ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ОБРАЗОВАНИЮ
Государственное образовательное учреждение высшего профессионального образования «Уральский государственный университет им. А.М. Горького»
Кафедра иностранных языков

Инновационная образовательная программа
«Опережающая подготовка по прорывным направлениям развития науки, техники и гражданского общества на основе формирования инновационно-образовательного пространства классического университета в партнерстве с академической наукой, бизнесом, органами власти с использованием мирового опыта в области качества образования и образовательных технологий»
Направление ИОП «Педагогическая инноватика»

III. Задания для самоконтроля по дисциплине «Английский язык для магистрантов и аспирантов естественных факультетов университетов»

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Text 1. *Read the text and substitute equivalent English phrases for Latin ones.*

The Creation of the World

It was long, long ago in terra incognita, in the times immemorial which are called B.C.

There was nothing there: neither men, nor women, neither animals, nor scientists. But there was God Almighty with his true and devoted assistants − the angels. He was really very mighty and powerful, omnipotent, as they put it; he was also very eager and anxious to find some application to his inexhaustible energy. He was thinking, pondering and speculating on it ad infinitum. What could he do? And he decided to create something grand, viz. the World. He knew a priori it would take him in toto circa 7 days. Indeed it took him 7 days, i.e. a whole week, to materialize his idea.

Prima facie it seemed difficult to him only in parvo, but in vivo this procedure turned out to be rather troublesome. His modus operandi was as follows: ab initio he commenced with creating the Earth itself. Great things should be done first. It's very important to get your priorities right before doing the work. He created the Earth on the first day, at 0 o'clock a.m. and began to contemplate the results of his endeavour. He did not like to see the Earth so smooth and flat. So, estimating all pro et con, he decided to make some addenda. He poured water and threw stones on the exterior. Thus, seas, oceans and mountains, etc. appeared on the surface of it.

Mutatis mutandis, God mediated a little on what was to be done next. He summoned his angels and consulted them in re the problem. Sui generic council gathered the same day p. m. The decision of God et al was unanimous: there should be life on the Earth, e.g. animals, fowl, i. e. the Fauna and the Flora; every animal and bird, etc. will form a pair and mate and produce the like. Int al the creation of these took them 5 days in toto.

On the sixth day the first man, Adam, was made. He was unique versus other animals, differing from them par excellence in that he was the only specimen of Man and also in the fact that only he and he alone possessed Mind. Adam's locus/ habitat was in Elysium, i.e. Paradise (N.B.: Paradise is considered to be the place of perfect bliss). Adam was to live in situ, among the ever blossoming apple trees, playing the lute and listening to the singing of birds ad interim.

Ipso facto, Adam's way of life was to prove that he was in a perfect state of eternal bliss. But it turned out to be vice versa. Adam felt lonely and asked God Almighty, who was known to be omnipresent and omnipotent, to give him a wife. God hesitated a little pro forma, then took one of Adam's ribs, which happened to be a spare one, an extra one, pulled it out of Adam's chest and put it vitro. As a result of his experiment the first woman, Eve, appeared. What happened afterwards everyone knows a posteriori: they committed a mortal sin were driven away from Paradise, they lost Paradise. Since that time on Adam and Eve's descendants et seq generations have been living in constant pains and hard labour.

It should be said ad hoc that the life of all people A.D. is not a bed of rose.

Vocabulary from Latin and English Equivalents

ab initio	at first, from the beginning
A.D. (Anno Domini)	of our Era
addenda	an addition, appendix
ad hoc	to the point
ad infinitum	for ever, indefinitely
ad interim	meanwhile, in the meantime
a.m. (ante meridiem)	in the morning
a posteriori	from the experience, empirically
a priori	in advance, before the experiment
C. (circa)	nearly, about
e.g. (exampli gratia)	for example
et al. (et alia)	and others
etc. (et cetera)	and so on
et seq. (et sequentia)	and the subsequent
exterior	outward aspect, outside, outer

extra	additional
fauna	animals
flora	plants
habitat	place of living
id. (idem)	the same author, book, etc.
i.e. (id est)	that is
in ex	completely, fully
in parvo	a little
in re	concerning
in situ	in/on the place
int al (inter alia)	by the way
in toto	altogether
in vitro	in the tube
in vivo	under existing conditions
ipso facto	from the very fact
locus, loci	a location
modus operandi	a way of action
mutatis mutandis	with the necessary alterations
N.B. (nota bene)	Note! ; Pay attention!
omnipotent	possessing infinite power
omnipresent	being everywhere
par excellence	primarily, mainly, largely
p.m. (post meridiem)	in the afternoon
prima facie	at first sight
pro et con(tra)	for and against
pro forma	to observe the form
sui generic	particular, special, unique
terra incognita	an unknown country, region
vice versa	on the contrary, the other way round
viz. (videlicet)	namely, that is

v.s. (versus)		against

Text 2. *Read the interview and comment on the scientific implications of rian May's book.*

Music and the spheres

In 1969, Brian May*, lead guitarist of the legendary rock band Queen, gave up a career in astrophysics to pursue his dream of becoming an international rock star. Now, almost four decades later, the two strands of his life, music and astronomy, are coming back together. He is currently finishing the PhD he started at Imperial College London back when Queen was just beginning to take off. He has also co-authored a popular book on cosmology, Bang! The complete history of the universe. On the eve of the book's publication,* Marcus Chown *caught up with May at his home in Surrey, UK, which is complete with a shiny observatory dome.*

How did you become interested in astronomy?

I must have been 7 or 8. I saw Patrick Moore's *Sky at Night* TV programme and it blew me away. It wasn't just the stars, it was also the programme's incredible theme music by Sibelius. So my love of astronomy and my love of music were born at the same time. I badgered my dad to get me the record and to let me stay up late and watch the programme.

What was the subject of your PhD at Imperial?

It was on the zodiacal dust that appears to orbit the sun. You can actually see it quite easily with the naked eye from a dark site − part of the black sky behind the stars is brighter than the rest because of sunlight reflected from the dust. Nobody was sure whether the dust particles swept around with the planets or orbited in the opposite direction. We did observations from Tenerife. By looking at the Doppler shift of a particular wavelength of sunlight absorbed by the dust, we found evidence to suggest that most of it goes around with the planets. We published a couple of papers, one in *Monthly Notices of the Royal Astronomical Society* and one in *Nature*.

Why did you abandon your PhD?

I was writing up the thesis, working as a math teacher at a comprehensive school in Brixton, south of London, which I loved, and doing the music too. I wasn't getting much sleep! I actually completed a draft of my thesis, but my departmental head wanted "more interpretation". I did it, but then he wanted even more interpretation. So I decided that I needed to move on. At the time, there was an opportunity with Queen we really couldn't let pass.

Did anyone try to persuade you to stick with science?

My dad was upset about me abandoning my PhD for music. He thought being a scientist was a better career. Thankfully, though, he came around. He worked as a draughtsman on the development of Concorde, and one of the great pleasures of my life was flying him over to New York on Concorde for the first concert Queen played at Madison Square Garden.

Did it nag at the back of your mind over the years that you'd left your scientific work incomplete?

Not really. I considered myself lucky to be doing what I was doing in music.

What inspired you to return to your PhD after all these years?

You get to this age and you think, I'm still alive when some friends aren't, and you ask yourself, "Why am I here? What should I be doing?" So there's that. But a crucial event was inviting professor Francisco Sanchez to the opening of our musical *We Will Rock You* in Madrid. He had been a kind of extra supervisor for me in Tenerife. Francisco asked, "Are you going to finish your PhD?" and I said, "Yes!" I felt the strands of life coming together again. Crucially, Francisco said I could submit my thesis to the University of La Laguna.

It seems remarkable that, after 30-odd years, your thesis isn't out of date.

That's the peculiar thing. The subject did not attract much attention during those years in between, but it's actually become topical recently because of the discovery of extra solar planets. Some of these planetary systems seem to have zodiacal dust clouds just like ours. I need new data to update things. Garik Israelian, an American astronomer friend of mine is helping me. We are planning to make new observations.

How did the book on cosmology come about?

I've been a friend of Patrick Moore's for years. We both have the twin interests of astronomy and music, though rock music is not Patrick's thing. We were in Scotland to see an annular eclipse of the sun in 2003. Over lunch in a pub afterwards Patrick said, "I want you to write a book with me." The idea was to do a history of the universe. Day one: creation; day two: inflation… and so on.

What was your reaction?

I was flattered. I thought Patrick would forget about it. But he didn't. He's very astute. He definitely saw it as an opportunity to reach a new audience. Eventually, I agreed, but I was reluctant. I didn't feel confident or capable and had to be dragged kicking and screaming to the project. It wasn't until we were halfway through that I had anything valuable to contribute. I have a perfectionist streak. So I was able to say, "I don't understand this. Are we explaining this simply enough?" I took on the role of making the book accessible to as many people as possible. I also know about getting things noticed. I came up with the title, *Bang!*, and the book cover, which features a fanciful bang, a composite lenticular print that will "explode" as you walk past it.

What was it like working on the book?

