"Adrenaline Rush"

IMAX Film

Theme: The Science of Risk

The educational value of NASM Theater programming is that the stunning visual images displayed ***engage*** the interest and desire to learn in students of all ages. The programs do not substitute for an in-depth learning experience, but they do facilitate learning and provide a framework for additional study elaborations, both as part of the Museum visit and afterward. See the "Alignment with Standards" table for details regarding how *"Adrenaline Rush"* and its associated classroom extensions, meet specific national standards of learning.

What you will see in the *"Adrenaline Rush"* program:

- A modern test of a parachute designed 500+ years ago by Leonardo da Vinci
- Lots of spectacular skydiving and BASE jumping footage
- The biological basis underlying risk taking

Things to look for when watching *"Adrenaline Rush":*

- How skydivers can control their movements (to some degree) by changing body position
- The movement of the ball during the "Sky Ball" game
- The statement about having faith in the "physics of the parachute"
- The five Norway cliff jumpers jumping together do not fall at the same speed
- The construction and materials used in the test da Vinci parachute

Learning Elaboration While Visiting the National Air and Space Museum

Among many other adrenaline-related artifacts on display at NASM are these famous examples:

- The very first airplane, the *Wright Flyer*, the centerpiece of the Wright Brothers and the Invention of the Aerial Age Gallery. The first flight MUST have been a real "rush!"
- Lindbergh's first solo flight across the Atlantic was a "rush!" See his *Spirit of St. Louis* on display in the Milestones of Flight Gallery.
- Breaking the "Sound Barrier" for the first time must have been a "rush," too; see Chuck Yeager's famed *Glamorous Glennis* on display in the Milestones of Flight Gallery.

A good second stop to expand on your *"Adrenaline Rush"* experience might be a place you might not have considered, the Early Flight Gallery. Two EF artifacts are of particular interest:

- The Lilienthal Hang Glider: It is one thing to soar hundreds of feet above the ground in one of today's ultra-light aircraft, complete with rip-stop nylon and a hi-tech composite frame. Imagine doing the same in a glider made of wood and canvas….
- Flight was not the only way the early aviation pioneers got an "adrenaline rush." Glen Hammond Curtiss, creator of the famed "June Bug" and "Jenny" aircraft, began his career by racing motorcycles (more like motor-driven bicycles). In 1907, Curtiss drove the V-8-powered cycle in our collection at a speed of 136 MPH (218 KPH)!

Thousands of books and articles have been written about adrenaline-producing activities related to aviation and Space exploration, and a good starting point is the many books and related materials available at the **Museum Store** in each NASM building.

Post-Visit Discussion Points to Align Program Material with National SoLs

High School

see High School Alignment Table
"Strong alignment" is shown in red on the Table and in bold-faced text below

S A2: Understanding Scientific Inquiry

Leonardo da Vinci conceived of the basic concept of a parachute half a millennium ago. One of the central themes of *Adrenaline Rush* (AR) is the testing of that concept (hypothesis). Hypothesis formation and testing is a central part of the process of scientific inquiry.

S B4: Motions and Forces

- Sky diving and BASE jumping are intimately related with the consequences of the force of gravity acting on a freely-falling body.
- BASE jumpers have to open their parachutes quickly, but sky divers can fall for a minute or more (depending on the height from which they jump). BASE jumpers are still accelerating downward when their 'chutes open, but sky divers are usually falling at a constant speed (called "terminal velocity"). In that case, the force of air resistance has become so strong that it balances gravity, and the sky diver falls no faster. They can alter their speed by changing their body position, but there is a limit to their downward speed.
- Much is made in the film about using a "wing suit" to actually fly. Are the jumpers "flying" in the true sense of the word? Have the class research the four forces affecting flight as preparation for a class discussion on this topic.

S B5: Conservation of Energy; Entropy

Energy cannot be created or destroyed, but it can be converted from one form to another. Energy from the airplane (sky divers), or expended in climbing the object from which a BASE jumper will jump, is stored as gravitational potential energy in the jumper. When they jump, that potential energy is converted into kinetic energy as the jumper accelerates downward. Jumpers can orient their bodies by making small movements, and can convert some of their downward motion into forward motion with the wing suit or by just holding themselves in the correct position. However, they can neither climb nor even hold level flight (the lift force they experience is always less than gravity).

