А.В. Вдовичев
Н.Г. Оловникова

Английский язык
для магистрантов и аспирантов

English
for Graduate and Postgraduate students

Учебно-методическое пособие

•ФЛИНТА•

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Рецензенты:
канд. филол. наук, доцент, зав. кафедрой иностранных языков
факультета энергетического строительства БНТУ *Н.П. Мартысюк*;
канд. филол. наук, доцент *Е.А. Мисуно*

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Пособие содержит научные, научно-популярные и общественно-политические тексты, а также комплексы упражнений и заданий для развития навыков устной и письменной речи на английском языке. Тематическое содержание соответствует программе-минимуму по иностранному языку для слушателей магистратуры и аспирантуры языковых и неязыковых специальностей вуза. Каждый раздел данного учебного пособия включает в себя упражнения по переводу, устной практике, усвоению активной лексики, тексты для изучающего и просмотрового чтения и последующего анализа.

Адресуется слушателям магистратуры и аспирантуры языковых и неязыковых специальностей вузов Российской Федерации и преподавателям как учебное пособие и в качестве вспомогательного учебно-методического материала.

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Introduction

Nowadays it is impossible to imagine our life without science and technology. Much attention is paid to scientific development at the level of higher education. The English language proved to be the main means of communication in the field of research, development and science. That is why graduate and postgraduate students have to understand the bulk of information that is provided in English.

This textbook can be regarded a guide to reading scientific and popular scientific texts in various fields, about the greatest inventions and researchers of the past and present as well as about perspectives of scientific development.

The textbook consists of 5 units:

1. What Is Science?
2. Evolution of Science
3. Knowledge Society
4. Perspectives of Science Development
5. Science in Our Everyday Life

Each unit contains 26 tasks (from A to Z) providing brainstorming activities, reading comprehension, vocabulary work, creative and interactive tasks, tips for graduates and postgraduates about presentations, thesis writing, communication skills needed in the field of their research as well as tasks for development of skills of speaking and writing in English. The texts are selected in the way as to make all graduates and postgraduates be interested in the topics discussed, irrespective of their specialty and qualification.

All texts are accompanied by references of and links to the resources they are taken from. Both varieties of English are used: British and American. After the units there is a section with some additional texts that can be used during the classes of English.

In Appendices one can find some useful information about sciences that exist at present with the detailed definition, abbreviations of college degrees and academic and scientific titles (the US and European use).

The book will be quite useful in preparatory course for passing postgraduate exam in English.

The authors of the textbook would like to express their sincere gratitude to all those who helped them find interesting and useful information as well as to those who will use this book for their studies of English. We hope it will be very useful and we wish graduates and postgraduates all possible success in their researches, theses and scientific careers.

Unit 1

What is Science?

A. Read the following quotations about science and express your own opinion about science in general and about your field of science.

1) The origin of all science is in the desire to know causes; and the origin of all false science and imposture is in the desire to accept false causes rather than none; or, which is the same thing, in the unwillingness to acknowledge our own ignorance. (***William Hazlitt*** from ***The Atlas***)
2) Science sometimes builds new bridges between universes of discourse and experience hitherto regarded as separate and heterogeneous. But science also breaks down old bridges and opens gulfs between universes that, traditionally, had been connected. (***Aldous Huxley*** from ***Literature and Science***)
3) Let both sides seek to invoke the wonders of science instead of its terrors. Together let us explore the stars, conquer the deserts, eradicate disease, tap the ocean depths and encourage the arts and commerce. (***John F. Kennedy*** from ***Inaugural Address***)
3) When we say "science" we can either mean any manipulation of the inventive and organizing power of the human intellect: or we can mean such an extremely different thing as the *religion of science,* the vulgarized derivative from this pure activity manipulated by a sort of priestcraft into a great religious and political weapon. (***Wyndham Lewis*** from ***The Art of Being Ruled***)
4) Science does not aim, primarily, at high probabilities. It aims at a high informative content, well backed by experience. But a hypothesis may be very probable simply because it tells us nothing, or very little. (***Karl R. Popper*** from ***The Logic of Scientific Discovery***)

B. Write down 5—10 sentences expressing your ideas about science.

C. Read the definitions of "science" and choose the one, which suits best to your ideas about science from exercise B.

No.	Definition	Source
1.	1) the systematic study of the nature and behaviour of the material and physical universe, based on observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms 2) the knowledge so obtained or the practice of obtaining it	*Collins English Dictionary, 8th Edition*

	3) any particular branch of this knowledge the pure and applied sciences 4) any body of knowledge organized in a systematic manner 5) skill or technique 6) *(archaic)* knowledge	
2.	any system of knowledge that is concerned with the physical world and its phenomena and that entails unbiased observations and systematic experimentation. In general, a science involves a pursuit of knowledge covering general truths or the operations of fundamental laws.	*Britannica*
3.	science is the study of the nature and behaviour of natural things and the knowledge that we obtain about them.	*Collins COBUILD Advanced Learner's English Dictionary, 4th edition*
4.	a branch of study in which facts are observed and classified, and, usually, quantitative laws are formulated and verified; involves the application of mathematical reasoning and data analysis to natural phenomena.	*McGraw-Hill Dictionary of Scientific and Technical Terms*
5.	1) a branch of knowledge conducted on objective principles involving the systematized observation of and experiment with phenomena, esp. concerned with the material and functions of the physical universe. 2) (a) systematic and formulated knowledge, esp. of a specified type or on a specified subject (political science). (b) the pursuit or principles of this. 3) an organized body of knowledge on a subject (the science of philology). 4) skilful technique rather than strength or natural ability. 5) *(archaic)* knowledge of any kind.	*Oxford English Reference*
6.	knowledge about the world, especially based on examination and testing, and on facts that can be proved	*Longman Dictionary of Contemporary English, 3rd edition*

D. Read the following text:

What is Science?

To understand what science is, just look around you. What do you see? Perhaps, your hand on the mouse, a computer screen, papers, ballpoint pens, the family cat, the sun shining through the window …. Science is, in one sense, our knowledge of all that — all the stuff that is in the universe: from the tiniest subatomic particles in a single atom of the metal in your computer's circuits, to the nuclear reactions that formed the immense ball of gas that is our sun, to the complex chemical interactions and electrical fluctuations within your own body that allow you to read and understand these words. But just as importantly, science is also a reliable process by which we learn about all that stuff in the universe. However, science is different from many other ways of learning because of the way it is done. Science relies on testing ideas with evidence gathered from the natural world. This website will help you learn more about science as a process of learning about the natural world and access the parts of science that affect your life.

Science helps satisfy the natural curiosity with which we are all born: why is the sky blue, how did the leopard get its spots, what is a solar eclipse? With science, we can answer such questions without resorting to magical explanations. And science can lead to technological advances, as well as helping us learn about enormously important and useful topics, such as our health, the environment, and natural hazards. Without science, the modern world would not be modern at all, and we still have much to learn. Millions of scientists all over the world are working to solve different parts of the puzzle of how the universe works, peering into its nooks and crannies, deploying their microscopes, telescopes, and other tools to unravel its secrets.

Science is complex and multi-faceted, but the most important characteristics of science are straightforward:

- Science focuses exclusively on the natural world, and does not deal with supernatural explanations.
- Science is a way of learning about what is in the natural world, how the natural world works, and how the natural world got to be the way it is. It is not simply a collection of facts; rather it is a path to understanding.
- Scientists work in many different ways, but all science relies on testing ideas by figuring out what expectations are generated by an idea and making observations to find out whether those expectations hold true.
- Accepted scientific ideas are reliable because they have been subjected to rigorous testing, but as new evidence is acquired and new perspectives emerge these ideas can be revised.
- Science is a community endeavor. It relies on a system of checks and balances, which helps ensure that science moves in the direction of greater accuracy and understanding. This system is facilitated by diversity within the scientific community, which offers a broad range of perspectives on scientific ideas.

To many, science may seem like an arcane, ivory-towered institution — but that impression is based on a misunderstanding of science. In fact:

- Science affects your life everyday in all sorts of different ways.
- Science can be fun and is accessible to everyone.
- You can apply an understanding of how science works to your everyday life.
- Anyone can become a scientist — of the amateur or professional variety.

The word "science" probably brings to mind many different pictures: a fat textbook, white lab coats and microscopes, an astronomer peering through a telescope, a naturalist in the rainforest, Einstein's equations scribbled on a chalkboard, the launch of the space shuttle, bubbling beakers …. All of those images reflect some aspect of science, but none of them provides a full picture because science has so many facets:

- **Science is both a body of knowledge and a process.** In school, science may sometimes seem like a collection of isolated and static facts listed in a textbook, but that's only a small part of the story. Just as importantly, science is also a process of discovery that allows us to link isolated facts into coherent and comprehensive understandings of the natural world.
- **Science is exciting.** Science is a way of discovering what's in the universe and how those things work today, how they worked in the past, and how they are likely to work in the future. Scientists are motivated by the thrill of seeing or figuring out something that no one has before.
- **Science is useful.** The knowledge generated by science is powerful and reliable. It can be used to develop new technologies, treat diseases, and deal with many other sorts of problems.
- **Science is ongoing.** Science is continually refining and expanding our knowledge of the universe, and as it does, it leads to new questions for future investigation. Science will never be “finished”.
- **Science is a global human endeavor.** People all over the world participate in the process of science.

(from ***Understanding Science: An Overview***)

E. Check your reading comprehension. Choose the best answer (only one variant is possible). What do the underlined words from exercise D mean?

1) ***stuff***
(a) rubbish
(b) substance
(c) medicine
(d) cloth

2) ***hazard***
(a) chance
(b) accident
(c) venture
(d) danger

3) ***rigorous***
(a) strictly exact
(b) severe
(c) inflexible
(d) harsh

4) ***accuracy***
(a) neatness
(b) ability
(c) precision
(d) stability

5) ***rainforest***
(a) tropical wood
(b) rainy zone
(c) tropical climate
(d) wet woodland

6) ***endeavor***
(a) struggle
(b) essay
(c) aim
(d) attempt

F. Match the words in the left column with their definitions in the right column.

1) ***atom***
2) ***multi-faceted***
3) ***amateur***
4) ***ongoing***
5) ***coherent***
6) ***facilitate***
7) ***accessible***
8) ***enormously***
9) ***rely***
10) ***equation***

a) continuing, or continuing to develop
b) make it easier for a process or activity to happen
c) trust someone or something to do what you need or expect them to do
d) practicing an art or occupation for the love of it, but not as a profession
e) exceeding of all ordinary bounds in size or amount or degree
f) the smallest part of an element that can exist alone or combine with other substances to form molecules
g) easy to understand because the information is presented in an orderly and reasonable way
h) a statement in mathematics, showing that two quantities are equal
i) having a variety of different and important features or elements.
j) easy to obtain or use, to understand and enjoy

G. Fill in the gaps in the sentences below with the words from the list.

model equip clear reinforce argument explicit operations distinguishable formulate theory

1) It is important that the cognitive skills involved in such activities be defined in a … and rigorous enough way to make it possible to specify how they develop and how this development is best supported educationally.

2) Students, it is claimed, should be able to … a question, design an investigation, analyze data, and draw conclusions.
3) Scientific thinking is more closely aligned with … than with experiment and needs to be distinguished from scientific understanding (of any particular content).
4) Young children are especially insensitive to the distinction between … and evidence when they are asked to justify simple knowledge claims.
5) Skilled scientific thinking always entails the coordination of theories and evidence, but coordination cannot occur unless the two are encoded and represented as … entities.
6) The phases of scientific thinking themselves— inquiry, analysis, inference, and argument—require that the process of theory-evidence coordination become … and intentional, in contrast to the implicit theory revision that occurs without awareness as young children's understandings come into contact with new evidence.
7) Research suggests that children lack a mental … of multivariable causality that most inquiry learning assumes.
8) Educators want children to become skilled scientific thinkers because they believe that these skills will … them for productive adult lives.
9) Social scaffolding (supporting) may assist less able collaborators to monitor and manage strategic … in a way that they cannot yet do alone.
10) The two endeavors … one another: understanding informs practice and practice enhances understanding.

H. Learn the following words and word combinations with 'science' and 'scientist'.

SCIENCE

- To advance science
- To promote science
- To foster science
- Applied science
- Basic science
- Behavioral science
- Domestic science
- Information science
- Library science
- Linguistic science
- Military science
- Natural science
- Naval science
- Physical science
- Political science
- Popular science
- Social science
- Space science

	• An exact science
SCIENTIST	• a nuclear scientist • a political scientist • a social scientist

(Source: ***BBI Combinatory Dictionary of English by M. Benson, E. Benson, & R. Ilson***)

I. What is the difference between the following synonyms:

1) research
2) survey
3) exploration
4) examination
5) analysis
6) fact-finding
7) investigation
8) enquiry (inquiry)
9) study
10) discovery

J. Read the following text and make up a summary (3—5 sentences):

Teaching Science and Technology

As the twentieth century ended, it was clear that science and technology played significant roles in the lives of all people, including future employment and careers, the formulation of societal decisions, general problem solving and reasoning, and the increase of economic productivity. There is consensus that science and technology are central to living, working, leisure, international competitiveness, and resolution of personal and societal problems. Few would eliminate science from the curriculum and yet few would advance it as a curriculum organizer. The basic skills that characterize science and technology remain unknown for most.

