WORKBOOK 1

1-1. How would you devise a dice game so the dice always landed showing 6's?

You must manipulate the dice in some way. The traditional way is weighted or "loaded" dice. Extra weight is added to the side opposite the "6" face.

1-2. How many times would you have to toss a pair of dice to get the dice both showing 7?

Since dice do not have the property of a 7 face, this could never happen, no matter how many times you tossed them. Unless you create a new dice with 7 on it - 7's are not a natural or spontaneously possible result. Natural processes can only produce the options which exist before the process works on them.

1-3. How might the information above help detect unnatural manipulation or cheating in gambling casinos?

Natural processes can only give results in proportion to the number of natural options available, eg. the 6 face should show up approximately one-sixth of the time in a game involving dice. If one result occurs more often, or less often than the number of options would indicate, then the game has been manipulated.

1-4. Since Pasteur's day (1848), we have discovered many ways of separating left and right handed chemicals. In every case, it has been achieved only by mechanisms that are not a natural property of the chemical system, eg. intelligent scientists. We have no case in the past 150 years where separation of left and right handed mixtures has occurred by natural or spontaneous means. **Does this fact help the hypothesis that life originated by a spontaneous process? Explain your answer.**

No. If there are two possible options then natural processes will always result in an even mixture of the two. Living cells contain exclusively left handed amino acids, when both right and left handed molecules are possible. This is an unnatural result.

1-5. It has been observed over the past 150 years that any pure sample of left handed amino acid outside a living body automatically changes to a mixture of 50% left handed and 50% right handed amino acids with time. **Does this support the concept life originated by spontaneous generation?**

No. The process of producing a mixture of right and left handed molecules occurs only after the living thing has died. It does not help to explain how living things came into existence in the first place.

1-6. Because left handed amino acids change to a 50:50 mix at a measurable rate, geologists have tried to use this information to find how long ago a fossil died. The longer an animal has been dead, the closer its amino acids come to the 50:50 mix. **How does this affect the relevance of Miller's experiment? Explain.**

The origin of life is a transition from non-life to life. Miller's experiment produced a 50:50 mixture of amino acids - about as far away from life as you can get. Miller's experiment is only relevant if his mixture could be shown to spontaneously produce only left handed amino acids or some natural non life process could select only the left handed amino acids and use them to build proteins.

1-7. The review of Miller's experiment in the Time Magazine, October 11, 1994 stated:

"In 1953 University of Chicago graduate student Stanley Miller provided the first widely accepted experimental evidence. In a glass jar he created a comic-strip version of primitive earth. Water for the ocean. Methane, ammonia and hydrogen for the atmosphere. Sparks for lightning and other forms of electrical discharge. One week later he found in his jar a sticky goop of organic chemicals, including large quantities of amino acids, Lego blocks for the proteins that make up cells. Case closed, or nearly so, many scientists believed.

Now this textbook picture of how life originated, so familiar to college students just a generation ago, is under serious attack. New insights into planetary formation have made it increasingly doubtful that clouds of methane and ammonia ever dominated the atmosphere of primitive earth. And although Miller's famous experiment produced the components of proteins, more and more researchers believe that a genetic master molecule - probably RNA - arose before proteins did." (p.71) .....

"It was", says planetary scientist and White House Fellow, Christopher Chyba, "a beautiful picture." "Unfortunately", he adds, "it is probably wrong." (p.73)

What can be learned from this review about how strongly you should be committed to a scientific theory?

Scientific theories are constantly changing, especially when they seek to explain processes which cannot be directly observed. No scientist, creationist or evolutionist, was there to observe the first living cells come into existence. Even for processes which are occurring today new information is constantly being gathered and theories are being modified or substituted by new theories. Scientific theories provide a useful framework to work within. The history of science is littered with many theories that have been widely believed then later scrapped. Scientific theories should never become the basis of a belief system or commitment.

1-8. Some people have suggested if you give a spontaneous situation long enough it must produce the 'right' result at least once. For example, if a monkey hits the keys on a typewriter long enough, it must eventually type a piece of poetry by Shakespeare. Since the poem consists of letters and the monkey is hitting letters, then one possible combination of letters is a Shakespearean poem. Therefore, they argue, given long enough, it must be attained.

What do you think of this argument? (Hint: look for the assumption about the natural properties of letters, monkeys and typewriters and remember the dice).

Consider the amount of information and organisation involved. A poem is a string of letters which first must be placed in correct order (which we call words) which then must have meaningful spaces put in the right places, which are next arranged into lines of particular length, which must end with the appropriate words (to rhyme) which are lastly organised into stanzas.

Consider the natural properties of monkeys and typewriters - monkeys get rapidly bored with anything which does not produce food. Both monkeys and typewriters wear out long before the monkey could hit all possible combinations. When the monkey dies or the typewriter is broken the possibility of new information is zero.

Speculations involving situations which are not realistic might be interesting for philosophers but they do nothing to explain the real world.

WORKBOOK 2

2-1. One bacterial group is known to use right handed amino acids in the construction of its protein coat. When the proteins for the coat are in place, the bacteria then uses an enzyme to convert all the right handed amino acids to left handed.

Could such a two step protein coat manufacturing system arise spontaneously? Explain.