S C2: The Cell

Most of the mention in AR of stress and how the body responds to it may be beyond the scope of the high school standards, but can still serve as the starting point for class discussion on human nervous and endocrine systems. A subset of this particular standard deals with the regulation of cell function, partially in the context of genetic expression, but includes the regulation of cell activity and inter-communication by external stimuli. The stress-producing activity takes place at the cellular level, but more closely aligns with the following standard.

S C6: Behavior of Organisms

This standard deals explicitly with the functioning of the human nervous system and how it responds to external stimuli, so AR would certainly qualify as an "external stimulus" to a classroom discussion on behavior of organisms.

S E2: Understanding Science and Technology

Adrenaline Rush can be used as the example in a classroom discussion of the differences between "science" and "technology," the subject of this particular standard.

- da Vinci contemplated the parachute long before the underlying scientific principles of aerodynamics were understood. He was looking to solve a problem, allowing humans to "fly," not necessarily understand the deeper scientific principles involved.
- Modern parachute design and the underlying aerodynamic principles are well understood; it was never the intent of the investigators in AR to derive scientific principles from the testing of the da Vinci design.
- However, modeling and testing are very important parts of the technology development process (analogous to experimentation in the scientific method). Nobody could be certain that the da Vinci design was viable until it was actually flown.

S F5: Natural and Human-induced Hazards

For some, falling off a cliff would be a "natural hazard." For others, such as those in AR, cliff falling is most definitely a "human-induced hazard!" One of AR's sub-themes is how different people evaluate the risk/benefit trade-offs of extreme activities like cliff jumping.

S G1: Science as a Human Endeavor

The personalities and internal motivations of some of those who investigate human physiological responses to stress are a recurring subtext in AR. Given the popularity of extreme sports among those of high school-age, AR makes an engaging starting point for a discussion of the application of the scientific method in the testing of the da Vinci parachute design, and helps students better understand the motivation behind inquiry in general.

S G3: Historical Perspectives

The portrayal of Leonardo da Vinci in AR can stimulate a classroom discussion on the concurrent establishment of the scientific method as a problem-solving tactic and the tremendous growth in all aspects of the Human condition that accompanied the Renaissance, in which da Vinci played a key role.

T4: Technological Design: IV.2.Systems, modeling, and simulation

The testing of the da Vinci parachute makes a good case study of at least a portion of this particular standard. Da Vinci had many novel ideas, but the only record of his concept of a parachute is the single sketch shown in AR. He never tried to build a scale model for testing, nor did he try to build it "for real." To test the hypothesis that a parachute of that design could actually work, and minimize risk to human life in the process, might require modeling, simulation, and/or testing. The testing phase of the design of the da Vinci parachute was not shown in the film. The test parachutist was wearing a modern reserve parachute, and intended to use it to avoid having to land beneath a 250 pound parachute structure. A good topic for class discussion might be what kinds of things could have been done to test the parachute design with scale models, wind tunnels, dummy drops, etc., and whether or not the filmmakers actually performed some tests that did not make it into AR. What kind of testing might have been done if the test parachutist was not going to have a reserve safety parachute?

Post-Visit Discussion Points to Align Program Material with National SoLs

Middle School

see Middle School Alignment Table
"Strong alignment" is shown in red on the Table and in bold-faced text below

S A2: Understanding Scientific Inquiry

A main theme of *Adrenaline Rush* (AR) was the testing of a 500-year-old parachute design conceived by Leonardo da Vinci, but never tested or built. That testing process is an integral part of the process of scientific inquiry, as well as the development of new technology.

S B2: Motions and Forces

The sky diving and BASE jumping sequences depicted in AR make good examples of all parts of this particular standard:

- Description of motion: The idea of a free-falling sky diver is an engaging and easily-understood introduction to the concepts of position, direction of motion, and speed; all explicitly mentioned in the standard.
- When sky divers reach "terminal velocity," the forces of air resistance and gravity are in balance. As covered in this standard, no net force means no net acceleration, which means constant speed (in the absence of other net forces). Should a sky diver alter their body position so as to affect their air resistance, their speed changes until air resistance and gravity are back in balance. [A good visualization from AR of this point is when the five BASE jumpers jump off the Norwegian cliff together. Four of the jumpers start with more of a "head down" position to lower the air resistance (drag) they experienced. As a consequence, they had more rapid acceleration downward than the jumper who stayed more horizontal. All had to convert downward speed to forward speed in order to clear the slope below.]

S B3: Transfer of Energy

Gravitational potential energy and kinetic energy of motion, and their interrelationship, are not explicit parts of this standard at the middle school level. However, a discussion of how jumpers exchange height for speed, and then speed downward for forward speed and maneuverability, stimulated by scenes from AR, could be an appropriate part of a classroom discussion on energy.

