ФЕДЕРАЛЬНОЕ АГЕНТСТВО ПО ОБРАЗОВАНИЮ

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Look Around

*Рекомендовано УМО «Ядерные физика и технологии»
в качестве учебного пособия
для студентов высших учебных заведений*

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Основная цель пособия – научить студентов понимать техническую литературу по специальности и говорить на английском языке в рамках специальности.

Учебное пособие написано в соответствии с программой по иностранным языкам для неязыковых вузов и основано на современной концепции образовательного процесса, смещающей акцент с усвоения студентами готовых знаний на самостоятельную, познавательную деятельность.

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INTRODUCTION

WHAT MAKES A SCIENTIST?

A Scientist's Odyssey

Conversation with Victor Weiss-kopf

Read the interview.
Look up the underlined words.

What is it at the root of scientific progress? What is the temperament that makes... that makes you a scientist?

Well, I think that **in a way** it's really simple. It's just being interested in what's around you; you want to know. And I had this from my high school days. I didn't have a very good high school teacher in physics or in natural science, but somehow at that time, I just wanted to know and I read books – too many, you know – popular books on science. I was especially interested in astronomy and my parents gave me a telescope. I was interested in natural science. I looked at the stars, I read books about the stars. I read about atoms which, at that time of course, was a very important subject. So that was the way I came in. I just wanted to know what it was all about.

It is probably <u>a misperception</u>, but <u>one perceives</u> a scientist as cold, calculating, rational; but you don't agree with that formulation?

I don't at all. **On the contrary**, I always criticized the teaching establishment for <u>emphasizing</u> this coolness and <u>aloofness</u>. If you are a scientist, you must be objective, they say, you should not have your emotions play a role. I think that's all wrong. **A scientific inquiry is a human activity**. It's full of human drives – whatever you want: ambition, joy, or tragedy, whatever you take – and so in all my classes I always try to be different from other teachers. Of course, there are also teachers who think like me. **But I try to bring out the emotional angle, the joy of**

insight, which I always try to emphasize, how wonderful it is when you suddenly, or not so suddenly, understand something and see, "Ah-ha! It's this way!" And that emotional experience I think one has to transfer to the students.

You made a reference in your public lecture to "complimentarity of thinking," and I've heard you say elsewhere that it is something that you developed in your education as you studied quantum mechanics. Explain that.

I really got that from Niels Bohr. From my spiritual father. He always emphasized the complimentary angle, which means there are different ways of dealing with experience which are often seemingly contradictory. My first experience was in physics itself, in quantum mechanics. An electron is a wave and a particle – seemingly contradictory, but **it turns out** they are just two different sides, different aspects, of the same reality. Then Bohr generalized this and it was very impressive for me, I mean I was always extremely caught by these ideas, this different way of looking at it, that seeming contradictions are essential elements of human experience. Take an example of a piece of music, I happen to be very much interested in music.

You're a pianist?

I'm a pianist and **actually** before I **took up physics I was even thinking of going into music**; but **anyway** take a sonata, Beethoven's sonata. I mean you can describe this as vibrations of the air, you can you describe this as nerve synopses in your brain, but these are complimentary aspects of the musical aspects. Beethoven's sonata is an expression of emotions of a certain state of mind which, of course, is the most important part. Or take another example of the beauty of a sunset: one can look at it from the point of view of scattering of light, one can look at the wonderful color combinations. These are all **valid** – I would almost say equally valid – ways of looking at human experience. **Although** they seem contradictory, they are not contradictory; they are complementary and they add up. I think for me a sunset is more beautiful if I not only admire the color, but also think, "How did this color come about?"

How does one discipline this emotional element so that it doesn't take him away from a true analysis?

Well, one has to be careful even in art lets say, or in music. One has to be careful not to be **too** taken away by emotions because **after all**, the study of composing or playing a piece of music is also irrational, where you need emotions but they shouldn't run away with you. **In some ways** it's in science too: **Without emotions you would not be able to do something great in science**. .I'm quite sure that for Einstein the beauty of those ideas was very important, and that's an emotional reaction. **So** there is emotion even in science which people often suppress. The main point of complimentary ideas is that one way of looking at things, be it the scientific one, be it the religious one, be it the artistic one, is not enough, and deprives you of many ways of understanding your environment; but even more, it is very dangerous because if you only have one way approach, it is open for abuse.

Are you satisfied with the way our educational system brings science to young people?

No, definitely not; that area I have to criticize very much, not so much college education where of course everything can be done better, and I'm always satisfied if people think about better ways of teaching, but I think the college teaching is **relatively** good, except what I said before about emotions. But when you come to high school or elementary school, I think it's simply terrible **the way** science is taught in most high schools. There are always exceptions – good exceptions, fortunately – but if you look at the general way it is taught in high school it is simply just to **scare** the kids **off** the subject, because they don't get the essential joy of insight or **are even deprived of** the independent way of finding something. The teacher should lead the student **so that** he can find the answer himself, **either** by trying it out on the lab table **or** by thinking.

What about the moral education?

I believe that home **has a lot to do with it**, the education at home, not at school but at home. Life has taught me that everything is many sided. This is the complimentarity. You cannot be a pure scientist and nothing else. I think if I were only a scientist and were not passionately interested in music or art, and didn't take social problems much to heart, my life would be much poorer. **So in some ways** it's education that sets your life. As I said, the influence of the home is very important, with emphasis that you are brought up to grow a decent person. A human being is many sided. You can go either up or down Going up, spiritual development, is much more difficult. It takes mental efforts. Things are much more complicated than they seem to be. We must have a better education. An education that educates ideals and teaches a scientist that all things he will deal with are many sided and involve science, philosophy, arts, religion also, and social responsibility.

Professor Weisskopf, thank you very much for sharing your thoughts with us.

<u>Exercise 1</u>

Give your interpretation:

1. "A scientific inquiry is a human activity." What does he mean?
2. "I always try to be different from other teachers." In what does Weisskopf try to be different?
3. What does Weisskopf mean by "complementarity of thinking" and "the complementary angle?" Give an example from physics.
4. "Then Bohr generalized this." What did Bohr generalize?
5. "I was always extremely caught by these ideas." What ideas was he always caught by?
6. What is a Beethoven's sonata when looked at from the compementary angle?
7. What is a sunset when looked at from the complementary angle?
8. What do science and art have in common?

<u>Exercise 2</u>

Formulate the answer to the question:

1. What is life if defined as an odyssey?
2. What is the main point of complimentary ideas?
3. What does a scientific technological line which is pursued without looking at from the complimentary angle lead to?
4. Is Weisskopf satisfied with the way American educational system brings science to young people?
5. What does college teaching lack according to Weisskopf?
6. What important elements are neglected in teaching science in high and elementary school in the U.S.A. according to Weisskopf?

<u>Exercise 3</u>

Give your interpretation of the complementarity of experience.

scientific – experimental

artistic – creative

philosophical – theoretical

social – society-oriented

religious – intuitive, irrational

MATHEMATICS

CONVERSATION WITH CHAITIN, AN AMERICAN MATHEMATICIAN

This interview took place in a café at the airport. It's part of a "Bridge the gap" series of discussions and exchanges on science, art and humanity organized by the Center for Contemporary Art in Japan. The interviewer is Hans Obrist, a curator at the Museum of Modern Art of the city of Paris.

Read the interview. Look up the underlined words.

ON ENTERING THE FIELD OF MATHEMATICS

<u>O: Could you tell me a little about the beginnings of your entering the field of mathematics?.</u>

C: I started very, very young. I am self-taught, in fact. I have a high school degree, from the Bronx High School of Science. I don't have a college degree. I only have an honorary doctorate.

O: Can you tell me about your time at high school?

C: In 1956 when the Russians put Sputnik in orbit, the United States got terrified, so they started having special programs for gifted children to study science. I <u>benefited</u> from all of this. I went to a special high school for science called the Bronx High School of Science; there was a wonderful science and math library there. I was very fortunate that I was there at the right time, at a time when the United States was trying to make new scientists. I took university level courses in high school and they were wonderful courses because they were done by some of the best people in their fields. They were really new. They were not following the old <u>curriculum</u>, the old subjects. <u>In every way</u> they were **up-to-date** presentations of mathematics, physics, chemistry and biology. I didn't have to waste time on a course which was really **out of date.**

And I also went to a program at Columbia University for bright high school students on Saturday mornings. That was wonderful. One of the things they did, which was, may be, even better than the course itself, was that they let me use the Columbia University libraries. I was allowed to look at the books. I was reading immense quantities of books <u>on my own</u>. I was an <u>unbearable</u> child; my mind was ablaze with mathematics and scientific ideas.

O: It was early that your interest and study of mathematics started. Was there a book or something that triggered it?

C: Well, I swallowed up many books. I looked for books that I could study on my own, books that emphasized fundamental ideas. One of these books was "A Mathematician's Apology" by Hardy.

O: You read that so early?

C: I read it very, very early. It's a delightful book The normal textbooks <u>require</u> that you study one by one a vast series of textbooks. I looked for books that **enable** you to parachute or jump into a subject **without having to do** fifteen courses first.

O: It's a very different idea than people usually have of entering the mathematical field.

C: It takes tremendous emotion to do good mathematics, it is very difficult. You have to be inspired and you have to have tremendous drive to do it. You are not a machine, **by any means**, because the act of creation is magical. There is no rule for doing it in science, **the same way** there is no rule for doing it in the arts. There is no systematic way to do it. They can't teach you in school how to do it, they can just get out of your way!

<u>Exercise 1</u>

Prof. Chaitin has just had a talk at your university. You have questions to ask him. In groups. One of you is Prof. Chaitin, the others are students. Begin each question with: Professor Chaitin, I have a question to ask you.

1. You say you are self-taught. Do you mean you are not a college graduate?

2. You say the university level courses in high school were wonderful. What was the most wonderful thing about them?

3. You say 1956 was the year when the U.S. was trying to make new scientists. What was 1956 remarkable for?

4. You say the program at Columbia University was wonderful. What was the most wonderful thing about it?

5. You say you read immense quantities of books at the Columbia University libraries. What books did you look for?

6. You say "A Mathematician's Apology" by Hardy is a delightful book. What is so extraordinary about it?
7. What do you mean that man is not a machine?

ON THE CREATIVE LIFE: SCIENCE vs. ART

C: There is a problem with creativity. I recently read an article called "Hitting the Wall" about the problems one has **as** one grows older, and the article **made** me think of the biography of Feynman by Gleick. There is a passage in that biography that really affected me. Feynman says that the greatest moment for him in his life is when he has an idea and he **realizes** the idea is really significant and important, and it will reveal new things. This is a period of euphoria and extremely intensive work. The interviewer then asks, "How many times in your life **has this been the case?"** Feynman said, "Well, may be five times in my life!" "And how long does this period of intense euphoric activity last?" Feynman said, May be two, three weeks!" So, the conclusion is that the intense, creative life of Feynman, the Nobel Prize winning physicist, may be five times three weeks, may be fifteen weeks in his life!

And then the question is what do you do **the rest of** your life?! Well, the answer is you are working very hard trying to get the next idea, preparing the subconscious, trying to see where there is a new path. There is routine science, normal science and there are paradigm shifts. Routine science is the kind of thing you might do in industrial labs, and it is really technology, almost. But science at its deepest level is an intensely creative activity, just like the arts.

O: The artist Christian Boltanski describes a similar situation in the life of an artist: that artist has three, four ideas in his life when something truly new pops up.

C: Yes. Then almost all of a sudden you find a new style. If you are a painter, you all of a sudden find a new way of looking at the world and your paintings change. And people don't realize how emotional this is, people think that in science you just discover things, but you don't invent. And the artist invents; Shakespeare invented his plays. People think that the scientist discovers how the world works. **That may be the case**, but you have to imagine a beautiful new theory before you can verify it. And most of the beautiful theories you imagine fail. The first step is an act of imagination. There is no systematic way to ask nature to reveal something which is a quantum leap forward.

Experiments do not tell you that you have to go in a **particular** new direction. You have to imagine that a whole new **approach** may be possible, that a beautiful new theory is possible, before you can get to work systematically to develop it and verify it experimentally. In science experimental work does not systematically lead to new theories. It is an act of imagination, it is a tremendously emotional thing too. You have to throw your whole personality at the problem

O: I had a discussion with Roger Penrose. He says that the actual invention seldom happens in the laboratory or the studio, it very often happens in between, it could happen as one crosses the pedestrian stripe….

C: Right. I almost never have new ideas in my office. What I do in my office is. I type papers into my computer, for instance. But I will have a new idea while swimming or going for a drive, in the strangest places!

In pairs ask and answer questions.

1. What is the greatest moment in the life of a true scientist?
2. What is science at its deepest level?
3. What period proceeds a discovery or an invention?
4. What are paradigm shifts?
5. What is the difference between "to discover" and "to invent"?
6. What makes science and the arts alike?
7. Where do scientists happen to get new ideas?
8. What does Chaitin do in his office?

ON THE NON-LINEARITY OF SCIENCE PROGRESS

O: One of the main differences one often resorts to in terms of art and science is that from an art point of view, one tends to think that inventions are not cumulative, in a sense, that there is a non-linearity. It is very difficult to read art history as progress.

C: One has this beautiful, utopian notion that science marches forward step by step in understanding. The history is much more dramatic than that. Boltzman committed suicide, and today he is considered one of the greatest scientists of the nineteenth century. He was one of the inventors of statistical mechanics. One of the reasons he committed suicide was because the leading intellectual figure in Vienna at that time was Ernst Mach and Mach didn't believe in atoms and all of Boltzman's work depended on the existence of atoms.

1. What does the non-linearity of science progress mean?
2. Could you give an example of the non-linearity of science progress?
3. What did Boltzman invent?

Another example is Maxwell, the other great scientist of the end of the nineteenth century. James Clerk Maxwell came up with Maxwell's equations for electromagnetism. The leading physicist of his time was Lord Kelvin, who decided that Maxwell was wrong. And when Maxwell died, there were only a handful of young physicists in England who thought that Maxwell was right.

Actually, **it was the German scientist Hertz who** found experimental evidence for the propagation of electromagnetic waves, **who turned the tide.**

What did Maxwell do in science?
What is the essence of his theory?
Why wasn't his theory accepted when he was alive?

O: So they were kind of too early?

C: Well, there are many stories like this. But of course when they write a history of science, they like to take all of that out and make it sound like science is a step-by-step march forward and that everyone agrees when a new idea comes. To show how little **that is the case** in science, as in other fields, there is a beautiful quote from Max Planck. Planck was one of the inventors of quantum theory, a very revolutionary theory. He did this work around nineteen-hundred. It was really the first step in the direction of quantum theory.

Max Planck made a remark that a new scientific theory never triumphs by convincing its opponents. The opponents are never convinced. What happens is they die and are replaced by a new generation who grew up with the new ideas and view them as natural **rather than** foreign

And I think **that is also the case** that very often deep scientific ideas are completely impractical when they start, **even though** fifty or a hundred years later they may have numerous technological consequences. So, **in a way**, deep science is like art because artists typically are in trouble. Well, the same is true with a lot of revolutionary science. It takes many years for a revolutionary idea to convince people and it takes many years for possible technological and economic consequences to develop.

1. **What theory did Max Planck invent?**
2. **When did he invent this theory?**
3. **What remark about science progress did he make?**
4. **Why is scientific community so conservative?**

ON COMPUTERS AND CYBERNATICS

When the work is first done it is completely impractical. Nuclear physics before the Second World War was like studying Greek poetry. There were only a handful of people who studied nuclear physics and it had no practical consequences. Computer technology, **in a way**, was a spin off a philosophical controversy about the foundations of mathematics: doubt about **whether mathematics has a firm foundation and how to make it firm.**

One of the suggestions, about a hundred years ago, was by a famous mathematician David Hilbert. And Hilbert said that we should formalize mathematics, make an artificial language for mathematical reasoning. That project failed in a very interesting way. Because the notion of total formalization, of a completely artificial language, where it is mechanical to see what something means, is, in fact, the most tremendous technological success of this past century: the computer! These artificial languages are everywhere now. But they are not artificial languages for **mathematical reasoning**. They are not for doing reasoning or deduction, which is what Hilbert wanted. They are languages for calculating, for algorithms, for programming.

1. Who is David Hilbert?

2. What does Chaitin mean when he says that Hilbert's project of formalizing mathematics failed in a very interesting way?

3. What does formalizing mathematics mean?

4. What are programming languages used for?

O: So Hilbert actually invented a computer?

C: **In a way**, yes. There is a clear intellectual line, a thread that you can follow.

O: And how do you see the whole cybernetic movement in relation to Hilbert? Was that influenced by him? Is there a link?

C: I think that there is a link because the key person is Turing. And Turing was trying to settle some of the questions that were very clearly asked by Hilbert. And **in order to** do this Turing had to come up with the notion of **a general-purpose computer** as a mathematical device, as a logical concept. He did this before there were any computers, in 1936. It is a fantastic piece of work; tremendously imaginative and profound. Turing was also interested in artificial intelligence, in programming computers to play chess. He was interested in morphogenesis, which is how the embryo develops and how an animal gets its shape: the design, for example, of the fur or the colors on a zebra or on a bird, the emergence of pattern in biological organisms. He was interested in all of these questions and, of course, cybernatics is man and machine, biology and technology.

O: And feedback loops…

C: Feedback loops, right. Norbert Wiener wrote a very popular book, an intellectual best-seller called 'Cybernatics'. It was thanks to that book that the word was known in the United States. Unfortunately, in the United States you can't use the word "cybernatics" anymore, because a large quantity of papers which were informal were published and created the impression that it was a field which was very superficial. So, in fact, if you do a piece of work on cybernatics, it is better not to call it cybernatics because that word has a bad reputation in the United States, **at least** there. May be in Russian they still call it cybernatics. I think they **used to**.

1. What is a general-purpose computer?

2. What is Turing's contribution to data processing technology?

3. What is morphogenesis?
4. What is cybernatics?
5. What is a feedback loop?
6. Why can't you use the word "cybernatics" in U.S. any more?

ON MOLECULAR BIOLOGY

C: I have a friend, who first was a mathematician and then became a computer scientist and who just spent the summer at Cold Spring Harbor Lab in Long Island, which is one of the great centers of research in molecular biology. I visited him there and he told me that molecular biology is really digital. You can clearly see digital information in biological organisms, and each cell is like an entire computer, **it turns out.** It is just amazing how complicated a cell is. The DNA is being turned on and off all the time. The cell is constantly doing things rebuilding itself. It has loops, it controls itself. It's like a programming language where genes are being turned on and off all the time. Cells are constantly being removed, replaced. The body is constantly rebuilding itself. The body isn't static. Jack **was wildly enthusiastic about** this, and the fact that a mathematician is wildly enthusiastic about biology shows that the time is ripe for a new cybernatics. You may use a different word, but the progress in molecular biology has gotten to a point now, where it is clearly the most exciting thing going on at this time in science, I think. It is not physics, that's not where the excitement is now. I heard a lovely lecture by a young woman, Laura Landwebber, who is a professor of molecular biology at Princeton University and she was saying how genes, in fact, are split into pieces. She is interested in doing computation with DNA, among many other things. She was explaining to us at a conference **that I was at** in Santa Fe, New Mexico, that, in fact, some genes are split into pieces on separate chromosomes and they have holes in them and different gaps and **so** they have to be spliced together and the whole thing looks very much like what goes on in a digital computer **in many ways**.

1. What is a cell comparable with?
2. What does a cell look like?
3. What do we mean when we say that the body isn't static?

4. What makes a cell and a computer alike?
5. What does he mean when he says that biology is digital?

Then at my lab I heard another lecture, by a physicist, Marcelo Magnasco, who is now doing biology at Rockefeller University in Manhatten. He explained to us that the body constantly rebuilds itself. Cells are constantly being told to self-destruct. There is a name in Greek for that, apoptosis: programmed cell death. Cells are ordered to self-destruct. One of the sources of cancer is if the cell doesn't obey. When something goes wrong in a cell the body gets rid of it and replaces it; the body is constantly rebuilding. For example, the reason why exercise is good for you is because the body is constantly rebuilding itself **depending on** what it sees it needs. And all of this is really very exciting, I think, intellectually.

1. What is one of the sources of cancer?
2. Why is exercise good to the body?

ON SUPERSTRING THEORY

C: **Of** the things I like personally, is a theory which has a few fundamental ideas, unifying ideas. My mind works **that way**. I like unifying ideas. I don't like complicated technical theories. The science of the future **may** well get much more complicated. And, who knows **whether there will be unifying ideas? So**, **may be**, it is a psychological need in some of us researchers to try and find these unifying ideas. But the physical world may decide that we are wrong. **It may turn out** that things are very complicated and messy.