No. Spontaneous processes produce 50:50 mixtures of amino acids. A process which produces exclusively right handed versions of one amino acid at a particular site in a bacterium is just as non-spontaneous as processes which produce exclusively left handed amino acids in the rest of the bacterium.

2-2. Does the observation that amino acids in your body are exclusively left handed and the sugars in your RNA exclusively right handed fit the explanation life could have originated unnaturally by manipulation through the supply of outside information? Explain your answer.

Exclusively right handed sugars present the same problem for the spontaneous generation of life by natural processes as exclusively left handed amino acids. To get a pure solution of right handed sugar molecules requires external manipulation just as the production of pure left handed amino acids does.

2-3. Is RNA more or less likely to spontaneously arise than protein? Explain your answer.

Since RNA contains a sugar molecule which can occur in both left and right handed forms, then exclusively right handed RNA sugars have the same likelihood of spontaneous generation as proteins do, i.e. zero.

2-4. Life involves thousands of complex molecules as well as proteins and RNA. Many of these complex molecules have an L & D form. Only one form of these molecules is used in the living cell.

Does life seem to be more like the result of (a) spontaneous reaction caused by the natural properties of molecules, or (b) the unnatural manipulation of these molecules due to the supply of Outside Information? Explain.

Processes which have successfully produced exclusively right or left handed molecules have all involved intelligent manipulation of the system, whether it be Pasteur's patient separation of crystals or modern organic chemistry techniques. Our observations of spontaneous processes which produce amino acids or sugars all produce mixtures of right and left handed molecules. Therefore, based on the observed evidence of molecules, life appears to be more likely the result of intelligent manipulation.

LIFE FROM OUTER SPACE?

2-5. What is the probability the amino acids in the Murchison meteorite came from earthly contamination after it fell? Explain.

The fact that the amino acids in the meteorite were all 50:50 LH/RH mixtures means that they were not from recently living earthly contamination. Likewise, earthly contamination cannot explain the amino acids which are not normally found in the earth's natural environment.

2-6. What is the probability that the amino acids in the Murchison meteorite are from living things? Explain.

Unlikely. The meteorite contained some amino acids which are not found in living cells on earth. Cellular processes involving proteins could not work unless the molecules were made of exclusively one form of amino acid. Our observations of amino acids are that life contains one form, spontaneous processes produce both. The meteorite molecules were mixtures - therefore most likely from a non-living source.

2-7. Radioastronomy has revealed the existence of organic molecules outside our solar system. **If some of these molecules had L and D forms and were formed spontaneously, what prediction could you make about the number of L and D forms present?**

All our observations of spontaneous processes is that they produce mixtures of L and D forms. It would be a reasonable prediction that any organic molecules formed in space which could have L and D forms would be 50:50 mixtures.

2-8. A report 9th August 1995 in the Courier Mail Brisbane Australia stated:
"Two Australian scientists have been invited to search for life on Mars. Canberra geologist Richard Henley and Macquarie University palaeontologist Malcolm Walter will meet in London in January to discuss strategies to hunt for ancient "Martians".... The United States space agency NASA is expected to launch the first of four probes to the red planet in November 1996. The probes are expected to take six months to reach Mars.

They believe the key to success lies in extinct volcanic hot springs.....

The probes will be directed to land on fossilised hot springs to search for chemicals indicative of primitive forms of life."

Now that we have been to Mars (July 1997) did anything discovered on Mars support the spontaneous evolution of life?

To date of printing this Guide (January 1998), nothing has been found which supports the spontaneous generation of life.

WORKBOOK 3

Evolution is often defined as the change in gene frequency within a population. The classic example of such a change in gene frequency is the alteration in numbers of dark and light forms of the peppered moth in England. These moths tend to rest on the trunks and branches of trees. Prior to the industrialisation of parts of England the light forms were more common. After many years of industrialisation the air pollution had blackened the tree bark on which the moths rested the dark forms became more common. Now that pollution in England is being cleaned up, the trees are cleaner and the light moths are increasing in number again.

The explanation for the change is that prior to industrial pollution the dark forms resting on clean trees were more visible to the birds which preyed on the moths so they tended to get eaten, leaving the less visible light forms to breed. The situation was reversed when the trees were blackened by pollution - the light moths were eaten and dark ones, now well camouflaged on the blackened trees, were left to breed.

3-1 Is this a good example of natural selection by the environment altering the frequency of genes.

Yes. As the environment changed, the frequency of the two variations of the pigment gene in the moth changed.

3-2 Does this represent the addition of new genetic information to the moth population?

No. The genes for dark and light forms existed prior to the change in the environment and are still there.

3-3 Have peppered moths evolved because of natural selection acting on them?

No. There were black and white variations of the moths before the environment changed. They are still the same species of moth after two environmental changes.

3-4 Do any known mutations increase the number of types of genes, ie the amount of information, in a population?

No. Mutations, at best, cause variations of already existing genes, (eg. different coloured fly eyes) or, at worst, remove genes from some of the population (eg. genetic diseases involving loss of an enzyme or protein.)

3-5 Do any known mutations result in the evolution of one type of organism into another type of organism?

