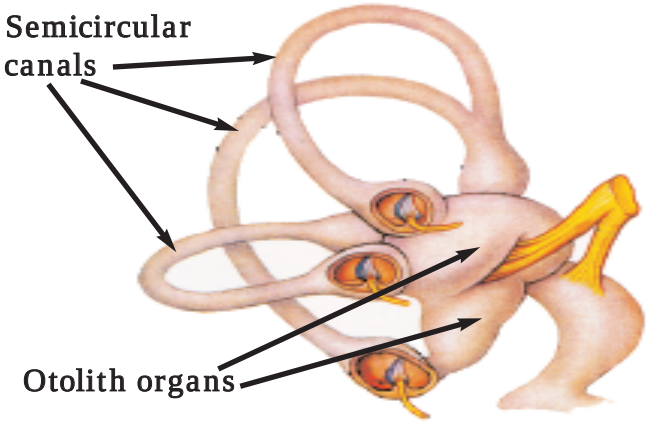
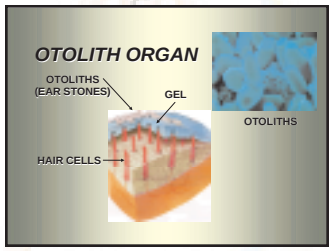
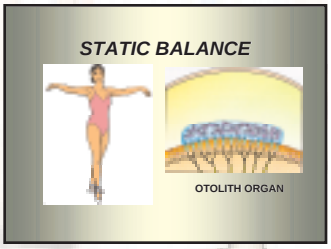
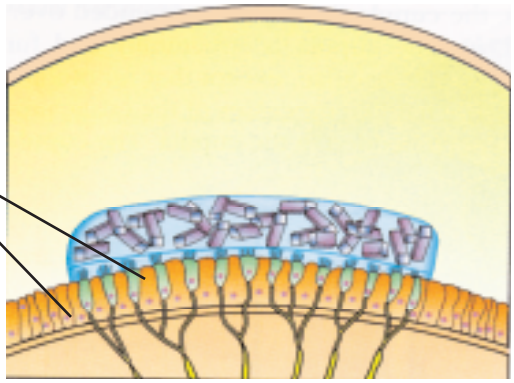
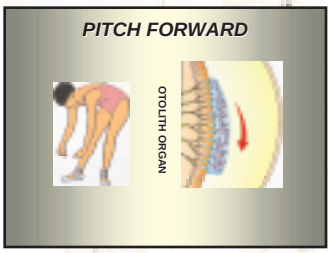
BALANCE YOUR LIFE IN MICROGRAVITY

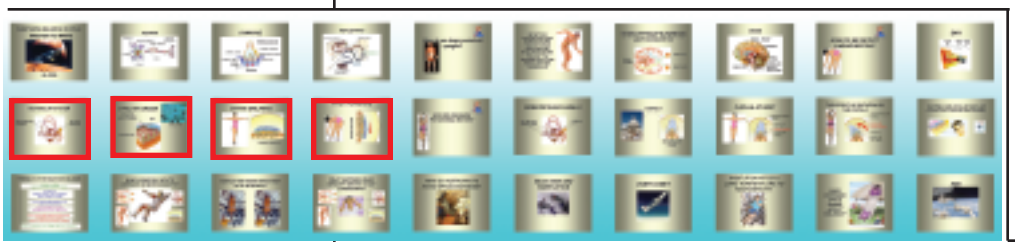
Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
11  Show VESTIBULAR SYSTEM	Describe the appearance of the otolith organs and the semicircular canals. Explain that these structures help maintain orientation and balance.	
12  Show OTOLITH ORGANS	Describe the structure of the otolith organs.	A sack containing fluid (endolymph) and a gel topped with microscopic stones (otoliths, oto=ear, lith=stone)
13  Show STATIC BALANCE	Observe the orientation of the hairs in the otolith structure.	The hairs are oriented vertically.  The Otolith Organ
14  Show PITCH FORWARD	Observe the movement of the otoliths, gel, and hairs. Explain how the dancer would know that she is leaning forward.	Gravity acting on the otoliths pulls the gel downward, bending the hairs and triggering a nerve impulse (depolarization) to the brain.