O: And how do you see the supersymmetry of superstring theory as a unifying idea, unifying quantum mechanics and relativity? Did you read Green's book "The Elegant Universe"?

C: Well, superstring theory is a very good example. It has no experimental evidence in its favor. The arguments in favor of superstring theory are really of an aesthetic kind. **So far** there is no way to test the theory. People just say that it is so beautiful, it has to be true...They all say there is no alternative. I'm exaggerating a little. Not everybody thinks **that way**. Some of **the old-timers** like Shelly Glashow who has a

Nobel Prize in Physics and **used to be** at Harvard, don't like superstring theory.

O: So you would say the beauty of superstring theory is an attractor?

C: It attracts young people. By the beauty of the ideas, I think one would have to say that is the real reason. It involves some mathematics that is very difficult, and connects it with fundamental ideas...So you have to be good at both subjects to work in this field. But Shelley Glashow **used to** say, "This isn't physics, it is theology!", because there is no way of testing it. Superstring theory deals with energies which are so high that there is no conceivable way to test it in the foreseeable future. Witten, the leading figure in superstring theory, says superstring theory is physics from a century in the future, We are getting glimpses of it, but this theory is not for now, it's a theory for one hundred years from now.

1. What do you know about superstring theory?

2. What energies does it deal with?

3. Why is there no way to test it?

4. What kind of idea may the supersymmetry of superstring theory turn out to be?

5. Who does it attract?

6. What fields are you supposed to be good at to work with superstring theory?

ON HOW TO BECOME A SCIENTIFIC GENIUS

O: Witten leads me to the question about what Gardner calls "Creating Minds".

C: Let me tell you my personal theory of how somebody becomes a scientific genius. Look at Wittgenstein, for example. Wittgenstein was a lunatic. He was a philosopher, not a scientist. He is considered a great philosopher, right? But there are lots of lunatics in uninteresting ways. Let me make my point in science. To create a new theory of science, you have to be mad. You have to have this unjustified belief that all the **current** theories are wrong and that the physical universe is completely different. At the time you do this, the reason you are a genius, is because you are doing this when there is almost no evidence. Is it that by telepathy you read God's thoughts? No, what happens is that you have **prejudice** for some reason. May be you believe in astrology. May be, you have some philosophical prejudice or some religious prejudice or some psychological aspect that leads you to believe in this crazy idea. If the physical world **does not happen to believe in** this idea, then you **are considered to be** a fool or an eccentric. But if it happens that the physical world also believes in this idea, then you are considered a genius and everybody says, "How did you do it?"

1. Who is Wittgenstein considered to be?
2. What is Chaitin's personal theory of how somebody becomes a scientific genius?

When Einstein did his theories, he had the right psychology for relativity, but he hated quantum mechanics. And he had no interest in high energy physics, he spoke of it with contempt. He said it was like zoology, because there were so many sub-atomic particles. He wanted to understand just the electron, he just wanted fundamental knowledge. Murray Gell-Mann, who is at the Santa Fe Institute, is not at all like Einstein. Einstein was only interested in the most basic ideas. Murray Gell-Mann is interested in everything. He knows dozens of languages, he is interested in birds, he has a tremendous memory. He has an encyclopedic mind, the kind of mind which he needed to deal with high energy physics, with the particle zoo. It is a zoo and you needed a mind that could take this enormous number of facts and organize it. It helps if you have a personality that is needed at the moment to take the next major step.

1. What is the difference between Einstein's and Murray Gell-Mann' minds?
2. What does Chaitin compare high energy physics with?
3. What do you have to have to take the next step in science?

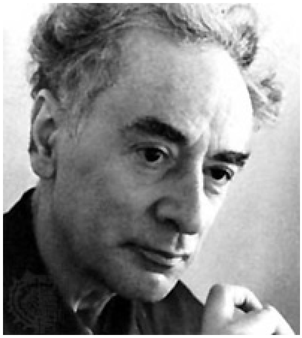
O: Can you tell me your thoughts on genius, which you mentioned with relation to Wittgenstein?

C: There is an element of madness in the sciences as much as in the arts, I think. You see, you have to be crazy to think something at a time when there is almost no evidence for it and go off in the direction from

the rest of the scientific community. And the scientific community will usually fight you. Then they will erase the history of how all of your contemporaries who had the political power fought against these new theories! That will be erased to make it sound like science is progressing linearly, always going forward. Science, of course is also full of emotion, of controversy and politics, because human beings are political animals. Science is a human activity and it is much more akin to the arts than people realize. Now, of course, there is art that isn't art, and that is also true of science. There is science which is very short-term or which is done only for immediate, financial or technological gain. That science can be very valuable, very useful, **the same way** that bad books can make a lot of money. In the United States they will sell a million copies of a book by Stephen King. And I don't think Stephen King has any desire to write great literature.

1. Why does Chaitin claim that one has to be mad to create a revolutionary theory?
2. Why does scientific community fight revolutionary theories?
3. What philosopher said that man is a political animal?

THEORETICAL PHYSICS



Lev Davidovich Landau

Born January 22, 1908

Read the text. Look up the underlined words. Translate the underlined sentences in writing.

The Soviet theoretical physicist Lev Davidovich Landau (1908–1968) developed a mathematical theory that explained the properties of superfluidity and superconductivity of helium at temperatures close to absolute zero.

Lev Landau, called "Dau" by his students and close associates, was born on Jan. 22, 1908, in Baku, the capital of Azerbaidzhan, to parents of middle-class Jewish background. At 14 he entered the University of Baku; then, in 1924, he transferred to Leningrad State University. In 1927 he graduated with a doctorate from the faculty of physics. Between 1927 and 1929 he continued his postgraduate studies at the Physico-technical Institute of Leningrad.

In 1929 Landau left the Soviet Union to study for a year and a half at the Institute for Theoretical Physics in Copenhagen **as well as** at scientific centers in Germany, Switzerland, Great Britain, and the Netherlands. During his stay at the institute in Copenhagen, he became closely associated with the Danish physicist Niels Bohr. Bohr invited Landau in 1933 and 1934 to attend several conferences on theoretical physics. When abroad, Landau published at the age of 22 his classic theory on the diamagnetism of electrons in a metal (Landau's diamagnetism).

Soon after returning to Leningrad, in 1932 Landau received an assignment to head the theoretical section of the Ukrainian Physicotechnical Institute; he also joined the faculties of the Kharkov Institute of Machine Construction and the University of Kharkov. In Kharkov the Landau school of theoretical physics had its beginning.

Between 1938 and 1960 Landau, together with his student and collaborator E. M. Lifshits, wrote a series of volumes under the heading of *Course of Theoretical Physics,* covering mechanics, classical field theory, quantum mechanics, relativistic quantum theory, statistical physics, fluid mechanics, theory of elasticity, electrodynamics of continuous media, and physical kinetics. Some of the sections are actually based on original research performed by the authors. There are **few** works on contemporary physics that match the *Course of Theoretical Physics* in terms of clarity of exposition and scope of treatment; it is **therefore** not surprising that in April 1962 this veritable encyclopedia received the Lenin Prize.

Low-temperature Physics

In 1937 Landau arrived at the Institute of Physical Problems of the Soviet Academy of Sciences to head its theoretical section. He concentrated on certain paradoxical results obtained from experiments with helium near absolute zero. Helium II is virtually frictionless in its motion; **yet** when it is placed between two rotating disks, a force, indicating the presence of viscosity, can be measured. In another experiment a flask containing liquid helium was immersed in a bath of liquid helium and then heated; liquid helium was observed to flow out of the flask, but the flask remained full. To explain this paradoxical behavior of liquid helium, Landau regarded helium II as a "quantum liquid" whose properties could not be treated **within the framework of classical mechanics**. He presumed that helium II possessed two simultaneous forms of motion: normal, which is viscous and transports heat, and superfluid, possessing neither viscosity nor thermal conductivity.

The paradox **associated with** the non-emptying flask was resolved by Landau's theory, which predicted a superfluid countercurrent whose behavior **conforms to** the hydrodynamic laws governing ideal and nonviscous fluids with irrotational flow. Landau's theory also predicted that two velocities of sound waves occur if sound is transmitted through helium II. The first sound wave oscillates in helium II as does an ordinary sound wave in an ordinary fluid. But the second sound wave is unique to superfluids. Landau called this wave a "zero" sound wave. For his work in low-temperature physics Landau received the Stalin Prize in 1941, the Fritz London Award in 1960, and the Nobel Prize in 1962.

Exercise 1

Answer the questions in writing.

1. What field was Landau concerned with?
2. What theory made him world famous?
3. What is the Danish physicist Niels Bohr famous for?
4. How did Landau happen to become associated with Niels Bohr?
5. How long did he stay abroad?
6. What scientific centers abroad did he study at?
7. What is Landau's diamagnetism?
8. Where did the Landau school of theoretical physics have its beginning?
9. Why was "The Course of Theoretical Physics" by Landau and Lifshits so highly appreciated?
10. What section did Landau head at The Institute of Physical problems of The Soviet Academy of Sciences?

Exercise 2

In pairs formulate questions and give answers.

1. Landau developed a theory………. (What theory?)
2. He graduated from……………….. (What faculty?)
3. He continued his postgraduate studies …. (At what Institute?)
4. He left the Soviet Union ……… (For how long?) (What ….. for?)
5. Bohr invited Landau to attend ……. (What conferences?)
6. Landau published his classical theory ………… (What theory?); (Where?); (How old was he when...?)
7. Landau received an assignment to ……… (What assignment?)
8. At the Institute of Physical Problems he concentrated on …… (What?)

Exercise 3

You are going to have a conference dedicated to Lev Landau. Summarizing the **answers to the questions (ex. 1 and ex. 2), prepare a talk.**

Exercise 4

(In groups)

You are having a talk at the conference. The audience asks you the above questions.

<u>Exercise 5</u>

Answer the questions in writing.

1. What results did Landau obtain from the experiments made with helium close to absolute zero?
2. Why were the results paradoxical?
3. What theory did Landau develop on the results of the experiments with liquid helium close to absolute zero?
4. How was the paradox associated with the non-emptying flask resolved by Landau's theory?
5. What happens when sound is transmitted through helium II according to Landau?
6. What is a zero sound wave according to Landau?
7. Why is the mathematical theory developed by Landau worth the Nobel Prize? What contribution to science did he make?

<u>Exercise 6</u>

Round table talk. In groups. You give the answer to the first question and address the next student with the next question.

LANDAU-GINSBURG THEORY OF SUPERCONDUCTORS

Landau-Ginsburg theory is a triumph of physical intuition. It is the central theory for understanding the properties of superconductors in magnetic fields.

Read the text. Look up the underlined words. Translate the underlined sentences in writing.

FYI (for your information)

The superconductor is an element, inter-metallic <u>alloy</u>, or <u>a compound</u> that will conduct electricity without resistance below a certain t°. Resistance is <u>undesirable</u> because it produces losses in the energy flowing through the material. <u>Once set in motion, electrical current will flow for ever in a **closed loop** of superconducting material, making it **the closest** thing to **perpetual motion** in nature.</u>

INTRODUCTION

Superconductors are materials which below a critical temperature have zero resistance. They can carry currents that will not decay and are very useful in the development of supercomputers. They fall into two categories, type I and type II. Which one they belong to depends upon **the effect** that a magnetic field **has upon** them.

TYPE 1 SUPERCONDUCTORS

Type 1 superconductors are perfect diamagnetics below their critical temperature, **that is,** they repel any magnetic flux that attempts to enter. This means that a strong enough magnet will **induce a current** in the conductor, which will produce an opposing magnetic field, and the magnet will float above the superconductor. This is called the Meissner-Ochsenfeld effect. Above the critical temperature, or the critical field strength, superconductivity **eliminates**, and the conductor's opposing field **collapses** and the magnet drops.

TYPE 2 SUPERCONDUCTORS

All the **original** superconductors, like mercury, fall into the category of type 1. **As** research continued, a new group emerged, which had two critical field strengths for a given temperature. Below the lower one these materials, (mostly alloys, **with the exception** of niobium and vanadium) act exactly like type 1 superconductor, and above the high field strength they act like normal materials at low temperatures.

Type 2 superconductors have unique properties that type 1 superconductors don't. They have a zero resistance but **do allow** a certain amount of flux penetrate (a magnetic field exists inside the conductor). This means that they are **no longer** perfect diamagnetics. There is no theory of superconductors **as yet.** Superconductors are believed to split into many layers, some superconducting, some not. Each normal conductor produces 1 quantum of flux. The magnetic flux is quantized on the same scale as energy. **As** the field strength increases, so does the number of cores of normal material. Eventually the material becomes completely dominated by the cores of normal material and superconductivity eliminates.

Exercise 1

Checking up understanding (in groups)

1. What is a superconductor?
2. Why is a superconducting material considered to be the closest thing to perpetual motion?
3. What is a supercomputer?
4. Why are superconductors useful in the development of supercomputers?
5. What effect does magnetic field have upon superconductors?
6. What is a diamagnetic?
7. What does the fact that diamagnetics repel any magnetic flux mean?
8. What is Meissner-Ochsenfeld effect?
9. At what temperature do superconductors lose superconductivity?
10. Why is it possible to say that superconductivity eliminates above the critical temperature, or the critical field strength? What makes temperature and field strength similar?
11. Why can't type 2 superconductors be considered perfect diamagnetics?
12. How does it happen that type 2 superconductors allow a magnetic flux to enter?
13. What makes achieving superconductivity without cooling a challenging task?

Exercise 2

Make up sentences using the below expressions. Follow the text.

1. to conduct electricity
2. to produce losses
3. to set in motion
4. a closed loop
5. perpetual motion
6. to repel magnetic flux
7. to induce a current
8. to produce an opposing magnetic field
9. to collapse

<u>Exercise 3</u>

(In groups)

Draw a picture of the experiment with Meissner-Ochsenfeld effect and explain what happens.

HIGH TEMPERATURE SUPERCONDUCTORS

Read the text and translate the underlined sentences.

Up till around 1986, all known superconductors had critical temperature of below 23 Kelvin. They could be cooled by helium, which in a liquid form is expensive and dangerous. In 1987, the research laboratory in Zurich started experiments on using oxides as superconductors. <u>The oxide used was copper, which was found to have a critical temperature of 30 Kelvin.</u>

The research was focused on trying to find a room temperature superconductor. A year and a half later the critical temperature reached over 77 Kelvin. This was a **breakthrough**. Superconductivity was achieved using liquid nitrogen. <u>It proved to be much cheaper and safer than liquid helium.</u>

Today, the highest critical temperatures are approaching 200 Kelvin **that is** over two thirds of the way to achieving superconductivity without cooling.

<u>Exercise 4</u>

You are a researcher of the research laboratory in Zurich. Write a report on the research done.

TRIO WINS NOBEL PRIZE IN PHYSICS

Stockholm, Sweden, Oct. 7 – Two American citizens and a Russian won the 2003 Nobel Prize in physics for theories about how matter can show <u>bizarre</u> behavior at extremely low temperatures. The Royal Swedish Academy of Sciences cited Alexei Abrikosov, Anthony Leggert and Vitaly Ginsburg for their work **concerning** two phenomena called superconductivity and superfluidity.

Superconductivity and superfluidity

<u>The two phenomena the researchers studied are linked, in that superconductivity arises from how pairs of electrons behave, while superfluidity comes about from pairing of atoms.</u>

Superconductivity is the ability of some materials to conduct electricity without resistance when they are chilled to extremely low temperatures. Superconducting magnets are used to produce powerful magnetic fields for **standard body scanning technique** called **magnetic resonance imaging**, or MRI.

Researchers hope to harness superconductivity for such uses as power lines that can conduct current without waste to resistance and high-speed trains that float above the tracks.

Superfluidity occurs when liquid helium is chilled to near absolute zero, the coldest anything can get. The liquid begins to flow freely with little apparent friction. It can even climb up the sides of a beaker.

Phill Schewe, a physicist and chief science writer at the American Institute of Physics, said superfluidity doesn't appear to have as many applications as superconductivity. But "it may well prove to be important just because it is so odd," he said.

The Swedish Academy said researchers can use superfluid helium to study other physical phenomena, like how order can **turn to** chaos. Such research might illuminate the ways in which turbulence arises, "one of the last unsolved problems of classical physics,' the Swedish academy said.

Exercise 5

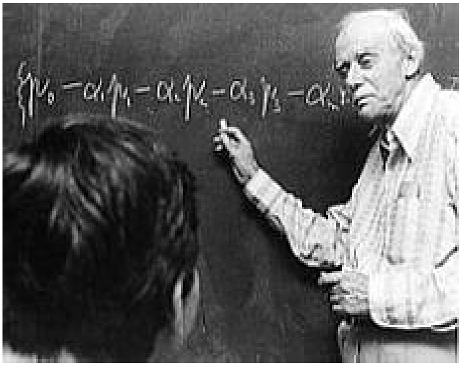
Write out of the text the sentences concerning practical applications of superconductivity and superfluidity.

PAUL ANDRIAN MORICE DIRAC

Paul Andrian Morice Dirac – 1902–1984

Paul Dirac received the Nobel Prize in Physics in 1933 at the age of 31.

P.A.M. Dirac as a young man



Paul Dirac in his 80's

Read the interview. Look up the underlined words. Translate the underlined sentences in writing.

The following interview with Paul Dirac was conducted by David Peat (DP) and Paul Buckley (PB) in the early 1970's.

DP: Do you feel that there is the same excitement today in physics that there was in the twenties and thirties?

The problems are more difficult now and there is little hope of making rapid progress which there was in those days. Excitement is usually combined with the hope of making rapid progress, when any second-rate student can do really first-rate work. But the easier fundamental problems have **by now** all been worked out. The ones that are left are very difficult to work on, and one doesn't feel able to get the right basic ideas for handling them.

DP: Do you feel that the progress in particle physics is fruitful?

It's not really fundamental: it's collecting a mass of information and one doesn't really know how to get the basic ideas from it. Just like in the early 1920s one had a mass of spectroscopic information and it needed Heisenberg to find the real basis of a new theory from that wealth of material.

DP: Do you think a unification theory necessarily will have to include relativity?

I should think so, **ultimately**. Perhaps not gravitation; gravitation is rather separate from ordinary atomic physics and it plays very little role.

DP: The quantization of relativity seems to be an insurmountable problem to most people. It is something you have worked on.

One can deal with it **up to** a certain point, but one cannot complete the theory in a satisfactory way.

DP: Could you summarize your thinking on the large numbers hypothesis?

The large numbers hypothesis **concerns** certain dimensionless numbers. An example of a dimensionless number provided by nature is the ratio of the mass of the proton to the mass of the electron. There is another dimensionless number which connects Planck's constant and the electronic charge. This number is about 137, quite **independent of** the units. When a dimensionless number like that turns up, a physicist thinks there **must** be some reason for it. Why should it be, well, 137, and not 256, or something quite different?. At present one cannot **set up** a reason for it, but still people believe that with future **developments** a reason will be found.

Now, there is another dimensionless number **which is of importance.** If you have an electron or a proton, the electric force between them is **inversely proportional to the square of the distance**; the gravitational force is also inversely proportional to the square of the distance; the ratio of those two forces does not depend on the distance. The ratio gives you a dimensionless number. That number is extremely large, about ten **to the power thirty-nine**. Of course it doesn't depend on what units you're using. It's a number provided by nature and we should expect that a theory will some day provide a reason for it.

How could you possibly expect to get an explanation for such a large number? Well, you might connect it with another large number – the age of the universe. The universe has an age. because one observes that the spiral nebulae, the most distant objects in the sky, are all receding from us with a velocity proportional to their distance, and that means that at a certain time in the past, they were all extremely **close to** one another.The universe started quite small or perhaps even as a mathematical point, and there was a big explosion, and these objects were shot out.. **The ones that** were shot out fastest are **the ones that** have gone the farthest from us. That explains the relationship (Hubble's relationship) that the velocity of recession is proportional to the distance, and **from the** connection we get the age of the universe. It's called the big bang hypothesis. There is a definite age when the big bang occurred. The most **recent observations** give it to be about eighteen billion years ago.

Now you **might** use some atomic unit of time **instead of** years, years is quite artificial, **depending on** our solar system. Take an atomic unit of time, express the age of the universe in this atomic unit, and you again get a number of about **ten to the thirty-nine**, roughly the same as the previous number.