For one type of organism, eg. a reptile, to evolve into another type of organism, eg. a bird, large amounts of information must be added and large amounts of information deleted at the same time. No mutations (with or without Natural Selection) have ever been observed to cause this type of change in an organism.

3-6 The DNA of chimpanzees is about 1% different to human DNA.

List some of the differences in human biology this 1% is responsible for.

Speech, brain size, IQ, erect posture, 2 hands, 2 feet, (as opposed to 4 hands), dsitribution and length of hair, face shape, no penis bone.

3-7 The 1% difference in DNA between humans and chimpanzees is often used to argue that man must be closely related to these creatures.
What implications does the discovery of DNA polymerase (DNAp) have on this claimed relationship?

DNAp functions to keep the DNA the same. Therefore the 1% difference will stay 1% different so the claim for relationship is meaningless. The existence of DNAp implies the human and chimp DNA have always been 1% different.

WORKBOOK 4

THE FIRST FOSSIL LIFE

Fossilised stromatolites (mat-like structure formed by blue green algae) have been found in sediments of the Pilbara Block region of Western Australia. They are regarded by many as the oldest fossils on earth. Stromatolites are found still living not far away in Shark Bay Western Australia. Another deposit of micro fossils is found at "North Pole" in Western Australia in similar Pre-Cambrian rocks. Micro fossils of bacteria, algae and blue green algae have also been found in the Bitter Springs formation of Central Australia which are also classified as Pre-Cambrian. To the date of printing of this text all known Pre-Cambrian micro fossils have almost identical representatives still alive today.

4-1. How complex is an algae or bacterial cell compared to a protein chain or an RNA molecule?

Far more complex. A bacterial cell consists of many different types of molecules in addition to proteins and nucleic acids. These interact with one another in a highly organised fashion. Comparing a bacterial cell with a protein or RNA molecule is like comparing a city containing many brick buildings with one of the bricks from one of the buildings.

4-2. Can protein and RNA survive outside living cells in today's world?

When exposed to the environment outside a living cell most proteins lose their highly specific folded structure and rapidly break down. Some tough fibrous proteins such as the hard keratin found in hair have survived for centuries. Hair has been found in medieval tombs but ancient Roman graves contain almost no hair. Enzymes and other intracellular proteins break down in a matter of hours outside cells unless they are deliberately preserved.

Outside the cell RNA also breaks down rapidly. Even within living cells mRNA molecules only exist, at most, for a matter of days.

4-3. Does the discovery of fully formed fossil cells help the evolutionary theory of Spontaneous Generation of life? Explain your answer.

No. The discovery of fully formed fossil cells indicates only that living things existed in the past and were somehow preserved as fossils. Such fossil cells do not show the transition from non-life to life any more than living cells in the world today. In fact, the fossil cells we find appear to be the same as living cells of the same kind today. This is why stromatolites are called "living fossils".

4-4. Does the discovery of fully formed fossil algae and bacteria cells in what many regard as the world's oldest fossil bearing rocks help the creationist case that life was specially created to produce its own kind? Explain your answer.

The discovery of fully formed fossil cells does not prove that life was created in the first place as the fossil cells only prove that fully formed cells have existed in the past and been buried. However it is consistent with the creationist view that life was specially created, fully functional.

The discovery of fossil cells which appear to have the same structure as living cells we see today is exactly what creationists would predict, based on the belief that living things were created to reproduce after their own kind.

4-5. Why does a matching reciprocal code of a DNA pair enable the repair of a Thymine dimer?

(Hint: Consider what would happen if both strands contain the same coded sequence which was hit by UV radiation. Could it be repaired?)

Having a matching reciprocal code on both strands of DNA enables one strand to act as a template for the other if one strand is damaged. When the damaged region of the one strand is removed the remaining strand enables the original code to be reinserted in the section that has been removed only because the coding is reciprocal.

4-6. The principle of Energy dissipation and loss of Information is also known as the Second Law of Thermodynamics. Can you list any known exceptions to the Second Law?

There are no recorded examples of natural or spontaneous exceptions to the second law of thermodynamics. (The miracles of Jesus Christ and some of His disciples as recorded in the New Testament are examples of non-natural exceptions, brought about by outside intervention.)

4-7. Comment on the statement "even though the universe in general is losing energy, local areas such as the earth are receiving energy from the sun, so it would be possible for life molecules to evolve on earth."

The earth does receive energy from the sun and living things make use of it. However, merely applying energy to non-living matter has never been shown to produce life or increased organisation. Living things can only make use of the sun's energy to build more living matter if they already have the existing cellular machinery to select only wavelengths of usable energy, trap it and direct it into an already existing biochemical pathway.

Raw energy from the sun's energy can be dangerous to life, eg sunburn, skin cancer.

WORKBOOK 5

5-1 Evolution is a theory associated with billions of years of change. The **proposition** that the history of the Universe has involved large quantities of **TIME** has been based on the rates of decay of radioactive substances such as Uranium. This radioactive decay involves large, more complex, and more energetic atomic Nuclei breaking down to smaller, less complex, less energetic atomic Nuclei. Evolution is a **proposition** where small non life molecules have built up into vastly more complex life molecules. This leads to a philosopher's nightmare. Vast time spans deduced from large atomic Nuclei **Naturally Breaking down** into smaller atomic Nuclei, are used as support for a process of small non life molecules **Naturally building up** into larger life molecules.