As the twenty-first century emerges, many nations around the world are arguing for the merger of science and technology in schools. Unfortunately many are resisting such a merger, mostly because technology (e.g., manual training, industrial arts, vocational training) is often not seen as an area of study for college-bound students. Further, such courses are rarely parts of collegiate programs for preparing new teachers. Few see the ties between science and technology, whereas they often see ties between science and mathematics. Karen F. Zuga, writing in the 1996 book *Science/Technology/Society as Reform in Science Education,* outlined the reasons and rationale for and the problems with such a rejoining of science and technology. A brief review of what each entails is important.

Although science is often defined as the information found in textbooks for secondary school and college courses or the content outlined in state frameworks and standards, such definitions omit most essential features of science. Instead, they concentrate wholly on the products of science. Most agree with the facets of science proposed by George G. Simpson in a 1963 article published in the journal *Science.* These are:

1. Asking questions about the natural universe, that is, being curious about the objects and events in nature.
2. Trying to answer one's own questions, that is, proposing possible explanations.
3. Designing experiments to determine the validity of the explanations offered.
4. Collecting evidence from observations of nature, mathematical calculations, and, whenever possible, experiments that could be carried out to establish the validity of the original explanations.
5. Communicating evidence to others, who must agree with the interpretation of evidence in order for the explanation to become accepted by the broader community (of scientists).

Technology is defined as focusing on the human-made world—unlike science, which focuses on the natural world. Technology takes nature as it is understood and uses the information to produce effects and products that benefit humankind. Examples include such devices as light bulbs, refrigerators, automobiles, airplanes, nuclear reactors, and manufactured products of all sorts. The procedures for technology are much the same as they are for science. Scientists seek to determine the ways of nature; they have to take what they find. Technologists, on the other hand, know what they want when they begin to manipulate nature (using the ideas, laws, and procedures of science) to get the desired products.

Interestingly, the study of technology has always been seen as more interesting and useful than the study of science alone. Further, the public has often been more aware of and supportive of technological advances than those of basic science.

(from ***Encyclopedia of Education***)

K. Translate your summary of the text from exercise J into Russian.

L. Answer the following questions to the text from exercise J:

1) What is the role of science and technology?
2) Do the nations argue for the merger of science and technology in schools?
3) How is often science defined?
4) What are the facets of science proposed by George G. Simpson?
5) How is technology defined?

M. Read the following text and render it in English:

Наука — важнейший ресурс обновляющей России

Российская наука за свою многовековую историю внесла огромный вклад в развитие страны и мирового сообщества. Своим положением великой мировой державы Россия во многом обязана достижениям отечественных ученых.

В современных условиях практическое использование естественнонаучных, гуманитарных и научно-технических знаний во все большей степени становится источником обеспечения жизнедеятельности общества, его духовного и физического здоровья.

Уровень развития науки во многом определяет эффективность экономической деятельности, обороноспособность, духовную и политическую культуру населения страны, защищенность личности и общества от воздействия неблагоприятных природных и антропогенных факторов.

Важным условием формирования отечественной науки являлось стремление охватить все направления исследований. В стране сформировалась обширная сеть научно-исследовательских организаций как фундаментального, так и прикладного характера. По многим направлениям отечественная наука занимала передовые позиции в мире. Это достигалось за счет высокого уровня ведущих научных школ, престижности труда ученого и привлечения в науку большого числа исследователей, а также за счет полноценного бюджетного финансирования. Однако административно-командный механизм в экономике, высокая степень закрытости научно-технической сферы, неоправданные ограничения прав интеллектуальной собственности снижали эффективность использования научного потенциала страны.

В настоящее время, когда расширяются возможности для свободы научного творчества, открытого обмена информацией и международного сотрудничества, положение российской науки могло бы качественно измениться. Однако системный кризис, сопровождающий период социально-политического переустройства страны, привел к тому, что перед отечественной наукой встали новые серьезные трудности: крайне недостаточное бюджетное финансирование научно-исследовательских и опытно-конструкторских работ не обеспечивает своевременного обновления материально-технической базы науки, создания нормальных условий жизни и труда ученых, осложняет эффективное государственное регулирование в научной сфере. Престиж профессии ученого упал в обществе до недопустимо низкого уровня, наука перестала быть привлекательной для талантливой молодежи. Со всей очевидностью возникла необходимость коренной реорганизации сферы науки, привлечения дополнительных источников финансирования. По-прежнему остро стоит проблема более эффективного использования результатов научных исследований в экономике.

Новыми тенденциями в развитии мирового сообщества стали расширение сотрудничества и кооперации государств в решении глобальных проблем, связанных с сохранением среды обитания, обеспечение достойного духовного и физического уровня жизни людей, поддержание здоровья человека. Происходит объединение усилий ученых и инженеров развитых стран в поиске и использовании новых источников энергии, освоении космического пространства, создании открытой информационной среды. Новая стратегия развития науки отдает приоритет исследованиям, имеющим значимость для самой перспективы существования мирового сообщества, для его устойчивого и безопасного развития.

Современные тенденции межгосударственной интеграции не означают, однако, исчезновения национальных интересов, в том числе в сфере науки. Более того, национальный научный потенциал будет во многом определять место страны в мировом сообществе, перспективы в конкурентной борьбе на внешнем рынке, возможности в решении ее внутренних проблем.

Масштабы и темпы развития отечественной науки должны обеспечить соответствие потенциала России уровню мирового научно-технического прогресса. Приоритетные направления научных исследований определяются также экономическим и геополитическим положением России, наличием природных ресурсов, имеющих глобальное значение, потребностями духовного развития нашего общества, гуманистическими традициями российской науки. Существенное влияние на выбор приоритетов продолжают оказывать и мировые тенденции в развитии человеческой цивилизации на рубеже двух тысячелетий.

Для реального преобразования жизни в России исключительно важное значение имеет развитие науки в регионах, способствующее их прогрессу с учетом экономических, ресурсных, экологических и культурных особенностей.

(from ***«Доктрина развития российской науки»***,
www.ris.extech.ru/texts/doctrina.rtf)

N. Prepare a public speech for 5—8 minutes (in Russian) about the role of science in our society. Make up an abstract (3—5 sentences) of the speech and point out some key words (5—10 words).

O. After presenting your speech give the key words and abstract to other students, who will render your speech in English.

P. Check the way you organize your speech/ text.

Introduction	*identifies the question and outlines the main topics in the content paragraphs*
Content Paragraphs (Body of the Speech)	*main topic and related topics: stated, explained and exemplified*
Conclusion	*summarizes the main topics and answers the question from the introduction*

Q. Read the following phrases, translate them and learn by heart.

Impersonal Points of View
There are those who say that…
It is often said that…
Many commentators are of the view that…
A common opinion is that…
A popular belief is that…

One argument put forward is that…
It can be argued that…
It is generally accepted that…

Personal Opinions

My personal view is that…
It seems to me that…
I tend to believe that…
I am of the opinion that…
I would argue that…
In my experience…

Commenting

Of course, …
Naturally, …
Evidently, …

Generalizing

Generally speaking, …
On the whole, …
…tends…
Typically, …
By and large …
…may/might/could…
Often/frequently/sometimes/usually…

Explaining Opinions

What this means is …
In other words, …
That is to say…
To be more precise…
In fact, …

Using Examples to Explain

For example, …
For instance, …
A good illustration of this is …
If we take an example…
Evidence for this is provided by …
We can see this when …

Explaining Cause and Stating Effect

One reason for this is …
The immediate cause of this …
One of the causes of this is…
This has resulted in …
As a result, …
This has led to …

Concluding

To summarize …
In conclusion, …

On balance, …
This is a complex issue with no clear answers …
If we look at both sides of the argument …

R. Read the following descriptions of some sciences. How can you amend or modify them?

1) Pedagogy	study of teaching methods, including the aims of education and the ways in which such goals may be achieved. The field relies heavily on educational psychology, or theories about the way in which learning takes place.
2) Philology	a term now rarely used but once applied to the study of language and literature. Nowadays a distinction is usually made between literary and linguistic scholarship, and the term philology, where used, means the study of language-i.e., linguistics (q.v.). It survives in the titles of a few learned journals that date to the 19th century. Comparative philology was a former name for what is now called comparative linguistics (q.v.).
3) Chemistry	the science that deals with the properties, composition, and structure of substances (defined as elements and compounds), the transformations they undergo, and the energy that is released or absorbed during these processes. Every substance, whether naturally occurring or artificially produced, consists of one or more of the hundred-odd species of atoms that have been identified as elements. Although these atoms, in turn, are composed of more elementary particles, they are the basic building blocks of chemical substances; there is no quantity of oxygen, mercury, or gold, for example, smaller than an atom of that substance. Chemistry, therefore, is concerned not with the subatomic domain but with the properties of atoms and the laws governing their combinations and how the knowledge of these properties can be used to achieve specific purposes.
4) Mathematics	the science of structure, order, and relation that has evolved from elemental practices of counting, measuring, and describing the shapes of objects. It deals with logical reasoning and quantitative calculation, and its development has involved an increasing degree of idealization and abstraction of its subject matter. Since the 17th century, mathematics has been an indispensable adjunct

	to the physical sciences and technology, and in more recent times it has assumed a similar role in the quantitative aspects of the life sciences.
5) Biology	study of living things and their vital processes. The field deals with all the physicochemical aspects of life. As a result of the modern tendency to unify scientific knowledge and investigation, however, there has been an overlapping of the field of biology with other scientific disciplines. Modern principles of other sciences — chemistry and physics, for example — are integrated with those of biology in such areas as biochemistry and biophysics.
6) Geography	the scientific study of the Earth's surface. Geography describes and analyzes the spatial variations in physical, biological, and human phenomena that occur on the surface of the globe and treats their interrelationships and their significant regional patterns.
7) Physics	science that deals with the structure of matter and the interactions between the fundamental constituents of the observable universe. In the broadest sense physics, which was long called natural philosophy (from the Greek *physikos*), is concerned with all aspects of nature on both the macroscopic and submicroscopic levels. Its scope of study encompasses not only the behaviour of objects under the action of given forces but also the nature and origin of gravitational, electromagnetic, and nuclear force fields. Its ultimate objective is the formulation of a few comprehensive principles that bring together and explain all such disparate phenomena.
8) Psychology	scientific discipline that studies mental processes and behaviour in humans and other animals. Psychology is the science of individual or group behaviour. The word psychology literally means “study of the mind”; the issue of the relationship of mind and body is pervasive in psychology, owing to its derivation from the fields of philosophy and physiology. Psychology is intimately related to the biological and social sciences.
9) Sociology	a branch of the science of human behaviour that seeks to discover the causes and effects that arise in social relations among persons and in the intercommunication and interaction among persons and groups. It includes the study of the customs, structures, and institutions that emerge from interaction, of the forces that hold together and weaken them, and of the effects that participation in groups and organizations have on the behaviour and character of persons. Soci-

	ology is also concerned with the basic nature of human society, locally and universally, and with the various processes that preserve continuity and produce change.
10) Political Science	the systematic study of government processes by the application of scientific methods of analysis. More narrowly and more traditionally, it has been thought of as the study of the state and of the organs and institutions through which the state functions. In most countries, political science is thought to be a single discipline, but the plural form has been used in France, as in the name of the École Libre des Sciences Politiques (now Institut d'Études Politiques de l'Université de Paris), founded in 1871 — although there is also an Association Française de Science Politique. Speculation about political subjects is not unknown in ancient non-Western cultures, but most students agree that the roots of political science are to be found in the earliest sources of Western thought, especially in the works of Aristotle, who is recognized by many as the founder of political science.
11) Economics	social science that seeks to analyze and describe the production, distribution, and consumption of wealth. The major divisions of economics include microeconomics, which deals with the behaviour of individual consumers, companies, traders, and farmers; and macroeconomics, which focuses on aggregates such as the level of income in an economy, the volume of total employment, and the flow of investment. Another branch, development economics, investigates the history and changes of economic activity and organization over a period of time, as well as their relation to other activities and institutions. Within these three major divisions there are specialized areas of study that attempt to answer questions on a broad spectrum of human economic activity, including public finance, money supply and banking, international trade, labour, industrial organization, and agriculture. The areas of investigation in economics overlap with other social sciences, particularly political science, but economics is primarily concerned with relations between buyer and seller.
12) Philosophy	the critical examination of the grounds for fundamental beliefs and an analysis of the basic concepts employed in the expression of such beliefs. Philosophical inquiry is a central element in the intellectual history of many historical civilizations.

(from ***Britannica***)

S. Read the following text and translate it into Russian:

Technology in the 20th Century

Technologies being studied at the dawn of the 21st century held out the promise of solutions to long-standing human problems. With genetically modified food crops and study of the human genome, biology was clearly on the verge of new departures. The fuel cell went through a series of improvements that promised that it might replace the internal-combustion engine as a means for propelling automobiles and a wide variety of other machines, with no emission of noxious products and reduced risk to health. Nuclear fusion, without the radiation risks of nuclear fission, might provide a vast source of electrical power later in the century.

Yet suspicion of technology and fear of its consequences, spawned by the terrible effects and threats of warfare and the impersonal nature of its challenge to the environment, left humanity concerned: would invention and discovery provide tools for future benefit or pathways toward future planetary disaster and restrictions on liberty?