Now you **might** say this is **a remarkable coincidence** .But it is rather hard to believe that. One feels that there must be some connection between these very large numbers, a connection which we can't explain at present but we shall be able to explain in the future when we have a better knowledge of **both** atomic theory and **of** cosmology.

Let us assume that these two theories are connected. Now one of these two numbers is not a constant. The age of the universe, of course, gets bigger **as** the universe gets older. **So**, the other one **must** be increasing also in the same proportion. That means that the electric force **compared with** the gravitational force is not a constant, but is increasing proportionally to the age of the universe.

The most convenient way of describing this is to use atomic units, which make the electric force constant; **then**, referred to these atomic units, the gravitational force will be decreasing. The gravitational constant, usually denoted by G when expressed in atomic units, is **thus** not a constant any more, but is decreasing inversely proportional to the age of the universe.

One would like to check the result by observation, but the effect is very small. However, one can hope that **with** observations that will be made within the next few years, it will be possible to check whether G is really varying or not. If it is varying, then we have the problem of fitting this varying G **with** our previous ideas of relativity. The ordinary Einstein theory demands that G shall be a constant. We **thus** have to modify it **in some way**. We don't want to abandon it altogether because it is so successful.

I have proposed **a way** of modifying it which refers to two standards of length, one standard of length which is used in the Einstein equations, and the other which is determined by observations **with** atomic apparatus. I should say that the idea of two standards of length and of G varying with time is not **original**. This sort of idea was first proposed by Milne about forty years ago.. But he used different arguments from mine. His equations are **in some respects** similar to mine: **in other respects** there are differences. **So** this theory of mine is **essentially** a different theory **although** based on some ideas which were first introduced by Milne. One should **give Milne credit for** having the insight of thinking that perhaps the gravitational constant is not really constant **at all**. Nobody else had questioned that previously.

DP: This theory has an important consequence for the creation of matter.

Yes, the amount of particles – elementary particles, protons and neutrons – in the universe is about **ten to the seventy-eight**, the square of the age of the universe. It seems again one should say that this is not a coincidence. There is some reason behind it, and **therefore** the number of particles in the universe will be increasing proportionally to the square of the age of the universe. **Thus**, new matter must be continually created.

There was previously a theory of **continuous creation of matter** called the **steady state cosmology**, but this theory of mine is different because the steady state cosmology demands that G shall be a constant. Everything **then** has to be steady, and **in particular** G has **to keep a steady value**. Now, I want to have G varying, and I also want to have continuous creation. It's possible to combine those two ideas and I have worked out some equations on possible models of the universe **incorporating** them.

PB: One of the consequences of your theory is that it rules out an expanding-contracting universe.

That is so, yes, because in **the** theory there will be a maximum size. This maximum size, expressed in atomic units, would give a large number which does not vary with the time. Now, I want all large numbers to be connected with the age of the universe **so that** they all increase **as** the universe gets older. If you have a theory giving you a large number, of the order of **ten to the thirty – nine**, which is constant, you must rule out that theory.

PB: This implies a constantly expanding universe.

Yes. It must **go on expanding** forever. It can't just turn around and contract, like many people believe.

PB: So that avoids the singularity at the end, so to say.

Yes, that is avoided; there is just a singularity at the beginning.

PB: There seems to be, or at least it is possible that one may observe such a thing as a black hole, which is a theoretical consequence of general relativity. That is also a singularity, is it not?

It depends on what **mathematical variables** you use. It would be a very local singularity **anyway**, not a cosmological one.

PB: It seems staggering to the imagination that the mass of the star is concentrating into a smaller and smaller volume. I know there are repulsive forces that can stop it at various stages, but finally, I understand that the star, that is five or ten times the mass of our sun, wouldn't stop.

That is what it seems, according to **current theories.**

PB: It is difficult to imagine such an object, but I suppose that is not a necessary condition for doing physics.

If you can find equations for it, that's all a physicist really wants to. It is quite likely that the laws will get modified under these extreme conditions; we'll have to try to find out what the correct laws are.

PB: The papers you produced have been universally considered beautiful. Were you guided by notions of beauty?

Very much so. One can't just make **random** guesses. It's a question of finding things that **fit together** very well. You're solving a problem, it might be a crossword puzzle, and things don't fit, and you conclude you've made some mistakes. Suddenly you think of corrections and everything **fits**. You feel great satisfaction. The beauty of the equations provided by nature is much stronger than that. It gives one a strong emotional reaction.

Exercise 1

Answer the questions in writing using the language patterns of the interview.

1. What theories does the unification theory include?
2. What numbers does the large numbers hypothesis concern?
3. How do scientists know how old is the universe?

4. From what can scientists get the age of the universe?

5. How can scientists explain the remarkable coincidence of the two numbers? What two numbers?

6. How did Paul Dirac come to the conclusion that the electric force is not a constant?

7. Gravitational G is not a constant according to Dirac. How did he come to this conclusion? What problem will we have here? What does the Einstein theory demand? Who was the first to question the gravitational constant?

8. What is the amount of elementary particles in the universe equal to? What remarkable coincidence can be traced here? In what way will the number of particles in the universe be increasing according to Dirac? What consequences does his hypothesis have?

9. What is the essence of the steady state cosmology theory? What does the steady state cosmology demand? In what way is Dirac's theory different?

10. What equations on the possible models of the universe did Dirac work out?

11. What are the consequences of Dirac's theory on the possible models of the universe? Does his theory agree with the current model?

12. What did the universe evolve from?

13. Can a black hole be considered a singularity?

14. What is a necessary condition for doing physics?

Exercise 2

A Round Table Talk. Answer the above question and address the next talker with the next question.

Exercise 3

Write a short essay on one of the below topics.

1. The state-of-the art of fundamental physics. Breakthroughs made over 30 years.

2. The progress made in elementary particle physics over 30 years.

Exercise 4

The conference "The Progress Made in Physics over 40 Years." You are giving a talk. The audience asks you questions and gives comments.

INTERVIEW BY LYNDON F. HARRIS WITH JOHN POLKINGHORNE, professor of mathematical physics at Cambridge

"When we say "the world" we usually mean our planet earth rather than the one hundred thousand million galaxies of the observable universe. We should enlarge our horizons."

Serving for twenty-five years as Professor of Mathematical Physics at Cambridge, Polkinghorne distinguished himself in the field of elementary particle physics and in 1974 was named as a Fellow of the Royal Society.

Read the interview, look up the underlined words and translate the underlined sentences in writing.

LH: Let's start with the subject of cosmology. There is **a great deal of** talk in scientific society about the extraordinary revolution presently taking place in human understanding, the shift from a Newtonian to an Einsteinian cosmology. What are the underlining issues, **taking into consideration** the shift from the dualistic thinking of Descartes and Newton to the present understanding of reality as one?

JP: I think two important things have happened. One is certainly associated with Einstein, the recognition of the relational character of reality. The Newtonian picture was that space was a sort of container, and there were little independent particles that whizzed around and banged into each other. That picture has been replaced by a unified understanding, derived from Einstein's general theory of relativity, that space and time and matter are all linked together, so that the world is relational in that sense.

Then there's been a second revolution of quantum theory, which **has brought about a number of** changes in our thinking about the world. First, the world is **no longer** tightly deterministic and mechanical; there is a probabilistic character to physical processes. And, of course, quantum theory also has its own relational character. **Once** two quantum entities interact with each other, they **retain** a very surprising power to influence each other, however far they are separate. Quantum theory also tells us that the world is not simply objective; somehow it's something more **subtle** than that. In some sense it is veiled from us, but it has a structure that we can understand.

JP: Can we speak about the laws of evolution?

Evolution, of course, is not something that applies to life here on earth; it applies to the whole universe. **After all**, the universe required ten billion years of evolution before life was even possible; the evolution of the stars and the evolving of new chemical elements in the nuclear furnaces of the stars were **indispensable prerequisites** for the generation of life. The laws that we understand as the laws of nature had to be **finely** tuned to make this possible. **The physical fabric** of the world had to be such **as to enable** that ten billion year preliminary evolution could produce the raw materials of life. Without it there would not have been the chemical materials to allow life to evolve here on earth. When we say "the world" we usually mean our planet earth, **rather than** the one hundred thousand million galaxies of the observable universe. We should enlarge our horizons. We should understand that the great Cartesian program of clear and certain ideas, of foundational knowledge beyond the possibility of doubt, is **unattainable.** A very helpful way is that of steering a middle course between thinking that you can prove things **in some logically decisive way**, and thinking there is no truth to be found or knowledge to be gained.

LH: In your book you stated that "**rather than** being the first of the new scientists, Einstein is really one of the last ancients." What do you mean by this?

JP: Of course, Einstein was a very great scientist indeed, and I have enormous respect for him, and great admiration for the discoveries he made. But he was very committed to a view of the objectivity of the physical world. He wanted the physical world to be picturable, wanted it to be deterministic, and he wanted these things, I think, because he believed those qualities would guarantee the reality of the physical world. Like all scientists, Einstein believed very passionately in the reality of the physical world, and that we really learn something of its nature in our scientific investigations**. I share that view**, but I don't think that means we have to commit ourselves to a purely objective view of the physical world in the classical sense. It's clear to me that quantum theory (a theory that Einstein hated and never truly accepted), shows us that the world is more subtle, more veiled than that. **Nevertheless**, all of us who work in quantum physics believe in the reality of a quantum world, and the realities of quantum entities like protons and electrons. The basic reason we believe this is not because they are objective in the classical sense – because they are not – but because **the supposition** of their existence **enables** us to understand, **to a great extent**, physical experience.

LH: Would you say a few words about Paul Dirac, his discovery of the positron, and the development of quantum physics?

JP: I learnt my quantum physics from Dirac, who was one of the founding fathers of the subject, a sort of scientific saint. He had **both** great singleness of mind **and** great humility. He made very significant discoveries through the pursuit of beautiful equations, but never emphasized his own part in them or attached his own name to them. One of the fascinating things about the physical world is that its fundamental structure seems always to be expressed in beautiful mathematics. **To me it suggests** that there is a Mind behind the structure of the world, and that our minds are somehow attuned to that Mind. One of the greatest minds of physics in the twentieth century, Dirac was not a **conventionally** religious person **at all.** In his young years he was rather opposed to religion, but became more understanding – **though** not exactly accepting – of it in later life. He was once asked what his fundamental beliefs were and he turned to a blackboard and wrote "the equations of physics are expressed in beautiful mathematics." It was mathematical beauty that led to his great discoveries. He discovered antimatter, and how **to put** quantum mechanics and relativity **together**.

LH: **Professor Polkinghorne, thank you very much for the pleasure of this interview**.

JP: **Thank you, Lyndon. I very much enjoyed the conversation**.

Exercise 1

a. Match the left column adjectives with the right nouns.

1. subtle	a. furnace
2. indispensable	b. fabric
3. nuclear	c. materials
4. physical	d. world
5. raw	e. beliefs
6. enormous	f. respect
7. basic	g. reason

8. significant	h. discovery
9. beautiful	i. equations
10. fundamental	j. sciences

b. Make up short, logical sentences with the above adjective noun combinations.

<u>Exercise 2</u>

a. Put the verbs in brackets into correct tenses (active or passive) and complete the sentences.

b. Formulate questions.

1. The Newtonian picture of the world ……… (to be replaced) (What ………. by?)
2. A unified understanding ……… (to be derived from) (What …… from?)
3. Space, time and matter ……… (to be linked together) (Tag question)
4. Quantum theory ……… (to bring about) (What?)
5. Quantum entities ………. (to retain) (What power?)
6. Evolution ……… (to apply to) (Tag question)
7. The laws of nature… (have to be tuned) ……… (Why?)
8. Einstein ……… (to want) ……… (Why?)
9. Einstein ……… (to accept) ……… (Why?)
10. The equations of physics ……… (to be expressed) ……… (Tag question)

<u>Exercise 3</u>

In pairs have a talk with Prof. Polkinghorne. One of you is Prof. Polkinghorne, the other is a Russian physicist (make up a dialogue on the basis of ex. 2).

<u>Exercise 4</u>

Read the interview again. Which Polkingstein's statements could you argue with? Formulate your arguments in writing. Begin with: I don't agree that….

Exercise 5

Write a short essay on one of the topics.

1. The underlying issues that motivated a revolutionary shift presently taking place in human thinking from a Newtonian to an Eisteinian cosmology.

2. The difference between Newtonian cosmology and that of Einstein.

3. The personality of Einstein as Polkingstein sees him.

4. The personality of Dirac as Polkingstein sees him.

Exercise 6

Class activity: Conference: "Einsteinian Cosmology."

Talkers give their talks, the audience asks questions and provides arguments in case of disagreement.

COMPUTER SCIENCE

THE COMPUTER

Read the text, look up the underlined words and translate the underlined sentences in writing.

Introduction

Computer is a machine that performs tasks, such as mathematical calculations or electronic communication, under the control of **a set of** instructions called a program. Programs are retrieved and processed by computer electronics, and the program results are stored or routed to output devices, such as video display monitors or printers. Computers are used to perform a wide variety of activities with reliability, accuracy and speed.

How Computers Work

The physical computer and its components are known as hardware. Computer hardware includes the memory that stores data and instructions; the central processing unit (CPU) that carries out instructions; the bus that connects the various computer components; the input devices, such as a keyboard or mouse that allow the user to communicate with the computer; and the output devices, such as printers and video display monitors, that **enable** the computer to present information to the user. The programs that run the computer are called software. Software **is generally designed** to perform a **particular** task, for example to write a letter, to draw a graph, or to direct the general operation of the computer.

The Operating System

When a computer is turned on it searches for instructions in its memory. Usually, the first set of instructions is a special program called the operating system, which is the software that **makes** the computer work. It prompts the user for input and commands, reports the results of these commands, stores and manages data, and controls the sequence of the software and hardware actions. When the user requests that a program run, the operating system loads the program in the computer's memory and runs the program. Popular operating systems, such as Windows, have a graphical user interface (GUI)-**that is**, a display that uses tiny pictures, or icons, to represent various commands. To execute these commands, the user clicks the mouse on the icon or presses a combination of keys on the keyboard.

Computer Memory

To process information electronically, data are stored in a computer **in the form** of binary digits, or bits, each having two possible representations (0 or 1). If a second bit is added to a single bit of information the number of representations is doubled, **resulting in** four possible combinations: 00,01,10, or 11.

A third bit added to this two-bit representation again doubles the number of combinations, **resulting in** eight possibilities: 000, 001,010, 011, 100,101, 110, or 111. **Each time** a bit is added, the number of possible patterns is doubled. Eight bits is called a byte; a byte has 256 combinations of 0s and 1s.

Input devices

Input devices, such as a keyboard or mouse, permit the computer user to communicate with the computer. Other input devices include a joystick, a rodlike device often used by game players; a scanner, which converts images such as photographs into binary information that the computer can manipulate; a light pen, which can draw on, or select objects from a computer video display by pressing the pen against the display surface; a touch panel, which senses the placement of a user's finger; and a microphone, used to gather sound information.

The Central Processing Unit (CPU)

Information from an input device or memory is communicated **via** the bus to the CPU, which is the part of the computer that translates commands and runs programs. The CPU is a microprocessor chip- it is a single piece of silicon containing millions of electrical components. Information is stored in a CPU memory location called a register. Registers can be thought of as the CPU's tiny scratchpad, temporally storing instructions or data. When a program is run, one register called the program counter keeps track of which program instruction comes next. The CPU's control unit coordinates and **times** the CPU's functions and retrieves the next instruction from memory.

In a typical sequence, the CPU locates the next instruction in the appropriate memory device. The instruction **then** travels along the bus from the computer's memory to the CPU, where it is stored in a special instruction register. **Meanwhile**, the program counter is incremented to prepare for the next instruction. The current instruction is analyzed by a detector, which determines what **the** instruction will do. Any data the instruction needs are retrieved via the bus and placed in the CPU' s registers. The CPU executes the instruction, and the results are stored in another register or copied to **specific** memory locations.

Output Devices

Once the CPU has executed the program instruction, the program may request that information be communicated to an output device, such as a video display monitor or a flat liquid crystal display. Other output devices are printers, overhead projectors, videocassette recorders, and speakers.

Exercise 1

Give Russian equivalents.

a set of, to be designed to, particular, operation, to control, to make somebody do something, that is, in the form, to result in, each time, any, via, to time, typical, then, meanwhile, specific, once

Grammar

…………………, S + Ving = причем

To process information electronically, data are stored in a computer in the form of digits or bits, **each having two possible presentations**.

Exercise 2

Comprehension (in pairs)

1. How would you define a computer?
2. What is computer hardware?
3. What does computer hardware include?
4. What is the function of the memory?
5. What is the function of the CPU?
6. What is the function of the bus?
7. What is the function of input devices?
8. What are icons used for?
9. What is the function of output devices?
10 What is the operating system? What is its function?
11. In what form are data stored in a computer?
12. What is the function of a scanner?
13. What is the CPU like?
14. What is the function of registers?

15. What is the function of the CPU's control unit?
16. What is the function of a decoder?

<u>Exercise 3</u>

Terms are expressed as a chain of Ns alternated with adjectives and participles. The last N in the chain is the basic one. Give Russian correspondence.

1. a graphical user interface
2. a CPU memory location
3. the program counter
4. an instruction register
5. a program instruction
6. a flat crystal liquid display

<u>Exercise 4</u>

Make up short, logical sentences with the below verbs and expressions.

1. to perform a task
2. to store data
3. to carry out instructions
4. to turn on (off) the computer
5. to control the sequence of instructions

6 to request

7. to load
8. to process information
9. to retrieve an instruction from memory
10. to determine
11. to execute an instruction
12. to communicate information to

FUTURE DEVELOPMENTS

Read the text, look up the underlined words and translate the underlined sentences in writing.

In 1965 semiconductor pioneer Gordon Moore <u>predicted</u> that the number of transistors contained on a computer chip would double every year. This is now known as Moore s Law, and it has proven to be somewhat accurate. The number of transistors and the computational speed of microprocessors currently doubles approximately every 18 months. Components continue to shrink in size and are becoming faster, cheaper and more versatile.

With the increasing power and versatility, computers simplify day-to-day life. Unfortunately, as computer use become more widespread, so do the opportunities for misuse. Computer hackers – people who illegally gain access to computer systems – often violate privacy and can destroy records. Programs called viruses or worms can replicate and spread from computer to computer, erasing information or causing computer malfunctions or failure. Other individuals use computers to embezzle funds and alter credit histories. New ethical issues have arisen, such as how to regulate material on the Internet and World Wide Web. Individuals, companies and governments are working to solve these problems by developing better computer security and enacting regulatory legislation.

Computers will become more advanced and they will also become easier to use. Reliable speech recognition will make the operation of a computer easier. Virtual reality, the technology of interacting with a computer using all of the human senses, will also contribute to better human and computer interfaces. Standards for virtual reality program languages, called Virtual Reality Modeling Language (VRML), are **currently** being developed for the World Wide Web.

Breakthroughs occurred in the area of quantum computing in the late 199Os.Quantum computers **under development** use components of a chloroform molecule (a combination of chlorine and hydrogen atoms) and a variation of a medical procedure called magnetic resonance imaging (MRI) to compute at molecular level. Scientists used a branch of physics called quantum mechanics, which describes the activity of subatomic particles (particles that make up atoms), as the basis for quantum computing. Quantum computers may one day be thousands to millions of times faster than current computers, because they **take advantage of** the laws that govern the behavior of subatomic particles. These laws allow quantum computers to examine all possible answers to a query at one time. Future uses of quantum computers could include large database queries.

Communication between computer users and networks will benefit from new technologies, such as broadband communication systems that carry significantly more data and carry it faster, to and from the vast interconnected databases that continue to grow in number and size.

a development – an innovation – the process of making a basic design more advanced
versatile – used for many different purposes
to violate privacy – to disturb, to interrupt, to break
to replicate – to make an exact copy of it
to embezzle funds – to take money illegally
to alter – to change
to enact legislation – to pass a law so that it becomes legal
to contribute to – to help to make smth better.
to take advantage of – to use
a query – a question
to benefit from – to profit from
ethics – moral beliefs and rules about right and wrong

Exercise 1

Checking up understanding (in pairs)

1. What field did Gordon Moore specialize in?
2. How did Moore formulate his law?
3. How accurate has his law proven to be?
4. Who are computer hackers?
5. What can a computer virus do?
6. What is virtual reality?
7. What ethical issues have arisen in the field of virtual reality?
8. What is being done to solve the ethical problems?
9. Along what lines will computers develop?
10. What computer languages are being developed for the World Wide Web?
11. At what level will quantum computers make calculations?
12. What is the basis of quantum computing?
13. What is the advantage of a broadband communication system?