The Science Philosophers Dilemma - Can both of these propositions be true at the same time? Explain your answer.

Observed naturally occurring process of breaking down cannot be used to explain an unobserved process of building up, i.e. a building may fall down because of chemical decay in the concrete and the force of gravity acting upon loosened bricks. However such processes in no way explain how the building was constructed in the first place.

Adding a vast amount of time does not change a process of decay or degeneration into one of construction. Time will only accentuate such a process, not change its nature.

5-2 If you succeed in winning a Nobel prize by being the first scientist to create life in a test tube, which of the following best fits your results?

a) life did evolve from non-life
b) life could evolve from non-life
c) life was created
d) life could have been created

Explain your answer.

Creating life in a laboratory today would show that the only observed transition from non-life to life has involved intelligent manipulation of matter, in this case by scientists. On this basis, the claim that the origin of life on earth was by intelligent creation is a reasonable claim.

5-3. Are the properties of the Hydrogen atom due to the Natural properties of its parts?

Surprisingly, the answer is No. The actual atom has more properties as an atom than the sum total of the separate properties of its parts, one electron and one proton, which implies the basic building block of all matter has the characteristics of a created object.

THE END IS IN THE BEGINNING

Two philosophers more than any others have had significant effect on modern man's thinking about the Origin of Life. Read their brief reviews and then answer the questions which follow.

In a book published 3 years after his death, Scottish philosopher, **David Hume (1711 - 1776)** argued any design seen in nature was not real, but only apparent. Hume's hypothesis was: given long enough, apparent design could result from processes due to **Natural Properties** alone.

In 1802 English philosopher **William Paley (1743-1805),** wrote a lengthy rebuttal to works such as Hume's.

So successful was Paley's argument that design always indicated a designer, it became popular for both scientists and theologians to argue that structures in nature which are infinitely more complex than a watch, (eg. the intricate construction of man's eye, the inter-relationship between plants and animals,) was overwhelming evidence life could not have arisen spontaneously but that unnatural manipulation, **Outside Information,** had been applied to matter by an external intelligent Creator God in order to make the life we see around us.

5-4 Hume's key assumption was that all combinations of matter are possible. What happens to his philosophy if this assumption is incorrect? Explain.

If this assumption is incorrect then the rest of Hume's argument falls to pieces as this is the basis of his argument.

5-5. What does Quantum Theory state about Hume's thought that all combinations are possible?

The discoveries of Quantum mechanics have shown that only certain combinations of energy and matter actually exist. Hume is wrong.

5-6. Whose thoughts - Paley's or Hume's - best fit the current state of knowledge about the possibility of life being a natural or spontaneous result of the properties of molecules?

The molecules of living things reveal properties which are not due to the natural properties of the parts which make them up, eg. exclusive left handed amino acids, instead of 50/50, DNA information which is not caused by the natural properties of the components of DNA. Such properties have a non-natural origin. This fits Paley's argument which compares living things with known designed things.

5-7. Evolutionist Professor of Microbiology, Michael Denton, stated in his book Evolution a Theory in Crisis 1986 (p.341) that: *"Paley was not only right in asserting the existence of an analogy between life and machines, but was also remarkably prophetic in guessing that the technological ingenuity realised in living systems is vastly in excess of anything yet accomplished by man".*

Has man invented any machine as sophisticated as the smallest life forms? What are the implications of your answer?

At the date of printing this text the smallest, most sophisticated man-made machines do not have the complexity of the simplest living cell. The emerging technology of designing and building microscopic structures and machines from individual molecules ("nanotechnology") is the nearest thing we have to the biochemical machinery seen in a cell. This is still at the very experimental stage and even when perfected will only be a copy of what already exists in the cell.

The implications of this are that the cell is the product of intelligent design in the first place and the designer and builder of the cell is more clever and more powerful than any human being.

5-8. On April 7, 1864 Pasteur reported to a scientific conference at Sorbonne France "There is now no circumstance known in which it can be confirmed that microscopic beings have come into the world without germs, without parents similar to themselves. Those who maintain this view are the victim of illusions of ill conducted experiments, blighted with error they have either been unable to perceive or unable to avoid".

Has anything been discovered since 1864 to alter Pasteur's conclusions? Explain.

Since 1864 scientists have been able to study micro-organisms and cells of multicellular organisms using sophisticated instruments and laboratory techniques Pasteur never dreamed of and have observed that all cells arise from "parents similar to themselves" ie other cells of the same kind.

No modern scientist would claim to contradict Pasteur's views on the present day origin of living cells. However many of the same scientists believe non living chemicals somehow must have evolved spontaneously into cells which evolved into all kinds of multicellular organisms. They regard the only other option of special creation as unacceptable.

HISTORIC BACKGROUND

IN THE BEGINNING

1-1. Could any of the above accounts of creation have been based on human observation?

No - because human beings are created beings. Therefore, no human beings could have observed events prior to their creation. Only the creator could observe the events of creation and reveal them to human beings.

1-2. Could any of the above accounts of the flood have been based on human observation?

Yes. The people who survived the flood would have observed it and then spoken and written about it.

