THE BAHAMAS GENERAL CERTIFICATE OF SECONDARY EDUCATION COMBINED SCIENCE SYLLABUS

1. INTRODUCTION

The information contained in this syllabus is intended to define the minimum requirements for preparing candidates for the Bahamas General Certificate of Secondary Education (BGCSE) Combined Science Examination.

The BGCSE Combined Science Examination is intended for students aged 16+ who have completed a course which satisfies the requirements of the syllabus.

The Scheme of Assessment is designed to assess the positive achievements of candidates of differing abilities.

The standard of the Examination will be equivalent to that of the GCE O level examinations, but is designed to provide certification for a larger population of students, and a grade range of A - G.

Through this examination candidates are being offered success through performance within their own ability range.

The syllabus allows for the implementation of varied methods of instruction and assessment while helping the candidate to develop the skills and understanding needed to derive maximum benefit from the subject content.

Coverage of the subject content is intended for a period of approximately **three** (3) years beginning in Grade 10. The Examination includes written components and a practical component. The guidance offered through the syllabus is intended to enhance the performance of student and teacher alike.

It is anticipated that the course will be taught in such a way that it will draw on the experience that students can bring from their everyday lives. It is hoped that teachers will take the opportunity throughout their teaching to incorporate technological applications and the social, economic and environmental implications of Science in our society.

The principal aim of the syllabus is to provide students with an appreciation of the scientific interpretation of the world, that will be of personal value to them and a good foundation for further scientific studies.

2. AIMS

The aims listed below include references to certain attributes and qualities which cannot and should not be assessed through formal examinations, but which do form an essential part of the Combined Science course. In this respect the Aims are broader than the Assessment Objectives which all refer to qualities and competencies that can be assessed. These aims are not listed in order of priority.

2.1 To provide opportunity for all students through well-designed, practical studies in Science, to obtain sufficient understanding and knowledge of the concepts, principles and applications of **Biology, Chemistry** and **Physics** and, where appropriate, other related sciences.

2.2 To become confident citizens in a technological world, able to take or develop an informed interest in matters of scientific importance.

2.3 To recognize the usefulness of scientific method and to appreciate its application in other disciplines and everyday life.

2.4 To develop abilities and skills that are relevant to the study and practice of science and are useful in everyday life.

2.5 To provide students with a suitable course should they cease to study science beyond this level.

2.6 To promote an awareness that the application of science may be both beneficial and detrimental to the individual, the community and the environment.

2.7 To ensure that students can follow instructions including those relevant to complying with safety.

2.8 To provide an appropriate scientific background for use in technical and vocational courses.

2.9 To encourage self-confidence and a positive sense of achievement which results in greater and continued curiosity, interest and enjoyment of the subject.

2.10 To stimulate an interest in caring for the environment.

3. ASSESSMENT OBJECTIVES

	CLUSTER OF ASSESSMENT OBJECTIVES		ASSESSMENT OBJECTIVES	TARGET WEIGHTING
1.	KNOWLEDGE WITH UNDER-STANDING		Candidates should show knowledge and understanding of scientific:	40%
		3.1.1	phenomena, facts, definitions, concepts, theories and generalizations;	
		3.1.2	vocabulary, terminology, conventions, (including symbols, quantities and units);	
		3.1.3	instruments and apparatus including techniques of operation and aspects of safety;	
		3.1.4	methods of measurement of quantities and their appropriate units;	
		3.1.5	application of learned facts and observations in terms of theories and models.	
2.	HANDLING INFORMATION AND PROBLEM SOLVING		Candidates should be able to demonstrate skills and ability to:	40%
		3.2.1	locate, select, organize and present information from a variety of sources;	
		3.2.2	translate information from one form to another;	
		3.2.3	select appropriate facts to illustrate a given principle, concept, law, theory, model or pattern;	

CLUSTER OF ASSESSMENT OBJECTIVES	ASSESSMENT OBJECTIVES	TARGET WEIGHTING
	3.2.4 solve problems by designing, conducting and interpreting the results of simple experiments;	
	3.2.5 present reasoned explanations for phenomena, patterns and relationships;	
	3.2.6 draw conclusions from experimental observations and other data;	
	3.2.7 recognize that the study and practice of science are subject to various limitations.	
3. **EXPERIMENTAL SKILLS AND INVESTIGATIONS**	Candidates should be able to:	20%
	3.3.1 use techniques, apparatus and materials (including the following of a sequence of instructions, where appropriate);	
	3.3.2 make and record observations, measurements and estimates;	
	3.3.3 interpret and evaluate experimental observations and data;	
	3.3.4 plan investigations and/or evaluate methods and suggest possible improvements (including the selection of techniques, apparatus and materials).	