BALANCE YOUR LIFE IN MICROGRAVITY

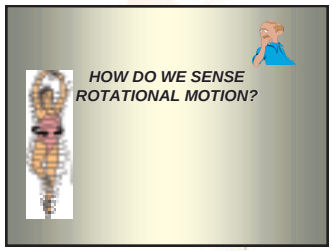
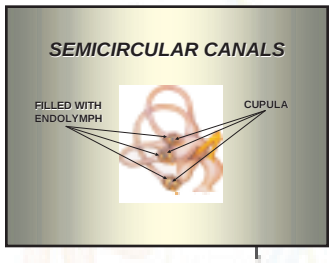
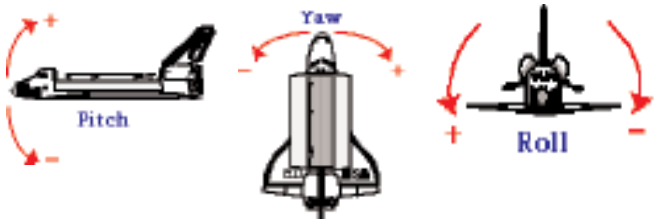
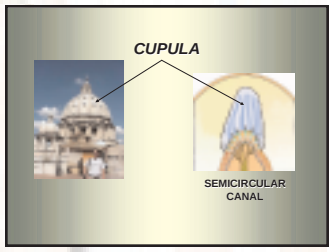
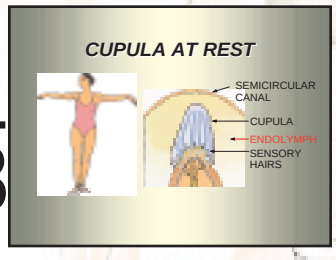
Teacher: Murray Perl Scientist: Dr Stephen Moore

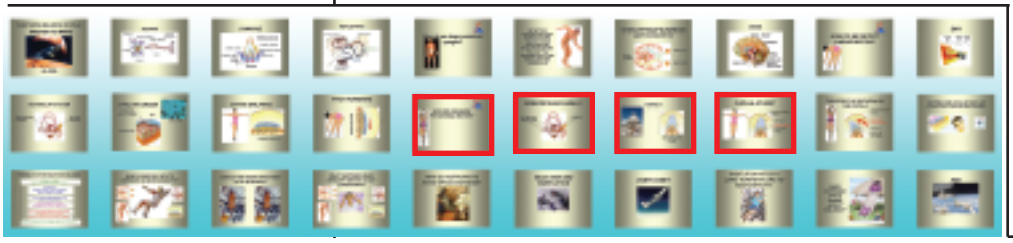
Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

How do we detect rotational motion?

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
15 	What is rotational motion?	The motion of an object around an axis in a circular path.
16  Show SEMI - CIRCULAR CANALS	Have students describe their structure. Describe the various ways the head can move. Ask why they would be oriented in three planes 90º apart.	The semicircular canals are oriented in three planes 90º apart to respond to motion in each plane (pitch, yaw, and roll). Using the shuttle as an example, here is a graphical example:  http://liftoff.msfc.nasa.gov/academy/rocket_sci/shuttle/attitude/pyr.html
17  Show CUPULA	Point out the architectural origin of the word.	Cupula is derived from the domed architectural feature on cathedrals.
18  Show CUPULA AT REST	Have students describe the structure of the cupula. Compare the structure of the cupula in the semicircular canals to the otolith organs	The cupula is a gelatinous structure like the gel in the otolith organs. It does not have otoliths on top because it does not respond to gravity, but to movement of the head.