S C3: Regulation and Behavior

This standard at the middle school level explicitly deals with, at least in part, behavior as a result of external stimuli. The chemical details of the neurological responses are beyond the middle school level, but AR does provide an engaging introduction to the concept of the interaction between stimulus and behavior.

S E2: Understanding Science and Technology

Adrenaline Rush aligns with two subsets of this particular standard. The first is, "Many different people in different cultures have made and continue to make contributions to science and technology," with da Vinci as a prime example. The second is, "Technological designs have constraints. Some constraints are unavoidable, for example, properties of

materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics." Material properties and human safety were major factors in the testing of the da Vinci parachute design.

S F4: Risks and Benefits

Alignment with this particular standard is a sure bet when the movie in question is sub-titled, "The Science of Risk!" Sky divers and BASE jumpers take risks that others would never accept, yet the risk-takers have "use(d) a systematic approach to thinking critically about risks and benefits" and made "important personal … decisions … based on perceptions of benefits and risks," as explicitly delineated in this standard.

S G1: Science as a Human Endeavor

Adrenaline Rush provides a good example of how the development of technology, akin to a scientific advancement, is a collective Human endeavor. A diverse group of people were involved with the development and testing of the da Vinci parachute, from da Vinci himself in Italy over 500 years ago to the group who built and tested the modern example.

S G2: Nature of Science

The development and testing of the da Vinci parachute in AR is similar to the scientific method. Both the development of new technology and scientific advancement involve some form of observation and experimentation. Da Vinci was inspired to think about flight by observing birds, and his sketch shown in AR was one result. Five centuries passed before da Vinci's idea was put to the test.

S G3: History of Science

Adrenaline Rush can be a good introduction to Leonardo da Vinci, allowing for a follow-up classroom discussion of his many accomplishments in many fields, and the overall importance of the Renaissance in general.

Life Skills: Thinking and Reasoning 4, Level III: 2. Experimental Verification

This particular standard deals with the importance of independent verification of new scientific results. The concept of flight testing a new technology such as the da Vinci parachute is similar; together they are a good topic for further class discussion.

Post-Visit Discussion Points to Align Program Material with National SoLs

Elementary School

see Elementary School Alignment Table
"Strong alignment" is shown in red on the Table and in bold-faced text below

S A2: Understanding Scientific Inquiry

The development and testing of the da Vinci parachute as portrayed in AR is a process very similar to the traditional "scientific method." Da Vinci made observations of birds, was inspired with thoughts of flight, and the parachute sketch was but one result (hypothesis). Da Vinci never built and tested his parachute (experimental verification), but the team in AR did. That test illustrated three subsets of this particular standard:

- "Scientists [engineers] use different kinds of investigations … including … doing a fair test (experimenting)" and
- "Scientists make their investigations public …" The fact that da Vinci sketched his idea for a parachute (not exactly a big promotion, but eventually his notebook was made public) made it possible for modern investigators to
- "Review and ask questions about the results of other scientists' work."

S B2: Position and Motion of Objects

Skydivers, BASE jumpers, and parachutes all use the "pushing" force of moving air to make things move. Jumpers can adjust their positions by small movements of a hand or foot, or can move forward as they fall by holding their body in the shape of a wing (especially if they wear a "wing suit" like in AR).

S C3: Organisms and Their Environment

Most of the material presented in AR about the body's chemical and physiological response to stress is beyond the scope of this grade range, however, the film could stimulate class discussion on the "organism's patterns of behavior are related to the nature of that organism's environment" section of this standard.

S E2: Understanding Science and Technology

A subset of this particular standard is, "People have always had problems and invented tools and techniques (ways of doing something) to solve problems. Trying to determine the effects of solutions helps people avoid some new problems." In the context of AR, da Vinci was not trying to solve a problem when he conceived the parachute; rather, he was pursuing a dream. The modern test team was trying to avoid "new problems" for the parachutist that would arise should the parachute fail during testing.

S G1: Science as a Human Endeavor

Adrenaline Rush provides a good example of how the development of technology, akin to a scientific advancement, is a collective Human endeavor. A diverse group of people were involved with the development and testing of the da Vinci parachute, from da Vinci himself in Italy over 500 years ago to the group who built and tested the modern example.