(from ***Scientific American: Inventions and Discoveries***, 2004)

T. Write a short essay (8—15 sentences) about links between science and technologies in the Russian Federation.

U. Insert the prepositions from the list and read the text aloud. Discuss it with other students.

for of (2) with (2) on in to at between into (2) from (2) by

Technology and Emotions

Except … the technologies of advertising (images, sounds, etc.), most people argue that technology is devoid … feelings, emotions and values. Technology for most people is cold and incapable … the types of intimacy found in everyday human life. Some people tend to feel that technology is neutral and any emotions associated … particular technologies are dependent … the way they are used. Others feel that technology is inherently good or inherently bad, and trust or distrust particular technologies. Some of these people concede that certain technologies have emotions, such as anger or pleasure that are embedded … the technology itself. They acknowledge that some technologies are quite durable and impervious to uses other than which they are designed. The technologies retain the imprint of the early intentions of their designers. The initial fixing of technologies is a powerful determinant of their uses overtime, similar … the initial denning of concepts and phrases. Other people who concede that technology has emotions or values admit that some technologies are quite pliable. These people suggest that technologies readily respond to various uses. So we arrive … a crucial question. Is it technologies or people that emote? Or is it both? We can also ask: If technology is so cold and devoid of emotion and values, then how can it generate such strong feelings and visceral responses?

The key to understanding the interrelations … technology and emotions is to avoid falling … the trap of original essences (Latour, 2000). Neither technologies nor people are immutable and neither has eternal qualities. Technologies change when they are used and people change when using technologies. One lesson is that technology and feelings cannot be separated. Technology in action necessarily generates emotions. A driver in a car may feel mobile and independent or trapped and dependent. Theorists argue that the spectrum of feelings for technology extends … technophilia (love of technology) to technomania (obsession with technology) to technophobia (fear of technology), or … technocracy (basic trust in technology) to luddism (basic mistrust of technology). They note that relationships … technology are rarely either love or hate, but most often fall somewhere in between. The more scientific theorists dismiss feelings that tend to extremes as irrational and overly subjective. Rational feelings are moderate, or moderated … objective facts about the nature of technology and human nature. Is it possible to stay cool and objective or do we uncontrollably have feelings, one way or another, toward technology? As teachers, can we merely advise children and teenagers to stay cool, or do we have to take their feelings … account?

(from ***Stephen Petrina "Advanced Teaching Methods for the Technology Classroom"***)

V. Put the verbs in brackets in the right tense-form and read the text. Discuss it with other students.

Intelligence

Intelligence **(to prove)** surprisingly difficult to define in a rigorous fashion. Clearly it refers in a general fashion to the level of ability to reason, solve problems, successfully respond to situations and so forth, but these range from mathematics to handling social situations, from understanding machines to solving crosswords and Sudoku puzzles. Psychologists such as Francis Galton (using the expression 'natural ability') and the American Raymond B. Cattell **(to begin)** attempting to study intelligence in the late nineteenth century, this culminating in the pioneering statistical studies of C. Spearman and, most famously, Alfred Binet and H. Simon in France who **(to produce)** the first intelligence test in 1904, to which all subsequent IQ (intelligence quotient) tests trace their origins. These all **(to focus)** primarily on reasoning ability and academic performance, ignoring social intelligence and emotional intelligence. One should stress here that it was the advent of universal education which **(to create)** the climate in which an assessment scale applicable to all children was required, IQ tests being Psychology's response to this. Throughout the twentieth century, IQ testing and theories of intelligence **(to enjoy)** a chequered and controversial history. IQ testing itself **(to evolve)** quite rapidly after Binet and Simon's work. Initially IQ **(to define)** as the ratio between mental age (MA) and chronological age (MCA) but it was obvious from the outset that this was inapplicable to people much over 15 years old and so was replaced by a statistical definition in terms of standard deviations from population norms. The term 'IQ' itself **(to introduce)** by the German psychologist Wilhelm Stern who converted the MA:CA ratio into a simple quantitative scale, defining MA = CA as 100. The definition of mean intelligence as 100 **(to continue)** ever since.

(from ***Graham Richards "Psychology. The Key Concepts"***)

W. Have you ever tested your intelligence? Often a verbal ability test is one of the parts of an IQ test. Try to do the following tasks checking your verbal abilities.

Verbal Ability Test

1) Change one letter only in each of the words below to produce a familiar phrase.

TAME FOOD CART ON

2) Which two words are most opposite in meaning?

commendable, plausible, banal, unlikely, receptive, offensive

3) Inside is to magma as outside is to: *sulphur, lava, crust, plate, earth, erupt*

4) ***GLACIATED MAT*** is an anagram of which two words, four letters and eight letters long, which are opposite in meaning?

5) Which word in brackets is most similar in meaning to the word in capitals?

PENITENT (pervasive, apologetic, impecunious, callous, invasive)

6) Only one set of five letters below can be arranged to spell out a five-letter English word. Find the word.

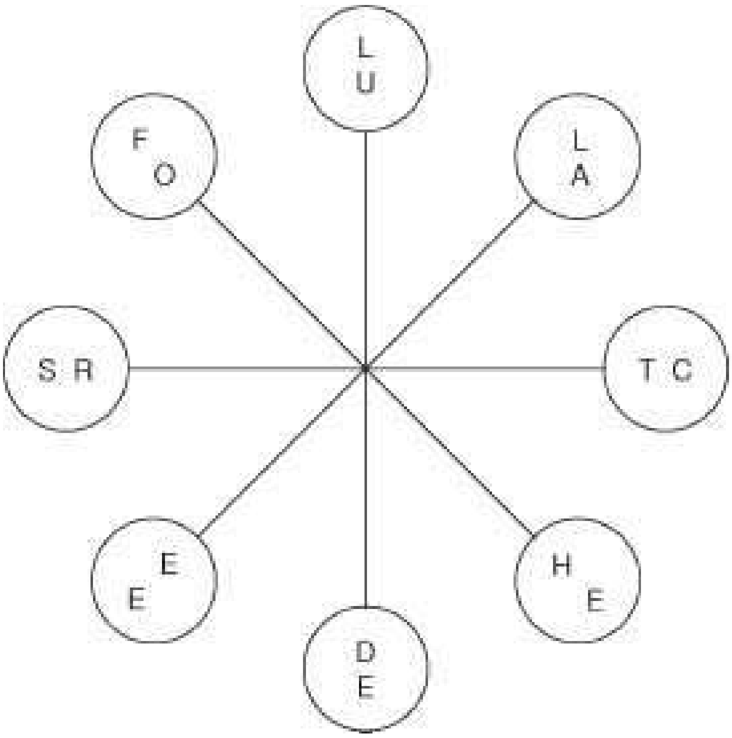
BLEIT

TONTE

TIUNP

GNEUR
HEMUT

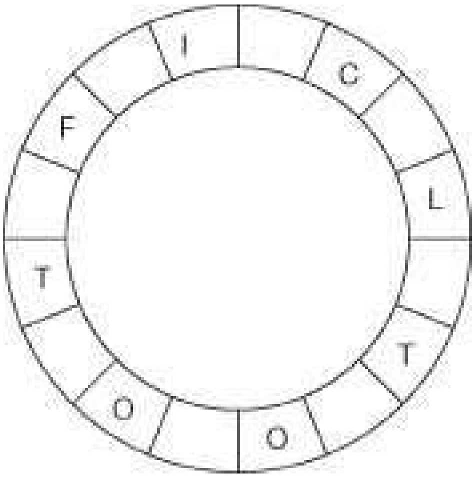
7) Find two eight-letter words that have opposite meanings by reading clockwise and, for each word, taking one letter at a time from each circle. Both words start at a different circle, but all letters in each word are in the correct order. Use each letter once each only.



8) What is the meaning of ***assiduous***?

a. living a strict life
b. forceful
c. persevering
d. ingenious
e. harsh or acidic

9) Find a familiar phrase reading clockwise. You have to find the starting point and insert the missing letters. Only alternate letters are shown.



10) Work from letter to adjacent letter horizontally and vertically, but not diagonally, to spell out a 12-letter word. Use each letter once each only. You have to find the starting point, and provide the missing letters.

N	**E**	**I**	**R**
*	**N**	**E**	**E**
E	**I**	*	**P**

X. Check your answers to the questions from exercise W with the key. Translate these words and memorize them.

Key to the Verbal Ability Test

1. take good care of
2. plausible, unlikely
3. lava
4. calm, agitated
5. apologetic
6. TUINP = input
7. desolate, cheerful
8. **c)** persevering
9. out of circulation
10. inexperience

Y. Would you like to become a scientist? What has influenced your choice? Discuss it with other students.

Z. Write an essay (15—25 sentences) using the vocabulary of this unit. Choose one of the following topics:

1) Science and Technology — Hazards of Today’s Life
2) Science is the First Step to Technological Progress
3) Science and New Challenges in the XXI Century

Unit 2

Evolution of Science

A. Read the following quotations about evolution of science and express your own opinion about evolution in general and about evolution of science in particular.

1) The modern world, which has lost faith in so many causes, still accepts science nearly unchallenged. Science to-day occupies the position held by the Roman Church in the Middle Ages: as the single great authority in a world divided on almost every object of loyalty. (***James K. Friend, J.W. Feibleman*** from ***What Science Really Means)***

2) Four epochs of science:
childlike,
poetic, superstitious;
empirical,
searching, curious;
dogmatic,
didactic, pedantic;
ideal,
methodical, mystical. (from ***Scientific Studies***)

3) It was a great step in science when men became convinced that, in order to understand the nature of things, they must begin by asking, not whether a thing is good or bad, noxious or beneficial, but of what kind it is? and how much is there of it? Quality and Quantity were then first recognized as the primary features to be observed in scientific inquiry. (***James Clerk Maxwell*** from ***The Scientist in Action*** by ***William H. George***)

4) Man, then cannot be happy through science, but to-day he can be much less be happy without it. (***Henri Poincare*** from ***The Foundations of Science***)

5) Science, like most human cultural phenomena, has evolved. What was allowable in the early nineteenth century is not necessarily allowable in the late twentieth century. Specifically, science today does not break with law. And this is what counts for us. We want criteria of science for today, not for yesterday. (***Michael Ruse*** from ***Science, Technology & Human Values***)

B. Write down 5—10 sentences expressing your ideas about evolution of any science.

C. Read the definitions of "evolution" and choose the one, which suits best to your ideas about science from exercise B.

No.	Definition	Source
1.	1) evolution is a process of gradual change that takes place over many generations, during which species of animals, plants, or insects slowly change some of their physical characteristics 2) evolution is a process of gradual development in a particular situation or thing over a period of time	*Collins COBUILD Advanced Learner's English Dictionary, 4th edition*
2.	1) the scientific idea that plants and animals develop gradually from simpler to more complicated forms 2) the gradual change and development of an idea, situation, or object	*Longman Dictionary of Contemporary English, 3rd edition*
3.	the processes of biological and organic change in organisms by which descendants come to differ from their ancestors, and a history of the sequence of such change.	*McGraw-Hill Dictionary of Scientific and Technical Terms*
4.	1) gradual development, esp. from a simple to a more complex form 2) a process by which species develop from earlier forms, as an explanation of their origins 3) the appearance or presentation of events etc. in due succession 4) a change in the disposition of troops or ships 5) the giving off or evolving of gas, heat, etc. 6) an opening out 7) the unfolding of a curve 8) Math. the extraction of a root from any given power	*Oxford English Reference*
5.	theory in biology postulating that the various types of animals and plants have their origin in other pre-existing types and that the distinguishable differences are due to modifications in successive generations. The theory of evolution is one of the fundamental keystones of modern biological theory	*Britannica*
	1) one of a set of prescribed movements 2) a. a process of change in a certain direction; unfolding b. the action or an instance of forming and giving something off ; emission	

6.	c. (1) a process of continuous change from a lower, simpler, or worse to a higher, more complex, or better state ; growth (2) a process of gradual and relatively peaceful social, political, and economic advance d. something evolved 3) the process of working out or developing 4) a. the historical development of a biological group (as a race or species); phylogeny b. a theory that the various types of animals and plants have their origin in other preexisting types and that the distinguishable differences are due to modifications in successive generations; also the process described by this theory 5) the extraction of a mathematical root 6) a process in which the whole universe is a progression of interrelated phenomena	*Merriam-Webster's Collegiate Dictionary, 11th Edition*

D. Read the following text:

Science in the Ancient World

In prehistoric times, advice and knowledge was passed from generation to generation in an oral tradition. The development of writing enabled knowledge to be stored and communicated across generations with much greater fidelity. Combined with the development of agriculture, which allowed for a surplus of food, it became possible for early civilizations to develop, because more time could be devoted to tasks other than survival.

Many ancient civilizations collected astronomical information in a systematic manner through simple observation. Though they had no knowledge of the real physical structure of the planets and stars, many theoretical explanations were proposed. Basic facts about human physiology were known in some places, and alchemy was practiced in several civilizations. Considerable observation of macrobiotic flora and fauna was also performed.

Science in the Fertile Crescent

From their beginnings in Sumer (now Iraq) around 3500 BC the Mesopotamian peoples began to attempt to record some observations of the world with extremely thorough numerical data. But their observations and measurements were seemingly taken for purposes other than for scientific laws. A concrete instance of Pythagoras' law was recorded, as early as the 18th century BC: the Mesopotamian cuneiform tablet Plimpton 322 records a number of Pythagorean triplets (3,4,5) (5,12,13), dated 1900

BC, possibly millennia before Pythagoras, but an abstract formulation of the Pythagorean theorem was not.

Significant advances in Ancient Egypt include astronomy, mathematics and medicine. Their geometry was a necessary outgrowth of surveying to preserve the layout and ownership of farmland, which was flooded annually by the Nile river. The 3,4,5 right triangle and other rules of thumb served to represent rectilinear structures, and the post and lintel architecture of Egypt. Egypt was also a center of alchemy research for much of the Mediterranean.