1-3. Of all the above accounts, the Genesis record of the creation of life and man has had the greatest influence on western public and scientific thought. Suggest why this has been so.

Western society is based on Christianity. In fact the sum total of Western countries used to be referred to as "Christendom." Until recently the Biblical view of the world predominated in Western beliefs about origins. This view of the world is that the universe, the earth and everything in it is the result of intelligent planning and design by a personal creator who is consistent in His dealings with the creation. This belief was basic to the development of the scientific method since science can only proceed on the assumption that the world behaves in a logical and consistent manner. This is not possible in belief systems founded on the idea of many conflicting gods, one capricious god or chance random process with no-one in control.

1-4. Virtually every traditional culture has a written or oral account which usually includes two or more of the following features:

(a) A unique and divine origin for life and man.
(b) A golden age or a time when there was no death, war, fighting or winter and summer extremes.
(c) A time when degeneration, moral and physical, entered the human world.
(d) A catastrophic flood as judgement upon the earth.
(e) The survivors of this flood were the ancestors of all present day man.

Why might these themes have such consistent threads through ancient accounts on the origin of life?

They are all based on real history. The account of any historical event which is not written down and copied faithfully will inevitably get distorted as pieces of it are forgotten and other pieces are added to fill the gaps or enhance the reputation of the storyteller. After many retellings only the bare outline of the original story may survive amongst many fanciful additions. Writing it down hinders or prevents this distortion, which is why legal contracts are written down.

BACKGROUND CLASSIC GREEK

2-1. Were these Ancient Greek ideas based on direct human observation or experiments?

No, they were pure speculation. The Greeks were great thinkers but they rarely did practical experiments. For the ancient Greeks the ideal life was one of leisure. Practical experiments were too much like hard work and therefore only fit for slaves. Also, there was little point in doing practical experiments if the world was at the mercy of a group of capricious gods who may change the way things work at any time.

GREEK EXCEPTIONS

3-1. How would the views of Socrates have challenged the prevailing Greek views of the day? (Hint: See Database 2)

Socrates believed that only one, all powerful god was in charge of the universe and mankind. The prevailing view was of many gods of limited (but supernatural) power. In the minds of those who believed in many gods Socrates' view would be an offence to the individual gods and therefore their followers. These gods were egotistical and vengeful and had the potential to wreak havoc in the environment or on mankind if they were offended. Therefore, Socrates' ideas were considered a threat to society.

3-2. Was Socrates' view on a Divine Creator of life a new idea?

No. It can be traced back in writings and oral history long before the Greek empire. The ancient Israelites had a Divine Creator in their written law from the time of Moses.

3-3. Is it a compliment to be called "sophisticated"?

Only if you place a high value on being a clever thinker without necessarily being a right thinker. There is no value in being a clever thinker or speaker, if you are at best wrong, or at worst deceitful. It is interesting that the modern understanding of "sophisticated" meaning "worldly wise" has kept the sense of smartness but lacking in real worth.

SPONTANEOUS GREEK GENERATION

4-1. How similar were Aristotle's views to the modern theory of evolution?

They were similar in that he believed living things were spontaneously generated from matter such as soil and water. However, they were different in that Aristotle believed some sort of organising intelligence or creator was necessary for life to be formed. Modern day evolutionists believe that no outside intelligence is necessary.

Aristotle did not believe that organisms changed from one kind to another. His idea of higher and lower beings was merely descriptive of their relative complexity. This is very different from the modern day theory of evolution which is based on the idea that organisms change from one kind to another.

4-2. If knowledge comes only from the senses, where did Aristotle's ideas of invisible principles such as soul, and active and passive principles come from?

They could not have arisen from direct observation. Aristotle could have concluded they were necessary to explain the things he could observe or sense, eg. the complexity of living things. He could also have received them from other people.

4-3. Consult a recent Encyclopaedia to discover what the modern Gaia theory is. Is it really new?

The Gaia theory is a an idea which regards the earth as a living organism and all the individual species on it, including human beings, as being merely part of this "super-organism." Therefore it is to the earth that human beings owe their allegiance and have the responsibility not to do anything which would harm or change the earth. This idea is very similar to the Greek belief in the earth as the goddess Ge which gave rise (directly or indirectly) to living things on the earth. Although the terms "mother earth" or "mother nature" are not used in the professional literature "Gaia" is usually personified as a 'female' in the present day scientific followers.

GREEK Vs ROME

5-1. If revealed knowledge and natural knowledge were both about truth would they tell different stories?

No. If two stories about the same thing contradict each other they cannot both be true. They may both be wrong, but not both right.

5-2. Is Aquinas' way of dividing truth helpful?

No. It only confuses the issue. It implies that it is possible for people and things to exist in different realms which can ignore or contradict one another. It also implies that the spiritual and the physical, and revelation and reason have no relationship with one another. Eventually the concept of absolute truth and error is lost. In the end it becomes impossible to make moral judgements and define anything as "right" or "wrong." History shows that societies based on these ideas degenerate into corruption and chaos as the people have no standards of truth on which to base laws.

5-3. What does Bacon's struggle tell us about the influence and role of theologians and philosophers on universities?

