PUPIL RESEARCHER INITIATIVE

Collision Course

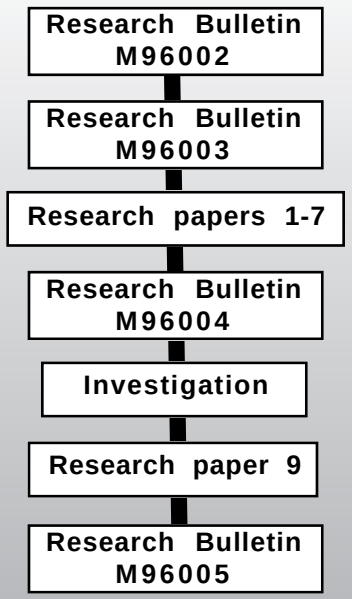
Pupil Research Brief

Teachers' Notes

Syllabus Coverage *Subject Knowledge and Understanding*

- ❑ comets have orbits which are far from circular
- ❑ comets are very much closer to the Sun at some times than at others. This is when they can be seen
- ❑ the further away an orbiting body is from the Sun the longer it takes to make a complete orbit

Route through the Brief



Introduction

In this Brief pupils learn that the Earth has been hit several times by massive objects from space in the distant past. They are presented with information that suggests an impact from a comet or an asteroid may occur in the future, and the consequences for life on the planet could be devastating. They are asked to assess the risk of such an event occurring again and they conduct experiments that allow them to estimate the physical damage a massive object would cause to the Earth. They are also required to make recommendations as to what plans, if any, should be made to detect and track Near Earth Objects to give early warning of an imminent collision.

Experimental and investigative skills

- planning an investigation
- obtaining evidence
- analysing evidence and drawing conclusions
- evaluating evidence

Prior knowledge

Before attempting the Brief, pupils should already have knowledge of the Solar System, its planets and the asteroid belt. They should also know a little about comets and about meteors.

Pupil Research Brief

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Running the Brief

Pupil grouping

Pupils could work in a number of groupings during this Brief. Suggestions are:

Initial briefing -	whole class; teacher briefly introduces topic and sets the context for the Brief
Introductory STAR - Centre Bulletins	individual or pairs
Background papers- selected from papers 1-7	individual or pairs
Research Bulletin - M96004 (Paper 8) and investigation	pairs, threes or fours (depends on equipment availability)
Analysis of results-	pairs, threes, fours, or individually if work is to be assessed
Papers 9 and 10 -	individual or pairs
Communication -	compilation of reports- individual or groups and whole class discussion of work (optional)

Timing

The Brief should take at least 3 hours of classroom time. It can be used as part of an examination course, but it could also be used in a science or astronomy club context.

Activities

The teacher should issue the pupils with the **Study Guide** which provides pupils with a summary of what they should produce as they work through the Brief. It can also act as a checklist for pupils to monitor their own progress. Pupils are then given STAR Centre **research bulletins M96002 and M96003**. These papers set the scene, outlining the topic they are to study and listing the activities contained in the Brief. The second paper (M96003) splits up the Brief into four sections.

Section 1 - Background information
Seven information sheets are presented in the form of simulated magazine articles.

Research paper 1 *The Doomsday crash*. This paper presents information about what the likely effects the impact of a massive meteorite would have on Earth.

Research paper 2 *Meteorites 4 Cars 0*. This paper is about the four known incidents of meteorites hitting cars.

Research paper 3 *Tracking the Peekskill meteorite*. This article gives an account of how astronomers calculated the orbit of a particular meteorite that crashed to Earth in 1992.

Research paper 4 *Earth's greatest hits*. This sheet explains how modern imaging techniques have revealed the sites of massive meteorite collisions that occurred in prehistoric times.

Research paper 5 *Meteorite! In the beginning....* This gives information about the nature and composition of meteorites.

Research paper 6 *Rocking around the Solar System*. This is an article about asteroids.

Research paper 7 *Where do comets come from?* The article explains the origin of comets.

Pupils do not have to read all of these, but they should read and make notes on at least papers 1, 4, 6 and 7. Some papers could be used as reading homework assignments.