We had a third collaborator, Chris Lintott, a whizz-kid astronomer from Cambridge. He happened to be at our first meeting and it was immediately clear that he knew a lot more about modern cosmology than we did. I said, we have to include him as the third author. The three of us would meet at Patrick's house in Selsey on a Friday night, do a little gentle writing, have a couple of drinks, then hunt for Patrick's cat, Ptolemy, who is an accomplished escapologist. When we got up the next day we were in the mood for serious work. Patrick shocked us by writing the first draft in two weeks. We all then spent the next two years rewriting it. He was good about it. He didn't mind at all.

Did you enjoy the experience after your initial reservations?

I was wonderful. It was a re-entry into a world I'd loved as a kid. And I now have an inkling of what's going on in today's astronomy.

Did you get as much satisfaction from finishing the book as you would a piece of music?

Yes, I'm at least as excited about the book as an album. My ambition is that this will be a book that people buy and actually read, rather than leave on a shelf. But I don't know whether we've succeeded. It's a giant step. I'm quite nervous −in a good way.

Profile

Brian May is the lead guitarist of Queen. A songwriter and producer, he has put out several solo albums, and Queen's hit rock musical We Will Rock You premiered in 2002. May holds an honorary doctorate from the University of Hertfordshire. His book Bang! The complete history of the universe, written with Patrick Moore and Chris Lintott, was published in 2006 by Carlton Books.

(Taken from New Scientist, 2006)

Text 3. *Read the text and compile a guide-paper for would-be-post-graduate students. Be ready to present it for approval of a contest jury.*

How to Stand up for an Academic Degree

Instruction to Post-Graduate Students

It is no good writing a long thesis: it is not the novel "War and Peace" and you are not Leo Tolstoy. It is no use writing it briefly either: it either testifies to your great talent or lack of brains. Your opponents will forgive you neither.

Do not put on airs: it is not worth thinking that you alone are clever and all others are fools. Avoid using the arrogant first person singular: instead of saying "I assume", "I suppose" use "It is assumed…" or "We suppose…"

Try the scientific value of your paper on your relatives and colleagues. If your paper is sophisticated enough, they will start yawning and fall asleep in no time, while listening to it or reading it.

The sections that cause fits of laughter or anxiety need rewriting.

Although you will enjoy listening to the compliments of experienced people, do not be deceived by their singing praises to you.

Avoid inviting young scholars as your would-be opponents: they are always glad to jump at the opportunity of showing off and discrediting others. It is always more practical to invite merited and older scientists because the older they become the kinder and lazier they get.

If you aim at achieving success, read your paper in front of a mirror even if you dislike doing it.

When on rostrum, try to behave properly. Even if you cannot help feeling excited, stop swinging the pointer over the heads of the listeners, keep from waving hands, abstain from shouting and blowing your nose loudly.

Control your voice: if you try to speak as monotonously as you can, the learned members of the Academic Board will start thinking of their affairs or dozing off.

Proceed demonstrating slides, tables, graphs and you will succeed in hitting the target.

Summing up, express your appreciation and gratitude to all the people present, keeping strictly to the table of ranks.

When the formal procedure is over, providing you were a success, do not forget to invite everybody for refreshments and a cup of coffee or tea.

Text 4. *Read the article and prepare your own presentation developing one of the ideas from the interview.*

Physics Goes to Hollywood

If you enroll for a physics class at the University of Central Florida, you may be in for a big surprise. Instead of being sent to the campus bookshop to buy course books, you'll be directed to the local video store to rent a few DVDs. T he directors of this class, Costas Efthimiou *and Ralph Llewellyn, believe they have hit on a novel way of getting non-science students not just to bury their hatred of physics but to embrace the subject with enthusiasm.* Marcus Chown *talked with Efthimiou about the course that he says is designed to challenge the pseudoscientific ideas propagated by the entertainment industry − and to show students some of the joys of physics.*

How did you come up with the idea of teaching physics using movies?

In 2001 I was given the task of teaching physics to several hundred students at the University of Central Florida who were not majoring in the subject. The students simply did not get what I was teaching. In fact, I was taken aback by their aggression. The whole thing was such a miserable experience that when I was asked to teach the course again I said no − unless I was able to try something new. For a while I'd had this idea in my head about using films to teach .I was also aware of Lawrence Krauss's best-seller *The Physics of Star Trek* [Flamingo, 1997], though I hadn't read it at the time. I talked to Ralph Llewellyn, who had been teaching physics to non-science students at the university for a number of years, and we decided to give it a go.

Are you trying to make scientists out of the students?

No. Our goal is to show the students, and the public, that science is fun and entertaining when expressed through popular activities. We also want to promote science literacy and attack pseudoscientific beliefs that have been gaining ground over the last two decades. Research indicates that the entertainment industry is partially responsible for this trend. Our course is a way of challenging ideas that the industry presents about the supernatural.

What does the course involve?

Before each class, we ask the students to rent a video. They're perfectly happy to rent 10 videos at $4.50 a time over the course, whereas before they were reluctant o buy a single book. At home, they watch the video, pick three scenes where they think physics plays a role, and write a paper on whether they think it's realistic or not. It doesn't matter whether they are right or wrong. The point is to get them thinking rationally about what they are viewing. When they come to class, we replay the scenes and discuss them.

Can you give me an example of a scene from a film and you use it?

One of the films we use is *Armageddon*, one of the worst films ever made. An asteroid is on a collision course with the Earth, and NASA sends Bruce Willis to the rescue. He drills a hole in the asteroid and plants a nuclear bomb there that splits it into two fragments which miss the Earth. We get students to work out whether this is realistic, based on data presented in the movie. First they estimate the asteroid's mass. Then, using a reasonable assumption about the size of the explosion, they estimate the deflection speed of the fragments. Finally, they estimate the time it would take for the fragments to collide with the Earth and the distance they are deflected during this period. What they discover is that all Willis would really manage would be to create two asteroid fragments that would hit the Earth about two city blocks apart. It's quite a sophisticated calculation that involves applying two principles: the conservation of momentum in two directions − parallel to the trajectory of the asteroid and perpendicular to it − and the conservation of energy. We call it a Fermi problem, a back-of-the -envelope calculation characteristic of the physicist Enrico Fermi, who famously dropped a scrap of paper at the first atomic bomb test in 1945 and from its horizontal deflection estimated the blast at about 10 kilotons of TNT.

Are there other Fermi calculations you can do from movie scenes?

There's another scene in *Armageddon* where they generate artificial gravity by spinning the Mir spacecraft. The problem, as the students discover, is that this doesn't work because the amount of artificial gravity generated by centrifugal force varies widely from one part of the space station to another.

This doesn't happen in the pinwheel space station in 2001: *A space odyssey* because everyone lives in the rim of the wheel, where the centrifugal force due to rotation is the same everywhere. You can estimate the size of the wheel − about 100 metres across − as you can see people in the windows. Combining this with the spin rate, which you can also estimate from the film, gives you the artificial gravity, which turns out to be close to 1g. Stanley Kubrick and Arthur C. Clarke were careful to get things absolutely right. Unfortunately, students find the film impossible to watch because of its lack of dialogue.

What other types of films do you use?

We've developed several different flavours of our course. One is science fiction. We also use action films such as *Eraser* or *Tango & Cash* or *Speed 2: Cruise control.* But we get far and away our best response from students when we use pseudoscientific films such as *The Sixth Sense* and *White Noise*. There seems to be a deep-rooted belief in things like extrasensory perception, vampires and crop circles, which is difficult to shift. From the feedback we get from the students we know we are making them more skeptical, and the debate in class often gets so furious we have to step in and call a halt.

Does it matter that Hollywood gets it so wrong in modern science-fiction movies?

No, I don't think it does. What I do think is seriously dangerous, though, is when movies portray pseudoscience − everything from telepathy to remove viewing − as real. I tell the students that physics is stranger than pseudoscience but they are attracted to pseudoscience and repelled by physics because the former requires no work and the latter does.

What do your students think of the course?

The response is very positive. Some say: "I would watch movies anyway, but now I'm getting credits for it!" Others complain that they can't watch movies for enjoyment any more − they end up analyzing scenes for how realistic they are.

What are the best and worst movies as far as the physics is concerned?

Contact, based on the Carl Sagan book and starring Jodie Foster, is pretty good. It gets all sorts of stuff spot on, including the physics of wormholes. The worst film is *The Core*, in which a US military project stops the outer core of the Earth rotating. It has to be restarted with nuclear bombs. There isn't a minute in that film where the writers haven't rewritten the laws of physics.

Profile

Costas Efthimiou obtained his BSs from the University of Athens and his PhD from Cornell University. Since August 2000, he has been at the department of physics at the University of Central Florida. Two years later he developed the "Physics in Films" course with Ralph Llewellyn in an effort to revitalise the traditional physical science course that is offered in almost every university and college in the US. It has been in continuous development ever since.