Exercise 2

Make up short logical sentences with the below expressions. E.g. Computer hackers gain access to computer systems illegally.

1. to gain access to
2. to violate privacy
3. to destroy records
4. computer malfunctions
5. a question arises
6. speech recognition
7. to interact with the computer
8. to contribute to
9. a breakthrough
10. to be under development
11. to take advantage of
12. at one time.
13. to benefit from.

Exercise 3

In pairs formulate questions and give answers.

1. Moore predicted ……… (What?)
2. Moore's law has proven to be accurate (general question)
3. Hackers gain access to computer systems ……… (How?)
4. Viruses can spread from computer to computer ……… (What?)
5. New ethical issues have arisen ……… (What ………?)
6. Individuals, companies and governments are solving ethical issues ……… (How?)
7. Breakthroughs occurred in the area of quantum computing ……… (When?)
8. Quantum computers under development use ……… (What?)
9. Quantum mechanics describes ……… (What?)
10. The laws governing the behavior of subatomic particles allow quantum computers to ……… (What?)
11. Communications between computer uses and networks will benefit from ……… (What new technologies?)

<u>Exercise 4</u>
Brainstorming
(In groups)

1. What is a chip?
2. What is a transistor?
3. What is a computer virus?
4. What is virtual reality?
5. What issues does computer ethics consider?
6. How can one protect computers from hackers?
7. In what way is it possible to increase the number of transistors on a chip?
8. In what way is it possible to make computer components smaller, cheaper, more versatile?
9. What will the improvement of computer components result in?
10. What is the advantage of quantum computers over modern computers?
11. What are the advantages of broadband communication systems?

PRESS RELEASE

2007 PHYSICS NOBEL PRIZE AWARDED TO FRENCH PHYSICIST ALBERT FERT

Paris, October 9, 2007

Read the text. Make up a list of the terms used in the text and explain their essence and **functions.**

The 2007 Nobel Prize has just been awarded to Albert Fert, Professor at the University of Paris. It rewards his discovery of giant magnetoresistance (GMR) and his contribution to the development of spin electronics, or spintronics. GMR was **in particular** at the origin of <u>high performance magnetic read heads</u>, which are today used in all <u>hard drives</u> The prize was also awarded to Peter Grunberg, who with his team in Germany obtained similar results at almost exactly the same time.

Albert'Fert's research in the field of nanosciences, and especially his discovery of giant magnetoresistance, **has already had a major impact on** information and communications technologies. Since 1997, all hard disk drive read heads have used the giant magnetoresistance of magnetic **multilayers in order to** read the information recorded on magnetic disks. The performance of such heads has made it possible to multiply the amount of information stored on one disk **a hundredfold.**

Translate the paragraph in writing.

Giant magnetoresistance was discovered in 1988 and led to the emergence of a new kind of electronics, called spintronics, which, like GMR, **makes use of** the influence of electron spin on electrical conduction. Albert Fert **has made a significant contribution to** the development of spintronics, especially in the field of so-called **spin transfer phenomena**, which will have major applications such as the switching of **magnetic memory devices** and the construction of **radiofrequency oscillators** for professional electronics. **Spintronics is today a booming nanoscience**. **The trend** is toward hybrid systems that **associate** magnetic materials **with** semiconductors or molecules, which **promises** numerous applications in the fields of information technology and telecommunications.

Exercise 1

a. Finish up the sentences.

b. Formulate questions. Follow the text (to be done in writing).

1. Fert's discovery of giant magnetoresistence had a major impact on ……… (What technologies ?)
2. In order to read the information recorded on magnetic disks hard disk drive read heads use ……… (What?)
3. The performance of such heads has made it possible to multiply the amount of information stored on one disk ……… (How many times?)
4. Giant magnetoresistance was discovered in ……… (When?)
5. Giant magnetoresistance led to ……… (What ……… to?)
6. Spintronics makes use of ……… (What?)
7. Albert Fert has made a significant contribution to ……… (What fields?)
8. Spin transfer phenomena will have such applications as ……… (What applications?)
9. Spintronics is today ……… (What kind of science?)
10. Hybrid systems associate ……… (What?)

11. Association of magnetic materials with semiconductors or molecules promises numerous applications in the fields ……… (In what fields?)

Exercise 2

(In groups)

One of you is Fert, the others are computer scientists, who ask him the above questions.

Exercise 3

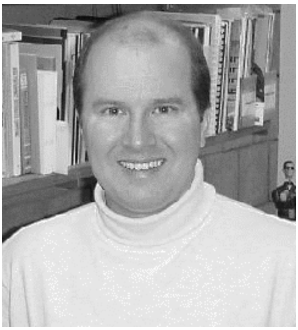
What did Albert Fert discover? Write a summary.

Exercise 4

(In groups)

Discuss if Fert's discovery is worth a Nobel prize. Would you vote for him if you were in the jury? Ground out your point of view.

INTERVIEW WITH BRUCE MAGGS, VICE_PRESIDENT FOR R@ DEVELOPMENT AT AKAMAI TECH



Read the interview.

I: Can you tell us a little about yourself?

B: Sure. I am a computer scientist. I am a professor at Carnegie Mellon (CMU). I grew up in Illinois. I **went to the university** at MIT, in Boston; I **received my undergraduate degree** and my Ph.D. there. After that I **served as** a postdoc at MIT and then I went to NEC labs, a big research institute, established by the Japanese company. After spending three and a half years there I **came to** CMU. I have been here for seven years. I **took three semesters off** to a company called Akamai that started. While at Akamai I was **the vice-president for research and development** and I was **in charge of managing all engineering efforts**.

In pairs. One of you is an interviewer, the other is Bruce Maggs.

1. **What is your field?**
2. **What is your position in Carnegie Mellon?**
3. **What university did you go to?**
4. **What did you do after that?**
5. **What is NEC labs?**
6. **How long did you stay there?**
7. **What did you do then?**
8. **How long have you stayed here?**
9. **How did you happen to come to Akamai?**
10. **What was your position in Akamai?**
11. **What were you in charge of?**

I: Can you tell us about your research interests?

B: I worked in the general area of **parallel computing**. **In particular** I studied the problem of what should the general structure of a parallel computer be. You have many independent processors connected with some sort of communication network: how should the network look like, and how should the processors make use of it? I **have become interested in networking**. After my stay at Akamai **I've shifted my focus**. I was mostly a theoretician before, but now **am working on problems** that are **somewhat** more intermediate. In the end I think that most of the work I will do will have some sort of **theoretical justification.**

1. **What are your research interests?**
2. **What problem did you study in particular?**
3. **What should the general structure of a parallel computer be?**
4. **Why have you shifted your focus after your stay in Akamai?**
5. **You are mostly a theoretician, aren't you?**
6. **What problems are you working on now?**

I: This is great, because I have many questions about the relation between theory and practice, and how they blend. **Let me ask** exactly that: **How do you view** the relationship between systems research and theory? <u>They seem to be rather disjoint</u>; the two communities don't talk to each other that often. What do you think?

B: I think there are <u>a few</u> **misconceptions**, and in fact there is <u>a **fair** amount</u> of interactions between the two. But **finding common ground**, where work done from one point of view **is** immediately **beneficial to** the other is a challenge. The theoretician can apply their most powerful tools when there is a nice, clean, abstract model and the system builders can t**ake advantage of** theoretical ideas when **the implementation details** are **manageable** and not horrendously complicated.. It's true**, though**, that people tend to view themselves as being in one camp or the other. **Therefore** some real effort has to go into making connections with the other side. And there is only a small number of people who are well-known in both communities. Other common misconceptions are that theoreticians are impractical and system builders are incapable of **theoretically sound designs.** I think that both of these are wrong. I think that theoreticians, when they have been properly "educated" with **the real systems issues** in a **particular** domain, can develop the right models and apply the right tools to improve the best designs that could be constructed without having **a theoretical basis**. I also think that the people in systems can appreciate and even derive good theoretical designs. I have seen, **at least** at Akamai, that theoreticians were able to rapidly and eagerly **become integrated into big systems building projects**. Details of, say, how Linux **implements some networking protocols** cannot be easily learned by a theoretician in a short time, but working with the system builders you **get to know** these details, and **have a feel for** why things are **the way** they are. It's possible for theoreticians **to have** **a big impact on** the design of really big systems. Especially when what is cast into software will have to scale to magnitudes of thousands of machines, and terabytes of data collected.

1. You say there are a few misconceptions between systems research and theory. Can you explain what you mean?
2. What do you mean by finding common ground?
3. How do you view the relation between theory and practice? What is the challenge here?
4. Is it possible for a theoretician to become integrated into big systems building projects?

I: You are pushing me to ask you about Akamai.

B: Akamai is the leader in **Internet content delivery.** What that means is that Akamai serves, for example, the images that appear on the most popular web sites in the world. Akamai has, may be, 1400 customers. The customers use Akamai for the actual **delivery of the bits that make up the images or the video streams rendered on the end user workstation**. Akamai has a lot of high-profile customers, such as Yahoo, Microsoft, Apple, CNN, and these customers have outsourced the problem of quickly **delivering the data to** the end-users. Akamai has established servers all over the world; over 8000 servers in more than 50 countries at around 500 locations. When the end-user goes to visit, say, Yahoo, (using **a web browser**), the pictures will be sent to the user not from the central location, where Yahoo has its master web servers, but from one of Akamai's locations, which is usually much closer to the end-user than the central location..

1. **What is Akamai Tech mostly concerned with?**
2. **What does being the leader mean?**
3. **How many customers does it have?**
4. **What do the customers use Akamai for?**
5. **What high-profile customers does it have?**

I: Did you bring from your work at Akamai some interesting problems to work on during your "academic life?"

B: I did. In a start – up, or in any rapidly growing company, there's little time **to ponder a problem in the thorough fashion** that **we're used to** in academia. You really appreciate the luxury **once** you are back in academia. During the course of the design of the Akamai system many technical problems arose for which there was an immense solution that could be put into place and we had great confidence in, and **yet intriguing problems were left unsolved** because they didn't **have immediate priority**. I brought back with me **a number of** problems motivated by phenomena that we saw in the design of the Akamai system. **Although** I was unable to **perform my usual research duties** at Akamai I wouldn't view it as an interruption in my research. Today I'll have much better context into which to think about networking problems, and a lot more experience to draw on to understand **both** what problems are important **and** what kind of solutions would have some **feasibility**.

1. In what order do you solve problems at Akamai?

2. Why were some problems left unsolved at Akamai?

3. What is the difference in the tempo of research in a rapidly growing company and that in academia?

Exercise 1

Prepare a short talk on.

a. The relationship between systems research and theory.

b. Akamai Teck as the leader in Internet Content delivert.

Exercise 2

Formulate a number of questions you'd like to ask Bruce Maggs.

Exercise 3

(In groups)

One of you is the president at Akamai. Another is the vice-president. He is giving a talk. The others are computer scientists from MEPHI, who ask them questions.

COMPUTER SECURITY TECHNOLOGY

CRYPTOGRAPHY

Read the text. Translate the underlined sentences in writing.

Cryptography is a method of storing and transmitting data in a form that only those it is intended for can read and process. It is considered a science of protecting information by encoding it into an unreadable format. Cryptography is an effective way of protecting sensitive information **as** it is stored on **media** or transmitted through confidential network communication paths. One of the goals of cryptography, and the mechanisms that make it up, is to hide information from unauthorized individuals. However, with enough time, resources, and motivation, hackers can break most algorithms and reveal the encoded information. **So** a more realistic goal of cryptography is to make obtaining the information **too work – intensive and time consuming to be worthwhile** for a hacker. The first encryption methods date back to 4000 years ago. With the relatively recent birth of the internet, encryption **has gained new prominence** as a vital tool in everyday transactions and has become an integrated part of the computing world. Keeping secrets gives individuals and groups the ability to hide their true intentions, **gain a competitive age**, and **reduce vulnerability**, among other things.

Encryption is used in hardware devices and in software to protect data, banking transactions, corporate extranet transmissions, e-mail messages, web transactions, wireless communications, storage of confidential information, faxes, and phone calls. The code breakers and cryptanalysis efforts and the amazing **number-crunching capabilities** of the microprocessors hitting the market each year have quickened the evolution of cryptography. Cryptanalysis is an important part of cryptography. It is the science of studying and breaking the secrecy of encryption processes. When carried out by the "good guys", cryptanalysis **is intended** to identify flaws and weaknesses so that developers can go back to the drawing board and improve the components. It is also performed by curious and motivated hackers, to identify the same types of flaws, but with the goal of obtaining the encryption key for unauthorized access to confidential information.

Today cryptography **is** deeply **rooted** in every part of our communications and computing world. As our dependency upon technology increases, so does our dependency upon cryptography, because secrets will always need to be kept.

a medium (media) – a carrier of information, **to gain a competitive edge** – to get a competitive advantage, **number-crunching capabilities** – fast processing of big amounts of information, **to be intended for** – to be designed for, **to authorize** – to allow, **to be worthwhile** – to be **beneficial, vulnerable – unable to defend itself, to gain prominence** – to become important, **to encrypt** – to code

Checking up understanding (in pairs)

1. What is cryptography?
2. Is cryptography considered to be a science?
3. What science is it considered to be?
4. What is one of the goals of cryptography?
5. Is this goal realistic? Why?
6. What is a more realistic goal?
7. How has communication been protected throughout history?
8. What abilities does keeping secrets give individuals and groups?
9. What is encryption used for?
10. What is cryptanalysis?
11. What is cryptanalysis intended for when carried out by "good" guys?
12. What goals do hackers have when performing cryptanalysis?
13. Who is a hacker in other words?

Exercise 1

Make up questions using the expressions below and the question words:

In what form? In what way? How? On what media? Through what communication paths?

Model: How can vulnerability be reduced*?*

1. to store data
2. to transmit data
3 to process information
4. to intend information for smbd

5. to protect information
6. to encode information
7. to obtain information
8. to break an algorithm
9. to reveal the encoded information
10. to encrypt information
11. to reduce vulnerability

Exercise 2

What is the English for?

цель, носители информации, заинтересованность, трудоемкий процесс, неотъемлимая часть, истинное намерение, сообщение, разработчик, шифр, доступ к информации, секретная информация

Public Key Cryptography

Read the text. Look up the underlined words.

Mathematicians have tried hard to solve the key distribution problem. The 1970s brought a clever mathematical discovery in the shape of "public key" systems. In these systems users do not need to agree on a secret key before they send a message. They work on the principle of a safe with two keys, one public key to lock it, and one private one to open it. Everyone has a key to lock the safe but only one person has a key that will open it again, **so** anyone can put a message in the safe but only one person can take it out. In practice the two keys are two large integer numbers. One can easily derive a public key from a private key but not **vice versa**. The system exploits **the fact that** certain **mathematical operations** are easier **to perform** in one direction than the other. Public-key cryptosystems avoid the key distribution problem but unfortunately their security depends on unproven mathematical assumptions, such as the difficulty of factoring large integers. An enemy who knows your public key can in principle calculate your private key because the two keys are mathematically related, **however**, the difficulty of computing the private key from the respective public key is exactly **that** of factoring big integers.

Quantum Factoring

It seems that factoring big numbers will remain **beyond** the capabilities of **any** realistic computing devices and **unless** mathematicians or computer scientists come up with an efficient factoring algorithm the public-key cryptosystems will remain secure. Or will they? **As it turns out** we know that **this is not the case;** the classical, purely mathematical theory of computation is not complete simply because it does not describe all physically possible computations. **In particular** it does not describe computations which can be performed by quantum devices. Indeed, recent work in quantum computation shows that a quantum computer can factor much faster than any classical computer.

Quantum computers can compute faster because they can accept as the input not a one number but a coherent superposition of many different numbers and subsequently perform a computation (a sequence of unitary operations) on all of these numbers simultaneously. This can be viewed as a massive parallel computation, but **instead of having** many processors working in parallel we have only one quantum processor **performing a computation** that affects all components of the state vector.

an integer number – ant. -fraction**, to avoid** – to try not to do, **an assumption** – a supposition, **subsequently**– hence, **a sequence** – a chain, **simultaneously** – at the same time

Checking up understanding

1. What fact does the "public key" cryptosystem exploit?
2. What does the security of the "public key" cryptosystem depend on?
3. On what condition will the "public key" cryptosystems remain secure?
4. Why can't the classical, purely mathematical theory of computation be considered complete?
5. Why can quantum computers compute faster?

ID Technology

FYI

an intrusion – an attack,

framework is a particular set of rules or methods that form a structure,

groundwork is early work which forms the basis for further work.

Read the text and translate the underlined sentences in writing.

Intrusion detection systems (IDSs) are an important component of defensive measures protecting computer systems and networks from abuse.

ID has been an active field of research for about two decades and provided a methodological framework that inspired many researches and laid the groundwork for **commercial** products. **Despite** substantial research and **commercial** investment, ID technology is immature, and its effectiveness is limited and should not be relied upon as a **sole means** of protection.

The Intrusion Perspective

Defining what constitutes an attack is difficult because multiple perspectives are involved. Attacks may involve any number of attackers and victims. The attacker's viewpoint is typically characterized by intent and risk of exposure. From a victim's perspective, intrusions are characterized by their manifestations, which may or may not include damage. Some attacks may produce no manifestations, and some apparent manifestations may **result from** system /network malfunctions. For an intrusion to occur, it requires both an overt act by an attacker and manifestation, observable by the intended victim, which results from that act.

A victim's view of an attack is usually focused on these manifestations:

What happened?

Who is affected and what are the consequences?

Who is the intruder?

Where and when did the intrusion originate?

How and why did the intrusion happen?

Meanwhile, the attacker **may** have quite a different view:

1. What is my objective?
2. What vulnerabilities exist in the target system?
3. What damage or other consequences are likely?

4. What attack tools are available?

5. What is my risk of exposure?

The goal of ID is to characterize attack manifestations **so as to** positively identify all true attack without improperly identifying false attacks. The motivation for using ID technology may vary. Some users may be interested in collecting forensic information to locate and prosecute intruders. Others may use ID to trigger actions to protect computing resources. Still others may use ID to identify and correct vulnerabilities.

to rely upon – to depend on, **exposure** – detection, **apparent** – obvious, **malfunction** – failure, **overt** – obvious, **an objective** – a goal, **forensic** – legal, **to prosecute** – to accuse of a crime**, to trigger** – to provoke

Grammar

1. **without + Ving** – не делая чего-то **e.g.** without improperly identifying false attacks
2. **for + N + to V** – для того, чтобы **e.g.** For an intrusion to occur

Exercise 3

In pairs ask and answer questions.

1. What is the goal of ID?
2. What has research into ID provided?
3. What are the three motives for using ID technology?

Exercise 4

a. You are the victim. Analyze the questions formulated in the text logically and grammatically. Write them down into your notebook without looking at the original sentences.

b. You are the attacker. Do the same.

Exercise 5

Match the left column adjectives with the right nouns. Use articles.

1. defensive	a. a product
2. active	b. a field of research
3. methodological	d. technology
4. commercial	e. machines

5. substantial	f. means of protection
6. immature	g. effectiveness
7. limited	h. measures
8. sole	i. framework
9. additional	j. manifestations
10. observable	k. research

Maintaining Networking Security is More Fun than Work

FYI

1. **Maintaining networking security** is regular checking networking infrastructure and reducing vulnerabilities.

2. **Networking infrastructure** is facilities, services and equipment that are needed for an organization to function properly.

Read the text and translate the underlined sentences in writing.