Science in the Greco-Roman world

In Classical Antiquity, the inquiry into the workings of the universe took place both in investigations aimed at such practical goals as establishing a reliable calendar or determining how to cure a variety of illnesses and in those abstract investigations known as natural philosophy. The ancient people who are considered the first *scientists* may have thought of themselves as *natural philosophers*, as practitioners of a skilled profession (for example, physicians), or as followers of a religious tradition (for example, temple healers).

The earliest Greek philosophers, known as the pre-Socratics, provided competing answers to the question found in the myths of their neighbors: "How did the ordered cosmos in which we live come to be?" The pre-Socratic philosopher Thales, dubbed the "father of science", was the first to postulate non-supernatural explanations for natural phenomena such as lightning and earthquakes. Pythagoras of Samos founded the Pythagorean school, which investigated mathematics for its own sake, and was the first to postulate that the Earth is spherical in shape. Subsequently, Plato and Aristotle produced the first systematic discussions of natural philosophy, which did much to shape later investigations of nature. Their development of deductive reasoning was of particular importance and usefulness to later scientific inquiry.

The important legacy of this period included substantial advances in factual knowledge, especially in anatomy, zoology, botany, mineralogy, geography, mathematics and astronomy; an awareness of the importance of certain scientific problems, especially those related to the problem of change and its causes; and a recognition of the methodological importance of applying mathematics to natural phenomena and of undertaking empirical research. In the Hellenistic age scholars frequently employed the principles developed in earlier Greek thought: the application of mathematics and deliberate empirical research, in their scientific investigations. Thus, clear unbroken lines of influence lead from ancient Greek and Hellenistic philosophers, to medieval Muslim philosophers and scientists, to the European Renaissance and Enlightenment, to the secular sciences of the modern day. Neither reason nor inquiry began with the Ancient Greeks, but the Socratic method did, along with the idea of Forms, great advances in geometry, logic, and the natural sciences. Benjamin Farrington, former Professor of Classics at Swansea University wrote in 1944:

"Men were weighing for thousands of years before Archimedes worked out the laws of equilibrium; they must have had practical and intuitional knowledge of the principles involved. What Archimedes did was to sort out the theoretical implications of this practical knowledge and present the resulting body of knowledge as a logically coherent system."

and again:

"With astonishment we find ourselves on the threshold of modern science. Nor should it be supposed that by some trick of translation the extracts have been given an air of modernity. Far from it. The vocabulary of these writings and their style are the source from which our own vocabulary and style have been derived."

The level of achievement in Hellenistic astronomy and engineering is impressively shown by the Antikythera mechanism (150—100 BC). The astronomer Aristarchus of Samos was the first known person to propose a heliocentric model of the solar system, while the geographer Eratosthenes accurately calculated the circumference of the Earth. Hipparchus (ca. 190 — ca. 120 BC) produced the first systematic star catalog. In medicine, Herophilos (335 — 280 BC) was the first to base his conclusions on dissection of the human body and to describe the nervous system. Hippocrates (ca. 460 BC — ca. 370 BC) and his followers were first to describe many diseases and medical conditions. Galen (129 — ca. 200 AD) performed many audacious operations— including brain and eye surgeries— that were not tried again for almost two millennia. The mathematician Euclid laid down the foundations of mathematical rigor and introduced the concepts of definition, axiom, theorem and proof still in use today in his *Elements*, considered the most influential textbook ever written. Archimedes, considered one of the greatest mathematicians of all time, is credited with using the method of exhaustion to calculate the area under the arc of a parabola with the summation of an infinite series, and gave a remarkably accurate approximation of Pi. He is also known in physics for laying the foundations of hydrostatics and the explanation of the principle of the lever. Theophrastus wrote some of the earliest descriptions of plants and animals, establishing the first taxonomy and looking at minerals in terms of their properties such as hardness. Pliny the Elder produced what is one of the largest encyclopedias of the natural world in 77 AD, and must be regarded as the rightful successor to Theophrastus.

For example, he accurately describes the octahedral shape of the diamond, and proceeds to mention that diamond dust is used by engravers to cut and polish other gems owing to its great hardness. His recognition of the importance of crystal shape is a precursor to modern crystallography, while mention of numerous other minerals presages mineralogy. He also recognises that other minerals have characteristic crystal shapes, but in one example, confuses the crystal habit with the work of lapidaries. He was also the first to recognise that amber was a fossilized resin from pine trees because he had seen samples with trapped insects within them.

(from ***History of Science, Wikipedia***)

E. Check your reading comprehension. Choose the best answer (only one variant is possible). What do the underlined words from exercise D mean?

1) ***fidelity***
(a) awareness
(b) devotion
(c) loyalty
(d) demand

2) ***outgrowth***
(a) result
(b) support
(c) elimination
(d) direction

3) ***cure***
(a) care
(b) develop
(c) endure
(d) remedy

4) ***deductive***
(a) implied
(b) logic
(c) precise
(d) constructive

5) ***empirical***
(a) theoretical
(b) contemplated
(c) experimental
(d) assumed

6) ***precursor***
(a) successor
(b) follower
(c) heir
(d) predecessor

F. Match the words in the left column with their definitions in the right column.

1) advance
2) inquiry
3) secular
4) alchemy
5) accurately
6) applying
7) reasoning
8) recognition
9) influential
10) confuse

a) not connected with or controlled by a church or other religious authority
b) exactly, correctly, error-free
c) a process of thinking carefully about something in order to make a judgment
d) having a lot of influence and therefore changing the way people think and behave
e) forward movement or progress
f) the act of realizing and accepting that something is true or that something is important
g) making use of as relevant or suitable
h) a process of trying to discover facts by scientific methods
i) to fail to differentiate from an often similar or related other
j) a form of chemistry studied in the Middle Ages, which was concerned with trying to discover ways to change ordinary metals into gold

G. Fill in the gaps in the sentences below with the words from the list.

structure basic information evidence inherited engineering components findings reactions infant extent established geneticist prehistoric mechanics bacterial dominant diseases grasped

1) Although the influence of heredity has been recognized since … times, scientific understanding of inheritance is a fairly recent event.
2) Modern genetics began with the work of Gregor Mendel, an Austrian monk whose breeding experiments with garden peas led him to formulate the … laws of heredity.
3) Mendel concluded that his plants … two factors (one from each parent) for each of the hereditary traits he studied.
4) He further deduced that these factors do not mix in the offspring, that some factors are … over others, and that a parent plant randomly transmits one factor from each pair to an offspring.
5) Mendel published his … in 1866, but his discoveries were not appreciated by the scientists of his day.
6) By the turn of the century, however, the intellectual climate had changed; in 1900 a number of researchers independently rediscovered Mendel's work and … its significance.
7) The … science of genetics flowered rapidly.
8) By 1902 Walter Sutton of the United States had proposed that chromosomes — major … of the cell nucleus — were the site of Mendel's hereditary factors.
9) The Hardy-Weinberg law, which … the mathematical basis for studying heredity in populations, was independently formulated by the English mathematician Godfrey H. Hardy and the German physician Wilhelm Weinberg in 1908.
10) In 1910 the American … Thomas Hunt Morgan began his studies with the fruit fly, Drosophila melanogaster.
11) Morgan provided … not only that genes (as Mendel's factors had come to be called) occur on chromosomes but that those genes lying close together on the same chromosome form linkage groups that tend to be inherited together.
12) During the 1940s George W. Beadle and Edward L. Tatum of the United States demonstrated that genes exert their influence by directing the production of enzymes, proteins that facilitate chemical … in the cell.
13) By 1944 Oswald T. Avery had shown that deoxyribonucleic acid (DNA) was the chromosome component that carried genetic … .
14) The molecular … of DNA, however, was not deduced until 1953 by James D. Watson of the United States and Francis H.C. Crick of Great Britain.
15) By 1961 the French geneticists François Jacob and Jacques Monod had developed a model for the process by which DNA directs protein synthesis in … cells.
16) These developments led to the deciphering of the genetic code of the DNA molecule, which in turn made possible the recombinant DNA techniques that hold immense potential for genetic … .
17) Modern genetics studies include population genetics (the study of genetic patterns within populations), classical genetics (how traits are transmitted and expressed),

cytogenetics (the … of heredity within the cell), microbial genetics (the heredity of microorganisms), and molecular genetics (the molecular study of genes and related structures).

18) To some …, these divisions are artificial; every field overlaps with other genetic fields, and all have implications for the other biological sciences.

19) Genetics has been applied to the diagnosis, prevention, and treatment of hereditary …; to the breeding of plants and animals; and to the development of industrial processes that utilize microorganisms, study of heredity in general and of genes in particular.

H. Learn the following words and word combinations with 'evolution' and 'evolutionary'.

EVOLUTION	• A gradual evolution • Historical evolution • Evolution from … • Evolution into … • Evolution to …
EVOLUTIONARY	•Evolutionary biology •An evolutionary process •Evolutionary changes

(Source: ***BBI Combinatory Dictionary of English by M. Benson, E. Benson, & R. Ilson***)

I. What is the difference between the following synonyms:

1) evolution
2) development
3) advance
4) growth
5) progress
6) phylogeny
7) maturation
8) evolvement
9) production
10) formation

J. Read the following text and make up a summary (3—5 sentences):

The human being and the need to learn

Maslow's 'hierarchy' of needs is usually represented as a hierarchy. D. Child suggested that the need to know comes at the top of the hierarchy, but in the third edition of his text, he has adapted this slightly and omitted the highest stratum. At the same time, he has continued to highlight the significance of knowledge and understanding. Maslow certainly considered the need to know but claimed that knowledge has a certain ambiguity about it, specifying that in most individuals there is both a need to know and a fear of knowing. However, the fear of knowing may be the result of social experiences rather than being basic to the person. The need to know may be fundamental, even if the consequences of that knowledge may be dangerous. If this is the case, then Child's suggestion does require further consideration. Does the need to know actually occur at the apex of the hierarchy? Is there a progression through the hierarchy, which occurs only when the more preponderant needs are satisfied? Is it even a hierarchy? Argyle suggested that the main supporting evidence for the hierarchy comes from the lower end but that there 'is not such clear evidence about the upper part of the hierarchy'. Houston *el al.* claimed that the order of needs is itself arbitrary and that the exact order is not particularly important. If the order is unimportant, then both Maslow's and Child's construction of a needs hierarchy is open to reconsideration.

Child may be correct when he suggested that the intellectual pursuit of knowledge is a higher order need, but this may only be true for the academic pursuit of knowledge. But the fact that Tough has suggested that many people undertake learning projects implies that the need to learn may be quite fundamental to the human being. Indeed, this need may be better understood as being one to learn rather than to know and understand since individuals need to learn in order to comprehend the world in which they live and to adapt themselves to it. If this is the case, then the need to learn is quite basic and should perhaps occur lower in Maslow's hierarchy because the individual is conscious of the need to learn from very early in life, as is manifest in children from the time that they acquire the facility of language (and ask the question 'why?') and during the process of the formation of the self.

Elsewhere this theme has been expanded a little in the context of the religious development of the individual. Without seeking to rehearse that argument, some of its conclusions are summarized here because of their significance to this discussion. It is suggested that the processes of the formation of the self and of beginning to make sense of the objective world occur simultaneously during early childhood. Indeed, Luckmann maintains that a human organism becomes a self, constructing with others an 'objective and moral universe of meaning'. Prior to the construction of this universe of meaning, however, it must be recognized that every individual poses many questions of meaning. This process of focusing upon the 'unknowns' of human experiences begins in childhood and appears fundamental to humanity. Nearly every parent has experienced that period during which their child persistently asks questions about every aspect of its experience. Initially these questions appear to be restricted to its immediate experience but as the child's universe expands its questions of meaning change. Answers, however, demand different types of knowledge: empirical, rational, pragmatic, belief, and so on. Hence, learning initially progresses, unfettered by the boundaries of the disciplines, as a result of a process of questioning at the parameters of children's experiences. As the questions are answered children acquire a body of knowledge, so the learning need receives some satisfaction. During early childhood these questions are overt and the learning experience explicit. When children attend school, however, teachers (and other adults) sometimes attempt to provide information that bears little or no relation to the questions being posed at that time and, therefore, the knowledge being transmitted may appear irrelevant to the recipient. Unless the teacher is able to demonstrate its relevance and create a questioning attitude there may be little internal stimulus to learn what is being transmitted. (This does not mean that children do not want or need to learn, only that they may not want to learn what is being transmitted.) However, by the time children mature, answers to many of the questions may have been discovered and the adults socialized into the objectified culture(s) of society. The adult appears to ask fewer questions. But during periods of rapid social change the questioning process is evoked. During traumatic experiences the accepted internalized body of knowledge may not be able to cope with the situation and the questioning process is reactivated. Schutz and Luckmann write: I only become aware of the deficient tone of my stock of knowledge if a novel experience does not fit into what has, up to now, been taken as a taken-for-granted valid reference scheme'.

In other words, when individuals' biographies and their current experience are not in harmony, a situation is produced whereby they recommence their quest for meaning and understanding. It is this disjuncture that underlies the need to learn and this has been developed much more thoroughly in other works. While the need to learn occurs continuously throughout most of the lifespan, the religious questions are raised intermittently throughout life, so that the process is never really complete. Perhaps, as Tough has implied, questions are asked much more frequently than adult educators have generally assumed, so that the learning need is ever prevalent.