(Taken from New Scientist, 2006)

Text 5. *Read the text and express your own opinion about Grigori Perelman's contributions to geometry and other revolutionary insights.*

A controversy behind the biggest prize in mathematics highlights a troubling crack in its foundations. Mathematician Marcus du Sautoy *reveals all*

Burden of Proof

THERE can't be many people that would turn down a Nobel prize. So after the International Mathematical Union announced in August 2006 that it was awarding what some consider the mathematical equivalent, the prestigious Fields medal, to the Russian mathematician Grigori Perelman, it may seem surprising that Perelman decided to refuse it. He was supposed to have received the award in August 2006 from King Juan Carlos of Spain at the International Congress of Mathematicians in Madrid.

Perelman was to have been awarded the Fields medal for work made public four years ago that proves a century-old idea about the nature of four-dimensional geometry, the Poincaré conjecture. There is more at stake in Perelman's snub than wounded pride. In a confusing twist, two Chinese mathematicians, Huai-Dong Cao of Lehigh University in Pennsylvania and Xi-Ping Zhu of Harvard University, published "a first written account of a complete proof" of the Poincaré conjecture in June 2006, according to The Asian Journal of Mathematics, where it appeared. The underlying issue that emerges when you add together Perelman's work and attitude, the Chinese claims, and the problems of attributing proper credit, is that mathematicians are finding it increasingly difficult to decide whether or not something has been proved.

Proof is supposed to be what sets mathematics apart from the other sciences. Traditionally, the subject has not been an evolutionary one in which the fittest theory survives. New insights don't suddenly overturn the theorems of the previous generation. The subject is like a huge pyramid, with each generation building on the secure foundations of the past. The nature of proof means that mathematicians, to use Newton's words, really do stand on the shoulders of giants.

In the past, those shoulders have been extremely steady. After all, in no other science are the discoveries of the Ancient Greeks still valid today as they were at the time. Euclid's 2300-year-old proof that there are infinitely many primes is perhaps the first great example of a watertight proof.

It works like this. Suppose a mathematician comes with a finite list of primes and claims there are no more. Euclid showed that there must be a prime missing from the list. Multiply all the primes on the list together and then add one to this number. This new number is not divisible by any of the primes on the list because you always get remainder one. So Euclid's new number is either another prime itself or divisible by a prime that is missing from the list. If you add this new prime to the list, repeating Euclid's trick will always show that any finite list is missing a prime.

Euclid's proof is rapier-like in its uncompromising destruction of anyone who thinks there are only a finite number of primes. It is also surprisingly simple, which means you can check it.

Since Euclid's time, proofs have become ever more sophisticated, with some now extending over thousands of pages. They still have to be checked, of course, and that has become a daunting task. The proof of the classification of finite simple groups, a kind of periodic table of mathematical symmetry, for example, was announced in 1982. Stretching to over 10,000 pages, it was authored by hundreds of mathematicians − and it turned out to be incomplete. In the early 1990s mathematicians trying to master the argument in its entirety discovered that a portion of the proof was missing. After battling for some years the gap was finally plugged in 2004, but it took a paper whose proof was more than 1200 pages long.

Such logical holes are one thing, but mathematicians have also had to come to terms with the possibility of a new kind of error: computer programming mistakes. In 1977, the four-colour theorem, a suggestion that any political map can be shaded using just four colours without any borders sharing the same two colours, became the first major theorem to be proved with the help of a computer. The proof has survived nearly 30 years without someone redrawing the boundaries of Europe and finding they need five colours, but the possibility still remains that a glitch is hiding somewhere in the mass of computer code that could kill the proof.

A further twist on the computer proof issue came in 1998, when Thomas Hales of the University of Pittsburgh in Pennsylvania announced a computer-assisted proof of the Kepler conjecture. This confirmed mathematically what every grocer intuitively knows: that a hexagonal pyramid is the most efficient way to stack oranges. Hales proved that no other configuration can fit more oranges into a given space than this hexagonal lattice.

In the proof Hales showed how the problem can be reduced to a large but finite number of calculations that would confirm that the grocer's symmetrical stack of oranges is the most efficient. "Large number" hardly covers it, however: the calculations are so numerous that Hales needed the help of a computer to complete the proof. In the end, it consisted of 250 pages of conventional mathematical argument and over 3 gigabytes of computer code and data.

Trial by jury

So how do we know Hale's proof is correct? If we're being picky, we don't. The *Annals of Mathematics*, the premier mathematical journal, appointed a committee of 12 referees to check the proof. Most papers get one referee. The referees reported back that, due to the difficulty of checking all the computer data, they were only 99 per cent certainty. This is why the involvement of computers has unsettled some in the community. Even deciding how to publish such a proof took much debate. Eventually the journal accepted the 250 pages of theoretical argument (*Annals of Mathematics*, vol162, p1063) but banished the computer data to another journal for publication.

Given the complexity of many modern proofs, perhaps it isn't surprising that even now, four years on from the initial excitement over Perelman's announcement, mathematicians are still cagey about whether he has really proved the Poincaré conjecture. In fact the award citation speaks of Perelman's contributions to geometry and other revolutionary insights, and not of the Poincaré conjecture directly. The award committee is non-committal about whether the Poincaré proof is complete. It states that "the mathematical community is still in the process of checking his work to ensure that it is entirely correct and that the conjectures have been proved". Nevertheless, the decision to award Perelman the Fields medals will be widely regarded as some validation of his proof.

Widely, but not exclusively. The Chinese paper, which stretches to 318 pages, claims to have completed what Perelman only started. Perelman's preprints provided "guidelines", according to the Chinese newspaper the *People's Daily*. "Guidelines are totally different to complete proof of theories," Yang Le, a member of the Chinese Academy of Sciences, told the newspaper.

It seems that the one person who doesn't really care about what's going on is Perelman. In 1996 he snubbed the European Mathematical Society when he turned down a prize; it looks like he's done it again. John Ball, president of the International Mathematical Union, spent two days with him in St Petersburg in Russia, trying to persuade him to accept. Although Perelman's reasons for turning down the prize are complicated, they centre on his feelings of isolation from the mathematical community and his desire not to be used as a symbol to attract younger mathematicians to a profession he has personally become disillusioned with.

Nothing so far seems to be able to garner Perelman's cooperation − not even the million-dollar prize set aside for the person or people that prove the Poincaré conjecture. To collect the prize, offered by the Clay Mathematics Institute, the paper must be refereed by a reputable mathematical journal and survive the scrutiny of the wider community for two years after it is published. Perelman didn't submit his proof to a journal. Instead it remained in preprints that he had posted on the web. It seems he has proved the conjecture to his own satisfaction and made the proof freely available to others, and for him that is enough.

If the Clay prize is ever claimed, the million dollars will be divided according to how much of the puzzle individual people have completed, and when they do this Clay's legal and mathematical team are going to find themselves walking a tricky tightrope. There is an even more difficult task facing mathematics, however. Mathematicians are beginning to engage with the increasingly complex issue of what exactly constitutes a proof. Perhaps the subject is moving into a more Darwinian age of survival of the fittest. Hopefully what will outlive all the controversy over the Poincaré conjecture is the new dawn in our understanding of the geometry of space that Perelman has brought. Despite all the controversy, his work is both astounding and profound, and fully deserving of the highest recognition.

Beauty and the brute

In the mathematical universe, computers and brute force can only get you so far. Consider one of the great unsolved problems about prime numbers: can you generate a sequence of numbers in which the difference between all the numbers is the same − an arithmetic progression − of any length you want in which all the numbers are prime numbers?

For example, 3,5,7 is an arithmetic progression of primes of length three. For a progression of length four, you could take 5, 11, 17, 23, four primes that differ by 6. The largest known sequence has 23 primes in a row. If you start at the prime 56, 211,383,760,397 and count on 44,546,738,095,860 and you get another prime. Count on another 44,546,738,095,860 and you get a third prime. If you keep doing this you get 23 primes in an arithmetic progression. This was discovered (using a computer) in 2004 by Markus Frind, Paul Jobling and Paul Underwood.

However, none of this constitutes a proof that you can get any length sequence you want. The mathematical universe that is observable by experiment represents an infinitesimal and often unrepresentative fraction of the infinite expanse of numbers. Mathematicians have been deceived in the past by seemingly convincing but ultimately incomplete data. In 2004, Terence Tao of the University of California, Los Angeles (who, as it happens, also won a Fields medal this week), in collaboration with Ben Green of the University of Bristol, laid the issue to rest beautifully, proving that it is theoretically possible to find a suitable sequence of any length you want somewhere in the universe of numbers. Compared with many proofs, Tao and Green's proof is far from arduous in its length and complexity, but they needed about 50 pages and relied on the proofs of many other authors. The only frustrating thing is that it is a non-constructive proof: it tells you the sequences exist but it doesn't tell you how to find them.

The Poincaré conjecture

Take a two-dimensional piece of malleable rubber sheeting. You can wrap it up to make the surface of a ball or roll it up and bend the resulting tube round to make a bagel shape with a hole in the middle, called a torus. These are two fundamentally different things, for the following reasons. If I tie a lasso around the ball, then I can shrink the loop in the lasso until it vanishes by sliding the lasso towards one of the "poles"; every such loop can be shrunk to a point. But on the bagel, the loop in a lasso that is tied through the hole in the middle and back round cannot be shrunk to nothing.