In spite of the popular belief about universities being dedicated to the pursuit of truth, they are usually ruled by thinkers who are dedicated to preserving their own ideas.

THE NEXT SPONTANEOUS GENERATION

6-1. Do any things in DATABASE 6 still happen?

In terms of observation, these things still happen. It is the explanation of why these things happen that has changed.

6-2. Which ones have you seen happen?

Most students are not familiar with horse troughs or wheat storage. However, it is possible to get them to observe the soil after rain or do some simple experiments with meat or milk and simply record what they see.

6-3. Are there any DATABASE 6 observations you don't believe could happen? Explain why not.

Use this question as a way to get students to understand the difference between observations, beliefs and explanations. The observation that worms appear in the soil after rain is not the same as the belief that soil turned into worms, or produced the worms.

OF MICE AND MEN

7-1. What experiment could you set up to disprove the idea that mice grow out of wheat?

Ensure that the wheat does not contain any mice to start with. Then place it in a container which prevents mice from entering the wheat.

7-2. How difficult would it be to show that mud does not 'spontaneously' turn into living things if you do not have a microscope?

This would be difficult, since microscopic eggs/spores, etc. you could not see, may hatch/germinate into life forms you could see.

7-3. What facts would you need to know about insect life cycles before you could prove or disprove the idea that dead meat turned into crawling maggots which became living flies?

You would need to know that insects reproduce by laying eggs and that the eggs hatched into maggots, which in turn metamorphosed into flies which then laid more eggs. As most insect eggs are tiny but visible to the unaided eye or with low magnification, this is not difficult to observe. However, it required someone to be inquisitive enough to want to know how insects reproduce and then make the relevant observations and experiments.

7-4. Do long thin worms appear in horse troughs and if so, where do they come from?

Worms do appear in horse troughs after horses have drunk at them if the water is not changed very soon. They hatch from eggs which are carried in the horses hair. When the horse drinks at the trough the eggs are washed into the water, where they hatch.

THE COMING OF EMPIRICAL SCIENCE

8-1. To the best of our knowledge Bacon never performed a scientific experiment in his life, so why would he have believed it should work?

Bacon believed in a creator who was consistent and unchanging in character and that the creation reflected his character. Therefore the world should behave in a consistent and predictable manner. Therefore, if a process could be observed under the same conditions many times the results should always be the same.

8-2. It is commonly believed today that Philosophy, Science and Religion are 3 separate and mutually exclusive disciplines. Is this a valid approach to knowledge?

No, They are inextricably linked. Science used to simply mean "knowledge." It has come to mean knowledge gained by observation of the material world. Philosophy and religion determine how people interpret such observations, or even whether one can or should make such observations.

8-3. Do many theories make it to the point of being regarded as a law? How should this affect your commitment to any scientific theory?

Not many theories become laws. It is not possible to claim that you have tested every possibility of even the most simple process. For example, according to the law of gravity every particle of matter in the universe is attracted to every other particle in the universe in spite of the fact no-one has tested every particle in the universe. However, no one has found an exception to this law so far and it is reasonable to regard gravity as a law.

It is important to remember that most scientific theories are explanations of a number of observations which appear to fit together.

REDI'S INSECT EXPERIMENTS

9-1. What had Redi proved?

Redi proved that the rotting meat alone did not produce maggots.

9-2. Explain why his experiments had proved this.

By keeping the meat inaccessible to the flies but still allowing it to rot.

9-3. Some people quickly accepted that Redi had disproved spontaneous generation. They agreed he had shown non-living things cannot give rise to living things. What part of his experiment is convincing?

The fact that maggots were not seen when the flies were denied access to the meat, even though the meat still rotted.

9-4. How did Redi deal with the objection that sealed jars could not develop flies because the meat used up the air before flies had time to spontaneously develop?

The second experiment allowed air into the jars through the gauze but kept flies out.

9-5. Some proponents of spontaneous generation claimed support from new observations made by Anton van Leeuwenhoek who had focused the newly discovered microscope on a drop of pond water and discovered a new world of previously invisible organisms. Proponents of spontaneous generation quickly concluded microscopic animals developed from water only. What does this suggest about people's ability to 'let facts speak for themselves'?

Facts or observations do not "speak for themselves." They are always interpreted in terms of beliefs. Facts can often be fitted into wrong beliefs. Even when this happens, the facts are still the same.

9-6. Do you think the problem in the Question 9-5 might ever apply to you?

It must happen to all human beings. We learn beliefs whether we are formally indoctrinated with them or not, even if it just by copying those of people around us. Ideas about the origin of life can only ever be beliefs as no-one can go back in time and observe it happening. We can try to fit observations about living things into our beliefs about origins.

9-7. Without a microscope, how would you have disproved the claim of the defenders of spontaneous generation that microscopic pond organisms spontaneously develop from water only?

This would be very difficult indeed as it would be almost impossible to do an experiment where you could be sure you have removed all the microscopic life in the same way Redi was able to eliminate flies from his jars of meat. The only thing you could do is look for any changes (eg. cloudiness) in water which has been treated to kill living things (eg. by boiling), compared with water which is untreated. Even this is not foolproof as some micro-organisms can survive boiling.

DEBATING 'THE FORCE'

10-1. If you were Spallanzani, what additional experiments might you have done to disprove Needham's objection?