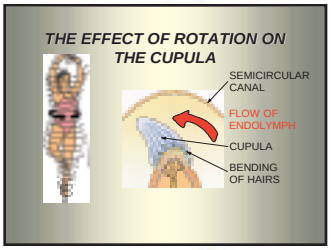
BALANCE YOUR LIFE IN MICROGRAVITY

Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

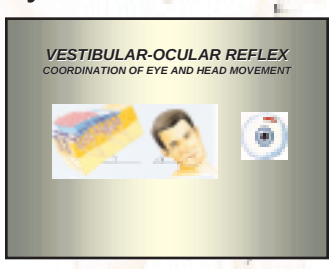
Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
19  **Show THE EFFECT OF ROTATION ON THE CUPULA**	Describe what happens to the cupula as the dancer spins.	The movement of the fluid (endolymph) in the semicircular canal bends the cupula and the attached hairs triggering depolarization.
Application of scientific principles.	Why does the room appear to continue to spin even after the dancer stops?	The fluid (endolymph) continues to circulate for a short time after the bodies motion stops.

What is the role of the eyes in maintaining balance?

Have students pairs face each other, one takes the role of observer and the other is experimental subject. The subject will move his/her head from side to side while focused on the nose of the observer. The observer will note the movement of the subject's eyes. Reverse the roles and observe the eye movement.	Ask students to describe the relationship between the head movement and the eye movement.	The eyes move opposite to the movement of the head. The degree of movement is identical for the head and eyes.
	Ask students to describe the Vestibulo-ocular reflex.Why is this reflex?What is the function of this reflex?	The eyes move exactly opposite to the movement of the head because there is a reflex connecting the cupula to the visual cortex in the brain. This allows us to maintain focus on an object even while the head is moving. Without this reflex we would see the world bobbing up and down as we walked. (Imagine viewing the world as seen in the movie "The Blair Witch Project".)

20 

Show VESTIBULO-OCULAR REFLEX

BALANCE YOUR LIFE IN MICROGRAVITY

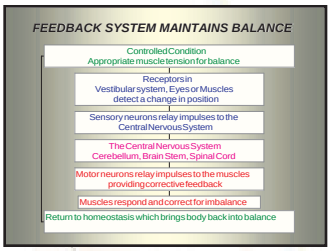
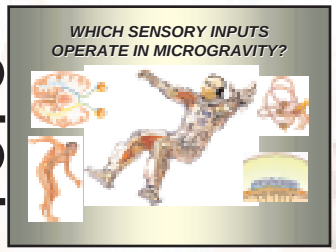
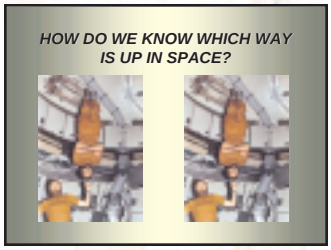
Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

How does the brain integrate sensory input to maintain balance?

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
Medial summary	Have students recall the four major sources of sensory input used to maintain balance.	Muscles, eyes, otoliths, cupula in semicircular canals.
21  **Show FEEDBACK SYSTEM**	Ask student how they maintained their balance when standing on one foot.	Sensory input from muscles, eyes, otoliths, and cupula in semicircular canals causes the brain to respond by adjusting muscle tension to regain homeostasis.
22  **Show WHICH SENSORY INPUTS OPERATE IN MICROGRAVITY?**	Ask the class, which of the four sensory input modes depend on gravity? (Eyes)(Muscles)(Otoliths) (Semicircular canals) Why?	The otoliths and proprioceptors in the muscles depend on gravity to function. Review which components of the vestibular system are functioning in microgravity and which are not.
23  **Show HOW DO WE KNOW WHICH WAY IS UP IN SPACE?**	Ask students how astronauts know which way is up in microgravity.	Visual cues are the only method of orientation that operates in space.

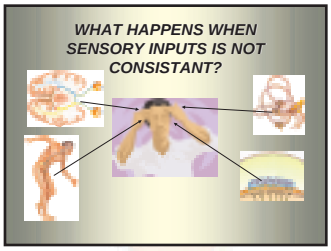
BALANCE YOUR LIFE IN MICROGRAVITY

Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
24  **Show WHAT HAPPENS WHEN THE VESIBULAR SYSTEM RECEIVES CONFLICTING INFORMATION?**	Have students hypothesize why conflicting signals from these sensory organs can cause motion sickness.	All the sensory inputs are integrated in the brain stem that also controls autonomic functions (peristalsis etc.)
Application of scientific principles.	Ask students if they have ever experienced an IMAX movie. Ask why they felt queasy even though they remained seated.	Conflicting signals from the eyes (apparent motion) and the vestibular structures in the ear (the body is stationary) can cause motion sickness.
Application of scientific principles.	Ask students why some of them get queasy when they read while riding in a car.	Reading from a page that appears to be stationary gives visual information which conflicts with the motion being detected by the vestibular structures in the ear.