Henri Poincaré knew 100 years ago that the ball was the only way to wrap up the two-dimensional sheet to make a shape around which the loop of a lasso could always be shrunk to nothing. The Poincaré conjecture concerns the same question one dimension up. Imagine wrapping up three-dimensional space in four dimensions to create various shapes, then tying lassos onto them. Are there 4D shapes around which lasso loops can always be shrunk to nothing? Grigori Perelman has shown that there is only one: the 4D equivalent of the sphere, known as the hypersphere.

Text 6. *Read the newspaper article and express your point of view on the subject.*

Russian Science Advances in U.S.

Russian scientists are hitting the big time in the West. Will this help the development of science in Russia?

Domestic business will fund cutting-edge cancer research projects in Russia. Nine scientific research groups have been awarded grants of $25 million to $50 million a year in a competition organized by the Russian Cancer Centre in Moscow, The grants are provided by the Protek pharmaceutical company that has been cooperating with the Centre for a long time. The entries were evaluated by 27 respected U.S. and Australian cancer experts, none of them of Russian descent (a strict competition rule). The organizers thus sought to avoid the pitfalls of the grant system and achieve maximum objectivity.

In an interview with *Moskovskiye Novosti*, one of the organizers, Prof. Andrei Gudkov, a former research associate at the Russian Cancer Centre and now head of the Lerner Research Institute Department of Molecular Biology (Cleveland, Ohio USA), talks about the triumph of Russian science in the West, as well as his personal career path.

From Observer to Designer

You've been living in the United States for 15 years now, heading a large research centre with 13 laboratories and more than 130 staff. What is the key to building a successful scientific career?

In the United States, I never looked for vacancies or sent my resumes to potential employers. Of these 15 years, I spent at Illinois University in Chicago. Nor was it my life's ambition to leave Russia at any cost. In the late 1980s, I was the head of a molecular biology laboratory at the Cancer Centre in Moscow. I first went to Chicago for four months, and while I was there I realized that I could do much more [in the United States than in Russia]. That realization outweighed all possible inconveniences, doubts, and misgivings. My associates and I decided that we would go to the United States to work for a year and would then return to Russia and continue our project on a different level. Before long, however, we all realized that returning to Russia would lead to professional degradation.

Step by step, we began to branch out into new areas and technologies, fitting into the infrastructure of American science. During those 11 years, my laboratory at Illinois University expanded considerably and we needed more funding, even though what we were getting was by no means insignificant. Such laboratories are usually funded through the National Institutes of Health − on average, $1.5 million for five years, one-third of which goes to the institute and $1 million the head of a laboratory can spend at his own discretion. This is enough to have a team that in addition to compulsory programs can conduct one innovative research project. A successful laboratory receives two or three grants. This is pretty good money for "pure science", but if you want to see the results of your work (new drugs, instruments, applied methodology, etc.) within your lifetime, more substantial investment and a different type of infrastructure are required. We were lucky. There were always companies that licensed our patents, and we developed steadily. The laboratory expanded to 30 research associates and outgrew American university standards.

That was when Prof. George Stark, director of the Cleveland Clinic Lerner Research Institute, called me, offering the position as head of the Department of Molecular Biology. He had come to Moscow in 1988, and my colleague Boris Kopnin and I invited him to visit the Cancer Centre.

Why did he choose you? Because you were cronies?

You'd better ask him, but cronyism had nothing to do with this. Perhaps he saw that our research at Chicago had transcended narrow disciplinary boundaries, becoming interdisciplinary and covering the entire spectrum, from basic to applied spheres (new drugs, new methods of treatments, etc.). Meanwhile, the Lerner Research Institute Department of Molecular Biology mainly engaged in fundamental research, and they wanted to move into medical applications, where I had experience. About eight years before, I realized that what we were doing could be quickly converted into innovative treatment procedures. I understood that I already knew enough to go from a person "disassembling the alarm clock" (something that we scientists are in principle doing throughout our life) into an engineer who could reassemble it and knew how to make it move faster, go off on time, and so on and so forth. So a person turns from a simple observer into a designer. Many scientists are ready for this technically and intellectually, but not psychologically.

Did the move up the career ladder limit the scope of your experimental research?

This is in fact what usually happens. Many scientists simply do not need an administrative position, and at first I thought so too. But George talked me into coming to take a look, and that made me change my mind. I realized that my experimental research capability would increase greatly with the relatively small administrative "costs of doing business". The Cleveland Clinic Foundation is a giant medical centre with an annual budget of $5 billion and a staff of about 30,000. The scientific research standards there are very high. Most importantly, many of the things that we were doing needed urgent clinical trials and comprehensive cooperation with clinicians, which was very difficult to do at a university.

It is commonly believed that a scientist who comes to work in the United States loses his freedom, cannot do what he likes, and so forth.

When a child moves from a kindergarten to school, he is disappointed that he cannot draw all day long, but has to learn reading and writing. Yet when he has completed a course of studies, he can once again do what he likes, but on a different level. A tough, demanding system creates a field where you have to prove yourself. If you are a success, if you turn out to be among the best in a certain area, you get more freedom than before. And with this freedom comes a new level of research funding.

But how often does this really happen?

Those who enjoy authority in the Russian scientific community achieved recognition in the West. I can mention many names of my Russian colleagues who have gained worldwide recognition in biology: Ruslan Redzhitov (Yale University), Alexander Chervonsky (Chicago University), Alexander Rudensky (Washigton State University), Alexander Varshavsky (California Institute of Technology), Igor Roninson (Cancer Centre, Albany), Yury Lazebnik and Grigory Yenikolopov (Cold Spring Harbor Laboratory), and others.

Freedom acquired too soon is also bad. In the past, a junior research associate in Russia could independently test an idea that had come into his head without jeopardizing his laboratory's financial status. The share of bad-quality products in Russian science was substantially higher than in West. There was no feedback mechanism. Although the Russian system was very good for people with a high creative potential, the "brilliant eccentrics", the American system could prove disastrous for them.

Triumphant March

Russian names are increasingly coming up in news of major scientific achievements. Are these mostly people who left Russia in the early 1990s?

Yes, among others. In the past several years, indeed, Russian names have been taking centre stage in international science. It takes on average 10 years for a scientist to9 find his feet and prove his worth. Those who "invested" themselves into this system in the early 1990s are now beginning to receive "dividends". Their names are near the bottom of citation lists: These are mostly project supervisors. But there are also many Russian names at the beginning and in the middle of the list − as a general rule, those who left recently, as soon as they completed a course of graduate studies. Whereas in the first instance, this is a triumph of Russian science, in the second, it is a triumph of the Russian educational system. I graduated from the Department of Virology at the Moscow State University (MGU) School of Biology, and I do not know where I could have received a better education. But this is what upsets me: We received an excellent education, the best education in the world, and we did not pay our debts. My teachers − Prof. Garry Abelev, Prof. Vadim Agol, and Prof. Yury Vasilyev − stopped reading lectures a year ago, while many of their students have left Russia. We are trying to do something. For example, Sergei Nedospasov, a corresponding member of the Russian Academy of Sciences, has organized a training program in cancer immunology. Leading lights in international cancer immunology come to Russia with week-long lecture courses, many of them former Russian citizens.

The triumph march of Russian names is of course a very good thing, but how is the situation going to evolve at home?

I believe that the key lies in creating a series of new-look institutions in Russia. Perhaps there will be major investors, patrons of sciences, who, like U.S. billionaire and film producer, Howard Hughs, will establish a medical research institute whose grants will be coveted by scientists throughout the world. The old institutions could be used as a platform for creating a new scientific space. Choose the best researchers and provide them with sufficient project funding, and if they can survive within this corrupt system of kickbacks and bureaucratic terror, then something might eventually change.

Is there any sign of progress in Russia?

Indeed, there is. Take, for instance, the grant competition that was held at the Russian Cancer Centre. It is an attempt to create this kind of space. I hope that everything will fall into place and turn out well.

Fact Box

Andrei Gudkov graduated from the MGU School of Biology in 1978, earning his D.Sc. degree 10 years later. At the Russian Cancer Centre, he studied genetic mechanisms of cancer and the drug resistance of tumor cells. He moved to the United States in 1990, obtaining a position at the Illinois University Department of Genetics where he worked on new approaches to identifying tumor-forming genes. His team made a number of scientific discoveries. For example, in 1999, they offered a new method of protection against radiation with a substance called pifithrin that proved effective in protecting mammals against lethal doses of radiation, opening prospects for minimizing side effects from cancer treatment.

In 2001, Andrei Gudkov headed the Department of Molecular Genetics at the Cleveland Clinic Foundation Lerner Research Institute, where he continued his program of identifying new genes and developing new drugs. Two years ago, he estab-

lished a bio-technological company developing drugs to fight cancer and protect the human organism against harmful impacts.

(By Yelena Kokurina, The Moscow News 2006)

Text 7. *Read the text and comment on the scientific significance of space discoveries.*

Astronomers Find Earth-like Planet

WASHINGTON − For the first time, astronomers have discovered a planet outside our solar system that is potentially habitable with Earth-like temperatures − a find researchers described as a big step in the search for life in the universe.

