IMPACT! THE MAKING OF A METEORITE – NEW VISUALIZATIONS FOR MUSEUMS AND CLASSROOMS.
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Introduction: Impacts, large and small, are one of the primary processes shaping the formation and evolution of the solar system. There has been a phenomenal increase in the ability of individual researchers to simulate impacts using desktop computers, but only a few have offered the results of their simulations in animated form. Public interest in impact events is high, but the level of understanding is relatively low. The goal of this E/PO project is to create engaging and scientifically accurate animations and images of impact processes in the solar system specifically designed to dispel commonly held misconceptions and improve general understanding among a broad lay audience.

New video product: We present a new 7-minute DVD product titled *IMPACT! The making of a meteorite*. The video is a self-contained explanation of the 'lifetime' of a meteor. The content includes observations of impact craters on planets and asteroids; visualizations of the Asteroid Belt; animations of collisions between asteroids; explanation of resonances in the asteroid belt and perturbation of an asteroid fragment toward Earth; explanation of meteors with high and low impact velocities; explanation and visualizations of the range of outcomes from impacts by meteors with different velocities and sizes. The material complements most museum exhibits and classroom instruction on meteorites. The video is on display in the new Meteorites exhibit at the Harvard Museum of Natural History (HMNH), which opened in December 2005.

Scientifically accurate visualizations: The visualizations in the video are derived directly from orbital data, spacecraft and telescopic images, and numerical simulations. The animations of the orbits of members of the Main Asteroid Belt and Near Earth Asteroid populations were provided by the Minor Planet Center at the Smithsonian Astrophysical Observatory [1]. Rendering of planetary orbits utilize the equations of motion capabilities in Alias® Maya 7 Unlimited software package [2].

Simulations of collisions between asteroids were derived using the `pkdgrav` *N*-body gravity code [3-5]. Impact cratering visualizations are based on calculations with Sandia National Laboratory's `CTH` shock physics code [6].

Adobe® Photoshop and After Effects were used to create and edit two dimensional graphics. The composite video content was produced using Apple® Final Cut HD.

Development and testing: The general lay knowledge of meteorites and impact cratering was assessed through a series of interviews with adult visitors to the HMNH and 8th grade students at Noble Middle School, the public school in Berwick, ME. Students were interviewed before and after completion of the Full Option Science System (FOSS) Planetary Science middle school curriculum, which includes study of impact craters and meteorites [7].

Interest in meteorites and impact events is very high, but lay knowledge of the origin of meteorites, the frequency of encounters, and the outcome of impact events is relatively low. Upon completion of the FOSS planetary science curriculum, the student's knowledge of impact events is considerably higher than the average lay person. In general, 8th grade students were able to identify exaggerations in animations of impact events produced for movies such as Paramount Picture's *Deep Impact* (1998). Students expressed a keen interest in and respect for scientists and their research. When presented with scientifically accurate visualizations, students appreciated knowing that the images were derived from research. The students also grasped non-realistic looking representations of impact events and understood the value of more abstract visualizations, e.g., representing asteroids as a collection of small spheres. While animations of impact events were quickly understood by the students, two-dimensional graphs of information, such as the frequency of impact events, were not as easily digested and require more time and accompanying explanation.

During formative evaluations, students provided feedback on concepts learned from the new video. Students commented that the range of outcomes from impact events between asteroids was much larger than expected. The role of gravitational perturbations in the delivery of meteorites was previously unknown. Students were not aware that meteors have a range of impact velocities and why. Prior to completion of the FOSS curriculum, students were surprised by the range of outcomes of meteor encounters with Earth.

Future work and distribution: Development of more visualizations is in progress, including animations of different size impact cratering events. The final E/PO product will be an interactive DVD with a user-motivated question and answer section, multiple short visualizations of different types of impact events, and the longer video *IMPACT! The making of a meteorite*. The DVD will be distributed with an educational guide for teachers or exhibitors, the answers to frequently asked questions, and the results of evaluations of the final product.

Please indicate your interest in receiving a copy of the completed E/PO product by sending an email to sstewart@eps.harvard.edu.

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