Section 2 - Risk assessment
In this section pupils are given a practical investigation to carry out. **Research paper 8 (Research bulletin M96004**) gives instructions on how to simulate the effect of large meteorite impacts on Earth. This involves preparing a tray of powder and dropping marbles, ball-bearings, golf balls, etc. onto the powder at different heights. Measurements of the size of craters and the length of the ejecta rays are made. The results of the experiments, together with the information found in research paper 1 should allow pupils to describe the effect that a large impact would have on Earth. **Research paper 10** (**Research Bulletin M96005**) contains a table and a graph summarising the chances of collision with massive objects from space. These should be used by pupils when writing their reports.

Section 3 - Detection
Research paper 9 gives information about meteoroid upper atmosphere impacts detected by US Department of Defence satellites between 1975 and 1992. **Research paper 10** explains that a programme called 'Spaceguard' has been proposed. This would

fund the construction of six observatories to survey the skies to look for Near Earth Objects. These two papers help pupils to prepare a brief section of their report about detecting objects that may collide with Earth.

Section 4 - Recommendations
Here pupils should decide what, if any, action should be taken to give us early warning of impacts from comets or asteroids. Are the odds against such a collision high enough to allow us to ignore the problem? Should we ensure that there is a comprehensive programme of surveillance of space in order to detect and track Near Earth Objects? If so, how do we prevent them colliding with Earth? These are questions pupils should address when writing their reports.

Investigation details

Research bulletin M96004 contains a list of possible investigations into the effects of an impact from a massive object on the surface of the Earth. The equipment they will need to make impact craters and to measure them is given, but pupils need to decide how to proceed. They could be split into different groups to investigate the effect of one of the four variables listed under the heading 'Investigation choices'. In every instance pupils (individually or in teams) should write out a plan showing how they are going to conduct the investigation to ensure that their tests are fair. When using powder as the impact surface it is important to test beforehand that it is of sufficient depth for the heights from which the different impact object masses are dropped.

When measuring crater diameter it is best to measure the outside of the rim rather than the inner diameter. Pupils might also investigate the relationship of the height of drop with the volume of the crater.

The practical work on ejecta rays is likely to use large amounts of powder that can be used only a few times before the paint discolours the powder too much, and so it may be advisable to put pupils into larger groups for these experiments. Ejecta rays are the trails of debris that fall round an impact crater in a 'star pattern'.

The heading 'Investigation interpretation' has a list of 6 questions that the results of the experimental work should answer. Questions 1 and 3 mention impactor velocity. Some pupils will need guidance on how to calculate the velocity on impact of the object they have dropped.

Pupils are asked to evaluate their results by addressing the first two points listed under the heading 'Investigation discussion'. The third point under this heading requires them to use their results to estimate the crater sizes that would be caused by impacts of meteorites of three different large diameters. Pupils have to decide how they can do this, for example, from extrapolation of their results.

Using IT. Pupils could use spreadsheets to produce graphs from their results, and to model the process of crater formation on a larger scale by extrapolation. Velocity of the object could be measured using light gates.

Technical details

(See Research bulletin M96004 in the Brief)

Safety issues

PLEASE NOTE: It is also important that you prepare your own risk assessments for the practical work in this Brief in the usual way.

Sodium hydrogen carbonate and Plaster of Paris ($CaSO_4.H_2O$): minimal hazard.

Harmful if swallowed in quantity. Seek medical advice.

Bouncing balls: danger of balls bouncing off hard surfaces (especially ball bearings and golf balls). (Small) danger of dust inhalation.

Wear eye protection.

Keep face away from impact area.

Assessment issues for *Experimental and Investigative Science* (National Curriculum for England and Wales, Northern Ireland Curriculum)

P	Planning	O	Obtaining evidence
A	Analysing evidence	E	Evaluating evidence

Crater formation investigations are introduced in Research bulletin M96004. For **Skill Area P**, highest mark levels are possible provided that scientific knowledge is used to plan strategy. The amount of guidance given to pupils will need to be taken into account.

For Skill Area O, the procedures used to obtain measurements and observations can be simple but attention to precision and reliability can allow pupils

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to achieve the highest mark range. For **Skill Areas A and E**, higher marks can be achieved if they relate results to predictions and to scientific knowledge, extrapolate, deal with the variability of measurements and compare their results and extrapolations to data obtained from other Solar System bodies.

Scottish syllabus coverage

Standard Grade Physics - *Space Physics*

Further pupil research opportunities

Pupils could do background research into past Earth impacts and their effects, and produce a display/exhibition. There has been a good deal written about this topic and there is a considerable interesting and useful information on the Internet.