The planet is just the right size, might have water in liquid form, and in galactic terms is relatively nearby at 120 trillion miles away. But the star it closely orbits, known as a "red dwarf", is much smaller, dimmer and cooler than our sun.

There is still a lot is unknown about the new planet, which could be deemed inhospitable to life once more is known about it. And it is worth noting that scientists's requirements for habitability count Mars in that category: a size relatively similar to Earth's with temperatures that would permit liquid water. However, this is the first outside our solar system that meets those standards.

"It's a significant step on the way to finding possible life in the universe," said University of Geneva astronomer Michel Mayor, one of 11 European scientists on the team that found the planet, on Tuesday. "It's a nice discovery. We still have a lot of questions."

The results of the discovery have not been published but have been submitted to the journal Astronomy and Astrophysics. Alan Boss, who works at the Carnegie Institution of Washington where a U.S. team of astronomers competed in the hunt for an Earth-like planet, called it "a major milestone in this business." The planet was discovered by the European Southern Observatory's telescope in La Silla, Chile, which has a special instrument that splits light to find wobbles in different wave lengths. Those wobbles can reveal the existence of other worlds.

What they revealed is a planet circling the red dwarf star, Gliese 581. Red dwarfs are low-energy, tiny stars that give off dim red light and last longer than stars like our sun. Until a few years ago, astronomers did not consider these stars as possible hosts of planets that might sustain life. The discovery of the new planet, named 581c, is sure to fuel studies of planets circling similar dim stars. About 80 percent of the stars near Earth are red dwarfs.

The new planet is about five times heavier than Earth. Its discoveries are not certain if it is rocky like Earth or if it's a frozen ice ball with liquid water on the surface. If it is rocky like Earth, which is what the prevailing theory proposes, it has a diameter about 1 1/2 times bigger than our planet. If it is an iceball, as Mayor suggests, it would be even bigger. Based on theory, 581c should have an atmosphere, but what is in that atmosphere is still a mystery and if it is too thick that could make the planet's surface temperature too hot, Mayor said. However, the research team believes the average temperature to be somewhere between 32 (0 Celsius) and 104 degrees (40Celsius). That set off celebrations among astronomers. Until now, all 220 planets astronomers have found outside our solar system have had the "Goldilocks problem." They have been too hot, too cold or just plain too big and gaseous, like uninhabitable Jupiter.

The new planet seems just right − or at least that is what scientists think. "This could be very important," said NASA astrobiology expert Chris McKay, who was not part of the discovery team. "It doesn't mean there is life, but it means it's an Earth-like planet in terms of potential habitability." Eventually astronomers will rack up discoveries of dozens, maybe even hundreds of planets considered habitable, the astronomers said. But this one − simply called "c" by its discoverers when they talk among themselves − will go down in cosmic history as No.1. Besides having the right temperature, the new planet is probably full of liquid water, hypothesizes Stephane Udry, the discovery team's lead author and another Geneva astronomer. But that is based on theory about how planets form, not on any evidence, he said.

“Liquid water is critical to life as we know it,” co-author Xavier Delfosse of Grenoble University in France, said in a statement. “Because of its temperature and relative proximity, this planet will most probably be a very important target of the future space missions dedicated to the search for extraterrestrial life. On the treasure map of the Universe, one would be tempted to mark this planet with an X.” Other astronomers cautioned it is too early to tell whether there is water on the planet. “You need more work to say it’s got water or it doesn’t have water,” said retired NASA astronomer Steve Maran, press officer for the American Astronomical Society. “You wouldn’t send a crew there assuming that when you get there, they’ll have enough water to get back.” The new planet’s star system is a mere 20.5 light years away, making Gliese 581 one of the 100 closest stars to Earth. It is so dim, you cannot see it without a telescope, but it is somewhere in the constellation Libra. Before the European discovery, a paper in the journal *Astrobiology* theorized that red dwarf stars were good candidates. “Now we have the possibility to find many more,” Bonfils said.

(By Seth Borenstein, The Associated Press)

Text 8. *Read the text and be ready for a comprehension checkup.*

A Glimpse of Supersolid

SOLID HELIUM CAN BEHAVE LIKE A SUPERSOLID By Graham P. Collins

Solids and liquids could hardly seem more different, one maintaining a rigid shape and the other flowing to fit the contours of whatever contains it. And of all the things that slosh and pour, superfluids seem to capture the quintessence of the liquid state − running through tiny channels with no resistance and even dribbling uphill to escape from a bowl.

A superfluid solid sounds like an oxymoron, but it is precisely what researchers at Pennsylvania State University have recently witnessed. Physicists Moses Chan and

Eun-Seong Kim saw the behavior in helium 4 that was compressed into solidity and chilled to near absolute zero. Although the supersolid behavior had been suggested as a theoretical possibility as long ago as 1969, its demonstration poses deep mysteries.

Rotation is one way that superfluids reveal their peculiar properties. Take a bucket of ordinary liquid helium and rotate it slowly, then cool it down to about two kelvins, so that some of the helium becomes superfluid. The superfluid fraction will not rotate. Because part of the helium is motionless, the amount of force required to set the bucket and helium rotating is less than it would be otherwise. Technically, the helium's rotational inertia decreases.

Chan and Kim observed such a decrease of rotational inertia in a ring of solid helium. They applied about 26 atmospheres of pressure to liquid helium, forcing the atoms to lock in place and thereby form a fixed lattice. They observed the oscillations of the helium as it twisted back and forth on the end of a metal rod. The period of these torsional oscillations depended on the rotational inertia of the helium; the oscillations occurred more rapidly when the inertia went down, just as if the mass of the helium decreased. Amazingly, they found that about 1 percent of the helium ting remained motionless while the other 99 percent continued rotating as normal. One solid could somehow move effortlessly through another.

So how can a solid behave like a superfluid? All bulk liquid superfluids are caused by Bose-Einstein condensation, which is the quantum process whereby a large number of particles all enter the same quantum state. Chan and Kim's result therefore suggests that 1 percent of the atoms in the solid helium somehow form a Bose-Einstein condensate even while they remain at fixed lattice positions. That seems like a contradiction in terms, but the exchange of atoms between lattice sites might allow it. A characteristic of helium would tend to promote such an exchange − namely, its large zero-point motion, which is the inherent jiggling of atoms that represents a minimum amount of movement required by quantum uncertainty. (It is the reason helium ordinarily only occurs as a gas or a liquid: the extremely lightweight atoms jiggle about too much to form a solid.) Supporting the idea of condensation, the two researchers did not see superfluidity in solid helium 3, an isotope of helium that as a liquid undergoes a kind of condensation and becomes superfluid only at temperatures far below that needed by liquid helium 4.

Another possibility is that the crystal of helium contains numerous defects and lattice vacancies (yet another effect of the zero-point motion). These defects and vacancies could be what, in effect, undergo Bose-Einstein condensation. But all those theories seem to imply that the superfluidity would vary with the pressure, yet Chan and Kim see roughly the same effect all the way from 26 to 66 atmospheres. Douglas D.Osheroff of Stanford University, the co-discoverer of superfluidity in helium3, calls the lack of pressure dependence "more than a bit bewildering." He says that Chan and Kim have done "all the obvious experiments to search for some artifact." If they are correct, Osheroff adds, then "I don't understand how supersolids become super. I hope the theorists are thinking about it seriously."

(Taken from Scientific American, January 2005)

Check up comprehension

1. Why do superfluids seem to capture the quintessence of the liquid state?
2. What have the researchers at Pennsylvania State University witnessed recently?
3. How can a solid behave like a superfluid?
4. What does Douglas D.Osheroff of Stanford University think about the discovery of superfluidity in helium 3?
5. What is your own opinion of the observed evidence of superfluidity?

Text 9. *Read the text and write a synopsis of the text in five sentences.*

Math Without Words

Numerical Reasoning Seems Independent of Language By Philip E. Ross

Nineteenth-century German mathematician Carl Friedrich Gauss used to joke that he could calculate before he could talk. Maybe it was no joke. Recent work casts doubt on the notion that language underlies mathematical ability and perhaps other forms of abstract thinking. Writing in the March 1 *Proceedings of the National Academy of Sciences USA*, scientists from the University of Sheffield in England describe impressive mathematical abilities in three middle-aged men who had suffered severe damage to the language centers of their brains. “There had been case studies of aphasics who could calculate,” says study co-author Rosemary Varley. “Our new take was to try to identify roughly parallel mathematical and linguistic operations.”

Varley and her colleagues found that although the subjects could no longer grasp grammatical distinctions between, say, “The dog bit the boy” and “The boy bit the dog,” they could interpret mathematical formulas incorporating equivalent structures, such as “59 −13” and “13 −59.” The researchers found ways to pose more abstract questions as well. For instance, to investigate the subjects’ understanding of number infinity, they asked them to write down a number bigger than 1 but smaller than 2, using hand motions for “bigger” and “smaller” and a flash of the eyebrow, indicating surprise, for “but.” Then they asked the subjects to make the number bigger but still smaller than 2 and to reiterate the procedure. The subjects got the answer by various means, including the addition of a decimal place: 1.5, 1.55, 1.555 and so forth.