Telecommunications and networking use various mechanisms, devices, software, and protocols that are interrelated and integrated. Networking is one of the more complex topics in the computer field, **mainly** because so many technologies and concepts are involved. A network administrator or engineer must know how to configure networking software, protocols and services, and devices; deal with interoperability issues; install, configure and interface with telecommunications software and devices; and troubleshoot effectively. A security professional must understand these issues and be able to analyze that a few levels deeper to recognize fully where vulnerabilities can arise within networks. This can be an overwhelming and challenging task. However, if you are someone who enjoys challenges and appreciates the intricacies of technology, then maintaining security and networking infrastructures may be more fun than work. As a security professional, you cannot advise others on how to secure an environment if you do not fully understand how to do so yourself. To secure an application that contains a buffer overflow, for example, you must understand what a buffer overflow is, what the outcome of the exploit is, how to identify a buffer overflow properly, and possibly how to write program code to remove this weakness from the program. To secure a network architecture, you must understand the various networking platforms involved, network devices, and how data flow through a network. You must understand how various protocols work, their purposes, their interaction with other protocol, how they may provide exploitable vulnerabilities, and how to choose and implement the appropriate types of protocols in a given environment. You must also understand the different types of routers, switches, and bridges, when one is more appropriate than the other, where they are to be placed, their interactions with other devices, and the degree of security each device provides. The many different types of devices, protocols and security mechanisms within the environment provide different functionality, but they also provide a layered approach to security. Layers within security are important, so that if the attacker is able to bypass one layer, another layer stands in the way to protect the internal network. Many networks have routers, firewalls, intrusion detection systems, antivirus software, and more. Each specializes in a certain piece of security, but they all should work in concert to provide a layered approach to security. Although networking and communications are complicated topics to understand, it is the complexity that makes it the most fun for those who truly enjoy these fields.

to configure computing software – выбрать конфигурацию программных средств, **interoperability** – совместное функционирование сетей, **to troubleshoot** – находить неисправности, **an intricacy** – сложность, **an environment** – оборудование, **an application** – приложение, программа; **a buffer** – буфер (дополнительное устройство памяти для промежуточного хранения данных); **an overflow** – переполнение, **an outcome** – результат, **an exploit** – использование, **an architecture** – структура, **a platform** – платформа (программно-аппаратная среда, в которой выполняется прикладная система); **to implement** – осуществлять, **a router** – программа, занимающаяся прокладыванием маршрутов в локальной вычислительной сети; **a bridge** – мост (устройство, соединяющее несколько локальных сетей); **a protocol** – протокол (процедура регистрации и коммутации сообщений); **a layer** – уровень

Grammar

1. It is ………..that – именно

e. g. It is the complexity that makes it the most fun for those who truly enjoy these fields.

Exercise 6

Give answers to the questions in writing. Follow the text.

1. What must a network engineer know?
2. What must a security professional understand?
3. Is it a challenging task?
4. In what case is maintaining security more fun than work?
5. What makes the most fun?
6. How can a network engineer secure an application that contains a buffer-overflow?
7. What must a security professional know to secure a network architecture?
8. Why are layers important for maintaining security?
9. How is it possible to provide a layered approach to security?

Exercise 7

(In groups)

Two of you are experts in networking security, the others are students majoring in it. They ask the experts the above questions.

INTERVIEW WITH Dr. DAVID DEUTSCH, THEORETICAL PHYSICIST OF THE CENTRE FOR QUANTUM COMPUTATION AT THE UNIVERSITY OF OXFORD

In this interview, a Special Topics correspondent talks with Dr. David Deutsch, of the Centre for Quantum Computation at the University of Oxford, about his career in quantum theory and computer research.

Read the interview. Translate the underlined sentences in writing.

ST: How did you get started working on quantum theory, and how would you describe the progression of your research?

DD: Throughout my research career I **have been interested in** the most fundamental issues. I **got into** quantum mechanics because it is the deepest knowledge known to science. I did various kinds of work on quantum field theory, in the hopes of making progress on quantum gravity. I worked on quantum measurement theory and **so** became an advocate of the many-universe interpretation.

I saw that there was a need to extend the idea of Alan Turing and others of a universal computer to use quantum-mechanical physics. And I did that: I proposed the universal quantum computer and proved it was universal. I showed it had properties that **no** existing computer had.

ST: That raises two questions. First, how do you define fundamental?

DD: A fundamental idea is one which is needed in the understanding, or in explanations of many other ideas. **For instance**, the laws of thermodynamics are fundamental laws. You don't just need them to understand how steam engines work, but to understand how microchips and supernovas work. The word "explain" is important here. Not just "predict." Prediction is a characteristic of scientific theory, but it's not the most important one, the most important one is explanation. A fundamental theory is needed in the explanation of many diverse things. The more and more diverse phenomena the theory can explain, the more fundamental it is.

ST: Now the second question: What constitutes a universal computer?

DD: It's perhaps not obvious to **lay man** that all existing computers, **the one** you have on your desk, the supercomputers that the National Security Agency uses, and the computer in your watch and so on, all of them **are**, **in terms of** their repertoire of possible computations, completely **identical to** each other. They **differ** only **in** speed and **memory capacity**. Any one of them, if you let it run long enough or give it enough memory, will be able to completely duplicate all the functions of any other one. That property is called universality. Alan Turing was the first person to postulate a universal computing machine and prove it was universal within a certain domain. But that was for classical physics, not quantum physics. My innovation was to redo his work using **explicitly** quantum physics **instead of implicitly** classical physics.

ST: When did you do that work; where was it published and what was the impact?

DD: That was in the early 1980s and published in 1985 in the Proceedings of the Royal Society of London. That paper began the modern subject of the quantum theory of computation, which asks about the many types of computation that a quantum computer can do but a classical computer cannot do, no matter how much extra memory and extra time it is given.

ST: Is it a difficult transition to move from tackling fundamental questions about the universe to tackling fundamental questions about computation?

DD: What it mainly takes is for the link to be there. **I'm neither particularly interested in** making new and better kinds of computers, **nor** in understanding the theory of computation **for its own sake**. What I want to work on is what is fundamental: to understand the important issues of the foundations of physics, what quantum theory means, what it is telling us about the structure of reality, and so on. To do that, it **turns out** one has to express the laws of physics and explanations of physical processes in terms of computation and information flow. And that is true, regardless of whether you're thinking of a computer or any physical process. The universality that exists in the world means that when you're studying the general theory of how information can flow around inside a quantum computer, you are automatically studying the general theory of how information can flow. That **in turn** means you're discussing physics **in general**, because **any** physical process can be regarded as **information processing**. Any kind of experiment you can think of doing, where you prepare some physical system **in a certain way**, **according** to a certain system or algorithm, and you let it do something and then measure it according to some algorithm and get a result, **either** a number **or** a yes or no, all that is information processing, The structure of the universe or of physical reality is based on information flow. And the best formalism and language and theory for understanding that is the theory of computation, but computation as implemented in the deepest-known physical laws. That means the quantum theory of computation.

ST: One of your highly cited papers was "Quantum Privacy Amplification and the Security of Quantum Cryptography over Noisy Channels." Do you think quantum cryptography will be a practical method of insuring privacy in communication?

DD: Some time in the next few years it's going to actually be implemented and it's going to revolutionize secure communications**. I am not an expert in experimental physics**, and I'm less of an expert in engineering or marketing, but I can still say that sometime in the next few years, the range, reliability, and scope of quantum cryptographic devices will be enough to allow them to be actually used in real life. That will mean that communication can be perfectly secure. Also, most of the existing classical secure methods are becoming insecure because they will become vulnerable to attack by quantum computational algorithms. **By sheer coincidence**, quantum computational algorithms just happen to be **particularly** suitable to cracking classical codes.

ST: What about the future of quantum computation in general?

DD: Practical applications of quantum computation in general are far more distant. Quantum computation is one of the greatest challenges facing experimental physics. Going to the moon is nothing compared with it. It is also a very beautiful area of study because it appears to involve practically the whole of physics and it stretches the theoretical and experimental resources of every branch of physics. It's cool in that way. But it does mean we are talking about decades **before** anything useful comes out. **Although well before** quantum computers are practical or before we know how to do quantum computation in the laboratory, the quantum theory of computation is already teaching us a lot about physics.

ST: What are your goals for your future research?

DD: I don't really set goals. I have hopes. I just want to work on things that are fundamental. I have always wanted to do that. With or without success, this is all I **have ever wanted** to do.

Exercise 1

(In groups)

Ask and answer questions one by one.

1. What is a fundamental idea; What are examples?
2. What do all existing computers differ in?
3. What is universality?
4. How did he see the extension of Turing's idea of a universal computer?
5. What does the quantum theory of computation mean?
6. When is quantum cryptography method going to be implemented; What impact will it have?
7. What characteristics must quantum cryptographic devices have to be used in real life?
8. What will the application of cryptographic devices mean?
9. Why are most of the existing classical secure methods becoming insecure?
10. Why are practical applications of quantum computation far more distant than quantum cryptographic devices?
11. Why does Deutsch call quantum computation a very beautiful area of study?
12. What are his goals?
13. Is it correct to set goals in studying fundamental issues? Why not?

Exercise 2

Formulate questions and give answers to them in a dialogue form in writing.

1. Throughout my research career I have been interested in ……… (What issues?)

2. I got into quantum mechanics because ……… (Why?)

3. I worked on ……… (What theory? What were you particularly interested in?)

4. I became an advocate of the many-universe interpretation. (How?)

5. I saw there was a need to extend the idea of Alan Turing of a universal computer. (How?)

5. I proposed ……… (What?) and proved ……… (What?)

6. I showed ……… (What?)

7. What I want to work on ……… (What?)
8. Any physical process can be regarded as ……… (How?)
9. The structure of the universe is based on ……… (What …… on?)
10. I don't set goals. (Why?)
11. I want to work on things ……… (What things?)

Exercise 3

(In groups)

David Deutsch is giving a talk at your University. One of you is David Deutsch, the others are students majoring in computer security technology. They ask him the above formulated questions.

NANOTECHNOLOGY

MOLECULAR ENGINEERING

What is nanotechnology?

Webopedia's definition of nanotechnology.

A field of science whose goal is to control individual atoms and molecules to create computer chips and other devices that are thousands of times smaller than **current** technologies permit. Current manufacturing processes use lithography to imprint circuits on semiconductor materials. **While** lithography has improved dramatically over the last two decades – to the point where some manufacturing plants can produce circuits smaller than one micron (1,000 nanometres) – it still deals with aggregates of millions of atoms. It is widely believed that lithography is quickly approaching its physical limits. To continue reducing the size of semiconductors, new technologies that juggle individual atoms will be necessary.

Whatisit com definition

Nanotechnology, or, as it is sometimes called, molecular manufacturing, is a branch of engineering that deals with the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter.

Merriam-Webster' s Collegiate Dictionary definition

Art of manipulating materials on an atomic or molecular scale especially to build microscopic devices.

The About. com definition at the physics portal:

The development and use of devices that have a size of only a few nanometers. Research has been carried out into very small components, which depend on electronic effects and may involve movement of a countable number of electrons in their action.

Read the text and translate the underlined sentences in writing.

WHAT IS NANOSCALE?

Although a meter is defined by the International Standard Organization as the length of the path travelled by light in vacuum during a time interval of 1/299 792 458 of a second and a nanometer is by definition 10^{-9} of a meter, this does not help scientists to communicate the nanoscale to non-scientists.

The nanoscale is about a thousand times smaller than micron, **that is**, about 1/80,000 of the diameter of a human hair. Approximately 3 to 6 atoms can fit inside of a nanometer, **depending on** the atom. The prefix " nano" means ten to the minus ninth power, or one billionth. **Rather than** asking anyone to imagine a millionth or a billionth of something, relating nanotechnology to atoms makes the nanometer easier to imagine. **While** few non-scientists have a clear idea of how large an atom is, defining a nanometer as the size of 10 hydrogen, or 5 silicon atoms in a line is within the power of the human mind to grasp. The exact size of the atoms is less important than communicating **the fact that** nanotechnology is dealing with the smallest parts of matter that we can manipulate.

WHAT DO TECHNOLOGISTS DEAL WITH?

They develop and use devices that have a size of only a few nanometers. Nanotechnologists manipulate single molecules and atoms.

Checking up understanding (in pairs)

1. What is Webopedia's definition of nanotechnology?
2. What techniques do current manufacturing technologies use?
3 What is lithography?
4. What is the difference between lithography and nanotechnology?
5. What is Whatisit definition of nanotechnology?
6. What is Webster' s dictionary definition ?
7. What is the About. com definition?
8. What components has research been made into?
9. How is a meter defined?
10. What is the relation between a meter and a nanometer?
11. What is the relation between the nanoscale and the microscale?
12. How many atoms can fit inside of a nanometer?
13. What does the prefix "nano" mean?
14. What do nanotechnologists deal with?

<u>Exercise 1</u>

Translate the sentences.

The infinitive

1. To continue reducing the size of semiconductors, new technologies that juggle individual atoms will be necessary.

2. Nanotechnology is the art of manipulating materials on an atomic or molecular scale to build microscopic devices.

Much more than miniaturization

To many people, nanotechnology may be understood as a process of ultra-miniaturization. **Philosophically**, changes in quantity **result in** changes in quality (1). **Shrinkage** in device size may lead to a change in operation principle (2), **due to** quantum effect, which is the physics that governs the motion and interaction of electrons in atoms (3). In fact, the product miniaturization will require new process measurement and control systems (4) that can span across millimeter, micrometer and nanometer-sized scales (5) **while accounting for** the associated physics that governs the device and environment interaction at each **specific** size scale.

philosophically – theoretically, **to result in** – to give rise to, **shrinkage** – decrease, **to govern** – to guide, **to account for** – to take into consideration, **specific** – particular

Formulate questions.

What? (1)

What? (2)

What? (3)

What? (4)

What control systems? (5)

A completely new world

<u>Phenomena at the nanometer scale are likely to be a completely new world</u>. Properties of matter at nanoscale may not be as predictable as **those** observed at larger scales. Important changes in behavior are caused (1) not only by **continuous** modification of characteristics with diminishing size, but also by the emergence of totally new phenomena such as quantum confinement, a typical example of which is that the

color of light emitting from semiconductor nanoparticles depends on their sizes (2). Designed and controlled fabrication and integration of nanomaterials and nanodevices is likely to be revolutionary for science and technology.

Nanotechnology can provide unprecedented understanding about materials and devices and is likely to affect many fields. By using structure at nanoscale as **a tunable physical variable**, we can greatly expand the range of performance of existing chemicals and materials (3). Alignment of linear molecules in an ordered array on a substrate surface (self – assembled monolayers) can function (4) as a new generation of chemical and biological sensors. Switching devices and functional units at nanoscale can improve computer storage and operation capacity (4) **by a factor of a million** (5). Entirely new biological sensors **facilitate** early diagnostics and disease prevention of cancers. Nanostructured ceramics and metals have greatly improved mechanical properties (6), **both** in ductility **and** strength.

to predict – предсказывать, **continuous** – непрерывный, **to diminish** – уменьшать, **confinement** – ограничение, **a variable - п**еременная, **alignment** – выстраивание, **an array** – массив, **to facilitate** – облегчать, **ductility** – ковкость

Formulate questions.

1. What ……… by?
2. What ……… on?
3. What?
4. How?
5. How many times?
6. What properties?

Characterizing the performance and properties of nanostructures

Property characterization of nanomaterials is challenging **because of** the difficulties in manipulating structures of such small size. New tools and **approaches must be developed to meet new challenges** (1). **Due to** the high size and structure selectivity of nanomaterials, their physical properties could be quite diverse, **depending on** their atomic-scale structure, size and chemistry.

performance – работа, КПД, **an approach** – подход, **to meet** – удовлетворять

Formulate a question.

1. What new tools and approaches ……… ?

Exercise 2

(In groups)

Ask all the above formulated questions and give answers. Two of you are experts in nanotechnology, the others ask them questions.

Not just an engineering process

Traditionally, manufacturing **is attributed to** an engineering field. For manufacturing, we must **go beyond** engineering. **Once** we approach the atomic scale precision and control, fundamental physics and chemistry have to be applied. The nanoscale manufacturing is multidisciplinary – involving but not limited to mechanics, electrical engineering, physics, chemistry, biology and biomedical engineering. The future view of nanomanufacturing is the integration of engineering, science and biology. This complex task requires not only innovative research and development themes, but also a new education system for training future scientists and engineers.

to attribute – приписывать, **to go beyond** – выходить за пределы, **once** – когда, **to require** – требовать

Answer the questions in pairs.

1. What is the traditional manufacturing attributed to?
2. What fields does the nanoscale manufacturing involve?
3. What does the nanoscale manufacturing require?

Large-scale manipulation and self- assembly

Manipulation of nanostructures relies on **scanning probe microscopy**. Using a **fine tip**, atoms can be manipulated for a variety of applications. This type of **approach** is outstanding for scientific research. For manufacturing, an array of scanning tips, if synchronized, may be used for achieving atom-by-atom engineering. But the building rate is rather slow. If a device has a size of five nanometers and a scanning tip can move 10 atoms per second, it will take about six months to build 10 devices on **an eight-inch wafer**.

The **ultimate** solution is self-assembly. Like many biological systems, self-assembly is the most fundamental process for forming a functional and living structure. The genetic codes and sequence built in a biosystem guide and control the self-assembling process. Self-assembly is the organization and pattern formed naturally by the fundamental building blocks such as molecules and cells. Designed and controlled self-assembly is a possible solution for future manufacturing needs.

assembly – сборка, **a tip** – остриё, **fine** – тонкий, **a wafer** – плата, **ultimate** – окончательный, **a sequence** – последовательность

Answer the questions in pairs.

1. What process forms a functional and a living structure?
2. What guides and controls the self-assembling process?
3. What are the natural fundamental building blocks of self-assembly?

Conclusions

Nanotechnology, like any other branch of science, **is primarily concerned with** understanding how nature works. Our efforts to produce devices and manipulate matter are at a very primitive stage **compared to** nature. Nature has the ability to design highly energy efficient systems that operate precisely and without waste, fix only that which needs fixing, do only that which needs doing, and no more. We do not, **although** one day our understanding of nanoscale phenomena may allow us to replicate **at least** part of what nature accomplishes with ease. New industries will be generated as a result of this understanding, **just as** the understanding of how electrons can be moved in a conductor by applying a potential difference led to electric lighting, the telephone, computing, the internet and many other industries, all of which would not have been possible without it.

What is new about nanotechnology is our ability to not only see, and manipulate matter on the nanoscale, but our understanding of atomic scale interactions.

Nanotechnology is at a very early stage in our attempts to understand the world around us, and will provide inspiration and drive for many generations of scientists.

Tim Harper

About the author

Tim Harper is the Founder and President of CMP Cientifica, and the coauthor of the Nanotechnology Opportunity Report, described by NASA as the defining report in the field of nanotechnology.

Answer the questions in pairs.

1. What is science concerned with?
2. What ability does nature have?
3. What possibilities would the understanding of nanoscale phenomena open up for scientists?

<u>**Exercise 3**</u>

Translate the sentences.

Gerund

1. Rather than asking anyone to imagine a billionth of something, relating nanotechnology to atoms makes the nanometer easier to imagine.
2. Defining a nanometer as a size of 10 hydrogen atoms in a line is within the power of the human mind to grasp.
3. The exact size of the atoms is less important than communicating the fact that nanotechnology is dealing with the smallest parts of matter.
4. By using structure at nanoscale as a tunable physical variable, we can greatly expand the range of performance of existing chemicals and materials.
5. The understanding of how electrons can be moved in a conductor by applying a potential difference led to electric lighting.

Participle

1. Designed and controlled fabrication and integration of nanomaterials and nanodevices is revolutionary in science and technology.
2. The genetic codes and sequence built in a biosystem guide and control the self assembly process.
3. There is current work being done on the nanoscale at Universities, major corporations and military and NASA labs.
4. Self-assembly is the organization and pattern formed naturally by the fundamental building blocks such as molecules and cells.

Complex Subject

1. Phenomena at the nanometer scale are likely to be a completely new world.

2. Fabrication and integration of nanomaterials and nanodevices may prove revolutionary for science and technology.

3. Nanotechnology is certain to affect many fields.

4. The astounding possibilities nanotechnology is going to entail are estimated to happen from 5 to 30 years from now.

Give Russian equivalents.

current, dramatically, depending on, that is, approximately, rather than, to result in, due to, specific, continuous, performance, both…and, because of, once, an approach, any other, compared to, although, at least

Give Russian correspondence of the terms used in nanotechnology.

a manufacturing process
a process measurement
a control system
the device and environment interaction
quantum confinement
a tunable physical variable
alignment of linear molecules
an ordered array
a self-assembled monolayer
a switching device
a functional unit
computer storage
operation capacity
atomic scale precision and control
scanning probe microscopy
atom-by-atom engineering
a building rate
an eight-inch wafer
a self-assembling process
a highly energy efficient system
a potential difference
atomic scale interactions

Expressions

1. a field of science; a branch of engineering
2. thousands of times smaller
3. to imprint circuits on semiconductor materials
4. to deal with, to be concerned with
5. It is widely believed that…
6. to carry out research
7. to relate to
8. to range from ….to
9. to fit inside of
10. to impact many fields
12. by a factor of a million
13. to develop new tools and approaches
14. to meet new challenges
15. to rely on
16. for a variety of applications

Translate the sentences using the above expressions. Follow the text.