(from ***"Adult Education and Lifelong Learning"*** by ***Peter Jarvis***)

K. Translate your summary of the text from exercise J into Russian.

L. Answer the following questions to the text from exercise J:

1) Do you know all the components of Maslow's 'hierarchy'?
2) When does the need to know come?
3) What kind of processes occur simultaneously during early childhood?
4) What should a teacher do to make the internal stimulus to learn bigger?
5) When do people recommence their quest for meaning and understanding?

M. Read the following text and render it in English:

История развития Академии наук Российской Федерации

Создание Академии наук прямо связано с реформаторской деятельностью Петра I, направленной на укрепление государства, его экономической и политической независимости. Петр понимал значение научной мысли, образования и культуры народа для процветания страны. И он начал действовать "сверху".

По его проекту Академия существенно отличалась от всех родственных ей зарубежных организаций. Она была государственным учреждением; ее члены, получая жалование, должны были обеспечивать научно-техническое обслуживание государства. Академия соединила функции научного исследования и обучения, имея в своем составе университет и гимназию.

27 декабря 1725 г. Академия отпраздновала свое создание большим публичным собранием. Это был торжественный акт появления нового атрибута российской государственной жизни.

Академическая Конференция стала органом коллективного обсуждения и оценки результатов исследований. Ученые не были связаны какой-нибудь господствующей догмой, пользовались свободой научного творчества, активно участвуя в противоборстве картезианцев и ньютонианцев. Практически неограниченными были возможности публиковать научные труды.

Первым президентом академии был назначен медик Лаврентий Блюментрост. Заботясь о соответствии деятельности Академии мировому уровню, Петр I пригласил в нее ведущих иностранных ученых. В числе первых были математики Николай и Даниил Бернулли, Христиан Гольдбах, физик Георг Бюльфингер, астроном и географ Жозеф Делиль, историк Г.Ф. Миллер. В 1727 г. членом Академии стал Леонард Эйлер.

Научная работа Академии в первые десятилетия велась по трем основным направлениям (или "классам"): математическому, физическому (естественному) и гуманитарному. Фактически Академия сразу включилась в умножение научного и культурного богатства страны. В свое распоряжение она получила богатейшие коллекции Кунсткамеры. Были созданы Анатомический театр, Географический департамент, Астрономическая обсерватория, Физический и Минералогический кабинеты. Академия имела Ботанический сад и инструментальные мастерские. Здесь трудились крупные ботаники И.Г. Гмелин и И.Г. Кельрейтер, основатель эмбриологии К.Ф. Вольф, знаменитый натуралист и путешественник П.С. Паллас. Работы по теории электричества и магнетизма проводились Г.В. Рихманом и Ф.У. Эпинусом. Благодаря исследованиям академических ученых закладывались основы для развития горного дела, металлургии и других отраслей промышленности России. Велись работы по геодезии и картографии. В 1745 г. была создана первая генеральная карта страны — "Атлас Российский".

Деятельность Академии с самого начала позволила ей занять почетное место среди крупнейших научных учреждений Европы. Этому способствовала широкая известность таких корифеев науки, как Л. Эйлер и М.В. Ломоносов.

Целую эпоху в истории Академии и российской науки составила научная, просветительская и организаторская деятельность великого ученого-энциклопедиста Михаила Васильевича Ломоносова. Он обогатил ее фундаментальными открытиями в химии, физике, астрономии, геологии, географии; внес большой вклад в разработку истории, языкознания и поэтики; организовал в 1748 г. первую химическую лабораторию; активно участвовал в 1755 г. в основании Московского университета, ныне по праву носящего его имя.

С 1728 г. стал издаваться журнал, или, точнее, ежегодный сборник трудов "Комментарии Петербургской академии наук" (на латинском языке), который приобрел в ученом мире популярность и авторитет одного из ведущих научных изданий Европы.

Была создана собственная типография, которая быстро завоевала прекрасную репутацию, и ей было поручено издание всей литературы в стране, кроме церковной. Это сразу обозначило ведущую роль Академии в общем развитии российской культуры.

Уже в 1736 г. известный французский физик Дорту де Меран писал: "Петербургская академия со времени своего рождения поднялась на выдающуюся высоту науки, до которой академии Парижская и Лондонская добрались только за 60 лет упорного труда".

В 1746 году состоялось назначение первого русского президента Академии, им стал граф К. Г. Разумовский. В Академию начали избираться отечественные ученые. Первыми русскими академиками стали С. П. Крашенинников — автор первой естественнонаучной книги ("Описание Земли Камчатки"), написанной на русском языке, М.В. Ломоносов, поэт В.К. Тредиаковский, а позже астрономы Н.И. Попов, С.Я. Румовский, П.Б. Иноходцев, натуралисты И.И. Лепехин, Н.Я. Озерецковский, В.Ф. Зуев и др.

Распространению научных знаний активно содействовали издания Академии. В "Примечаниях на Ведомости" печатались статьи о природных явлениях, минералах, машинах и приборах, о путешествиях, о дальних странах и народах, о болезнях и их лечении, о поэтическом и драматическом искусстве, об опере и многом другом. Большая аудитория была у издававшихся Академией на двух языках "Календарей" или "Месяцесловов", в которых также регулярно выходили статьи на исторические и естественнонаучные темы. И хотя к концу века набирали силу частное книгоиздательство и журналистика, в пропаганде науки сохранили лидерство именно академические издания (это лидерство мы сохраняем и до сих пор). Разнообразна была тематика издававшегося Академией в 1755—1764 гг. на русском языке журнала "Ежемесячные сочинения, к пользе и увеселению служащие". Позднее появились "Академические известия" и другие популярные издания, помещавшие статьи академиков и переводы иностранной научно-популярной литературы.

В XVIII в. почетными членами и членами-корреспондентами стали более 160 иностранных ученых (Ф. Вольтер, Д. Дидро, Ж. Даламбер, К. Линней, Б. Франклин и другие). В свою очередь, почетными членами зарубежных академий стали Л. Эйлер, М.В. Ломоносов, И.И. Лепехин, С.Я. Румовский, П.С. Паллас.

В 1783 г. параллельно с Петербургской академией наук начала работать Российская академия, основной задачей которой являлось составление словаря русского языка. Ее членами были знаменитые русские писатели и поэты — Д.И. Фонвизин, Г.Р. Державин, с 1833 г. гений русской поэзии А.С. Пушкин, а также ученые С.К. Котельников, А.П. Протасов, С.Я. Румовский и другие. Одним из инициаторов создания и первым председателем этой Академии была княгиня Е.Р. Дашкова. В 1841 г. Российская академия была упразднена, а часть ее членов влилась в Академию наук, составив Отделение русского языка и словесности.

(from ***«Академия наук в истории Российского государства» by Yu.S. Osipov, www.ras.ru***)

N. Prepare a public speech for 5—8 minutes (in Russian) about the evolution of science you are involved in. Make up an abstract (3—5 sentences) of the speech and point out some key words (5—10 words).

O. After presenting your speech give the key words and abstract to other students, who will render your speech in English.

P. When preparing a speech or a presentation as well as when writing your research you should organize search for information you require in a certain way. Read the table below with the questions you have to ask yourselves and see if you can answer them.

The basic question	Examples of ways in which it might be assessed
1. Do I know what I'm doing?	Have I drawn up a plan (a protocol) for what I intend to do? Do the proposed studies cover all the criticisms likely to be made? Are the statistical methods valid?
2. Do my proposed experiments meet accepted ethical standards?	If my experiments involve human beings or animals, do they meet accepted standards? Could my work adversely affect the environment or the place where I am doing fieldwork?
3. What practical and political considerations need to be addressed?	Is publication of my work likely to break any official secrecy regulations? Could publication invalidate a later application for a patent? Are collecting or other permits required?
4. How will I record the work as it proceeds?	How will I record what I read? How will I record what I do? How will I ensure that my records are complete? How will I ensure that I can access the records again when I or others need them?

Q. Read the following piece of advice about how to read literature that you need for your thesis. Translate this text into Russian. Remember it and try to use it in your research work.

As you read, it's important to concentrate on works closely tied to your thesis topic. Early in the project, as you immerse yourself in the subject, you need to do some general background reading. A little meandering is par for the course, and it's fine. But as your topic takes shape, your focus should become clearer, sharper.

Maintaining this focus is particularly important when you read longer books. Some parts may bear on your thesis, but others do not. Read shrewdly. Use the table of contents and the index. Feel free to skip some chapters and skim others. You have my permission! Zero in on the key material in your reading and in your notes. Your goal is to extract what you need without getting bogged down in the rest. Remember: ***You are reading to write***.

Tips:

- Read selectively.
- Don't read everything; focus on works directly related to your topic.
- Don't read everything at the same speed; read the most important works more carefully.
- Remember that you are reading to write.

(from ***"How to Write a BA Thesis"*** by ***Ch. Lipson***)

R. Read the following descriptions of evolution of some sciences. How can you amend or modify them?

Physics	The Scientific Revolution is a convenient boundary between ancient thought and classical physics. Nicolaus Copernicus revived the heliocentric model of the solar system described by Aristarchus of Samos. This was followed by the first known model of planetary motion given by Kepler in the early 17th century, which proposed that the planets follow elliptical orbits, with the Sun at one focus of the ellipse. Galileo ("*Father of Modern Physics*") also made use of experiments to validate physical theories, a key element of the scientific method.
Chemistry	The history of modern chemistry can be taken to begin with the distinction of chemistry from alchemy by Robert Boyle in his work *The Sceptical Chymist*, in 1661 (although the alchemical tradition continued for some time after this) and the gravimetric experimental practices of medical chemists like William Cullen, Joseph Black, Torbern Bergman and Pierre Macquer. Another important step was made by Antoine Lavoisier (*Father of Modern Chemistry*) through his recognition of oxygen and the law of conservation of mass, which refuted phlogiston theory. The theory that all matter is made of atoms, which are the smallest constituents of matter that cannot be broken

	down without losing the basic chemical and physical properties of that matter, was provided by John Dalton in 1803, although the question took a hundred years to settle as proven. Dalton also formulated the law of mass relationships. In 1869, Dmitri Mendeleev composed his periodic table of elements on the basis of Dalton's discoveries.
Geology	Geology existed as a cloud of isolated, disconnected ideas about rocks, minerals, and landforms long before it became a coherent science. Theophrastus' work on rocks *Peri lithōn* remained authoritative for millennia: its interpretation of fossils was not overturned until after the Scientific Revolution. Chinese polymath Shen Kua (1031—1095) was the first to formulate hypotheses for the process of land formation. Based on his observation of fossils in a geological stratum in a mountain hundreds of miles from the ocean, he deduced that the land was formed by erosion of the mountains and by deposition of silt. Geology was not systematically restructured during the Scientific Revolution, but individual theorists made important contributions. Robert Hooke, for example, formulated theory of earthquakes, and Nicholas Steno developed the theory of superposition and argued that fossils were the remains of once-living creatures. Beginning with Thomas Burnet's *Sacred Theory of the Earth* in 1681, natural philosophers began to explore the idea that the Earth had changed over time. Burnet and his contemporaries interpreted Earth's past in terms of events described in the Bible, but their work laid the intellectual foundations for secular interpretations of Earth history. Modern geology, like modern chemistry, gradually evolved during the 1700s and early 1800s.
Astronomy	Aristarchus of Samos published work on how to determine the sizes and distances of the Sun and the Moon, and Eratosthenes used this work to figure the size of the Earth. Hipparchus later discovered the precession of the Earth.

	Advances in astronomy and in optical systems in the 19th century resulted in the first observation of an asteroid (1 Ceres) in 1801, and the discovery of Neptune in 1846. George Gamow, Ralph Alpher, and Robert Hermann had calculated that there should be evidence for a Big Bang in the background temperature of the universe. In 1964, Arno Penzias and Robert Wilson discovered a 3 kelvin background hiss in their Bell Labs radiotelescope, which was evidence for this hypothesis, and formed the basis for a number of results that helped determine the age of the universe. Supernova SN1987A was observed by astronomers on Earth both visually, and in a triumph for neutrino astronomy, by the solar neutrino detectors at Kamiokande. But the solar neutrino flux was a fraction of its theoretically-expected value. This discrepancy forced a change in some values in the standard model for particle physics.
Biology, **Medicine,**	In 1847, Hungarian physician Ignác Fülöp Semmelweis dramatically reduced the occurrence of puerperal fever by simply requiring physicians to wash their hands before attending to women in childbirth. This discovery predated the germ theory of disease. However, Semmelweis' findings were not appreciated by his contemporaries and came into use only with discoveries by British surgeon Joseph Lister, who in 1865 proved the principles of antisepsis. Lister's work was based on the important findings by French biologist Louis Pasteur. Pasteur was able to link microorganisms with disease, revolutionizing medicine. He also devised one of the most important methods in preventive medicine, when in 1880 he produced a vaccine against rabies. Pasteur invented the process of pasteurization, to help prevent the spread of disease through milk and other foods. Perhaps the most prominent, controversial and far-reaching theory in all of science has been the theory of evolution by natural selection put