Although subjects easily answered simple problems expressed in mathematical symbols, words continued to stump them. Even the written sentence “seven minus two” was beyond their comprehension. The results show quite clearly that no matter how helpful language may be to mathematicians − perhaps as a mnemonic device − it is not necessary to calculation, and it is processed in different parts of the brain. The idea that language shapes abstract thought was most forcibly propounded 50 years ago in the posthumously published writings of American linguist Benjamin Lee Whorf. He argued, among other things, that the structure of the Hopi language gave its speakers an understanding of time vastly different from that of Europeans. Although Whorf’s hypothesis continues to inspire research, a good deal of his evidence has been discredited. Much more widely respected is the proposal, associated with linguist Noam Chomsky of the Massachusetts Institute of Technology, that language, mathematics and perhaps other cognition all depend on a deeper quality, sometimes called "mentalese."

Chomsky suggested that the key part of this deeper quality might be a quite simple and uniquely human power of "recursive" calculation. Recursion, he and his colleagues argue, may explain how the mind spins a limited number of terms into an infinite number of often complex statements, such as "The man I know as Joe ate my apple tree's fruit." Recursion could also generate mathematical statements, such as "3 × (4/6 +27)/4." Chomsky's theory may, perhaps, be reconciled with the new evidence. Some scholars have argued that the brain may build its mathematical understanding with language and that the structure may still stand after the scaffolding is removed. Indeed, the one subject in the Sheffield study who had had doctoral-level training in a mathematical science did no better than the others in arithmetic, but he outperformed them at algebra.

Rochel Gelman, co-director of the Rutgers University Center for Cognitive Science, says that the brain-lesion studies offer much clearer evidence than can be obtained from the more common technique of functional brain scanning. "Pop someone in a scanner and ask a question, and you may get a lot of activation in language areas," she points out. "But it could be just because the subject is talking through the problem − recruiting language, although it's not a crucial component." The recent work, together with studies of animals and of children, strongly supports the independence of language and mathematics, Gelman says. "There are cases of kids who are bad with numbers and good with words and bad with words and good with numbers, a double dissociation that provides converging evidence."

Need to Know:

Word Help

Despite using different brain circuitry, language can still lend a helping hand to mathematical thought. People quickly pick up simple arithmetic, in part because *the natural numbers map easily to the single words used for counting, says Rochel Gelman, co-director of the Rutgers University Center for Cognitive Science. But, she notes, they have much more difficulty grasping the rational numbers (fractions), which do not map onto anything readily at hand.*

(Taken from Scientific American 2005)

Text 10. *Translate the text into Russian in written form.*

How To Write A Popular Scientific Article

J.B.S. Haldane

Most scientific workers desire to spread a knowledge of their subject and to increase their income. Both can be done by writing on science for the general public. In what follows I shall give some hints on how to do it.

The first thing to remember is that your task is not easy and will be impossible if you despise technique. For literature has its technique, like science, and unless you set yourself a very high standard you will get nowhere. So don't expect to succeed at your first, or even second attempt.

For whom are you writing? This is even more important than the choice of the subject. Moreover the length of the article will depend on where it is to be published.

Now for the subject matter. You may take a particular piece of research work, or a particular application of science. Or you may choose some general principle, and illustrate it from different branches of scientific work. For example an interesting article could be written on fruitful accidents. Priestley broke a thermometer, and the fate of the mercury from it led him to the discovery of oxygen.

Probably you will do better to begin on some more specialized topic, unless you are a student of the history of science.

Whatever the subject matter, it is important to remember that you want to interest or even excite your readers, but not to give them complete information. A number of the articles which are submitted to me from time to time are far too like examination answers. They give the impression that the author has looked the subject up, and tried to give a condensed summary of it. Such a summary may be all very well in a text-book, but will not hold the attention of a reader of popular articles, who does not contemplate severe intellectual exertion.

This does not mean that you must write for an audience of fools. It means that you must constantly be returning from the unfamiliar facts of science to the familiar facts of everyday experience. It is good to start from a well-known fact, say, a cheese. This will enable you to illustrate some scientific principle. But here again take a familiar analogy. If you know enough, you will be able to proceed to your goal in a series of hops rather than a single long jump.

If you try to write an article in this way, you will probably discover your own ignorance, especially of quantitative matters. It may take you twelve hours' reading to produce in intellectually honest article of a thousand words. In fact, you will have to educate yourself as well as your public.

When you have done your article, give it to a friend, if possible to a fairly ignorant one. Or put it away for six months and see if you still understand it yourself. You will probably find that some of the sentences which seemed simple when you wrote them, now appear very involved. Here are some hints on combing them out.

Can you get in a full-stop instead of a comma or a semi-colon? If so, get it in. It gives your reader a chance to draw his breath. Can you use an active verb instead of a passive verb or a verbal noun? If so, use it. Instead of "Open windows are often thought to be good for health", or "There is a widespread opinion that open windows are good for health", try "Many people think that open windows are good for health."

Try to make the order of the phrases in your sentences correspond with the temporal or causal order of the facts with which you deal. Instead of "Species change because of the survival of the fittest" try "The fittest members survive in each generation, and so a species changes."

Of course in the history of scientific discovery an effect is commonly known before its cause. And fairly often a mathematical theorem is known to be probably true before it is formally proved. If you enunciate your theorem before you prove it, you are apt to give the impression, as Euclid does, that you are producing rabbits from a hat.

Whereas if you lead up to it gently, you create less impression of cleverness, but your reader may find your argument much easier to follow. It's necessary for you to go slow and show him as many steps as you can in your arguments or causal chain, even if, in your own thinking, you skip some of them or take them backwards.

When you have written the article it may seem rather gaunt or forbidding, a catalogue of hard facts and abstract arguments. A critic may say it needs padding. I object to padding for padding's sake. It is characteristic of writers who are more interested in their own style than their subject matter, but out of place in a scientific article.

On the other hand you must do what you can to help your reader to link up your article with the rest of his knowledge. You can do this by referring to familiar facts or to familiar literature. I think it is worth while to show the continuity of human thought. I consider it desirable to point out that many people before me had a theory on the subject. I think that popular science can be of real value by emphasizing the unity of human knowledge and endeavour, at their best. This fact is hardly stressed at all in the ordinary teaching of science, and good popular science should correct this fault, both by showing how science is created by technology and creates it, and by showing the relation between scientific and other forms of thought.

A popular scientific article should, where possible, include some news. I try, as a rule, to include one or two facts which will not be familiar to a student taking a university honours course in the subject in question, unless his teachers keep well up with the periodical literature. Of course some care is needed in appraising new work. A very large number of alleged discoveries are not confirmed by subsequent workers. If, like myself, the writer is actually engaged in research, and has seen a number of his own bright ideas go west, he is less likely to fall into this particular trap.

In the early stages of popular writing it is well to write out a summary of the article, though I rarely do so myself. Here is a possible skeleton for an article:

Introduction. A well-known fact.

Central theme. The process of manufacture.

Why it is important.

Connections with other branches of science.

Practical suggestions.

That is one way of doing it. I have only described one way, and I do not claim that is the only way, or even the best possible way.

Text 11. *Read the text and be ready for a comprehension checkup.*

Butterflies on the Front Line

Accepting lifts from shifty Californian dope growers and bluffing gun-toting South Americans is not quite the life you would expect one of the world's top lepidopterists to lead. But Arthur Shapiro *takes it in his stride. As he tells* Michael Bond*, tracking butterflies for over three decades has left him far more concerned for their fate than his own*

What's changed that makes you worry?

For the past 35 years, walking a predetermined, identical route every two weeks, I've been recording the species at our 10 survey sites on a transect across California, from the San Francisco Bay Area to the eastern slope of the Sierra Nevada mountains. Initially I didn't count individuals, mainly because the number of species made that impossible. Since 1999 I've been able to count individuals at some sites because many species have plummeted to the point where it has become feasible. Other species have become extinct regionally.

Is that because of climate change?

It appears to be, though our initial analysis suggests it is not due to climate alone. We have evidence that a significant number of species are shifting their ranges uphill. We're also seeing species emerge earlier. Each year, I offer a pitcher of beer to the person who spots the first cabbage white to emerge in Yolo, Solano, and Sacramento counties. I usually win. This year it happened on 23 January, which is relatively late. On average the species appears up to 19 days earlier than it did 36 years ago.

Are we losing species?

I think what's most troubling is that we are losing populations of established, reliable species − those that breed in people's vegetable gardens. It's like discovering that cockroaches are becoming extinct in cities.

How do you set about catching a butterfly?

Normally with a net. You can catch them by hand if you have to. Earlier this week I picked up a Gulf fritillary, which breeds only on passion flowers, in my fingers. I picked one off as I was walking around. I can predict butterflies' behaviour fairly well. When my wife and I went to Colombia in 1977 to study a high-elevation butterfly only a handful of people had seen alive, I was able to catch them with uncanny accuracy because they are closely related to a butterfly I knew well.