4. SCHEME OF ASSESSMENT

The examination will comprise written papers and a practical component.

The design of the examination will allow candidates of a wide ability range to demonstrate what they know, understand and can do.

4.1 Differentiation

The purpose of this differentiated scheme of assessment, by using components that are designed to test particular parts of the ability range, is to examine candidates at levels at which they can demonstrate achievement and provide positive evidence of attainment.

It follows that if candidates are to obtain benefit from taking papers designed to meet their particular needs, Centres must take care to ensure that each candidate is entered for the combination of papers for which he or she is more suited.

4.2 Scheme of Assessment

The scheme of assessment, relative to the BGCSE Combined Science, is as follows:-

There will be **three** written papers available and a practical assessment which will be compulsory.

Papers 1 and 2, together with the **practical assessment**, are **compulsory** for all candidates.

Grades C-G will be awarded on the basis of the candidate's performance in this part of the examination. Papers 1 and 2 will be set on the core curriculum only.

Grades A and B will be awarded on the basis of candidates performance in Component 3 (Paper 3) and Component 4 (Practical Assessment) provided grade D or above has been achieved on the compulsory components.

COMPONENT 4 **Practical assessment (criteria remains the same).**

COMPONENT (PAPER)	DURATION	TITLE	PERCENTAGE WEIGHTING
1	1 1/4 hour	Paper 1 (Multiple-choice)	30%
2	1 1/2 hour	Paper 2 (Structured and short answer)	50%
3	1 1/2 hour	Paper 3 (Structured and free response)	80%
4		Practical assessment	20%

SUMMARY ASSESSMENT WEIGHTING AND AWARDING OF GRADES

For the award of grades C, D, E, F, G.

COMPONENT	DURATION	DESCRIPTION	PERCENTAGE WEIGHTING	POINTS
1	1 1/4 hour	50 Multiple-choice questions	30%	50
2	1 1/2 hour	Structured and short answer questions	50%	100
4		Practical assessment	20%	48
				198

For the award of grades A, B (in addition to components 1 and 2)

COMPONENT	DURATION	DESCRIPTION	PERCENTAGE WEIGHTING
3	1 1/4 hour	Structured and free-response questions	80%
4		Practical assessment	20%

5. COURSE CONTENT

The content for this Combined Science course includes topics from Biology, Chemistry and Physics. The content set out below does not provide a teaching order. It does however, represent the topics on which the candidate will be assessed.

BIOLOGY

CHEMISTRY

PHYSICS

CURRICULUM OBJECTIVES

The left column contains general themes and topic areas. The middle column contains specific concepts and principles that are compulsory for all candidates.

The right column contains additional concepts and principles required to obtain grades A and B.

BIOLOGY SECTION

SECTION I CHARACTERISTICS AND CLASSIFICATION OF LIVING ORGANISMS

	TOPIC	CORE	EXTENDED
1	**Characteristics of living organisms**	- The characteristics of living organisms: nutrition, excretion, respiration, irritability, growth, reproduction, and movement.	
2	**Classification of living organisms**	- The five kingdoms of classification (monera, protista, fungi, plant and animal), using basic characteristics of each kingdom and examples of each.	