It would be necessary to somehow allow the boiled gravy to have access to air but still keep micro-organisms out.

10-2. Despite the work of Redi and Spallanzani at the end of the 1700s, spontaneous generation still had much support. Can you suggest reasons for this? (HINT: See Biographies)

People still held, as a point of doctrine, that there were residual properties of creativity left in the ground and the water, originating from when God commanded the earth to bring forth living things. Therefore they didn't bother much with the evidence.

10-3. Needham added to the hypothesis of spontaneous generation by vegetative force the claim that it was necessary for fresh air to be in contact with the gravy to stimulate the vegetative force to produce new life forms. Needham claimed this was proved by the fact that when flasks were broken open and new air allowed into the gravy, growth was soon seen to result. Can you suggest why "air" might have caused these growths?

Air contains micro-organisms. Although micro-organisms need a moist environment to grow and multiply, many survive in air until they land in a suitable environment. Redi's boiled gravy would have been a good culture medium and organisms from the air would rapidly grow in it.

10-4. Despite the controversy, some were prepared to try to turn Spallanzani's experiments into a profit and by 1810, they had succeeded. Discover what Appert in France and Durand in England are famous for.

Appert and Durand reasoned that if food could be sealed in such a way as to keep air out once it had been sterilised by boiling, it should keep for a long time. Apert and Durand developed techniques for preserving food in sealed metal containers. This is the basis of the modern canned food industry.

10-5. Needham's hypothesis could have been disproved by designing an experiment to show that it was dust in the air that had life on it, which grew when the dust landed on the gravy. Design an experimental apparatus in which fresh air would be continually in touch with a sterilised gravy mixture and yet no growths enter the flask because no dust could settle onto the gravy.

Pasteur first solved this problem using a flask with an elongated bent neck which pointed down. This let in the air but caused any dust to settle before it came in contact with the experimental material. (See Section 12-1 to 12-5.)

(To help them understand the problem of keeping micro-organisms out, allow students to suggest some more modern day solutions, eg. a millipore type filter or a beam of radiation.)

POUCHET'S PROBLEM

11-1. Suggest why Pouchet's experiments, despite extra precautions at sterilising them, may still have produced living growths on the gravy before the seals were broken open.

There are some bacteria which actually thrive in environments where there is no oxygen (they are called anaerobic bacteria.) Some of these are capable of forming very tough spores which can survive harsh conditions. Pouchet's gravy could have been contaminated by these.

11-2. What effect might seemingly contradictory experiments and conflicting opinions amongst scientific experts have on the general public?

It is bound to cause confusion, and sometimes distrust in scientists.

THE DEMISE OF SPONTANEOUS GENERATION

12-1. What have Steps 1-5 of Pasteur's experiment demonstrated?

Pasteur demonstrated that nothing would grow in the boiled and cooled solution, even though it had access to air.

12-2. Does Pasteur's experiment help us understand Pouchet's results? Explain your answer.

Pasteur's experiments indicate that Pouchet's experiment must have been subjected to some kind of contamination.

12-3. What was Pasteur demonstrating in this part of the experiment?

The boiled and cooled solution is still capable of supporting life once some living things are introduced. Therefore the boiling has not removed any vegetative force. However it required the introduction of living matter for anything to grow.

12-4. Does this part of the experiment help you to explain Pouchet's results?

It is evident that Pouchet's results were due to contamination, not spontaneous generation.

12-5. Did Pasteur's experiment disprove Needham's ideas? If so, explain how.

Needham believed that the air contained a kind of "vegetative force" which enabled living things to grow. Pasteur showed that air alone was not enough to make things grow in the nutrient solution. Pasteur's solutions had access to air but not the dust and micro-ororganisms which normally float in the air.

12-6. In 1858, the famous German scientist, Rudolf Virchow, had concluded that 'living cells are derived only from pre-existing living cells'. Virchow rejected spontaneous generation of cells from non-living matter. Pasteur's experiment, a few years after Virchow's comment, was regarded as the end of the argument. Why do you think people accepted Pasteur's experiment as proving Virchow's "statement" beyond doubt.

Pasteur's experiment demonstrated that without living matter being present no new living matter arose. By this time other scientists had observed cells reproducing. These two observations fitted Virchow's statement that all cells are derived from pre-existing cells.

12-7. Pasteur discovered much about how to sterilise liquids such as milk. What famous process is named after him? What does this tell you about the side benefits of scientific research which, at first sight, may seem purely 'academic'?

Milk is preserved by a process called Pasteurisation. This involves heating the milk to a temperature sufficient to kill many micro-organisms, including those which cause human diseases. The milk still needs to be cooled to keep for more than a day.

If milk is heated to a higher temperature and sealed in an airproof container it can be kept for a long time without refrigeration. This process is sometimes called "ultrapasteurisation" and is the basis of "long life" milk.

12-8. Pasteur kept some other flasks (controls) which were allowed to sit for a long time without life developing in them. After this he deliberately broke off the long curved neck, and growths quickly developed on the culture. What was Pasteur showing?