1. Считают, что литография исчерпывает свои возможности.
2. Чтобы продолжать уменьшать размеры полупроводников, нужны новые технологии.
3. Нанотехнология изучает мельчайшие частицы материи, которыми может манипулировать человек.
4. Нанотехнология занимается разработкой, созданием и использованием приборов и электронных схем, имеющих размеры несколько нанометров.
5. В нанометре могут уместиться от 3 до 6 атомов.
6. Нанотехнология может оказать воздействие на многие области науки.
7. Для решения задач в области нанотехнологии необходимо создавать новые приборы и методы.
8. В настоящее время проводится исследование мельчайших компонентов, основанных на электронном эффекте.
9. Нанотехнология может увеличить память и КПД компъютера в миллион раз.
10. Как и все науки, нанотехнология пытается понять, как устроен окружающий нас мир.

DESIGN FOR THE FUTURE

(SMALL TALK WITH RALPH MERKLE, A KEY ADVOCATE OF MOLECULAR ENGINEERING)

Ralph Merkle is a key advocate of molecular engineering (nanotechnology), **a cutting-edge science** that involves rearranging molecules **in order to** create self-replicating manufacturing systems. He is **currently** an advisor to the Foresight Institute and a principal fellow at Zyvex. This is what he said in his interview which he gave for "Ubiquity" Magazine and Forum.

Read the interview Look up the underlined words and translate the underlined sentences in writing.

U: Bill Joy's recent article on the <u>perils</u> of today's advanced technologies – including nanotechnology – has certainly received a lot of attention, and we did a follow–up interview with him in Ubiquity. What are your thoughts on that subject?

M: Well, certainly the idea that nanotechnology would raise concern is something that actually was a major <u>impetus</u> for the founding of the Foresight Institute back in 1986 and in fact Bill Joy spoke at that meeting. <u>So one of the things that's a bit surprising is that Bill's concerns about nanotechnology seem to be quite recent, **even though** the understanding that this **particular** technology was going to be very powerful and would raise significant concerns has been around for at least a couple of decades</u>.

U: What do you think would explain the sudden increase of concern about this?

M: Well, I can't really address the specifics of Bill Joy's situation. I **do know** that nanotechnology is an idea that most people simply didn't believe, **even though** <u>the roots</u> of it go back to a lecture by Richard Feynman in 1959.

That was a very famous talk. He basically said that the laws of physics **would** allow us to arrange things molecule by molecule and even atom by atom, and that at some point it is <u>inevitable</u> that we **would** develop a technology that would let us do this. I don't think that it was taken very seriously at that time, but **as** the years progressed it gradually began to be more accepted. If you think that the technology is infeasible, you don't worry about what it might do and what its potential is. However, **as** you begin to understand **the fact that** we are going to have a very powerful manufacturing technology that will let us build a wide range of remarkable new products, then one of the things that arises a concern is that this new set of capabilities could create new problems and that these should be addressed..

Answer the suggested questions in writing.

1. What did Richard Feynman say in his famous lecture in 1959?

2. Why were his ideas not taken seriously by scientific community at that time?

U: But not the way Bill Joy is addressing them.

M: He **is calling for** a relinquishment, **as he puts it**, of research – and I think it's a very foolish strategy. If you look at the various strategies **available** for dealing with a new technology, **sticking your head in the sand** is not the most plausible strategy and in fact makes the solution more dangerous….

U: Why so?

M: For **at least** two reasons. The first, of course, is that we need to have a collective understanding of the new technology **in order to** ensure that we develop it appropriately. The second reason is that the new technologies that we see coming will have major benefits, and will greatly alleviate human suffering.

U: What are the most prominent opportunities it offers?

M: Well, certainly, what we see today is the entire planet, which has many limitations. I'm not quite sure how to express it, but certainly if you look at the human conditions today, not everybody is well fed. Not everyone has access to good medical care. And, clearly, if you have a lower cost manufacturing technology, which can build **a wide range of** products less expensively, it can build, among other things, better medical products. Disease and ill health are caused **largely** by damage at the molecular and cellular level, **yet** today's surgical tools are **too** large to deal with that kind of problem. A molecular manufacturing technology will let us build molecular surgical tools, and those tools will, **for the first time**, let us **directly** address the problems **at the very root level**.

1. What are disease and ill health largely caused by?
2. What's wrong with today's surgical tools?
3. What problems will molecular surgical tools let us address?

U: And besides the opportunities in medicine? What else?

M: On another level, food; the simple process of feeding the human population. Today **because of** technological limits there is a certain amount of food that we can produce per acre. If we were to have intensive greenhouse agriculture, if we could economically manufacture the appropriate computer controlled enclosures that would provide protection and would provide a very controlled environment for the growth of food we could have much higher production. It makes food less expensive. One of the great advantages is that molecular manufacturing will let us have a much lower cost infrastructure. **In other words**, today manufacturing takes place in very large facilities. If you want to build, for example, a computer chip, you need a giant semiconductor fabrication facility. But if you look at nature, nature can grow complex molecular machines using nothing more than a plant. Potatoes are a miracle of biology, and **yet** they are so inexpensive. The reason for this, of course, is that the potato can grow more potatoes. Potatoes are self replicating technology. And this demonstrates the feasibility of a basic capability, which is to have a self-replicating manufacturing base.

1. What factors limit the amounts of food produced per acre?
2. In what way is it possible to increase food production per acre?
3. What are the advantages of molecular manufacturing?
4. Why are potatoes so cheap?

U: How will artificial manufacturing systems be unlike living systems?

M: They will not have the marvelous adaptability that living systems have. They will, like a 747, use a refined source of energy – 747s use fuel. If you cut them off fuel, 747s do not fly. **In the same way** if we talk about molecular manufacturing systems, they will use a **specific** source of energy, a specific fuel, and cut off from that source of fuel, they won't function. They will not be biological in their design. They will be artificial. They will be brittle. Like machines built by human beings they will function correctly if we provide them with a very specific environment. But if that environment is changed they won't function **at all**.

1. What is the difference between molecular manufacturing systems and living systems?

U: Could you give us an example of a product that would be improved using molecular manufacturing?

M: The answer that comes most rapidly to mind is diamond. Diamond has a better **strength-to-weight ratio** than steel or aluminum alloy. **So**, it's much stronger and much lighter. If we had a shatterproof variant of diamond, we could have a remarkably light and strong material from which to make all of the products in the world around us**. In particular**, aerospace products – airplanes or rockets – **would** benefit immensely from having lighter, stronger materials. **So** one of the things that we can say with confidence is that we will have much lighter, much stronger materials, and this will reduce the cost of rockets. It will let us go into space for literally orders **of magnitude lower cost.**

There is a whole range of other capabilities. For example, lighter computers and lighter sensors **would** let you have more function in a given weight, which is very important if you are launching things into space, and you have to pay by the pound to put things there.

1. In what case is more function in a given weight very important?

U: Are there any other areas that would be significantly affected by nanotechnology?

M: The other area is in advanced computer technology. The computer hardware revolution has been continuing with remarkable steadiness over the last few decades. If you extrapolate into the future you find that in the coming decades we'll have to build molecular computers to keep the computer hardware revolution on track. Nanotechnology will let us build computers that are incredibly powerful. We'll have more power in the volume of a sugar cube than exists in the entire world today.

1. What does strength-to-weight ratio mean?

2. What products would benefit immensely from lighter, stronger materials?

3. What computers will we be able to build using molecular engineering?

U: Can you put any kind of timeframe on that?

N: We're talking about decades – and, probably, not many decades.

Exercise 1

Arrange the answers to the suggested questions into a talk on molecular engineering using introductory words: I'm not sure how to express it; certainly; as I said; so I think; the answer that comes most readily to mind; in particular; I can say with confidence.

Exercise 2

(In groups)

A round table talk. Give a talk on molecular engineering and address the next talker with one of the questions suggested in the interview.

ENERGY

A LOOK AT ENERGY FROM BRITAIN

ENERGY IS ONE OF THE GREATEST CHALLENGES OF THE CENTURY

Warm up activity

1. What is the function of the Sun in the solar system?
2. What man-made device can you compare the Sun with?
3. What are fossil fuels?
4. How did they form?
5. Will fossil fuels last forever?
6. How long will they last?
7. What impact do fossil fuels have on the environment?
8. What fuel do people in developing countries rely on?
9. How does burning wood affect the environment?
10. What is a green house effect?
11. What forms of fuel will people rely on in the future?
12. Are you for or against nuclear power? Why?

Read the first part of the text. Translate the underlined sentences in writing.

The sun is the source of all life on earth and **provides us with** almost all the energy we use. Fossil fuels, such as oil, gas and coal, are simply stored solar energy: the product of photosynthesis millions of years ago, **while** the renewable energy sources – solar, wind, tidal, wave, biomass and hydro – are all the direct result of the sun's energy. Only more recently have we obtained a small amount of energy from non-solar sources – nuclear and geothermal power.

In Britain each one of us uses the energy equivalent of 6 tons of coal each year. **Nearly** all of this – 94 % – comes from fossil fuels: oil, gas and coal. We also obtain a small amount of energy from uranium. These fuels will not last forever, and in the future we will have to rely on other forms of energy. There is enough oil and gas in the world for about 50 years, while coal will probably **last** longer – about 300 years.

Nuclear energy depends on supplies of imported uranium which **may run out** in the next 60 years. This form of energy **has failed to live up to its early expectations** and Britain produces less than 2 % of the total energy used by consumers.

In the future we will have **to rely on** other forms of energy, **in particular**, renewable sources, which will never run out. These sources have other advantages. For instance, they generally **have a smaller impact on** our environment than other forms of energy.

As fossil fuels become scarce, they will become more expensive. Will it **then** be **too** late to wish we had not wasted so much energy and had developed alternative sources earlier?

Checking up understanding.

1. What fuels does the sun provide us with?
2. What are these fuels called?
3. What is oil?
4. What is gas?
5. What is coal?
6. What forms of energy are renewable?
7. Are renewable forms of energy also the products of the sun activity?
8. What forms of energy are not the product of the sun's activity?

Grammar

1. Emphatic sentences

Reconstruct the usual word order.

Only more recently have we obtained a small amount of energy from non-solar sources.

2. I wish

Wish is used to say that we would like things to be different from what they are.

There is a problem of sequence of tenses here.

E.g. I wish we didn't waste so much energy. – Жаль, что мы тратим так много энергии.

I wish we hadn't wasted so much energy. – Жаль, что мы потратили так много энергии.

3. to fail to do – не смочь что-то сделать

Nuclear energy has failed to live up to its early expectations.

<u>Exercise 1</u>

You are a power engineer. Formulate questions you would like to ask your British colleague.

1. Each one of us uses the energy equivalent to 6 tons of coal each year. (How many tons of coal?)
2. We mostly rely on fossil fuel. (What fuel?)
3. We also obtain a small amount of energy from uranium. (What amount of energy?)
4. There is no uranium in Britain. (general question)
5. So, you depend on imported uranium,…? (tag question)
6. Nuclear energy has failed to live up to its early expectations,…? (tag question)
7. Britain produces less than 2 % nuclear energy of the total energy used by consumers. (How much nuclear energy?)
8. In the future the people of the world will have to rely on other forms of energy. (What forms of energy? Why?)

<u>Exercise 2</u>

Work in groups. A British power engineer is giving a talk on "Energy for Tomorrow's World". Ask him the above questions.

<u>Exercise 3</u>

Fill in the missing words (to be done in writing).

1. The sun is _______ of all life on earth.
2. The sun _______ almost all the energy.
3. Oil, gas and coal are _______.
4. The renewable energy sources are _______.
5. Britain _______ a small amount of energy from uranium.
6. Supplies of uranium may _______.
7. Nuclear energy has failed _______.
8. Britain _______ less than 2 % nuclear energy of _______.

Work in pairs. Read the above sentences to each other.

<u>Exercise 4</u>

Innumerate the advantages renewable forms of energy have over fossil and nuclear fuels.

Read the second part of the text.

THE SUN'S ENERGY

More energy arrives at the earth's surface in an hour than is consumed by the world in a whole year. Even in cloudy northern countries like Britain there is more than enough solar energy for our needs – the total falling on this country every year is more than one hundred times greater than all the energy used.

This energy can be used to heat buildings **either** directly (passive solar energy) **or** by use of solar collectors (active solar energy). The sun's energy, stored in plant or animal matter – biomass – can be converted into fuel. **Nearly** half the world's population relies on biomass, mostly in the form of wood, and it is the main fuel for 80 % of people in developing countries. The sun **is also responsible for** rain, which can be harnessed as hydro-power.

Falling or flowing water generates 25 % of the world's electricity. Waves are the result of winds over the ocean, and ways of harnessing this new source of energy are being developed at present, while the complex interaction between earth, moon and sun **results in** the tides, which can also be used to produce electricity.

Geothermal energy, which is not strictly speaking a form of solar energy, nor renewable, makes use of hot rocks underground to produce **either** hot water **or** electricity.

to be responsible for – to be the cause of something, **to harness** – to use, **to result in** – to give rise to, **a tide** – a current in the sea towards or away from the shore , **to make use of** – to use

Exercise 1

Put the verbs in brackets into the passive voice (to be done in writing).

1. More energy arrives at the earth's surface in an hour than (to consume) by the world in a whole year.
2. Solar energy (can/use) to heat buildings.
3. The sun's energy (to store) in plant and animal matter.
4. The sun's energy stored in plant and animal matter (to call) biomass.
5. The sun's energy (can/convert) into fuel.

6. Rain (can/use) as hydropower.
7. Ways of harnessing waves (to develop) at present.
8. Tides (can/use) to produce electricity.
9. Renewable energy (can/use) in a wide variety of ways.

Exercise 2

Work in groups. You are at the lecture. One of you is a university professor, the others are students, who ask him questions.

1. Solar energy can be used to heat buildings. (General question), (How?)
2. The sun's energy can be converted into fuel. (What fuel?),
3. Wood is the main fuel for 80% of the people in developing countries. (What…?)
4. Rain can be harnessed as hydropower. (General question) (How?)
5. Falling or flowing water generates 25 % of the world's electricity. (What amount of the world's electricity…?)
6. Ways of harnessing waves is being developed at present. (What ways…?)
7. The complex interaction between earth, moon and sun results in tides. (What….in?)
8. Tides can be used to produce electricity. (General question)
9. Geothermal energy produces either hot water or electricity. (What…?)
10. Solar and wind energy are cost-effective. (General question)

Exercise 3

Work in groups of six. One of you is a teacher. The teacher writes 2 questions below on five cards and asks students to choose a card and answer the questions. The teacher makes comments.

1. What is the function of the sun?
2. What are fossil fuels?
3. If the sun is active, why do scientists worry that fossil fuels will run out and search for alternative energy sources?
4. Why has nuclear energy failed to live up to its early expectations?
5. Why will petrol become more expensive with time?
6. What is biomass?
7. Why do we use wood to make a fire?

8. What is the mechanism of rain falling?
9. How are waves formed?
10. What do tides result from?

ENERGY FOR TOMORROW'S WORLD
NANOTECHNOLOGY'S POTENTIAL IMPACT ON ENERGY CRISIS

Translate the passage in writing.

"**Both** inventors **and** investors are betting that flexible sheets of tiny solar cells used to harness sun's strength will ultimately **provide** a cheaper, more efficient source of energy than the current smorgasbord of alternative and fossil fuels.

<u>Solar energy could furnish much of the nation's electricity if available residential and commercial rooftops were fully utilized</u>. **According to** the Energy Foundation, using available rooftop space could provide 710,000 megawatts across the United States, whose current electrical capacity is 950,000 megawatts."

San Francisco Chronicle August 2005

Answer the questions in writing.

1. What energy will fossil and alternative fuels be substituted for?
2. How will solar energy be accumulated?
3. In what case could solar energy furnish the US electricity needs?
4. What is the US current electrical capacity?

Summarizing the answers to the questions, say what San Francisco Chronicle writes.

Energy from Salt Water

Translate the passage in writing.

John Kanzius discovered that his radio frequency generator could release the oxygen and hydrogen from salt water and create an incredibly intense flame. He placed a test tube filled with ordinary salt water into a radio wave generator, blasting the salt water with 200 watt's- worth of directed radio-waves. Within seconds, a blue flame erupted from the top of the test tube. It **then** turned bright white and burned for several seconds at about 3,000 degrees Fahrenheit – the melting point of Titanium.

If this invention works out, the ramifications **could** be enormous. Cars **could** run on engines powered by salt water **instead of** gasoline.

Answer the questions in writing.

1. What does an incredibly intense flame result from?
2. Do you think his invention will work out? Why do you think so?
3. If it does, what advantages will his invention have?
4. What fuel are cars powered by now?

Say what you think about the discovery.

INTERVIEW WITH DR CHARLES TILL, NUCLEAR PHYSICIST AND FORMER LAB DIRECTOR AT ARGONNE NATIONAL LABORATORY IN IDAHO

"MANKIND IS GOING TO NEED VAST AMOUNTS OF ENERGY IN THE FUTURE"

Read the interview.

I: I have two questions to ask you. First, to what extent will energy conservation help to solve the energy problem?

T: I think that many engineers would agree that there is limited gain to be had from conservation. What does one mean by "conservation"? One simply means using less and using less more efficiently. But we are talking about 10 or 20 %. **Whereas** in the next 50 years energy consumption would be 100 or 200 %, or some very large number.

And so what energy source steps in? There is only one. It's coal. It's natural gas. Some limited additional use of the more exotic forms of energy, like solar and wind. But they are limited in what they can do. So it will be fossil fuel.

Now **the question,** of course, immediately **arises**, well, how long can it last? And **everyone has a different opinion on that**. One thing that is certain is that the increase in the use of fossil fuels will sharply increase the amount of carbon dioxide in the atmosphere. Another thing is certain. You will put a lot more pollutants into the atmosphere **as**

well, **in addition to** carbon dioxide. <u>One can argue whether there is the greenhouse effect or not.</u> <u>One can point to natural gas</u>. Well, natural gas has fewer pollutants, and it gives some **considerable factor** of perhaps two – more energy for the amount of carbon dioxide put into the air than does coal. But if you are increasing the amount of fossil fuels **by** a large number, like five, then the use of natural gas is not a long-term solution. It simply **somewhat** reduces what may be a very serious problem.

I: Now the second question: What do you think about solar energy?

T: Solar? No.

I: Wind?

T: No, small amounts only. The simplest form of pencil calculation will tell you that. But you know energy has to be produced for modern society on a huge scale. **The only way** you can do that is with energy sources that have concentrated energy in them: coal, oil, natural gas. And the quintessential example of it is a nuclear form of energy, where the energy is concentrated. With solar energy the main problem is gathering it. In a nuclear form of energy, it's there. It has been gathered.

I: In terms of day-to-day operation, which puts more radiation into the atmosphere: a coal plant or a nuclear plant?

T: Coal plants, by large margins.

I: Where is the radiation from?

T: The radiation is from the contaminants in the coal - .thorium, uranium. **They go right up the stack**. It's a large source of pollution.

I: No nuclear plants have been commissioned in this country since the late '70s. Plants that are seeking to relicense are having trouble with the U.S. Administration because of the waste issue.

T: Right. You see, nuclear power in this country has to be understood in the context that nuclear power was never needed as a present day source. It wasn't needed in the '50s, wasn't needed in the '60s, '70s, 80s, isn't really needed today. The U.S. is still very resource-rich with fossil fuels. And **currently** we can import as much oil as we want. And so, **as long as** you can do that, and if nuclear power is troublesome **in any way**, you just turn away from it. The present generation of nuclear reactors is a perfectly adequate electrical generation source. And it is disappointing to have our nation not to follow up on it. The exciting thing about nuclear power is its ability to handle mankind's needs in the future. The vast amount of energy that is possible to get from it.

Checking up understanding

(In groups)

1. What does one mean by "energy conservation"?
2. What percentage of energy can be conserved?
3. Why will the increase in the use of fossil fuels sharply increase the amount of carbon dioxide in the atmosphere?
4. Is there such a phenomenon as a greenhouse effect? What's your opinion?
5. What pollutants will be put into the atmosphere in addition to carbon dioxide if one uses fossil fuels?
6. Why can't natural gas solve the problem of environment pollution?
7. Do you agree with Dr. Till that the solar energy won't solve the energy problem? Why?
8. What energy sources have concentrated energy?
9. What is the main problem with the solar form of energy?
10. What radioactive contaminants does coal contain?
11. Is the U.S. Administration against nuclear plants? Why? What evidence is there in the interview to prove or disprove it?