Genetics	forward by the British naturalist Charles Darwin in his book On the Origin of Species in 1859. Darwin proposed that the features of all living things, including humans, were shaped by natural processes over long periods of time. Implications of evolution on fields outside of pure science have led to both opposition and support from different parts of society, and profoundly influenced the popular understanding of "man's place in the universe". However, Darwinian evolutionary models do not directly impact the study of genetics. In the early 20th century, the study of heredity became a major investigation after the rediscovery in 1900 of the laws of inheritance developed by the Moravian monk Gregor Mendel in 1866. Mendel's laws provided the beginnings of the study of genetics, which became a major field of research for both scientific and industrial research. By 1953, James D. Watson, Francis Crick and Rosalind Franklin clarified the basic structure of DNA, the genetic material for expressing life in all its forms. In the late 20th century, the possibilities of genetic engineering became practical for the first time, and a massive international effort began in 1990 to map out an entire human genome (the Human Genome Project) has been touted as potentially having large medical benefits.
Ecology	The discipline of ecology typically traces its origin to the synthesis of Darwinian evolution and Humboldtian biogeography, in the late 19th and early 20th centuries. Equally important in the rise of ecology, however, were microbiology and soil science—particularly the cycle of life concept, prominent in the work Louis Pasteur and Ferdinand Cohn. The word *ecology* was coined by Ernst Haeckel, whose particularly holistic view of nature in general (and Darwin's theory in particular) was important in the spread of ecological thinking. In the 1930s, Arthur Tansley and others began developing the field of ecosystem ecology, which combined experimental soil science with physiological

	concepts of energy and the techniques of field biology. The history of ecology in the 20th century is closely tied to that of environmentalism; the Gaia hypothesis in the 1960s and more recently the scientific-religious movement of Deep Ecology have brought the two closer together.
Social Sciences	Successful use of the scientific method in the physical sciences led to the same methodology being adapted to better understand the many fields of human endeavor. From this effort the social sciences have been developed.
Political Science	Although the roots of politics may be in Prehistory, the antecedents of European politics trace their roots back even earlier than Plato and Aristotle, particularly in the works of Homer, Hesiod, Thucydides, Xenophon, and Euripides. Later, Plato analyzed political systems, abstracted their analysis from more literary- and history- oriented studies and applied an approach we would understand as closer to philosophy. Similarly, Aristotle built upon Plato's analysis to include historical empirical evidence in his analysis. During the rule of Rome, famous historians such as Polybius, Livy and Plutarch documented the rise of the Roman Republic, and the organization and histories of other nations, while statesmen like Julius Caesar, Cicero and others provided us with examples of the politics of the republic and Rome's empire and wars. The study of politics during this age was oriented toward understanding history, understanding methods of governing, and describing the operation of governments. With the fall of the Roman Empire, there arose a more diffuse arena for political studies. The rise of monotheism and, particularly for the Western tradition, Christianity, brought to light a new space for politics and political action. During the Middle Ages, the study of politics was widespread in the churches and courts. Works such as Augustine of Hippo's *The City of God* synthesized current philosophies and

	political traditions with those of Christianity, redefining the borders between what was religious and what was political. Most of the political questions surrounding the relationship between Church and State were clarified and contested in this period. In the Middle East and later other Islamic areas, works such as the Rubaiyat of Omar Khayyam and Epic of Kings by Ferdowsi provided evidence of political analysis, while the Islamic aristotelians such as Avicenna and later Maimonides and Averroes, continued Aristotle's tradition of analysis and empiricism, writing commentaries on Aristotle's works. During the Italian Renaissance, Niccolò Machiavelli established the emphasis of modern political science on direct empirical observation of political institutions and actors. Later, the expansion of the scientific paradigm during the Enlightenment further pushed the study of politics beyond normative determinations. In particular, the study of statistics, to study the subjects of the state, has been applied to polling and voting. In the 20th century, the study of ideology, behaviouralism and international relations led to a multitude of 'pol-sci' subdisciplines including rational choice theory, voting theory, game theory (also used in economics), psephology, political geography/geopolitics, political psychology/political sociology, political economy, policy analysis, public administration, comparative political analysis and peace studies/conflict analysis. At the beginning of the 21st century, political scientists have increasingly deployed deductive modelling and systematic empirical verification techniques (quantitative methods) brining their discipline closer to the scientific mainstream.
	Historical linguistics emerged as an independent field of study at the end of the 18th century. Sir William Jones proposed that Sanskrit, Persian, Greek, Latin, Gothic, and Celtic languages all shared a common base.

Linguistics	After Jones, an effort to catalog all languages of the world was made throughout the 19th century and into the 20th century. Publication of Ferdinand de Saussure's *Cours de linguistique générale* created the development of descriptive linguistics. Descriptive linguistics, and the related structuralism movement caused linguistics to focus on how language changes over time, instead of just describing the differences between languages. Noam Chomsky further diversified linguistics with the development of generative linguistics in the 1950s. His effort is based upon a mathematical model of language that allows for the description and prediction of valid syntax. Additional specialties such as sociolinguistics, cognitive linguistics, and computational linguistics have emerged from collaboration between linguistics and other disciplines.
Economics	The basis for classical economics forms Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nations*, published in 1776. Smith criticized mercantilism, advocating a system of free trade with division of labour. He postulated an "Invisible Hand" that large economic systems could be self-regulating through a process of enlightened self-interest. Karl Marx developed an alternative economical system, called Marxian economics. Marxian economics is based on the labor theory of value and assumes the value of good to be based on the amount of labor required to produce it. Under this assumption, capitalism was based on employers not paying the full value of workers labor to create profit. The Austrian school responded to Marxian economics by viewing entrepreneurship as driving force of economic development. This replaced the labor theory of value by a system of supply and demand. In the 1920s, John Maynard Keynes prompted a division between microeconomics and macroeconomics. Under Keynesian economics macroeconomic trends can overwhelm economic choices made by

	individuals. Governments should promote aggregate demand for goods as a means to encourage economic expansion. Following World War II, Milton Friedman created the concept of monetarism. Monetarism focuses on using the supply and demand of money as a method for controlling economic activity. In the 1970s, monetarism has adapted into supply-side economics which advocates reducing taxes as a means to increase the amount of money available for economic expansion. Other modern schools of economic thought are New Classical economics and New Keynesian economics. New Classical economics was developed in the 1970s, emphasizing solid microeconomics as the basis for macroeconomic growth. New Keynesian economics was created partially in response to New Classical economics, and deals with how inefficiencies in the market create a need for control by a central bank or government.
Psychology	The end of the 19th century marks the start of psychology as a scientific enterprise. The year 1879 is commonly seen as the start of psychology as an independent field of study. In that year Wilhelm Wundt founded the first laboratory dedicated exclusively to psychological research (in Leipzig). Other important early contributors to the field include Hermann Ebbinghaus (a pioneer in memory studies), Ivan Pavlov (who discovered classical conditioning), William James, and Sigmund Freud. Freud's influence has been enormous, though more as cultural icon than a force in scientific psychology. The 20th century saw a rejection of Freud's theories as being too unscientific, and a reaction against Edward Titchener's atomistic approach of the mind. This led to the formulation of behaviorism by John B. Watson, which was popularized by B.F. Skinner. Behaviorism proposed epistemologically limiting psychological study to overt behavior, since that could be reliably measured. Scientific knowledge

	of the "mind" was considered too metaphysical, hence impossible to achieve. The final decades of the 20th century have seen the rise of a new interdisciplinary approach to studying human psychology, known collectively as cognitive science. Cognitive science again considers the mind as a subject for investigation, using the tools of psychology, linguistics, computer science, philosophy, and neurobiology. New methods of visualizing the activity of the brain, such as PET scans and CAT scans, began to exert their influence as well, leading some researchers to investigate the mind by investigating the brain, rather than cognition. These new forms of investigation assume that a wide understanding of the human mind is possible, and that such an understanding may be applied to other research domains, such as artificial intelligence.
Sociology	Ibn Khaldun can be regarded as the earliest scientific systematic sociologist. The modern sociology, emerged in the early 19th century as the academic response to the modernization of the world. Among many early sociologists (e.g., Émile Durkheim), the aim of sociology was in structuralism, understanding the cohesion of social groups, and developing an "antidote" to social disintegration. Max Weber was concerned with the modernization of society through the concept of rationalization, which he believed would trap individuals in an "iron cage" of rational thought. Some sociologists, including Georg Simmel and W. E. B. Du Bois, utilized more microsociological, qualitative analyses. This microlevel approach played an important role in American sociology, with the theories of George Herbert Mead and his student Herbert Blumer resulting in the creation of the symbolic interactionism approach to sociology. American sociology in the 1940s and 1950s was dominated largely by Talcott Parsons, who argued that aspects of society that promoted structural integration were therefore "functional". This structural functionalism approach was

	questioned in the 1960s, when sociologists came to see this approach as merely a justification for inequalities present in the status quo. In reaction, conflict theory was developed, which was based in part on the philosophies of Karl Marx. Conflict theorists saw society as an arena in which different groups compete for control over resources. Symbolic interactionism also came to be regarded as central to sociological thinking. Erving Goffman saw social interactions as a stage performance, with individuals preparing "backstage" and attempting to control their audience through impression management. While these theories are currently prominent in sociological thought, other approaches exist, including feminist theory, post-structuralism, rational choice theory, and postmodernism.
Anthropology	Anthropology can best be understood as an outgrowth of the Age of Enlightenment. It was during this period that Europeans attempted systematically to study human behaviour. Traditions of jurisprudence, history, philology and sociology developed during this time and informed the development of the social sciences of which anthropology was a part. At the same time, the romantic reaction to the Enlightenment produced thinkers such as Johann Gottfried Herder and later Wilhelm Dilthey whose work formed the basis for the culture concept which is central to the discipline. Traditionally, much of the history of the subject was based on colonial encounters between Europe and the rest of the world, and much of 18th- and 19th-century anthropology is now classed as forms of scientific racism. During the late 19th-century, battles over the "study of man" took place between those of an "anthropological" persuasion (relying on anthropometrical techniques) and those of an "ethnological" persuasion (looking at cultures and traditions), and these distinctions became part of the later divide between physical anthropology and cultural anthropology, the latter ushered in by the students of Franz Boas.

	In the mid—20th century, much of the methodologies of earlier anthropological and ethnographical study were reevaluated with an eye towards research ethics, while at the same time the scope of investigation has broadened far beyond the traditional study of "primitive cultures" (scientific practice itself is often an arena of anthropological study). The emergence of paleoanthropology, a scientific discipline which draws on the methodologies of paleontology, physical anthropology and ethology, among other disciplines, and increasing in scope and momentum from the mid — 20th century, continues to yield further insights into human origins, evolution, genetic and cultural heritage, and perspectives on the contemporary human predicament as well.

(from ***Wikipedia***)

S. Read the following text and translate it into Russian:

Aristotle was born in Stagira in north Greece, the son of Nichomachus, the court physician to the Macedonian royal family. He was trained first in medicine, and then in 367 he was sent to Athens to study philosophy with Plato. He stayed at Plato's Academy until about 347 — the picture at the top of this page, taken from Raphael's fresco *The School of Athens*, shows Aristotle and Plato (Aristotle is on the. right). Though a brilliant pupil, Aristotle opposed some of Plato's teachings, and when Plato died, Aristotle was not appointed head of the Academy. After leaving Athens, Aristotle spent some time traveling, and possibly studying biology, in Asia Minor (now Turkey) and its islands. He returned to Macedonia in 338 to tutor Alexander the Great; after Alexander conquered Athens, Aristotle returned to Athens and set up a school of his own, known as the Lyceum. After Alexander's death, Athens rebelled against Macedonian rule, and Aristotle's political situation became precarious. To avoid being put to death, he fled to the island of Euboea, where he died soon after.

Aristotle is said to have written 150 philosophical treatises. The 30 that survive touch on an enormous range of philosophical problems, from biology and physics to morals to aesthetics to politics. Many, however, are thought to be "lecture notes" instead of complete, polished treatises, and a few may not be the work of Aristotle but of members of his school.

A full description of Aristotle's contributions to science and philosophy is beyond the scope of this exhibit, but a brief summary can be made: Whereas Aristotle's teacher Plato had located ultimate reality in Ideas or eternal forms, knowable only through reflection and reason, Aristotle saw ultimate reality in physical objects, knowable through experience. Objects, including organisms, were composed of a potential, their **matter**, and of a reality, their **form**; thus, a block of marble — matter — has the potential to assume whatever form a sculptor gives it, and a seed or embryo has the potential to grow into a living plant or animal form. In living creatures, the form was identified with the soul; plants had the lowest kinds of souls, animals had higher souls which could feel, and humans alone had rational, reasoning souls. In turn, animals could be classified by their way of life, their actions, or, most importantly, by their parts.

Though Aristotle's work in zoology was not without errors, it was the grandest biological synthesis of the time, and remained the ultimate authority for many centuries after his death. His observations on the anatomy of octopus, cuttlefish, crustaceans, and many other marine invertebrates are remarkably accurate, and could only have been made from first-hand experience with dissection. Aristotle described the embryological development of a chick; he distinguished whales and dolphins from fish; he described the chambered stomachs of ruminants and the social organization of bees; he noticed that some sharks give birth to live young — his books on animals are filled with such observations, some of which were not confirmed until many centuries later.

Aristotle's classification of animals grouped together animals with similar characters into **genera** (used in a much broader sense than present-day biologists use the term) and then distinguished the **species** within the genera. He divided the animals into two types: those with blood, and those without blood (or at least without red blood). These distinctions correspond closely to our distinction between vertebrates and invertebrates. The blooded animals, corresponding to the vertebrates, included five genera: viviparous quadrupeds (mammals), birds, oviparous quadrupeds (reptiles and amphibians), fishes, and whales (which Aristotle did not realize were mammals). The bloodless animals were classified as cephalopods (such as the octopus); crustaceans; insects (which included the spiders, scorpions, and centipedes, in addition to what we now define as insects); shelled animals (such as most molluscs and echinoderms); and "zoophytes," or "plant-animals," which supposedly resembled plants in their form — such as most cnidarians.