Pasteur was showing that a long time did not make a difference. It also enabled him to repeat his experiment many times, i.e. obtain reproducible results. In every experiment it was the introduction of air containing micro-organisms which resulted in growth of living things in the nutrient solutions. Living things would not grow in the solutions until they were introduced from outside.

12-9. What do Pasteur's control flask experiments demonstrate about the need to investigate every possibility when you are seeking to solve a problem?

It is important to specify what you are actually trying to show in a scientific experiment. Pasteur believed his solutions would remain lifeless once free of micro-organisms but would grow living things once they were introduced from outside. His control flasks enabled him to repeat his experiment many times, as well as observe the effect of time on the solutions.

12-10. Pasteur's experiments proved that under all known present circumstances on earth, life comes only from life. Does this conclusion support or oppose the idea that 'earth's' original living things could have come into existence from non-living things by spontaneous generation?

The results of Pasteur's experiments go against the idea of spontaneous generation from non living matter.

12-11. What does Pasteur's experiment suggest about how life first originated on earth?

Pasteur only grew living things when they were introduced from outside. This is consistent with the idea that life was originally created by outside intervention and all living things formed on the earth since then have arisen by reproduction from the first life rather than by spontaneous generation from non-living matter.

12-12. In what way, if any, did Pasteur's experiments appear to reinforce the then popular belief that chemicals associated with living things (now known as organic chemicals) were somehow different than other chemicals ie. they had a 'vital force' or life difference?

The micro-organisms did not grow in the dust which settled in the neck of Pasteur's flask but they grew in the nutrient solution which was derived from living matter. People who were determined to believe in a "vital force" present in organic matter could claim that it was the vital force in the nutrient solutions which enable living things to grow.

12-13. What conclusions did Pasteur reach about the source of organisms that fermented substances such as milk, wine, or sugar beet juice, and what practical benefit have his conclusions been to mankind?

Pasteur concluded that the organisms which cause fermentation come from outside. Many of the organisms have been identified since Pasteur's time and put to use in many aspects of food technology. Pasteur's discovery has also been very helpful in enabling foods and beverages to be kept free of harmful micro-organisms. (Most micro-organisms are not harmful.)

DARWIN'S DAWNING

13-1. Much furore from Churchmen, Scientists and Educators followed the release of Darwin's book "*The Origin of the Species*". But one distinguished educator, Matthew Arnold (1822-1888) - graduate of Oxford, a noted poet, School Inspector, and Headmaster of the famous Rugby School - wrote in January 1871, "*I cannot understand why scientific people make such a fuss about Charles Darwin - why it's all in Lucretius*". Was he right? (Hint: see Database 3 & 4)

Yes. Lucretius believed that living things arose from the earth without a creator and developed from simple to complex. This is the modern day theory of evolution as proposed by Darwin and taken up by many others.

THE NEW SPONTANEOUS GENERATION

14-1. Since Pasteur had so clearly proved spontaneous generation is impossible under present conditions, how did Oparin logically step around Pasteur's proof?

Oparin proposed that the environment was so different in the past he believed that all present day observations and experiments could be ignored.

14-2. What does Oparin's manoeuvre show about how important it is to understand conditions under which experiments are done, before we interpret and apply any result?

Any experiments which attempt to prove Oparin's ideas must be understood to be based on his untestable belief that the earth was different in the past. Therefore, if you agree with Oparin the results will have some significance. If you do not believe that the earth has been different, any experiments based on his ideas are irrelevant and do not prove anything.

14-3. If at least one condition in an experiment is not known for sure, how certain can you be about what the results mean?

If an experiment, such as Oparin's, succeeds in making organic molecules from simple chemicals, it could mean that organic molecules may have been generated naturally in the past. But, if Oparin's assumed conditions are not known for sure, then such an experiment will merely prove that modern day organic chemists can make organic molecules in odd conditions.

14-4. In l924, what new tools were available for Oparin to view organic chemicals in space, which were not available to Pasteur in l860?

Spectroscopy - a method of identifying chemicals by the light they reflect enables 20th Century astronomers to identify chemicals in space.

14-5. How would Oparin's view of Spontaneous Generation have differed from Needham's? (HINT: See Biographies 4 & 10)

Needham was a staunch Catholic who opposed atheistic views. He believed that spontaneous generation was a result of the activity of a creator God. Oparin was an atheist and believed that spontaneous generation was the result of the natural properties of matter without any influence from a creator.

14-6. Would Oparin, an atheistic communist, have been open to research evidence for life having been created by God? Explain your answer.

An atheist is someone who believes there is no God. If there is no God then there is no outside intelligence to create things. Such a person would not be interested in experiments designed to search for evidence of creation if he has already decided that there was no creation.

14-7. Research the topic to see whether we can observe chemicals forming in space, or do we only observe chemicals which are in space? What difference might this make in evaluating Oparin's claims?

Astronomers are able to identify many chemicals in space. However, this does not prove they are being made in space, it merely proves that they exist in space. To prove that they are being made in space it would be necessary to observe a volume of space where no organic chemicals exist and then observe them appearing. Even then you have to be sure that the molecules are actually being made there and not moving in from another volume of space.

The fact that organic molecules exist in space is not proof that the same molecules were formed by natural processes on a planet, eg. earth. It may have no relevance to what happens on earth where conditions are vastly different than in stars or in space.