SECTION II ORGANISATION AND MAINTENANCE OF THE ORGANISM

	TOPIC	CORE	EXTENDED
1	**Cell structure and organization**	- The structure of an animal cell (liver cell) and a plant cell (palisade cell) as seen under a light microscope (cell wall, cell membrane, cytoplasm, nucleus, chloroplasts) - The differences in structure between plant and animal cells. - The relation of the structures seen under the light microscope to their functions.	- The additional organelles in an animal and plant cell as seen under an electron microscope (ribosomes, mitochondria, endoplasmic reticulum, golgi bodies, lysosomes, chromosomes).
2	**Levels of organization**	- Tissues as group of similar cells. - The structure of the following Tissues as it relates to their functions:root hair cells-absorption, red blood cells, xylem cells-transport - Organs and systems e.g.heart, lung, stomata (X- ref 6b,7a,b,8c,10a,11b,c).	- Types of tissue in animals and plants: epithelial, nerve, connective, blood, muscle, epidermal, vascular, photosynthetic.
3 (a)	**Diffusion**	- Diffusion as the movement of molecules from a region of higher concentration to a region of lower concentration down a concentration gradient. - The importance of a gas and or solute in diffusion. - water as a solvent.	
(b)	**Osmosis**	- The passage of water molecules from a region of higher concentration to a region of lower concentration through a partially permeable membrane. - The importance of osmosis in the uptake of water by plant and animal tissues (X-ref Section II 5c Translocation).	

	TOPIC	CORE	EXTENDED
4	**Enzymes**	- Enzymes as proteins which function as biological catalysts.	- The effect of temperature and pH on enzyme activity. - The use of enzymes in detergents.
5	**Plant nutrition and transport**		
(a)	**Photosynthesis**	- Photosynthesis and the word equation for the formation of simple sugars and oxygen. - The intake of raw materials the trapping and storing of energy (conversion of light energy into chemical energy), the formation of food substances and their subsequent storage.	- The effect of varying light intensity and temperature on the rate of photosynthesis.
(b)	**Transpiration**	- Relation of water vapour loss to cell surfaces, air spaces and stomata. - How wilting occurs.	- Xylem (support and conduction of water).
(c)	**Translocation**	- Translocation in terms of sugars and salts.	- Phloem (movement of sugars throughout the plant).
6	**Animal nutrition**		
(a)	**Diet**	- Diet as a balance between food intake and energy, growth and health requirements. - A balanced diet as supplying sufficient quantities of proteins, carbohydrates, fats,vitamins, water,minerals, fiber, and energy to sustain a healthy life. - A balanced diet as it relates to age, sex and activity of an individual. - The effects of malnutrition in relation to constipation and obesity.	- Deficiency diseases caused by lack of vitamins (A, B, C and D) and minerals (iron and iodine).

	TOPIC	CORE	EXTENDED
(b)	**Human alimentary canal**	- The gross structure of the alimentary canal in relation to ingestion, digestion, absorption, assimilation and egestion.	
(c)	**Mechanical and physical digestion**	- The four types of teeth and their functions. - The causes of dental decay and the proper care of the teeth. - Peristalsis as muscular contractions occurring in the digestive tract to help move food along the tract.	
(d)	**Chemical digestion**	- The importance of enzymes and their functions in the digestion of food.	- The names of enzymes which help to break down starches, proteins and fats. - The end products of digestion.
(e)	**Absorption**	- The small intestine as the region for the absorption of digested food. - The significance of villi in the ileum in increasing the internal surface area.	
(f)	**Assimilation**	- The role of the liver in the metabolism of glucose and amino acids; the role of fats as an economic storage substance. - The liver as the site for the formation of urea and the break down of alcohol.	

	TOPIC	CORE	EXTENDED
7	**Transport**		
(a)	**Heart**	- The gross structure and function of the heart and the effects of exercise on heart-Beat. - The likely causes of heart attacks (unsuitable diet, smoking, stress) and preventative measures.	- The effects of and the use of named drugs on heart rate (depressants, stimulants, and hallucinogens).
(b)	**Blood vessels**	- The structure and function of arteries, veins and capillaries; the double circulatory system.	- Coronary heart disease in terms of the blockage of the coronary arteries.
(c)	**Blood**	- The composition of the blood of a mammal. - The functions of blood including clotting. The transfer of materials between capillaries and tissue fluid.	- The immune system in terms of antibody production, tissue rejection and phagocytosis.
8	**Respiration**	- Respiration as the release of energy from food substances in living cells.	- The equation for respiration in symbols.
(a)	**Aerobic respiration**	- Aerobic respiration as the release of a relatively large amount of energy by the breakdown of food substances in the presence of oxygen.	
(b)	**Anaerobic respiration**	- State the word equation for anaerobic respiration. - Its role in baking and brewing.	- The equation for anaerobic respiration in symbols.