Give your comments

(In groups)

1\. "Solar and wind energy are limited in what they can do." **What are they limited in?**

1\. "Everybody has a different opinion on that." **On what?**

2\. "Natural gas is not a long-term solution of the environment pollution" **Why not?**

3\. "Natural gas gives a considerable factor of perhaps two." **What factor does he mean?**

4\. "The simplest form of pencil calculation will tell you that." **What?**

5\. "A coal plant puts more radiation into the atmosphere than a nuclear plant." **Why?**

6\. "The U.S. is still very resource-rich with fossil fuels." **What fossil fuels is the U.S. rich with?**

7\. "…… if nuclear power is troublesome in any way…" **In what way is nuclear power troublesome?**

8. It is disappointing to have our nation not to follow up on it.” **What does he find disappointing? Why does he find it disappointing?**

NUCLEAR POWER ENGINEERING

The Nuclear Fuel Cycle
January 2007

Read the text and look up the underlined words. Translate the underlined sentences in writing.

The nuclear fuel cycle is the series of industrial processes which involve the production of electricity from uranium in nuclear power reactors (1). Uranium is a **relatively** common element (2) that is found throughout the world. It is mined in **a number of** countries (3) and must be processed before it can be used as fuel for a nuclear reactor (4). Electricity is created by using the heat generated in a nuclear reactor to produce steam and drive a turbine connected to a generator (5). Fuel removed from a reactor, after it has reached the end of its useful life, can be reprocessed to produce new fuel.

The various activities associated with the production of electricity from nuclear reactions **are referred to as** the nuclear fuel cycle. The nuclear fuel cycle starts with the mining of uranium (6) and ends with the disposal of nuclear waste (7).

With the reprocessing of used fuel as an option for nuclear energy the stages form a true cycle.

In pairs formulate questions and give answers.

1. What?
2. General question?
3. In what countries?
4. Why?
4. Why?
5. How?
6. What……..with?
7. What…….with?

Enrichment

Natural uranium consists primarily of a mixture of two isotopes (atomic forms) of uranium (1). Only 0.7 % of natural uranium is fissile or capable of undergoing fission (2), the process by which energy is produced in a nuclear reactor. The fissile isotope of uranium is uranium 238.

There are two enrichment processes in **large scale commercial use**, each of which uses uranium hexafluoride as feed: gaseous diffusion and gas centrifuge. They both use the physical properties of molecules, specifically the 1% mass difference, to separate the isotopes (4). The product of this stage of the nuclear fuel cycle is enriched uranium hexafluoride (5), which is converted to produce enriched uranium oxide.

In pairs formulate questions and give answers.

1. What?
2. How much natural uranium?
3. What isotope of uranium ….?
4. What properties?
5. What?

Fuel fabrication

Reactor fuel is generally in the form of ceramic pellets. These are formed from pressed uranium pellets (1) which are baked at a high temperature. The pellets are **then** encased in metal tubes to form fuel rods which are arranged into a fuel assembly ready for introduction into a reactor. The dimensions of the fuel pellets and other components of the fuel assembly are precisely controlled (2) to ensure consistency in the characteristics of fuel bundles.

In a fuel fabrication plant great care is taken with the size and shape of processing vessels to avoid criticality (a limited chain reaction releasing radiation). With low-enriched fuel criticality is most unlikely, but in plants handling special fuels for research reactors criticality is a vital consideration.(3).

In pairs formulate questions and give answers.

1. What……from?
2. Why?
3. Why?

Power Generation

Inside a nuclear reactor the nuclei of U-235 atom fission (split) and in the process release energy. This energy is used to heat water and turn it into steam (1).The steam is used to drive a turbine connected to a generator which produces electricity (2).The fissioning of uranium is used as a source of heat in a nuclear power station **in the same way that** the burning of coal, gas or oil is used as a source of heat in a **fossil fuel power plant**.

In pairs formulate questions and give answers.

1. What ……for?
2. What……for?

Uranium and Plutonium Recycling

When a uranium-based energy produces energy in a nuclear reactor some of the neutrons produced by fission are captured by U238 nuclei which are transformed into plutonium Pu239. Like uranium 235 Pu239 is fissile. Plutonium is therefore necessarily a by-product of uranium fission.

Yet this plutonium represents **a great deal of** potential energy. Complete fission of one gram of plutonium generates more heat than complete combustion of one ton of oil (1).

Today plutonium is recycled in light water reactors (2), which are the most **common** nuclear reactors in the world. This makes it possible to save enriched uranium by replacing it with plutonium and prevents plutonium from ending up in end-waste being separated during spent fuel reprocessing.

The plutonium can be **directly** made into mixed oxide (MOX) fuel in which uranium and plutonium oxides are combined. In reactors that use MOX fuel plutonium substitutes for U-235 in normal uranium oxide fuel.(3)

In pairs formulate questions and give answers.

1. How much heat?
2. In what reactors?
3. What uranium isotope?

Exercise 1

Give Russian correspondence of the terms and N combinations used in nuclear power production literature.

an enrichment process, 1% mass difference, a fuel fabrication plant, the dimensions of fuel pellets, a vital consideration, a processing vessel, low-enriched fuel criticality, a source of heat, a fossil fuel power plant, uranium-based fuel, nucleus-nuclei, a by-product of uranium fission, a light water reactor, a fuel rod ,a fuel assembly, spent fuel reprocessing.

Exercise 2

Make up short, logical sentences with the below expressions and write them down. Follow the text.

to undergo fission
to separate
to be formed from
to be arranged into
to be controlled
to split
to release energy
to avoid criticality
to turn into
to be transformed into
to be recycled
to be combined

Exercise 3

You are an expert in nuclear power engineering.

Get ready for an interview. Here is a list of questions the interviewer wants to ask you. Make notes.

1. What is an isotope?
2. What does "to be fissile" mean?
3. By what process is energy produced in a nuclear reactor?
4. What is criticality?
5. Why is great care taken with the size and shape of processing vessels?
6. Why is criticality a vital consideration?
7. Which is the most common nuclear reactor?

8. What does plutonium recycling make possible?

9. What is MOX fuel?

10. What isotope of uranium does plutonium substitute for in reactors that use MOX fuel?

Exercise 4

(Class activity)

Two of you are experts in nuclear power engineering. The others are students majoring in this field, who ask them the above questions.

ASTROPHYSICS

HOW WAS THE UNIVERSE CREATED?

Our curiosity has led us to question our place in this universe and furthermore, the place of the universe itself. In all times people have been wondering: How did our universe begin? How old is our universe? How did matter come to exist? **Obviously**, these are not simple questions and much time and effort **has been spent** looking for some clue. **Yet,** much of what we know now is only speculation. True to the nature of science, a majority of the answers we have got only led to more intriguing and complicated questions. <u>Science seems to be a process of questioning</u>. Every new answer **gives rise to** a new question.

Warm-up activity

<u>Exercise 1</u>

Match the definitions given below with these words:

cosmos, cosmology, astronomy, astrophysics, a galaxy, a telescope, a detector, a lens, matter, an electromagnetic spectrum

1. a long instrument that is shaped like a tube and has lenses inside it ....
2. a thin piece of transparent material such as glass with a curved surface which makes things appear clear, larger or smaller ....
3. a universe having an order and pattern ....
4. the physical part of the universe consisting of solids, liquids and gases ....
5. a huge group of stars and planets that extends over many millions of light years ....
6. an instrument which is used to measure something ....
7. the study of the origin and nature of the universe ....
8. an ordered range of different sized waves, for example, light waves, radio waves or sound waves ....
9. the study of the stars, planets and other natural objects in space ....
10. the study of the physical and chemical structure of the stars, planets and other natural objects in space ....

Exercise 2

Ask your partner to give a definition of the above astronomical phenomena and devices. Model: What is a telescope?

WHAT IS RED SHIFT?

Read the passage and give a definition of blue shift.

In physics and astronomy, red shift occurs when the visible light from an object is shifted towards the red end of the electromagnetic spectrum. **More generally**, red shift is defined as an increase in the wavelength of electromagnetic radiation received by a detector **compared with** the wavelength emitted by the source. This increase in the wavelength corresponds to a decrease in the frequency of the electromagnetic radiation. **Conversely**, a decrease in wavelength is called blue shift.

THE BIG BANG THEORY

Read the text. Look up the underlined words. Translate the underlined sentences.

Many scientists **once** believed that the universe had **neither** beginning **nor** end and was infinite. **After** the development of the big theory, **however,** the universe could **no longer** be considered infinite. It was forced to take on the properties of a finite phenomenon, possessing a history and a beginning.

About 15 billion years ago a tremendous explosion started the expansion of the universe. This explosion is known as the big bang. At the point of this event all matter and energy was concentrated at one point. What existed **prior to** this event is completely unknown and is **a matter of pure speculation**. It was not a **conventional** explosion but **rather** an event filling all of space, with all of the particles of the embryonic universe rushing away from each other. The big bang **actually** was an explosion of space within itself unlike an explosion of a bomb where fragments are thrown outwards. The big bang laid the foundation of the universe.

The origin of the big bang theory can be credited to Edwin Hubble. Hubble made the observation that the universe is **continuously** expanding. He discovered that a galaxy's velocity is proportional to its distance from the earth. Galaxies that are twice as far from the earth move twice as fast. **Another** observation is that the universe is expanding in every direction. This observation means that it has taken every galaxy **the same** amount of time to move from a common starting position to its **current** position.

Since the big bang the universe has been continuously expanding and, **thus,** the distance between the clusters of galaxies has been increasing. The phenomenon of galaxies moving away from each other is known as the red shift.. **As** the light from distant galaxies approach the earth the distance between the earth and the galaxy increases which leads to stretching wavelengths.

There is further evidence for the big bang. In 1964, two astronomers, Arno Penzias and Robert Wilson, detected a noise of extraterrestrial origin. **The noise didn't seem to emanate from one** location but, **instead,** it came from all directions at once. What they heard was the radiation from the farthest reaches of the universe which had been left over from the big bang. The discovery of the radioactive aftermath of **the initial** explosion lent much credence to the big bang theory.

Grammar

……………………, **with S + Ving =при этом**

……………………, with all of the particles of the embryonic universe rushing away from each other.

Exercise 1

Checking up understanding (in pairs).

1. What is the difference between an infinite and a finite phenomenon?
2. What kind of phenomenon is the universe?
3. What is the big bang?
4. Is it a conventional explosion?
5. What is the difference between the explosion of space and that of a bomb?
6. How old is the universe?
7. What observations did Hubble make?
8. What conclusions were made from Hubble's observations?
9. What phenomenon is known as red shift?

Exercise 2

Make up short, logical sentences with the words and expressions below (to be done in writing). Follow the text.

1. a finite phenomenon
2. a conventional explosion
3. a tremendous explosion
4. a matter of pure speculation
5. to lay (laid) the foundation of
6. to make an observation
7. to be proportional to
8. another consequence
9. it has taken every galaxy the same amount of time

Exercise 3

Translate the sentences.

1. Хаббл пришёл к выводу, что скорость галактики пропорциональна её удалению от земли.
2. С момента большого взрыва вселенная постоянно расширяется.
3. В 1964 году астрономы обнаружили шум внеземного происхождения.
4. Шум внеземного происхождения оказался (turned out to be) излучением, исходящим из самых дальних уголков вселенной.
5. Этот шум остался со времени большого взрыва.

Exercise 4

Cut down each paragraph of the text to topical sentences and write a summary of the big bang theory.

Exercise 5

(In groups)

You are participating in a conference on “How the universe was created.” Give a short talk and suggest your colleagues a question from checking up understanding exercise.

THE MOON

I had the ambition to not only go farther than man had gone before, but to go as far as it was possible to go. - Captain Cook

Though a satellite of the Earth, the Moon is bigger than Pluto. Some scientists think of it as a planet (four other moons in our solar system are even bigger).There are various theories about how the moon was created, but recent evidence indicates it formed when a huge collision tore a big chunk of the Earth away. Because it takes the Moon 27.33 days both to rotate on its axis and to orbit the Earth, the Moon always shows us the same face. We see the Moon **because of** reflected sunlight. .How much of it we see depends on its position in relation to the Earth and the Sun. The 27.3-day number is what scientists call a sidereal month, and it is how long it takes the Moon to orbit the Earth in relation to a fixed star. Another measurement, called a synodic month, is measured in relation to the Sun and equals 29.5 days. Full moons and new moons are measured by the synodic month. The Earth's gravity keeps the Moon in orbit, **while** the Moon's gravity creates tides. Like the four inner planets, the Moon is rocky. It is pockmarked with craters formed by asteroid impacts millions of years ago. **As** there is no weather, the craters have not eroded. **Since** the Moon has almost no atmosphere, a layer of dust or a footprint remain undisturbed for centuries. In the absence of the atmosphere, heat is not held near the planet, **so** temperature differences on the two sides are enormous. Daytime temperatures on the sunny side of the Moon reach 273 degrees F; on the dark side it gets as cold as -243 F. In 1999 researchers discovered a huge cloud of sodium gas trailing behind the Moon. The Lunar Prospector **provided evidence** of ice near the Moon's poles, perhaps as much as 6 billion tons. The Moon travels around the Earth at a little more than half a mile per second; its speed is slowing and the satellite is gradually moving away from the Earth.

Checking up understanding (in pairs)

1. What is a sidereal month and what does it equal?
2. What is a synodic month and what does it equal?

3. What do we call the two sides of the Moon?
4. What keeps the Moon in orbit?
5. What is the daytime temperature difference between the sunny side and the dark side?
6. What evidence did the Lunar Prospector provide?
7. How much ice is there near the Moon poles?
8. Why is the Moon gradually moving away from the Earth?

Exercise 1

Fill in the prepositions. Then check them against the text.

1. We see the Moon – reflected sunlight.
2. How much of the Moon we see depends – its position – the Earth and the Sun.
3. – four inner planets, the Moon is rocky.
4. The Moon travels – the Earth – a little more than half a mile – second.
5. The satellite is gradually moving away – the Earth.

Exercise 2

In pairs join these sentences using the suggestions in brackets (because of, while, though, as, so). Then check against the text.

1. The Moon is the satellite of the Earth.
   The Moon is bigger than Pluto.
2. It takes the Moon 27.3 days both to rotate on its axis and to orbit the Earth.
   The Moon always shows us the same face.
3. The Earth's gravity keeps the Moon in orbit.
   The Moon's gravity creates tides.
4. The Moon has almost no atmosphere.
   A layer of dust or a footprint remains undisturbed for centuries.
5. Heat is not held near the planet.
   There is an enormous temperature difference between the two sides of the Moon.
6. The Moon's speed is slowing.
   The satellite is gradually moving away from the Earth.

Exercise 3

A famous astrophysicist is giving a talk on the Moon at your University. Formulate questions that interest you to ask him.

1. There are various theories about how the Moon formed. (How?)
2. Recent evidence indicates it formed when a huge collision tore a chunk of the Earth away. (What?)
3. The Moon always shows us the same side. (Why?)
4. The Earth's gravity keeps the Moon in orbit. (What?)
5. The craters were formed by asteroid impacts. (What ………by?)
6. The Moon travels around the Earth at a little more than half a mile per second. (At what speed?)
7. The Lunar Prospector provided evidence of ice near the Moon's poles. (What evidence?)

Exercise 4

Work in pairs. One of you is an astrophysicist, the other is a student majoring in astrophysics, who asks him the above questions.

There are various theories concerning the Moon's origin. This is what Wilson Colin, American science fiction writer and philosopher, thinks.

Read the passage and translate the underlined sentence in writing.

… For a thousand years or so the Earth had no Moon. Then it captured a **space-wanderer**, a giant meteorite – our present Moon. The Moon was pulled slowly towards the Earth by the Earth's gravitation. It may sound **too** absurd to take seriously but I feel that the Moon is "radioactive" with strange alien forces that could **exercise a disturbing effect on** human mind. I should think the Moon emits energy which affects human thought processes, psychic energy. It's a kind of a giant transmitter and the Earth is a giant receiver.

Lunatics (sleepwalkers) are considered to be men whose minds are affected by the gravitational pull of the Moon. But why should the Moon affect the mind? The Moon exerts a curious pull on the human mind. I have a feeling it **has nothing to do with** gravity. I believe that the Moon was never a part of the Earth. Perhaps it was a comet that the Earth captured. Its chemical composition is quite unlike the Earth's.

Do you find Colin's speculations common sense or absurd? How do his speculations differ from the generally accepted theory of the origin of the Moon? What viewpoint do you share?

Arrange your ideas in three paragraphs:
1. The officially accepted theory.
2. Colin's speculations.
3. Your point of view.
Use the underlined introductory words:
I feel, I have a feeling, I believe, I should think, his ideas are too absurd to take seriously

A BLACK HOLE

Read the text. Look up the underlined words. Translate the underlined sentences in writing.

The anomalous black holes are concentrated areas of mass so massive that the mammoth force of gravity denies anything within a certain area around it from passing. This area is called the event horizon of a black hole.

We have given black holes their name because light from the event horizon can never be seen by any outside observer. We believe that black holes are created by the collapse of a red super-giant star. **As** these stars reach the end of their lives, an imbalance of inward and outward pressure forces the star to collapse.

We know black holes exist not because we can see them, but **because of** the impact they have on the space around them. And **yet**, they remain an enigma, a constant area of intrigue and curiosity.

WHAT IS GRAVITY?

Suppose you are standing on the surface of a planet. You are throwing a rock straight up into the air. Assuming you do not throw it too hard, it will rise for a while, but eventually the acceleration **due to** the planet's gravity will **make** it fall down. If you threw the rock hard enough, though, it would be able to overcome the planet's gravity. It would keep on rising for ever. The speed with which you need to throw the rock **in order that** it could overcome the planet's gravity is called the "escape velocity." The escape velocity depends on the mass of the planet: if the planet is extremely massive, then its gravity is very big, and the escape velocity is high. A lighter planet **would** have a smaller escape velocity than a more massive one. The escape velocity also depends on how far you are from the planet's center: the closer you are, the higher is the escape velocity. The Earth's escape velocity is 11.2 kilometers per second, **while** the Moon's is only 2.4 kilometers per second.

Now imagine an object with such enormous concentration of mass in such a small radius that its escape velocity is greater than the velocity of light. **Then**, **since** nothing can go faster than light, nothing can overcome the object's gravitational field. Even a beam of light would be pulled back by gravity and would be unable to escape.

The idea of mass concentration so dense that even light **would** be trapped in goes back to Laplace in the 18th century. Almost immediately **after** Einstein had developed general relativity, Karl Schwarzchild discovered a mathematical solution to the equations of the theory that described such an object. It was only much later that scientists started thinking seriously that such objects might actually exist in the Universe. Oppenheimer, Volkov and Snyder in the 1930's showed that when a massive star runs out of fuel, it is unable to support itself against its own gravitational pull, and should collapse into a black hole.

According to general relativity, gravity is a manifestation of the curvature of space time. Massive objects distort space and time. Near a black hole the distortion of space is extremely severe and causes black holes to have very strange properties. **In particular**, a black hole has "an event horizon". This is a spherical surface that marks the boundary of the black hole. You can pass in through the horizon, but you can't get out. In fact, **once** you have crossed the horizon, you'**re doomed to** move closer and closer to the "singularity" at the centre of the black hole.

You can think of the horizon as the place where the escape velocity equals the speed of light.

Outside the horizon, the escape velocity is less than the speed of light, **so** if you fire your rocket hard enough, it **would** obtain enough energy to get away. But if it finds itself inside the horizon, it won't be able to escape **no matter how powerful it is**. The spherical surface has a very high velocity. In fact, it is moving outwards at the speed of light. That explains why it is easy to cross the horizon in the inward direction, but impossible to get out. **Since** the horizon is moving outwards at the speed of light, **in order to** escape from it, you **would have to** travel faster than light. You can't go faster than light, **so** you can't escape from the black hole.

Grammar WOULD

1. бы – to express unreal conditioning.

2. would is used to talk about natural course and behavior of things as a result of some action. It is the less definite form of WILL.

Could corresponds to – **мог бы** in Russian.

Translate the sentences.

1. E.g.

If you threw the rock hard enough it **would** be able to overcome the planet's gravity.

In order to escape from the horizon, you **would have to** travel faster than the speed of light.

2. E.g.

A lighter planet **would** have a smaller escape velocity.

Even a beam of light **would** be pulled back by gravity and **would** be unable to escape.

<u>Exercise 1</u>

To understand what the escape velocity is, let's reconstruct the situation in pairs. Follow the text.

1. Where are you standing?
2. What are you doing?
3. Do you throw the rock hard?
4. What happens to it?
5. What makes it start to fall down?
6. If you threw the rock hard enough, would it be able to overcome the planet's gravity?
7. What would happen to it?
8. What do we call the speed with which we need to throw the rock to make it overcome the planet's gravity?