Technology: Design: Standard 4 (Considerations): Level II: Benchmark 5 (Constraints)

Under this benchmark, students must know that a number of constraints must be taken into account in creating a technological design. The design and testing of the da Vinci parachute aligns with the following Knowledge/skill statements for Benchmark 5:

- #2 Materials: Da Vinci did not try to actually make and fly his parachute design. The modern test used a wooden frame (readily available to da Vinci), but what fabric was used to make the parachute? (It looked like nylon.) How would that affect the "validity" of the test?
- #5 Safety: "Field" testing a parachute design places a human life at risk. What safety measures did the modern test team use? What more could they have done to increase the safety of their testing process? (Wind tunnel testing of parachute model; flight test with a manikin passenger, etc.) Elaboration discussion question: Why did the test parachutist "cut away" the da Vinci chute and land with their emergency modern parachute?

Resources for Learning Elaboration after the Visit to NASM

Thousands of books and articles have been written about adrenaline-producing activities related to aviation and Space exploration, but two good starting points are the many books and related materials available at the **Museum Store** in each NASM building, and the list of research and publications of NASM's expert curators:

- ***Aeronautics***: http://www.nasm.si.edu/research/aero/research.cfm
- Center for Earth and Planetary Studies: http://www.nasm.si.edu/research/ceps/research/research.cfm
- Space History: http://www.nasm.si.edu/research/dsh/research.cfm

National Air and Space Museum Gallery Web Pages

NASM Early Flight Gallery website: http://www.nasm.si.edu/exhibitions/gal107/index.cfm
Lilienthal Glider web page: http://www.nasm.si.edu/exhibitions/gal107/index.cfm#HANG
Curtis Racing Motorcycle: http://www.nasm.si.edu/exhibitions/gal107/index.cfm#MOTO

Biological Manifestations of Risk: Neurotransmitters, Seratonin, Endorphins

What is Adrenaline, and is that the proper term? "Epinephrine" is preferred in some circles. Whatever its name, it is produced in glands that sit atop the kidneys ("ad" means "top of," "renal" is a common root word for kidney).

University of Maryland Medical Center information on adrenal glands: http://www.umm.edu/endocrin/adrengl.htm

NOTE: Many sources of on-line information are at college/graduate levels, are commercial in nature, or in a "wiki" format that prevents them from being cited here.

Skydiving and BASE Jumping

U.S. Parachute Association: http://www.uspa.org/
Caterpillar Club: http://www.caterpillarclub.org/irvin/irvin.htm
Legal BASE Jumping: "Bridge Day" in West Virginia: http://www.bridgeday.info

Adrenaline Enthusiasts

National Geographic article: http://news.nationalgeographic.com/news/2004/07/0709_040709_sciencerisk.html

Leonardo da Vinci

NASA Middle School Web Quest: http://media.nasaexplores.com/lessons/04-065/5-8_2.pdf
American Institute of Aeronautics and Astronautics webpage: http://www.aiaa.org/content.cfm?pageid=425
BBC webpage: http://www.bbc.co.uk/history/historic_figures/da_vinci_leonardo.shtml and, for younger visitors, explore Leonardo's studio at: http://www.bbc.co.uk/science/leonardo/studio/main.swf
St. Andrews webpage: http://www-groups.dcs.st-and.ac.uk/~history/Mathematicians/Leonardo.html
Centennial of Flight webpage: http://www.centennialofflight.gov/essay/Dictionary/leonardo/DI31.htm
U.S. Air Force webpage: http://www.af.mil/history/leonardodavinci.asp

Elaboration Question: Why did the skydivers fill the tennis ball with lead before playing "Sky Ball?"
Clue #1: The Moon has no atmosphere, so parachutes won't work there. But if the lunar skydivers were using retro-rockets, would they still need to fill the tennis ball with lead in order to play "Sky Ball?"
Clue #2: The famous Galileo Feather/Hammer Drop Experiment, conducted on the Moon – see the transcript and video clip at: http://www.hq.nasa.gov/alsj/a15/a15.clsout3.html , time step 167:22:06

The IMAX "Adrenaline Rush" webpage (there is no AR Educators Guide available at this time):
http://www.imax.com/ImaxWeb/filmDetail.do?type=nowPlaying&movieID=code__._44986

NOTE: The activities portrayed in Adrenaline Rush are very dangerous. The subjects in the film are highly-trained experts, use state-of-the-art safety gear, and are willing to take extreme risks (and, as *adults*, they are legally-qualified to accept such risks). Many are seriously injured, or die, in the pursuit of the "adrenaline rush." AR provides a good learning opportunity and gives a vicarious thrill, but please -

DO NOT TRY THIS AT HOME!