You've done a lot of work in South America. How do you live when you are in the field there?

Very casually and very cheaply. Sometimes I camp. I generally travel by bus, which is easy in Latin America. I have got into the routine of staying at the very cheap places where the long-haul bus and truck drivers stay for $2 or $3 a night in bunk beds − bring your own toilet paper. I'm on the move most of the time: I'm trying to document the geographic distribution of certain groups of butterflies to understand how they evolved, so there's no need to linger in one place.

Do you meet butterfly enthusiasts on the road?

It surprises me that I don't meet more. I do meet some local enthusiasts, like the retired police chief in suburban Buenos Aires, who has opened a butterfly museum with private funding. I carry my life membership card for the society he founded. I also occasionally bump into other foreign researchers, like the time I arrived late one evening in the town of Esquel in Argentinean Patagonia. I knew there was a cheap hotel near the bus station. When I went to check in, there were some real tough-looking guys shooting pool in the lobby and drinking beer. I was carrying a butterfly net and I thought I could get into trouble here. So I walked to the next cheapest hotel. When I looked at the guest list I saw an old colleague of mine, the former director of the American Museum of Natural History's south-western research station in Arizona, had checked in. He and his wife were there collecting spiders.

Have you got into real trouble in South America?

Oh yes. One time I accidentally trespassed within the boundary of a nuclear facility. I was quickly surrounded by people with weapons. For situations like that I have a standard spiel about what I'm doing. I pointed out to the people interrogating me that the boundary was not clearly marked, it was just a barbed wire fence. In Latin America people climb over barbed wire fences all the time. Their eventual reaction was: "He's a harmless nut."

Has butterfly hunting got you into trouble in the US too?

Yes, even worse than in the south. I've had to deal with addled methamphetamine freaks and pot growers with side arms. When you poke around in remote areas you find all kinds of things, like people growing dope on public land. One time a colleague and I were rescued by a pot farmer in California's pot-growing triangle in the north-west when our pick-up got stuck in mud. He apologized for having to stop to, as he put it, "go tend my felonies."

How did you first become interested in butterflies?

My parents did not have the happiest of marriages: it was a long one, but a case of "for every sadist there is a masochist". So I stayed outdoors as much as I could, dabbling in everything − rocks, wild flowers, reptiles and amphibians. Gradually I narrowed it down to insects and then butterflies. Butterflies started to interest me around the age of 10 or 11.

Did you ever consider any other career?

As a kid, I thought of becoming a meteorologist. I've retained it as a hobby − my interests have remained fixated at juvenile stages throughout the decades. Given the convergence of the two topics in my research programme, it's worked out pretty well.

How have they converged?

The butterfly monitoring programme I've been running in California since 1972 means I have collected around 83,000 individual records of 159 butterfly species and subspecies at these sites, which in terms of data is second only to the UK monitoring programme. We have also collated monthly climate records from weather stations along the transect. I'm interested in relating the life cycle of butterflies to various elements of climate. Concern about global climate change is growing exponentially, and I am sitting on one of the biggest and most relevant sets of data on the planet.

Would you say butterflies are intelligent?

They're definitely capable of learning. There is a nearly forgotten 19th-century anecdote about a man who was raising tortoiseshell butterflies. He was in the habit of bringing a tray of moist gravel for them to drink. He did this at the same time every day. One day he was a little late and was flabbergasted to see the butterflies milling round the door waiting for him.

Butterfly hunters have a certain image. What do people make of you?

From my appearance, people tend to judge things about my lifestyle, cultural preferences and so forth that may not be valid. I like confounding them. For example, people are often flabbergasted to hear that I've been a registered Republican my entire voting life. They rarely ask why. The reason is when I was growing up in Philadelphia, the local Democratic government was corrupt and being a Republican was progressive.

Profile

Arthur Shapiro started recording the effects of climate on butterflies as a teenager in Philadelphia. He is now a leading expert, and professor of evolution and ecology at the University of California, Davis. He is also known for his detailed amateur weather forecasts. His Field Guide to the Butterflies of San Francisco Bay and the Sacramento Valley Regions, co-authored with Timothy D. Manolis, will be published in June by the University of California Press.

(Taken from New Scientist, 2007)

Check up for comprehension

1. What has A.Shapiro been doing for the past 35 years?
2. Why have other species become extinct regionally?
3. How does he set about catching a butterfly?
4. How did A.Shapiro first become interested in butterflies?
5. Would you say butterflies are intelligent?

Text 12. *Read the text and write a synopsis of the text in five sentences.*

Atomic Fingerprinting

Microscope discerns an atom's chemical identity

By Luis Miguel Ariza

Deciding whether a substance is, say, steel, brick, wood or plastic is easy − but not on the atomic scale, which lacks information about such everyday characteristics. Using an atomic-force microscope (AFM), however, an international team of physicists has developed a method of atomic "fingerprinting" that can determine the chemical identity of individual atoms on a surface mixed with all of them.

"Until now, there was not any technique that would allow us to identify atom by atom and see them at the same time," says Rubén Peréz of the Autonomous University in Madrid. Using their AFM approach, Óscar Custance and his collaborators at Osaka University, along with Peréz and his colleagues and others, could discern tin, silicon and lead, which are all chemically similar. The resulting image of the atoms resembles a granulated painting, where the "grains" − the individual atoms − are distinguishable in false color.

The ability to identify and manipulate atoms first gained prominence in 1989, when IBM scientists spelled out their company logo with xenon atoms. Back then, the physicists relied on a scanning tunneling microscope (STM), which detects atoms by a slight flow of electrons between the microscope tip and an atom. The STM, however, can identify only atoms of materials that conduct electricity.

In contrast, the fingerprinting AFM technique works for conductor and insulator alike. Like a phonograph, the AFM employs an ultrafine needle mounted on a flexible cantilever. As the needle gets dragged across a surface, it jogs up and down as it encounters atoms on that surface. This oscillation actually occurs because of the attractive forces associated with the onset of chemical bonding between the silicon in the tip and the atoms on the surface. The Japanese-Spanish team showed that the oscillation frequency depends on the atom's chemical nature. It thus enabled the researchers to identify different atomic species even if they exist in equivalent abundance, Peréz says, "like distinguishing a tree in a noisy, fuzzy forest."

In previous work, Custance and his team had demonstrated that they could use the AFM to move tin atoms strongly attached to a germanium surface, writing the letters "Sn" (tin's chemical symbol). Combining the method with atomic fingerprinting opens exciting possibilities for the AFM − researchers might be able to "visualize reactions with atomic resolution," Custance remarks. And, he adds, as microelectronics shrink into the nanoscale realm − 2,000 of today's transistors can fit across the width of a human hair − then "just by arranging a few atoms in predefined patterns, it could be possible to enhance the performance of the devices."

(Taken from Scientific American, 2007)

Text 13. *Read the text and write the translation of it.*

Escape From the Nucleus

Ionization via Quantum Tunneling Observed

By Alexander Hellemans

To break free from an atom, the negatively charged electron typically has to absorb a high energy proton, such as that from the ultraviolet (UV) or x-ray spectrum. The electron then gets excited enough to overcome the electrostatic attraction holding it to the positively charged nucleus and escapes, a process called ionization. A German-Dutch team has for the first time provided direct proof of an alternative mechanism. Powerful electric fields from a laser pulse can momentarily weaken the electrostatic bonds and enable the electron to quantum-mechanically tunnel away from the atom.

Leonid Keldysh, now at the Lebedev Physics Institute in Moscow, predicted the effect in 1964, and experiments have already proved that such unusual ionization can occur. But only with the advent of laser pulses lasting just a few hundred attoseconds can physicists observe the phenomenon. (One attosecond is a billionth of a billionth of a second). Attosecond laser pulses have already made it possible to probe the motion of electrons in atoms and molecules, and improved versions will allow researchers to track electron movements that occur, for instance, during chemical reactions.

Ferenc Krausz of the Max Planck Institute for Quantum Optics in Garching, Germany, and his team describe their ionization experiment in the April 5 *Nature*. Targeting a gas of neon atoms, the group first used a 250-attosecond UV laser pulse to nudge one electron farther away from the nucleus. Almost simultaneously the physicists fired an infrared pulse 5,000 attoseconds long whose electric field oscillates only a few cycles. The field weakened the electrostatic force and enabled the loosened electron to tunnel out, as quantum particles can do when confronted with a thin barrier. By increasing the time between the UV and infrared pulses in small steps, the researchers found that the number of neon ions formed rose in parallel, clearly indicating that whenever the electric field of the infrared laser pulse reached a maximum, the rate of produced ions increased as well.

Keldysh's theory of strong-field ionization has become part of many other theories, and the result is "not really a dramatic surprise," Krausz admits. But critically, "the team has shown a new way to make measurements" of electron dynamics, comments physicist Paul Corkum of Canada's National Research Council in Ottawa. And the technique could probe poorly understood processes in which electrons exchange energy with one another.