	TOPIC	CORE	EXTENDED
(c)	**Gaseous exchange**	- The features of gaseous exchange surfaces. - The differences in composition between inspired and expired air. - The effects of physical activity on rate and depth of breathing; the effects of cigarette smoke and air pollution on gaseous exchange structures (X-ref Chem. SectIII-2).	- The role of the ribs, intercostal muscles and diaphragm in ventilation of the lungs.
9	**Excretion and homeostasis in humans**	- Excretion as the removal of toxic waste materials, products of metabolism and substances in excess of requirement from Organisms. - The function of the kidney simply in terms of removal of urea and excess water. (no details of kidney structure required).	- The removal of carbon dioxide from the lungs.
10	**Coordination and response in humans**	- The ability to detect and to respond to stimuli.	

TOPIC	CORE	EXTENDED
(a)The nervous system	- The human nervous system in terms of the central nervous system (brain and spinal cord as areas of coordination) and the peripheral nervous system. - The differences between voluntary and involuntary actions.	- Simple reflex arc and a reflex action as ameans of integrating and coordinating stimuli with responses.
(b) Receptors	- Receptors which respond to specific stimuli: light, sound, touch, temperature and chemicals. - The structure and function of the eye.	- Pupil reflex inresponse to bright and dim light.
(c) Effectors	- The action of antagonistic muscles in the movement of the elbow joint. - functions of tendons, ligaments cartilage and synovial fluid.	
(d) Hormones	- The chemical control of metabolic activity by insulin and adrenaline. - The personal and social problems arising from drug abuse by reference to named drugs e.g Cocaine and alcohol.	- The use and abuse of steroids
11 Reproduction		
(a) Sexual Reproduction	- Sexual reproduction	- The advantages and disadvantages of sexual reproduction.

	TOPIC	CORE	EXTENDED
(b)	**Sexual reproduction in plants**	- The structure and functions of a named dicotyledonous plant e.g. *Bauhinia* (poor man's orchid) or *Vinca* (Sailor's cap). - Pollination. - The differences between self-pollination and cross-pollination - Seed formation and the structure of a non-endospermic seed. - Seed and fruit dispersal.	- The different structural adaptations of insect-pollinated and wind-flowers.
(c)	**Sexual reproduction in man.**	- The structure and function and function of human male and female reproductive systems, including the menstrual cycle, formation of gamates,sexual intercourse, fertilisation and implantation, development and birth.	- The roles of testosterone and oestrogen in the development and regulation of secondary sexual Characteristics.
(d)	**Methods of birth control**	- Methods of birth control: natural, chemical, mechanical, and surgical.	- The social and population aspects of birth control, including artificial insemination.
(e)	**Sexually transmitted diseases**	- The symptoms, signs and effects of gonorrhoea and syphilis. - The spread of the human immuno-deficiency virus (HIV) and methods by which it may be controlled.	

SECTION III RELATIONSHIPS OF ORGANISMS WITH ONE ANOTHER AND WITH THEIR ENVIRONMENT

	TOPIC	CORE	EXTENDED
1	**Energy flow**	- The Sun as the principal source of energy input into biological systems.	
2	**Food chains and food webs.**	- Food chains; food webs; producers;consumers: decomposers	- Energy losses between trophic levels and the advantages of short food chains (X-ref Sect II, 5(a).
			- Increased efficiency in supplying green plants as human food; the relative inefficiency, in terms of energy loss, of feeding crop plants to animals.
3	**Ecology**	- Ecosystem, habitat. - The diversity of life within an ecosystem,e.g. mangrove swamp; sandy seashore; rocky seashore. - Human influences on an ecosystem (including farming practices).	- Detailed study of coral reef mangrove swamp,beach, and rocky shore, including their economic importance; adaptation of organisms, effects of nature and man; economic importance.
4	**Pollution**	- The undesirable effects of water pollution by sewage and inorganic waste,and the pollution due to pesticides, herbicides and oil. - The undesirable effects of air pollution on gaseous exchange surfaces (X-ref Sect II 8c).	-Recycling of biodegradable versus non-biodegradable materials.

	TOPIC	CORE	EXTENDED
5	**Conservation**	- The need for the conservation of species, their habitats and of natural resources (use local examples: White Crowned pigeon, Hawksbill turtle, mahogany trees).	- The principal use of recycli of materials including an outline of the treatment of sewage (water) and trees (paper).
6	**Biotechnology**	- The application of biological processes for the production of useful materials or substances. - The need for biotechnology. - The economic importance of biotechnology. - Food technology and mariculture as examples of biotechnology.	- Cloning and hydroponics a examples of biotechnology. - One detailed method of biotechnology.