Aristotle's thoughts on earth sciences can be found in his treatise *Meteorology* — the word today means the study of weather, but Aristotle used the word in a much broader sense, covering, as he put it, "all the affections we may call common to air and water, and the kinds and parts of the earth and the affections of its parts." Here he discusses the nature of the earth and the oceans. He worked out the hydrologic cycle: "Now the sun, moving as it does, sets up processes of change and becoming and decay, and by its agency the finest and sweetest water is every day carried up and is dissolved into vapour and rises to the upper region, where it is condensed again by the cold and so returns to the earth." He discusses winds, earthquakes (which he thought were caused by underground winds), thunder, lightning, rainbows, and meteors, comets, and the Milky Way (which he thought were atmospheric phenomena). His model of Earth history contains some remarkably modern-sounding ideas:

The same parts of the earth are not always moist or dry, but they change according as rivers come into existence and dry up. And so the relation of land to sea changes too and a place does not always remain land or sea throughout all time, but where there was dry land there comes to be sea, and where there is now sea, there one day comes to be dry land. But we must suppose these changes to follow some order and cycle. The principle and cause of these changes is that the interior of the earth grows and decays, like the bodies of plants and animals. . . .

But the whole vital process of the earth takes place so gradually and in periods of time which are so immense compared with the length of our life, that these changes are not observed, and before their course can be recorded from beginning to end whole nations perish and are destroyed.

Where Aristotle differed most sharply from medieval and modern thinkers was in his belief that the universe had never had a beginning and would never end; it was eternal. Change, to Aristotle, was cyclical: water, for instance, might evaporate from the sea and rain down again, and rivers might come into existence and then perish, but overall conditions would never change.

In the later Middle Ages, Aristotle's work was rediscovered and enthusiastically adopted by medieval scholars. His followers called him *Ille Philosophus* (The Philosopher), or "the master of them that know," and many accepted every word of his writings — or at least every word that did not contradict the Bible — as eternal truth. Fused and reconciled with Christian doctrine into a philosophical system known as Scholasticism, Aristotelian philosophy became the official philosophy of the Roman Catholic Church. As a result, some scientific discoveries in the Middle Ages and Renaissance were criticized simply because they were not found in Aristotle. It is one of the ironies of the history of science that Aristotle's writings, which in many cases were based on first-hand observation, were used to impede observational science.

(from the article at ***the University of California***)

T. Write a short summary (8—15 sentences) about evolution of the science you are involved in both in the Russian Federation and in foreign countries.

U. Insert the prepositions from the list and read the text aloud. Discuss it with other students.

at(3) for(3) of(2) to by before in after

1) I take its [the Royal Society's] first ground and foundation to have been … London, about the year 1645, when Dr. Wilkins (then chaplain to the Prince Elector Palatine, in London), and others, met weekly at a certain day and hour, under a certain penalty, and a weekly contribution … the charge of experiments, with certain rules agreed upon among us.

2) When (to avoid diversion to other discourses, and … some other reasons), we barred all discourses of divinity, of state affairs, and of news, other than what concerned our business of Philosophy.

3) These meetings we removed soon … to the Bull Head in Cheapside, and in term-time to Gresham College, where we met weekly … Mr. Foster's lecture (then Astronomy Professor there), and, after the lecture ended, repaired, sometimes to Mr. Foster's

lodgings, sometimes … some other place not far distant, where we continued such enquiries, and our numbers increased.
4) About the years 1648—9 some … our company were removed to Oxford; first, Dr. Wilkins, then I, and soon after, Dr. Goddard, whereupon our company divided.
5) Those at London (and we, when we had occasion to be there) met as … .
6) Those of us at Oxford, with Dr. Ward, Dr. Petty, and many others of the most inquisitive persons in Oxford, met weekly (for some years) … Dr. Petty's lodgings, on the like account, to wit, so long as Dr. Petty continued in Oxford, and for some while after, because … the conveniences we had there (being the house of an apothecary) to view, and make use of, drugs and other like matters, as there was occasion. Our meetings there were very numerous and very considerable.
7) For, besides the diligence of persons studiously inquisitive, the novelty of the design made many to resort there; who, when it ceased to be new, began to grow more remiss, or did pursue such inquiries … home.
8) We did afterwards (Dr. Petty being gone … Ireland, and our numbers growing less), remove thence; and (some years before His Majesty's return) did meet at Dr. Wilkins' lodgings in Wadham College.
9) In the meanwhile, our company at Gresham College being much again increased, … the accession of divers eminent and noble persons, upon His Majesty's return, we were (about the beginning of the year 1662) by His Majesty's grace and favor, incorporated by the name of The Royal Society.

(from "***Selections from the Sources of English History***" by ***Charles W. Colby***)

V. Put the verbs in brackets in the right tense-form and read the text. Discuss it with other students.

Democracy, Identity, and Diversity

One of the more significant challenges (to face) by education in these times is how to balance regard for difference (often known as *pluralism* or *diversity)* with a sense of what is common to a nation, its people, and its government. Many political theorists (to believe) that in a political system such as that in place in the United States, holding certain things in common across all the people (to be) essential to sustaining a healthy, fully functioning democracy (a perspective we explored just a few pages back). John Dewey put it in just this way in his famous work *Democracy and Education.* He (to envision) progress toward becoming a more democratic society being dependent upon the increasing degree to which various groups shared common interests and basic values, and on the increasing freedom with which groups (to interact) with one another based upon these common interests and values. For some, however, valuing pluralism and diversity threatens this commonness, replacing it with such a range of differences that democratic governance becomes impossible to maintain. Viewed in this way, the challenge seems to be either commonness or pluralism, democracy or diversity.

There is, of course, an alternative resolution. It (to involve) finding a balance between the need for commonality in order to sustain the benefits of liberty and self-governance, and the need for difference in order to permit various cultures, languages, and value orientations to survive, even flourish. How, for example, do we support the Latino interest in the Spanish language and a culture other than the dominant American one, while ensuring sufficient commonality to sustain democratic governance? Questions much like this one can be (to raise) for all groups asserting a difference between themselves and a common or dominant culture. Such questions may also (to go) beyond race, ethnicity, and language, to issues of gender, physical and mental condition, religious belief, sexual orientation, and age.

(from ***"Approaches to Teaching"*** by ***G.D. Fenstermacher*** and ***Jonas F. Soltis***)

W. Write down all proper names from exercises D and R (names of people, places, nationalities, etc.), translate them into Russian. Pay attention to the spelling of Greek and Roman names, memorize how to spell them.

X. Write down all proper names from exercise M and translate them into English paying attention to the difference between spelling in Russian. Now spell the names of your fellow students and teachers translating them from Russian.

Y. How is the science you are involved in developing now in Russia? What are the perspectives of its further evolution? What new tendencies have appeared recently in your field of study in the world? Discuss it with other students.

Z. Write an essay (15—25 sentences) using the vocabulary of this unit. Choose one of the following topics:

1) Development of Fundamental Sciences in the Russian Federation.
2) Evolution of Humanities in the Russian Federation.
3) Evolution of Some Sciences Increases Danger for the Mankind.

Unit 3

Knowledge Society

A. Read the following quotations about knowledge and the attitude of society to it and express your own opinion about knowledge in general and about the attitude of the society to knowledge.

3) The real accomplishment of modern science and technology consists in taking ordinary men, informing them narrowly and deeply and then, through appropriate organization, arranging to have their knowledge combined with that of other specialized but equally ordinary men. This dispenses with the need for genius. The resulting performance, though less inspiring, is far more predictable. (***John Kenneth Galbraith*** from ***The New Industrial State***)
4) Science has two main functions in civilization. One is to give man a picture of the world phenomena, the most accurate and complete picture possible. The other is to provide him with the means of controlling his environment and his destiny. (***Julian Huxley*** from ***What Dare I Think?***)
5) Science is organized knowledge, and knowledge is of things we see. Now the things that are seen are temporal; of the things that are unseen science knows nothing and has at present no means of knowing anything. (***Sir William Osler*** from ***Science and Immortality***)
6) Science comes from the knowing that you want to know. (**Eli Siegel** from ***Damned Welcome — Aesthetic Realism Maxims***)
7) Knowledge for the sake of knowledge, as the history of science proves, is an aim with an irresistible fascination for mankind, and which needs no defence. The mere fact that science does, to a great extent, gratify our intellectual curiosity, is a sufficient reason for its existence. (***J.W.N. Sullivan*** from ***The Limitations of Science***)

B. Write down 5—10 sentences expressing your ideas about the value of knowledge.

C. Read the definitions of "knowledge" and choose the one, which suits best to your ideas about knowledge from exercise B.

No.	Definition	Source
1.	1) knowledge is information and understanding about a subject which a person has, or which all people have. 2) if you say that something is true to your knowledge or to the best of your knowledge, you mean that you believe it to be true but it is possible that you do not know all the facts. 3) if you do something safe in the knowledge that something else is the case, you do the first	*Collins COBUILD Advanced Learner's English Dictionary, 4th edition*

	thing confidently because you are sure of the second thing.	
2.	1) *obsolete* cognizance 2) a. (1) the fact or condition of knowing something with familiarity gained through experience or association (2) acquaintance with or understanding of a science, art, or technique b. (1) the fact or condition of being aware of something (2) the range of one's information or understanding c. the circumstance or condition of apprehending truth or fact through reasoning ; cognition d. the fact or condition of having information or of being learned 3) *archaic* sexual intercourse 4) a. the sum of what is known ; the body of truth, information, and principles acquired by mankind b. *archaic* a branch of learning	*Merriam-Webster's Collegiate Dictionary, 11th Edition (2003)*
3.	1) a. (*usu. foll. by of*) awareness or familiarity gained by experience (of a person, fact, or thing) (have no knowledge of that). b. a person's range of information (is not within his knowledge). 2) a. (*usu. foll. by of*) a theoretical or practical understanding of a subject, language, etc. (has a good knowledge of Greek). b. the sum of what is known (every branch of knowledge). 3) *Philos.* true, justified belief; certain understanding, as opp. to opinion. 4) = carnal knowledge.	*Oxford English Reference*
4.	1) the facts, skills, and understanding that you have gained through learning or experience 2) in the knowledge that knowing that something has happened or is true 3) *not to your knowledge* used to say that something is not true, based on what you know 4) information that you have about a particular situation, event etc in full knowledge of (=knowing all the details of a situation)	*Longman Dictionary of Contemporary English, 3rd edition*

	5) to the best of your knowledge used to say that you think something is true, although you may not have all the facts 6) without your knowledge without knowing what is happening	

D. Read the following text:

Conceptions of Knowing

An analytical study of knowledge ought to acknowledge that the word "knowledge" is significantly ambiguous—as are its equivalents in other languages, such as the Greek episteme, from which "epistemology" is derived. The principal meanings of these words can be arranged into three groups. The first group concerns abilities of various kinds, primarily cognitive abilities that result from learning but sometimes even motor abilities. One can know German or know how to walk on stilts; one can know how to give a rousing speech, how to use the library, how get to the airport, but also how to do a handstand or back flip. Another group involves acquaintance, familiarity, personal experience, and corresponding recognitional abilities. One can know a former teacher; one can know a person by name or by sight; one can know fear, love, or disappointment; and can know New York, Boston, or the neighboring university campus. The last group of meanings—perhaps it is a single meaning-concerns "facts gathered by study, observation, or experience," and conclusions inferred from such facts (as when one has an in-depth knowledge of particle physics)."1 What the dictionary describes as knowledge of facts can be described more plainly as knowledge-that:2 knowledge that snow is while, that grass is green, or that 2+2 = 4. It is this last sort of knowledge that is central to recent work in epistemology.

In the early part of the last century some philosophers, notably Bertrand Russell, considered acquaintance or direct experience the fundamental source of empirical knowledge; for them, knowledge-that ultimately arises from knowledge of. As they saw it, our subjective experiences are elements of our consciousness, and everything we know by perception arises from our experiences. This view is no longer widely held: most philosophers now contend that acquaintance involves a substantial amount of knowledge-that, and the directly experienced residue in experience is little more than a stimulus for interpretive acts that result in more knowledge-that. Just think of your knowledge of your own hometown. You know that it has various buildings, various streets, various parks; you know where your house or apartment was—you know that it was in such and such a place. You can call up memory images of places you recall, but these images simply bring more facts to mind. The prevalence of this new view of acquaintance—the idea that it is not a distinctive kind of knowledge more basic than knowledge-that—owes a lot to Wittgenstein's attack on what he called "private languages," and it may or may not be right or defensible. I shall have more to say about acquaintance in chapter five.

Before 1963 analytically-minded philosophers mostly agreed that knowledge-that could be understood as justified true belief. Edmund Gettier's now famous criticism of this account destroyed the agreement and stimulated a plethora of attempts to provide an improved definition. The philosophers seeking an improvement had two desiderata specifically in mind. They wanted a definition incorporating standards that would make it possible for ordinary human beings to know most of what they think they know, and they wanted a definition that would avoid Gettier examples and others relevantly like them. A definition having the first feature would be instrumental in avoiding skepticism, an outcome that could be expected if the required standards of evidence were set too high. They also assumed that a definition having the desired features would require a knower to possess an appropriate true belief.