What countermeasures can we take to reduce space sickness?

25  **Show HOW DO ASTRONAUTS AVOID SPACE SICKNESS?**	How do astronauts avoid space sickness?	Have students recall that astronauts only experience visual and inertial sensory inputs, which conflicts with the muscular and otolith inputs.

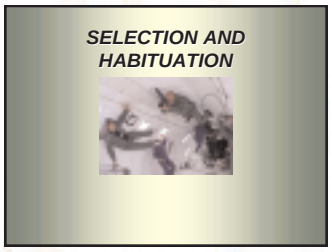
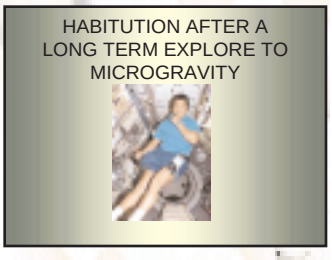
BALANCE YOUR LIFE IN MICROGRAVITY

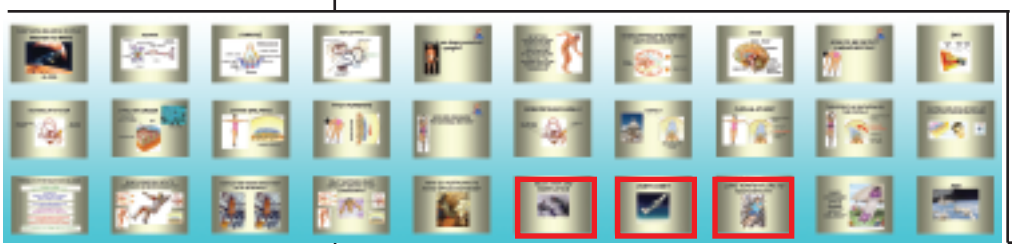
Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
26  **Show SPACE SICKNESS COUNTERMEASURES**	Explain that NASA has a KC 135 tanker aircraft that is modified to allow astronauts trainees to experience weightlessness. As the plane goes into a series of dives, astronaut trainees will float weightlessly for 30 seconds at a time.	
27  **Show SELECTION OF SUITABLE ASTRONAUTS**	Ask the class to indicate by a show of hands, how many students get sick while reading in a moving car. Why doesn't everyone get carsick? Which students would make suitable astronaut candidates?	There is great variability in individual tolerance to motion sickness. Candidates who show tendencies towards motion sickness are eliminated as astronaut candidates.
28  **Show HABITUTION AFTER A LONG TERM EXPLORE TO MICROGRAVITY**	Ask the class why nearly all astronauts overcome space sickness after about three days.	After about three days most astronauts become habituated to microgravity. Their vestibular-ocular system adjusts to sensory cues provided in microgravity.



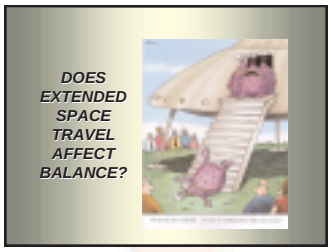
BALANCE YOUR LIFE IN MICROGRAVITY

Teacher: Murray Perl Scientist: Dr Stephen Moore

Standards: A, C, E, F, G

Materials: Lesson plan and visual presentation Time: One class period

Preparation: Read lesson plan; Review slides

Strategy / Activity	Question / Issue	Anticipated Response / Understanding
29  **Show the cartoon of the HOW DOES EXTENDED SPACE TRAVEL AFFECT BALANCE?**	Why did the alien stumble upon landing after a long space voyage?	Review the concept of habituation after long exposures to microgravity. The vestibular-ocular system must now readjust to the gravity on Earth. Example: The three astronauts who returned to earth from the Internation Space Station on a Russian-made rocket reported crawling on the ground when they landed on earth. This was due to their habituation to microgravity.
30