CHEMISTRY

SECTION I STRUCTURE OF MATTER

	TOPIC	CORE	EXTENDED
1	**The particulate nature of matter**	- States of matter. - Interconversion of states in terms of the kinetic theory.	
2	**Atoms, elements and compounds**		
(a)	**Atomic structure and the Periodic Table**	- Structure of the atom (proton, neutron, electron). - Charges and approximate relative mass of a proton, an electron and a neutron. - Atomic mass, atomic number. - Bases of the Periodic Table using atomic number and simple structure of the atom.	- Relative atomic mass. - Electron shells up to the third shell. - Significance of valency. - Families (I, II,VII, VIII) as explained by electronic structure.
(b)	**Elements, molecules and compounds**	- Difference between an element and a compound. - The molecule. - Differences between metals and non-metals e.g. ability to conduct electricity. - Differences between mixtures and compounds.	
(c)	**Ions**	- Formation of ions by electron loss or gain.	

	TOPIC	CORE	EXTENDED
(a)	**Production of energy**	- Production of heat energy by burning fuels. - Hydrocarbons as fuel. - Word equations for chemical reactions (related to heat).	- Symbolic equations for specific chemical reactions. - Radioactive isotopes e.g. Ur_{235} as a source of energy.
(b)	**Exothermic and endothermic reactions**	- Meaning of exothermic and endothermic reactions. Identify exothermic and endothermic reactions.	- Describe bond breaking as endothermic and bond forming as exothermic.
(c)	**Rate of reaction**		- Influence of concentration, catalysts, and surface area.

SECTION III THE ENVIRONMENT

	TOPIC	CORE	EXTENDED
1	**Natural cycles**	- Earth, ocean and atmosphere storage reservoirs of raw materials. - Simplified versions of carbon and water cycles.	- The nitrogen cycle.
2	**Air and water**	- Percentage composition by volume of air (N_2, O_2, CO_2, noble gases and variable amounts of water vapour). - Identification of oxygen using a glowing splint and carbon dioxide using limewater. - Simple explanation of respiration, combustion, and rusting. - Common pollutants of air (carbon monoxide, sulphur dioxide, oxides of nitrogen and lead compounds).	- Symbolic chemical equations. - Effects of combustion of fossil fuels and deforestation on the balance between O_2 CO_2. - The greenhouse effect.
3	**Water purification**	- Identification of pure water using boiling point (bp) melting point (mp) and anydrous copper sulphate. - Purification of water supply in terms of filtration and chlorination. - Water softeners. - Uses of water in home and industry.	- Effects of soap and detergent on hard and soft water.
4	**The Earth's crust, extraction and use of metals**	- Relative ease of obtaining metals from their ores (Al, Cu). - Uses of metals (Al, Cu).	- Use of Blast Furnace for production of iron from iron ore.

PHYSICS

SECTION I GENERAL PHYSICS

	TOPIC	CORE	EXTENDED
1	**Length and volume**	- The use of rulers and measuring cylinders to determine length and volume. - The use of clocks and devices for measuring an interval of time.	- The use of a mechanical method for measurement of small quantities e.g.burette, calipers. - How to measure a short interval of time.
2	**Density**	- Amount of matter in a given unit of volume. **density = mass/ volume** **(g/cm^3)**	
3	**Speed, velocity and acceleration**	- Speed and velocity, distance and displacement - Average speed of an object.	- Difference between speed and velocity. - Speed-time graph when a body is at rest, moving with changing speed. **v = d/t** **a = ▲v/t**
4	**Mass and weight**	- Familiarity with the idea of the mass of a body. - Weight as the result of a force acting on an object. - Understanding that weights (and hence masses) may be Compared using a balance.	- The concept of weight as the effect of a gravitational field on a mass.
5	**Temperature and heat**	- Measurement of temperature (Celsius, Fahrenheit, Kelvin). - Difference between heat and temperature. - Heat transfer by conduction, convection and radiation.	- Conversion from °C to °F and vice versa.

TOPIC	CORE	EXTENDED
Effect of heat on matter	- Thermal expansion of solids, liquids and gases (everyday applications and consequences of conduction, convection, and radiation).	