As an example, Krausz cites the "shake up" process in atoms that occurs when an energetic x-ray photon kicks out an electron close to the nucleus. While flying away, this electron could impart some of its energy to another electron, which would become excited and move farther away from the nucleus. Hence, a small delay might exist between the absorption of the x-ray photon by the ejected electron and the repositioning of the second electron. The delay, Krausz remarks, "could be as little as 50 attoseconds; nobody really knows." The length of the delay is not exciting, he explains − rather the point would be whether a delay existed at all. A delay would mean the second electron got energy from the first and was not coincidentally and simultaneously excited by the x-ray photon.

Krausz claims he has now achieved 100-attosecond UV pulses, so he may soon solve that puzzle. As the lasers improve, answers to other questions are sure to follow in the coming years, if not in the coming attoseconds.

(Taken from Scientific American, 2007)

Text 14. *Read the text and be ready for a comprehension checkup.*

What Is Life

− What is life? Attempts to define it bog down in hair-splitting exceptions, or go off in weird, uncontrollable directions.

− Aristotle called life, "the power of self-nourishment and independent growth and decay." He said the transition from inanimate to animate is so gradual that boundaries are indistinct. That definition, though not perfect, is probably as good as any other.

− Life isn't fragile. It thrives on adversity. Organisms live comfortably in boiling springs. Bacteria thrive in hot water inside nuclear reactors. Algae grow in salt pools at 59 degrees below zero. Trees buried and charred by volcanic lava put out shoots and bloom again. There is even life at the bottom of deep ocean trenches, thriving and reproducing under tons of pressure.

− That’s true. I’ve read somewhere about one kind of organism, called halophile, that must have salt to survive. It lives comfortably in a 30 per cent salt concentration. But remove a palophile from its natural environment, put it in fresh, clear, warm water, and it explodes and dies.

− Fancy that! It sounds like science fiction to me. In my school days we spoke only of organic and inorganic compounds. Anyway, what elements are you looking for in searching for living matter?

− Organic compounds contain carbon. Molecules of biological interest also contain hydrogen and oxygen, usually as proteins, carbohydrates and fats. A typical analysis of living matter (protoplasm) is 65% per cent oxygen, 18 per cent carbon, 11 per cent hydrogen, and 2 per cent nitrogen. Trace elements are the other 4 per cent.

− How did life begin?

− Scientists have a thousand theories about how life began. The one currently popular is called the Theory of Chemical Evolution.

− Does it mean that organic matter developed from inorganic matter?

− Could you tell us briefly about that theory?

− With pleasure. It goes like this:

The universe probably began about 15 billion years ago. Long before planets formed, nuclear reactions inside a billion stars created most of the known elements. The solar system condensed about 4.6 billion years ago from the dust and gas of long-dead stars.

− Did Earth have an atmosphere of a kind at that time? And if so, what was it like?

− Scientists think Earth’s original atmosphere was methane, ammonia, water and hydrogen. They believe the molecules important to biology − carbon, nitrogen and oxygen − existed in a hydrogenated form; that is they combined with free hydrogen to form methane (CH), water (HO) and ammonia (NH). Little or no free oxygen existed in the primordial atmosphere.

− How could life, that is organic matter, spring from these elements? What should the conditions be for living organisms to evolve from these elements?

– It has been proved to be possible by Dr. Stanley C. Miller and Prof. Harold C. Urey. They performed experiments at the University of Chicago that seemed to prove life could occur spontaneously under the right conditions.

– That's most interesting! What experiments did they perform?

– Miller and Urey combined methane, ammonia, water and hydrogen in a flask, then exposed the brew to electric discharges.

– And what did they get?

– What was the result of the experiment?

– They found amino-acids – the basic building blocks of life – in their chemical soup.

– Fascinating!

– Unbelievable!

– Fantastic!

– I don't grasp the idea. What are you driving at?

– What's the implication of this fact?

– It implies the following. Organic molecules on Earth apparently evolved when energy (either lightning, solar ultraviolet or heat) soaked the primordial atmosphere. These primitive chemicals accumulated in the oceans, where ever-more-complex molecules formed. Finally one or more of them was capable of reproduction and metabolism (Aristotle's self-nourishment and growth).

– When did life on Earth begin?

– Life began early in the 4.6 billion-year history of Earth.

– How can you date it? What makes you so sure about it?

– The oldest known fossils are 3.7 billion years old, already complex and well-developed.

– What do scientists think of the early life process? Was it similar to that of our time?

– Early life subsisted by photo synthesis, the process by which organisms absorb carbon from the atmosphere and give off oxygen as a waste product – as plants today. Through millions of years, the atmosphere gradually changed to its present oxygen-rich composition.

− Does that mean that Earth's early organic substances could not survive today?

− Absolutely correct. Charles Darwin recognized, in 1871, that organic evolution can occur only where living organisms and atmospheric oxygen are absent. I'll quote, if you like, his very words.

− That is most interesting.

− Please, do.

− "It is often said", Darwin wrote, "that all the conditions for the production of a living organism are now present which could ever have been present. But if we conceive, in some warm pond with all sorts of ammonia and phosphoric salts, light, heat and electricity present, that a protein compound was chemically formed ready to undergo still more complex changes, at the present day such matter would be instantly devoured or absorbed, which would not have been the case before living creatures were formed."

− In other words, organic material that might form today is destroyed rapidly. It is either eaten or oxidized. Have I understood you correctly?

− You have.

− I've got it! On the surface of a planet in an earlier (or different) evolutionary stage than our own, we might find direct evidence of the origin of life.

− Quite. It is very possible.

− We know only a little about life, its causes, origin and evolution. The Theory of Chemical Evolution is just that − a theory. It works, in one case we have studied: life as it occurs on Earth.

− But what of other planets in the solar system or orbiting some other star? Mars is the nearest such planet.

− Scientists ask a blizzard of questions about life. So do lay people.

Check up for comprehension

1. What are geological, biological, biochemical, chemical, physical and humanitarian concepts of life?
2. Does it exist only on Earth?
3. What is the range of physical conditions − temperature, amount of water, atmospheric composition − that can support life?
4. Can life arise and evolve in many directions or only a few?
5. Did life begin in just one place to spread across the universe?
6. Can life be created only from carbon atoms?
7. Or can some other elements do the job?
8. What's your idea of life?

Text 15. *Read the newspaper article and give a critical review of it taking into account the latest achievements in the field.*

Physicist Hawking to Fly Weightless

Cape Canaveral, Fla (AP) − Stephen Hawking has been imprisoned by his body for many years.

But for a few seconds on Thursday, the celebrated British physicist and author will float free, unrestricted by his paralyzed muscles and his wheelchair as he floats weightless on a zero gravity flight.

"I have wanted to fly in space all of my life," Hawking told the Associated Press in an interview Tuesday. "For someone like me whose muscles don't work very well, it will be bliss to be weightless." Hawking, 65, has the paralyzing disease ALS, also known as Lou Gehrig's disease. He will be the first person with a disability to fly on one of the flights offered by Zero Gravity Corp., a space tourism company. It has flown about 2,700 people on Florida-based flights since late 2004 and began offering flights in Las Vegas this week.

Unable to talk or move his hands and legs, Hawking can only make tiny facial expressions using the muscles around his eyes, eyebrows, cheek and mouth to communicate. Otherwise, he relies on a computer to talk for him in a synthesized voice. The computer is attached to his wheelchair and allows him to choose words on a computer screen through an infrared sensor on a headpiece that detects motion in his cheek. He raises an eyebrow to signal "yes", and tenses his mouth to the side to indicate "no."

Flying from Kennedy Space Center in Cape Canaveral, Florida, the modified jet creates the experience of microgravity during 25-second plunges over the Atlantic Ocean. The jet's interior is padded to protect the weightless fliers and equipped with cameras to record their adventure. Normally, the plane conducts 10 to 15 plunges for its passengers who pay $3,750 for the ride, although that fee has been waived for Hawking.

After the jet has reached its proper altitude, Hawking's assistants will lift him out of his chair and lay him on his back in the front of the cabin for the first plunge. Other plunges will be made only after the two doctors and three nurses who are accompanying him have made sure he is enjoying it. He will not have his wheelchair and talking computer on the jet with him, although his assistants will bring a laptop and a card with the letters of the alphabet in case Hawking wants to communicate beyond facial expressions.

"We consider … having him weightless for 25 seconds is a successful mission," said Peter Diamandis, chairman and CEO of Zero Gravity. "If we do more than one, fantastic." Gary A. Leo, president and CEO of the ALS Association, said there should be no medical concerns with someone who has the condition going on a zero-gravity flight, although any person who does should consult a physician.

Hawking, a mathematics professor at the University of Cambridge, has done groundbreaking work on black holes and the origins of the universe, making him one of the best-known theoretical physicists of his generation. He is also known for his book "A Brief History of Time." He has an ulterior motive for going on the flight other than the personal thrill of being weightless − Hawking believes in the importance of private space ventures and the need to reduce the cost of space tourism so that it’s accessible to more people.

“I am hopeful that if we can engage this mass market, the cost of space flight will drop and we will be able to gain access to the resources of space and also spread humanity beyond just Earth,” he said. “Sooner or later, some disaster may wipe out life on Earth. The long-term survival of the human race requires that we spread into space.”