Exercise 2

Explain:

1. The escape velocity depends on the mass of the planet.
2. The escape velocity also depends on how far you are from the planet's center.

Exercise 3

To understand what a black hole is, formulate questions to ask your university professor.

1. The value of gravity depends on the mass. (What?)
2. The escape velocity depends on the mass of the planet and on how far you are from the planet's center. (What?)
3. The Earth's escape velocity is 11.2 km per second. (Why?)
4. The Moon's escape velocity is 2.4 km per second. (Why?)
5. Nothing can escape from the object's gravitational field. (In what case? Why?)
6. Einstein developed general relativity theory. (What other theoriesy?)
7. Karl Schwarzchild discovered a mathematical solution to the equations of the general relativity theory. (Who?)
8. These researchers showed that when a massive star runs out of fuel, it should collapse into a black hole. (What researchers? Why?)
9. According to general relativity gravity is a manifestation of space time. (What?)

Exercise 4

Work in groups. You are at the seminar. The problem under discussion is "Black Holes." One of you is a university professor. The others are students, who ask him the above questions.

Exercise 5

Another point to be discussed at the seminar is gravity. The teacher gives you a list of questions to be answered in writing.

1. What theory of gravity is considered the most adequate at the moment?
2. How does gravity manifest itself in general relativity?
3. Why do the usual rules of geometry not apply to massive bodies?

4. Why do black holes have strange properties?
5. What is an "event horizon"?
6. What kind of place is the horizon?
7. Is the horizon static or moving?
8. At what velocity is it moving?
9. Why can't one escape from the black hole?

Exercise 6

Class activity. You are having a seminar on gravity. One of you is a university professor, who asks you the above questions.

DARK MATTER IN THE UNIVERSE

"Order is the first heaven's law"
Pope

As much as 90 percent of the matter in the universe is invisible. Detecting dark matter will help astronomers better comprehend the universe's destiny.

By Vera Rubin
Scientific American

Read the text, look up the underlined words and translate the underlined sentences in writing.

Most astronomers believe that as much as 90 percent of the stuff constituting the universe's matter does not radiate – it provides no glow that we can detect in the electromagnetic spectrum. This so-called missing matter is believed to reside within clusters of galaxies. Nowadays we prefer to call missing matter "dark matter" because it is the light not the matter that is missing.

Astronomers and physicists offer a variety of explanations for the dark matter. **On the one hand,** it could be ordinary material, **such as** ultrafaint stars, large and small black holes, cold gas or dust scattered around the universe – all of which emit or reflect too little radiation for our instruments to detect. It could even be a category of dark objects called MACHO's (massive compact halo objects) that lurk invisibly in the halos of surrounding galaxies and galactic clusters. **On the other**

hand, dark matter could consist of exotic, unfamiliar particles that we haven't yet figured out how to observe .Physicists **advance theories** about their existence, **although** experiments have not yet confirmed their presence. A third possibility is that our understanding of gravitation needs revision but most physicists do not **consider** this option seriously. **In some sense**, our ignorance of the properties of dark matter is tangled up with other outstanding issues in cosmology – such as how much mass the universe contains, how galaxies formed, and whether the universe will expand forever. Dark matter is very important to understand the size, shape and the ultimate fate of the universe. Its search is likely to dominate astronomy for the next few decades. Observing something you cannot see is difficult – but not impossible. Astronomers study dark matter by its effect on the bright matter that we do observe. **For instance**, when we see a nearby star wobbling, we infer from the calculations that "dark planet" orbits around it. Applying similar principles to spiral galaxies, we **account for** the motion of stars by **the presence** of dark matter.

When we observe the stars and clouds of gas orbiting the centers of spiral galaxies, we find that they move **too** quickly. Their unexpectedly high velocities signal that the gravitational tug is exerted by something bigger than **that** of the visible matter of the galaxy. **From** detailed velocity measurements we conclude that large amounts of invisible matter exert the gravitational force that holds the stars and gas clouds in high speed orbits, We deduce that dark matter is spread around the galaxy beyond the visible galactic edge and above and below the **otherwise** flattened, luminous galactic disk.

Looking at a single galaxy, astronomers see within the galactic radius (a distance of about 50,000 light-years) only about one tenth of the total gravitating mass needed to **account for** how fast stars are rotating around the galactic hub.

Translate the paragraph in writing.

In trying to discover the amount and distribution of dark matter in a cluster of galaxies, x-ray astronomers have found that galaxies within clusters are immersed in highly diffused clouds of 100 million degree gas – gas that is rich in energy, yet difficult to be detected. X-ray astronomers have learned to use the temperature of x-ray emitting gas and its extension **in the same way as** optical astronomers use the velocities of stars in a single galaxy. In both cases, the data provide clues to the nature and location of the unseen matter. In a cluster of galaxies, the extend of the x-ray emitting region and the temperature of the gas enable us to estimate the amount of the gravitating mass within the cluster's radius, which measures about 100 million light-years. In a typical case, when we add together the luminous matter and the x-ray emitting hot gas we are able to sense roughly 20 to 30 percent of the total gravitating mass of the cluster. The remainder, which is dark matter, remains undetected by our present day instruments.

Exercise 1

Reconstruct the relative sentences into questions.

1. at present the most outstanding issues in cosmology are:
2. how much mass the universe contains.
3. how galaxies formed.
4. whether the universe will expand forever

Exercise 2

Terms. Give their Russian correspondence and make up sentences with them. Follow the text.

1. galaxy clusters
   velocity measurements
   massive compact halo objects
   x-ray astronomers
   100 million degree gas
2. an x-ray-emitting gas
   an x-ray-emitting region

Verbs and expressions

1. to offer a variety of explanations
2. to advance a theory
3. to confirm a theory experimentally
4. to consider an option seriously
5. to conclude, to deduce
6. to reside
7. to spread
8. to account for
9. to dominate
10. to radiate

Exercise 3

Translate the sentences using the above verbs and expressions. Follow the text.

1. Полагают, что 90 % вещества во вселенной не излучает свет.
2. Полагают, что эти невидимые вещества находятся в кластерах галактики.
3. Астрономы и физики предлагают несколько объяснений того, что называется темной материей.
4. Физики выдвигают теории о существовании неких неизвестных частиц, хотя эксперименты не подтвердили их наличия.
5. Физики серьезно не рассматривают предположения о том, что необходимо пересмотреть наши представления о гравитации.
6. Вероятно, поиск темной материи будет основным направлением в астрономии в течение следующих десятилетий.
8. В настоящее время астрономы изучают темную материю посредством ее воздействию на материю, которая излучает свет.
9. Движение звезд можно объяснить наличием темной материи.
10. На основании измерения скоростей звёзд ученые делают вывод, что тёмная энергия распределена равномерно по всей галактике.

Exercise 4

Cut down each paragraph of the text to topical sentences and write a summary using introductory and connecting words: on the one hand, on the other hand, such as, although, for instance, otherwise, Yet.

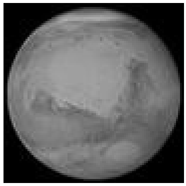
Exercise 5

A round table talk. You are astrophysicists from different countries. You got together to discuss the phenomenon of dark matter. Each of you is giving a short talk on dark matter and addresses his colleague, who sits next to him, with a below question.

1. What explanation do you offer for the dark matter?
2. Where is the dark matter believed to reside?
3. Do you also call the missing matter "dark matter"? Why?
4. What explanations for dark matter do astronomers offer?
5. What explanations for "dark matter" do physicists offer?

6. What is holding stars in high speed orbits?
7. How do astronomers study “dark matter”?
8. Why is “dark matter” not detectable by present day instruments?

CAN WE MAKE MARS HABITABLE?



Climate models suggest that human beings could transform the Red Planet into a more Earth-like world using current technologies.

By Christopher P. McKay

FYI – climate – ecology

INTRODUCTION

Read the text and translate the underlined sentences in writing.

More than 20 years ago the Mariner and Viking missions **failed to find evidence** that life exists on Mars’s surface, **although** all the chemical elements needed for life were present. That result inspired two biologists of the National Aeronautics and Space Administration Research Center **to consider** seriously whether Mars’s environment could be made hospitable to colonization by Earth-based life-forms.

Since then several scientists, using climate models and ecological theory, have concluded that the answer is probably yes: “**With** today’s technology, we **could** transform the climate on the planet Mars, making it suitable once more for life. Such an experiment **would** allow us to examine, on a grand scale, how biospheres grow and evolve. And it **would** give us an opportunity to spread and study life **beyond** Earth.”

Answer the questions.

1. What aim do scientists follow undertaking the experiment?
2. What makes the experiment practicable?

Why Mars?

The key physical properties of Mars are remarkably similar to **those** of Earth. On the both planets the length of the day is about 24 hours – an important **consideration** for plants that photosynthesize when the sun shines. Mars also experiences seasons, **as** the planet's axis is tilted to a similar degree as **that** of the Earth's. Because Mars is farther from the sun, a Martian year is almost **twice the length** of an Earth year, but plants should be able to adapt to such a difference. One unalterable difference between Earth and Mars is gravity. The gravity of Mars is about one third **that of** the Earth's. How life would adapt to reduced gravity is unknown. Microbes are likely to adjust easily to Martian gravity, and some animals might cope ***as well.***

Mars is **currently too** cold, **too** dry and its carbon dioxide atmosphere **too** thin to support life. But these parameters are interrelated, and all the three can be altered by a combination of human intervention and biological changes. The key is carbon dioxide. If we enveloped Mars in a thicker carbon dioxide atmosphere, with a surface pressure one to two times **that** of air at sea level on Earth, the planet would naturally warm up above the freezing point of water. Adding a bit of nitrogen to the atmosphere would help satisfy the metabolic needs of plants and microbes. And the small amount of oxygen that would be produced from the photochemical degradation of carbon dioxide **could** create a rudimentary but effective ozone shield for the planet. This carbon dioxide atmosphere would support plant and microbial life but wouldn't contain enough oxygen for animals.

Although humans would need to carry a supply of breathable air with them, a carbon dioxide Mars would still become a much kinder, gentler place than today's Mars. The higher temperatures and atmospheric pressure would make bulky space suits unnecessary. And the natural growth of plants would allow the cultivation of farms and forests on Mars's surface, **thus** providing food for human colonists or visitors.

To make Mars suitable for animals and humans, its atmosphere would have to be made more similar to Earth's, which is composed primarily of nitrogen, with oxygen levels being close to 20 percent and carbon dioxide levels less than 1 percent. The process of generating such an Earth-like, oxygen-rich environment would be much more difficult than simply thickening Mar's atmosphere. But to make Mars habitable, generating a carbon dioxide atmosphere would be the first logical step.

Grammar

WOULD 1. бы – to express unreal conditioning

2. to talk about the natural course and behavior of things as a result of some action. It is the less definite form of WILL.

E.g. If we enveloped Mars in thicker carbon dioxide atmosphere, the planet would naturally warm up above the freezing point of water.

E.g. Carbon dioxide atmosphere would support plant and microbial life but wouldn't contain enough oxygen for animals.

Checking up understanding

1. What is the quintessential ingredient for life to evolve?
2. Why is liquid water the quintessential ingredient for life to evolve?
3. Is there water on Mars?
4. Did Mariner and Viking bring any evidence that life exists on the surface of Mars?
5. What evidence inspired the biologists to consider that Mars could be made habitable?
6. What key physical properties of Mars are similar to those of the Earth?
7. What is an unalterable difference?
8. What Earth based life forms would adjust easily to Martian gravity?
9. What climatic parameters are interrelated?
10. What are scientists to do to alter the climatic parameters of Mars?
11. What gases is the Earth's atmosphere composed of?
12. What is the first logical step of transforming Mars into a more Earth-like world?

<u>Exercise 1</u>

Join the sentences using the suggestions in brackets. (although, but, as, because). Then check up against the text.

1. The planet's axis is tilted to a similar degree as that of the Earth's.
   Mars experiences seasons.
2. Mars is father from the sun.
   A Martian year is almost twice the length of the Earth year.
3. Mars is currently too cold, too dry and its carbon dioxide atmosphere too thin to support life.
   These parameters are interrelated.

4. Humans would need to carry a supply of breathable air with them. A carbon dioxide Mars would still be a much gentler planet.

Exercise 2

Terms. Give their Russian correspondence and make up short, logical sentences with them.

1. Sea level, freezing point, surface pressure, carbon dioxide, oxygen-rich environment.
2. Earth based life forms.

Exercise 3

Make the adjectives negative adding prefixes in, un, il.

hospitable, alterable, effective, necessary, logical, adaptable, adjustable, habitable

Exercise 4

Make up short, logical sentences using the verbs below and write them down. Follow the text.

1. to fail to find evidence
2. to consider
3. to conclude
4. to examine
5. to adapt to
6. to be interrelated
7. to alter
8. to adjust
9. to contain
10. to be composed of

Exercise 5

Cut down each paragraph to topical sentences and write a summary.

Exercise 6

Arrange your summary into a talk to convince the members of the scientific board that the experiment is feasible. Use introductory words to make your talk sound more enthusiastic:

I do believe, I am convinced, I should think, my feeling is, I must admit, as far as I can figure out, I expect

Exercise 7

Class activity. One of you is a biologist, another one is a climatologist, still another is an ecologist, and still another is an astrophysic-

ist. They are convincing the members of the board that the experiment is worth doing. The others are members of the scientific board, who ask them questions (use questions from checking up understanding exercise) and make their judgements.

CONVERSATION WITH NEIL DEGRASSE TYSON

Tyson is a leading astrophysicist, the director of the American Museum of Natural History's Hayden Planetarium. In this interview, he shares his thoughts on the latest findings in origins science and explains why he is not convinced there's intelligent life **beyond Earth**.

Read the interview. Look up the underlined words. Translate the underlined sentences in writing.

Nova: What makes the study of origins so hot right now?

Tyson: Well, one thing that distinguishes us today from the discoveries of the past is <u>the extent</u> to which the exploration of the universe has become multidisciplinary. It was unthinkable not long ago that a biologist or a paleontologist would be at the same conference as an astrophysicist. Now we have accumulated so much data in each of these branches of science <u>as it relates to origins</u> that we have learned that no one discipline can answer questions of origins alone. It requires the additional insights that one gets by <u>merging</u> not only the questions, but the answers, among scientific disciplines.

Now, for example, when we look for life on Mars, we need the astrophysicist to characterize the environment in which the planet is found. You need the chemist to understand the chemistry of the soils. You need the geologist to understand the rock formations. You need the biologist, because no one else will know what life will look like. <u>You might even need a paleontologist to look for life that does nor exist there today but might have left fossil remains</u>. And scientists in different disciplines don't speak the same language. They publish in different journals. It's like the United Nations: you come together, but no one speaks the same language, so you need some translators. But in the end, what happens is that new fields of astrobiology and astrogeology and astro-particle physics arise, and they begin to develop their own language that represents the intersection of the two, say, between astrobiology and biology. That's when you know that you have created a new subdiscipline, or even a brand-new discipline.

Answer the suggested questions in writing.

1. Why has the exploration of the universe become multidisciplinary now?

2. How can one get an additional insight into the problem?

3. What scientists are to work in collaboration to look for life on Mars?

4. What is the function of the astrophysicist?

5. What is the function of the chemist?

6. What is the function of the geologist?

7. What is the function of the biologist?

8. What is the function of the paleontologist?

9. How is a new brand-new discipline created?

Nova: What are some of the most exciting recent discoveries in origins science?

Tyson: **I would say** one, we nailed the age of the universe. Two, we have measured the existence of dark matter and dark energy. **Even though** we don't yet know what they are made of, we know we can measure **the effects they have on** the origin and the revolution of the universe. **Another** is the discovery that the moons of the solar system may be more interesting than the planets themselves.

Nova: How so?

Tyson: **It's contrary to our earliest expectations.** We used to think our moon is dry and barren, **so** why should we believe anybody else's moon is interesting? But if you look at the moons on Jupiter, for example, you find that one of them, Europa, is covered with ice, and below the ice is an ocean of water that is maintained in the liquid state by energy pumped into it from its orbit around Jupiter. Where there is water on Earth, you find life as we know it. **So** if you find water somewhere else, it becomes a remarkable draw to look **closer** to see if life of any kind is there, even if it's bacterial, which would be extraordinary for the field of biology.

Of Saturn 31 moons, Titan is especially targeted for its richness in organic compounds. It has an atmosphere. And it might have oceans, not of water but of liquid methane. You could only begin to imagine what kind of interesting chemistry we might find and what forms any possible life might take under such circumstances. **Perhaps** life not as we know it, but as we don't know.

1. How old is the universe?
2. What do we know about dark matter and dark energy? What do we not know yet?
3. What is Europa remarkable for?
4. What is the essential ingredient for life development?
5. What is Titan remarkable for?

Nova: What great origins-related discoveries would you hope for in the coming decades?

Tyson: The discovery of life somewhere **other than** on Earth. That is a first goal in our exploration of the cosmos. And what's fascinating is the question of whether that life has DNA. It's a fascinating question, because **either** DNA is inevitable as the foundation for the coding of life, **or** life started with DNA in only one place in the solar system and then spread through panspermia.. Panspermia allows life on one planet to be thrust back into space by some meteor impact.

Another possibility is that the life has encoding that **has nothing to do with** DNA. That **would** be more important for biology than finding other life with DNA, because it would be **a way** to encode life **that no one has dreamt of** before.

1. What is a first goal in the exploration of the cosmos?
2. What is panspermia?
3. What question about the origin of life does he find the most fascinating? Why?

Nova: What about as an astrophysicist? Do you have hopes for specific discoveries?

Tyson: I want to know what dark matter and dark energy are comprised of. They remain a mystery, a complete mystery. No one is any **closer to** solving the problem than when these two things were discovered.

Nova: Speaking of great discoveries, do you believe there's intelligent life elsewhere in the universe and, if so, will we ever detect it?

Tyson: **I'm not convinced yet.** I think that intelligence is such a narrow branch of the tree of life, this life of primates, who we call humans. **No other** animal, by our definition, can be considered intelligent. **So** intelligence can't be all that important for survival, because there are so many animals that don't have what we call intelligence, and they are surviving just fine.

1. What does he mean when he says "by our definition?" How do we define intelligence?

2. If intelligence is not that important for survival what is intelligence for? What is the function of intelligence?

Nova: Do you have high hopes for the James Webb Space Telescope, which is designed to study distant galaxies?

Tyson: Absolutely. It will be unprecedented in its ability to measure the formation of galaxies in the early universe, something the Hubble can't do. The Hubble telescope can measure them in different evolutionary stages, but it can't see them actually forming. And that's **a big gap** in our current knowledge right now, how galaxies form.

Nova: Regarding the origin of life, the astronomer Alan Dressler has written that every atom in our body save hydrogen was once at the center of a star. Can you explain that?

Tyson: Sure. The big bang <u>endowed</u> the universe with hydrogen and helium and not much of anything else. **That is,** nine out of ten atoms are hydrogen, about one out of ten is helium. <u>If there were no stars, that would be the beginning and the end of the universe.</u>

But there are stars, and stars manufacture heavy elements from light elements. They take hydrogen in and <u>fuse</u> the atoms to become carbon, and carbon fuses to become silicon and nitrogen, and so on. **Thus**, elements **other than** hydrogen and helium have **no** origin **other than** the centers of stars...And stars not only manufacture the heavy elements, they also explode them into space. **Since** life itself thrives on these heavy elements, we owe our very existence to stars.

1. What do the Hubble Space Telescope and the James Space Telescope differ in?

2. What elements did the big bang manufacture?

3. What do stars manufacture heavy elements from?

Exercise 1

Prepare a talk on one of the topics:

1. The origins science is a multidisciplinary science.
2 The recent discoveries in origins science.
3. Moons that attract astrophysicists in the solar system..
4. The discovery of life in space is a first goal in the exploration of the cosmos.
5. Dark matter and dark energy.
6. Intelligent life elsewhere in the universe.
7. The difference between the Hubble Space Telescope and the James Webb Space Telescope.
8. The origin of light and heavy elements.

Use expressions: I would say; to have an effect on, it is contrary to our earliest expectations; we used to think; to have nothing to do with; I'm not convinced yet; regarding; that is; since; thus; so; perhaps.

Exercise 2

Formulate logical questions to the statements in ex. 1.

E.g. Why has the origins science become a multidisciplinary science?

Exercise 3

A round table talk. You are scientists, specializing in different fields related to the exploration of the universe. You got together to discuss breakthroughs and challenges in origins science. Each of you gives a talk on one of the topics and addresses the next speaker with one of the questions formulated in ex. 2.

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LOOK AROUND

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