SECTION II FORCES AND MOTION AND ENERGY

	TOPIC	CORE	EXTENDED
1(a)	**Forces and motion**	- A force as a push or pull.	
(b)	**Types of forces**		
2	**Effects of forces**	- A force may produce a change in size and shape of a body. Unit of force is the newton (N). - Ways in which a force may change the motion of a body (friction).	- The relation between force, mass and acceleration. **F= ma**
3	**Energy, Work and Power**		
(a)	**Energy**	- Energy in different forms its transfer and conversion or application of the principle of energy conversion to simple examples. - Understanding of energy of motion and energy of position.	- Energy transfer in terms of work done and make calculations involving: **W = fd** **k.e. = ½ mv²**.
(b)	**Major sources of energy and alternative energy sources**	- Devices and processes in which energy is transferred from one form to another e.g. chemical/fuel energy.	- Various energy forms, hydroelectric, geothermal, nuclear, as alternative sources of energy.
(c)	**Power**	- The relation of power to energy transferred and time taken.	- Calculate energy using equations: **E = Pt** **P = W/t**

SECTION III WAVES, SOUND AND LIGHT

	TOPIC	CORE	EXTENDED
1	**General wave properties**	- Wave motion as shown by vibrations in ropes and springs and by experiments using a ripple tank. - The meaning of speed of waves, vibration, amplitude, wavelength and frequency. **Speed=frequency x wavelength.**	
2	**Sound**	- Sound waves are longitudinal waves. - Sound waves are produced when objects vibrate e.g.tuning forks,speakers, strings etc. - Need for media in transmission of sound. - The qualitative effects of thickness, tension and length on the frequency of a vibrating string.	- Simple model to show transmission of sound. - Diffraction of two sound sources of the same frequency. - The speed of s sound from echo experiments.
3	**Light**		
(a)	**Reflection of light**	- Laws of reflection from a plane mirror. - Effects of concave and convex mirrors using ray diagrams.	- Formation of images, including virtual, by concave and convex mirrors using ray diagrams.

	TOPIC	CORE	EXTENDED
(b)	**Refraction of light**	- What happens when light passes from one medium to another (refraction). - Why refraction of light takes place.	- The use of a single lens as a magnifying glass. - Calculate refractive index (n) given values for *i* and *r*. **n = sin *i*/sin*r***
(c)	**Sight**	- The process of seeing in humans. (X- ref to BIO. Sec. II, 11b).	- Use of lenses in eyeglasses.

SECTION IV ELECTRICITY AND MAGNETISM

	TOPIC	CORE	EXTENDED
1	**Electricity**	- Atomic model and cause of charged particles.	
2	**Current electricity**	- Current as a flow of electrons.Conductors and insulators. - Difference between a.c. and d.c. and their advantages and disadvantages.	
3	**Electric Charge**	- Electroscope to show charge of an object. - Law of charges.	- Electroscopes and insulated conducting objects.
(a)	**Current**	- The rate of flow of charge measured in amperes. - The use of an ammeter.	- Use the equation: **I = Q/t.**
(b)	**Potential difference**	-Understand that the potential difference (p.d.) across a circuit component is measured in volts. - The use of a voltmeter.	
(c)	**Resistance**	- Opposition to flow of electrons through a conductor.	- Use the equation: **R = V/I.**

	TOPIC	CORE	EXTENDED
4	**Electric circuits**	- Components, symbols and function (including switches, fuses, resistors, ammeters and voltmeters).	- Current (I) as the rate of of electron (charge) flow measured in coulombs per second **$I = Q/t$**
5	**Household electrical System**	- Houses are wired in parallel. - The use of fuses and switches.	- Cost of electrical energy. **Energy = Power x time**
6	**Dangers of Electricity**	- The hazards of damaged insulation, over-heating of cables and damp conditions.	
7	**Magnetism**	- Properties of magnets and ferromagnetic substances. - Factors determining field strength. - Methods of magnetization and demagnetization. - The properties of magnetically hard and soft materials. - The construction of an electromagnet.	- Electromagnetic induction as An energy transfer process.

RECOMMENDED TEXTBOOKS

NAME	AUTHOR
Balanced Science Books 1 & 2	Jones, Jones, Marchington & Acaster
C X C Integrated Science	June Mitchelmore, John Steward & John Phillips