The great number and variety of attempts to provide a definition satisfying the desiderata I mentioned make it fairly clear that the philosophers attempting to provide such an improvement were not working with a single knowledge concept that already existed and was generally accepted. They may have had illusions about what they were doing, but the reality is that they were attempting to *create* a knowledge concept that was philosophically preferable to the simple one that Gettier criticized. They wanted a better analytical account of what knowledge could be taken to be. As it happened, they did not definitely succeed in this endeavor: no generally accepted conception or account of the desired kind was ever created. Many philosophers continue with the hunt, but some have basically given up on it. Among the latter, Timothy Williamson came to the conclusion that "knowing does not factorize as standard analyses require." Instead of attempting to provide a definition of knowledge, Williamson offered a "modest nonreductive analysis," describing knowing as "the most general factive, stative [human] attitude"—factive in being attached only to truths, and stative in being a state rather than a process. But Williamson's nonreductive analysis does not appear to have attracted many adherents. Most philosophers appear to want a more informative account of knowing than Williamson's analysis provides.

The consensus that once existed on seeking an improved justified-true-belief (or JTB+) analysis of knowing broke down for other reasons. Some philosophers, such as Peter Unger and Robert Fogelin, did not believe that skepticism should be ruled out by easily satisfied standards for knowing. These philosophers even wrote books supporting versions of that generally abhorred doctrine. In taking a skeptical line they had little trouble satisfying the other desideratum for a JTB+ analysis of knowledge, the one requiring the avoidance of Gettier examples. Each of the examples Gettier actually gave presupposed that a person may know that P on the basis of inconclusive evidence—evidence that does not exclude the possibility that P is actually false. But supporters of skepticism normally endorse higher standards for knowing: they seek evidence that is logically conclusive. Since a skeptical scenario featuring Descartes' evil genius or Putnam's brains in a vat cannot be conclusively refuted (or ruled out with utter certainty) by any evidence plausibly available to an observer, a philosopher requiring conclusive evidence for knowing will end up with the view that no alternative scenario incompatible with skepticism can possibly be known to be true.

Thus far I have been speaking of assumptions about knowledge that philosophers have held since 1963. Before that further differences existed, particularly if we go back far enough. Plato held that knowledge (episteme) is infallible and, unlike belief, directed to an immutable object. Aristotle held knowledge to be either immediately certain or a demonstrative consequence, via the syllogism, of immediately certain premises. Descartes did not limit necessary inference to the syllogism, but like Aristotle he thought properly scientific knowledge, or *scientia,* required rational certainty: the subject's evidential basis for such knowledge must be conclusive. Earlier twentieth-century philosophers had a more flexible attitude to knowing. G. E. Moore held that "I know that P" sometimes does, and sometimes does not, imply "I know that P with utter certainty"; and in 1952 Norman Malcolm distinguished a strong from a weak sense of "knows," one implying that the subject is certain of something, the other not.

In everyday life we often apparently do speak of knowledge in what Malcolm called the weak sense; we seem to assume that people often have genuine knowledge when their evidence is logically inconclusive, when it does not exclude the possibility of error. We seem to assume this when, having looked at our watch, we say we know what time it is; we seem to assume it when, watching a television newscast, we say we know the Twin Towers have been destroyed by a terrorist attack; and so on. But sometimes we speak of it in what is pretty clearly a stronger sense, one requiring that a subject's evidence be logically conclusive or very close to it. In a recent letter to the *Scientific American,* a man calculated that to win the $160-million with his lottery ticket, he would have to beat the winning odds of 1 to 120,526,770. In spite of these odds, he was willing to buy the ticket, and when he bought it we would not agree that if his friend Tom believes he will lose, Tom knows he will lose if that is what will happen. In spite of the very strong evidence Tom possesses, the possibility remains that the man will win—and this is enough to defeat Tom's claim to know he will lose. In this case, actually knowing that the man will lose seems to require rational certainty: our evidence must be sufficient to rule out the possibility that he will win.

The idea that we do in fact commonly apply different standards of evidence or different levels of certainty in deciding whether this or that person has knowledge under these or those circumstances is now widely accepted, but some philosophers give "invariant" accounts of this diversity. According to some, knowledge-ascriptions based on weak standards are usually in fact false, though they may have some practical value; according to others, negative ascriptions ("S does not know that P") based on exceptionally strong standards are actually false, though they seem plausible in the context of some well-known skeptical arguments. The key issue in the whole debate is how the diversity that is apparent in assertions involving "knows that" is best accommodated theoretically, and what account of how knowledge may be understood is most illuminating. As it happens, I shall be defending a dual account in what follows, one in which a concept of knowing for certain is distinguished from a minimal concept that does not require rational certainty. My approach is not widely accepted at the present time, however; the most widely discussed alternative in recent years is some form of contextualism. Because of its popularity as well as its complexity and suggestiveness, I want to consider this sort of view first.

(from ***What is Knowledge?*** by ***Bruce Aune***)

E. Check your reading comprehension. Choose the best answer (only one variant is possible). What do the underlined words from exercise D mean?

1) ***ultimately***
(a) maximum
(b) negatively
(c) basically
(d) extreme

2) ***substantial***
(a) considerable
(b) tasty
(c) manifold
(d) long

3) ***prevalence***
(a) significance
(b) predominance
(c) closeness
(d) spread

4) ***plethora***
(a) quantity
(b) quality
(c) magnitude
(d) redundancy

5) ***inference***
(a) influence
(b) assumption
(c) impact
(d) commonality

8) ***conclusive***
(a) finishing
(b) summary
(c) convincing
(d) common

F. Match the words in the left column with their definitions in the right column.

1) ***analysis***
2) ***epistemology***
3) ***residue***
4) ***syllogism***
5) ***rational***
6) ***immutable***

a) the theory or science of the method or grounds of knowledge.
b) a statement with three parts, the first two of which prove that the third part is true
c) never changing or impossible to change
d) the fact that it contains many very different elements
e) likely to be true or valid
f) a careful examination of something in order to understand it better

7) ***infallible***	g) a person of extraordinary intellectual power
8) ***diversity***	h) a small amount that remains after most of it has gone
9) ***plausibly***	i) always right and never making mistakes
10) ***genius***	j) based on reason rather than on emotion

G. Fill in the gaps in the sentences below with the words from the list.

Particular innovation vital management key resources reasons access application positive work information

1) Mechanistic approaches to knowledge management are characterized by the … of technology and resources to do more of the same better.

2) Better accessibility to information is a …, including enhanced methods of access and reuse of documents (hypertext linking, databases, full-text search, etc.)

3) Networking technology in general (especially intranets), and groupware in …, will be key solutions.

4) In general, technology and sheer volume of information will make it … .

5) Such approaches are relatively easy to implement for corporate "political" …, because the technologies and techniques — although sometimes advanced in particular areas — are familiar and easily understood.

6) There is a modicum of good sense here, because enhanced access to corporate intellectual assets is … .

7) But it’s simply not clear whether … itself will have a substantial impact on business performance, especially as mountains of new information are placed on line.

8) Unless the knowledge management approach incorporates methods of leveraging cumulative experience, the net result may not be …, and the impact of implementation may be no more measurable than in traditional paper models.

9) Cultural/behavioristic approaches, with substantial roots in process reengineering and change management, tend to view the "knowledge problem" as a … issue.

10) Technology — though ultimately essential for managing explicit knowledge … — is not the solution.

11) These approaches tend to focus more on … and creativity (the "learning organization") than on leveraging existing explicit resources or making working knowledge explicit.

12) Organizational behaviors and culture need to be changed dramatically. In our …-intensive environments, organizations become dysfunctional relative to business objectives.

H. Learn the following words and word combinations with ‘knowledge’.

KNOWLEDGE

- to acquire knowledge
- to accumulate knowledge
- to gain knowledge
- to demonstrate knowledge
- to display knowledge
- to show knowledge
- flaunt knowledge
- to parade one's knowledge (of a subject)
- to communicate knowledge
- to disseminate knowledge
- to impart knowledge
- to absorb knowledge
- to assimilate knowledge
- to soak up knowledge
- to bring something to somebody's knowledge
- to brush up (on) one's knowledge (of a subject)
- to deny knowledge (of something)
- direct knowledge
- extensive knowledge
- inside knowledge
- intimate knowledge
- intuitive knowledge
- profound knowledge
- thorough knowledge
- rudimentary knowledge
- slight knowledge
- superficial knowledge
- fluent knowledge
- reading knowledge
- speaking knowledge
- working knowledge to have fluent knowledge of English
- to have reading/a reading knowledge of several languages
- common knowledge
- carnal knowledge
- knowledge about something/ somebody
- knowledge of something
- the knowledge to +
- the knowledge that + clause
- to somebody's knowledge (to my knowledge
- to come to somebody's knowledge

- to the best of one's knowledge

(Source: ***BBI Combinatory Dictionary of English by M. Benson, E. Benson, & R. Ilson***)

I. What is the difference between the following synonyms:

1) knowledge
2) cognition
3) competence
4) skills
5) conception
6) information
7) expertise
8) erudition
9) education
10) understanding

J. Read the following text and make up a summary (15—20 sentences):

Knowledge Building

In what is coming to be called the ‘‘knowledge age,’’ the health and wealth of societies depends increasingly on their capacity to innovate. People in general, not just a specialized elite, need to work creatively with knowledge. As Peter Drucker put it, ‘‘innovation must be part and parcel of the ordinary, the norm, if not routine.’’ This presents a formidable new challenge: how to develop citizens who not only possess up-to-date knowledge but are able to participate in the creation of new knowledge as a normal part of their work lives.

There are no proven methods of educating people to be producers of knowledge. Knowledge creators of the past have been too few and too exceptional in their talents to provide much basis for educational planning. In the absence of pedagogical theory, learning-by-doing and apprenticeship are the methods of choice; but this does not seem feasible if the "doing" in question is the making of original discoveries, inventions, and plans. Rather, one must think of a *developmental trajectory* leading from the natural inquisitiveness of the young child to the disciplined creativity of the mature knowledge producer. The challenge, then, will be to get students on to that trajectory. But what is the nature of this trajectory and of movement along it? There are three time-honored answers that provide partial solutions at best. Knowledge building provides a fourth answer.

One approach emphasizes foundational knowledge: First master what is already known. In practice this means that knowledge creation does not enter the picture until graduate school or adult work, by which time the vast majority of people are unprepared for the challenge.

A second approach focuses on subskills. Master component skills such as critical thinking, scientific method, and collaboration; later, assemble these into competent original research, design, and so forth. Again, the assembly—if it occurs at all—typically occurs only at advanced levels that are reached by only a few. Additionally, the core motivation—advancing the frontiers of knowledge—is missing, with the result that the component skills are pursued as ends in themselves, lacking in authentic purpose. Subskill approaches remain popular (often under the current banner of ‘‘twenty-first century skills’’) because they lend themselves to parsing the curriculum into specific objectives.

A third approach is associated with such labels as ‘‘learning communities," "project-based learning,’’ and ‘‘guided discovery.’’ Knowledge is socially constructed, and best supported through collaborations designed so that participants share knowledge and tackle projects that incorporate features of adult teamwork, real-world content, and use of varied information sources. This is the most widely supported approach at present, especially with regard to the use of information technology. The main drawback is that it too easily declines toward what is discussed below as shallow constructivism.

Knowledge building provides an alternative that more directly addresses the need to educate people for a world in which knowledge creation and innovation are pervasive. Knowledge building may be defined as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts. Knowledge building, thus, goes on throughout a knowledge society and is not limited to education. As applied to education, however, the approach means engaging learners in the full process of knowledge creation from an early age. This is in contrast to the three approaches identified above, which focus on kinds of learning and activities that are expected to lead eventually to knowledge building rather than engagement directly in it.

The basic premise of the knowledge building approach is that, although achievements may differ, the *process* of knowledge building is essentially the same across the trajectory running from early childhood to the most advanced levels of theorizing, invention, and design, and across the spectrum of knowledge creating organizations, within and beyond school. If learners are engaged in process only suitable for a school, then they are not engaged in knowledge building.

Learning and Knowledge Building: Important Distinctions

An Internet search turned up 32,000 web pages that use the term ‘‘knowledge building.’’ A sampling of these suggests that business people use the term to connote knowledge creation, whereas in education it tends to be used as a synonym for learning. This obscures an important distinction. Learning is an internal, unobservable process that results in changes of belief, attitude, or skill. Knowledge building, by contrast, results in the creation or modification of public knowledge—knowledge that lives ‘‘in the world’’ and is available to be worked on and used by other people. Of course creating public knowledge results in personal learning, but so does practically all human activity. Results to date suggest that the learning that accompanies knowledge building encompasses the foundational learning, subskills, and socio-cognitive dynamics pursued in other approaches, along with the additional benefit of movement along the trajectory to mature knowledge creation. Whether they are scientists working on an explanation of cell aging, engineers designing fuel-efficient vehicles, nurses planning improvements in patient care, or first-graders working on an explanation of leaves changing color in the fall, knowledge builders engage in similar processes with a similar goal. That goal is to advance the frontiers of knowledge as they perceive them. Of course, the frontiers as perceived by children will be different from those perceived by professionals, but professionals may also disagree among themselves about where the frontier is and what constitutes an advance. Dealing with such issues is part of the work of any knowledge building group, and so students must learn to deal with these issues as well. Identifying the frontier should be part of their research, not something preordained. The knowledge building trajectory involves taking increasing responsibility for these and other high-level, long-term aspects of knowledge work. This distinguishes knowledge building from collaborative learning activities. Keeping abreast of advancing knowledge is now recognized as essential for members of a knowledge society. Knowledge building goes beyond this to recognize the importance of creating new knowledge. The key distinction is between learning—the process through which the rapidly growing cultural capital of a society is distributed—and knowledge building—the deliberate effort to increase the cultural capital of society.

Shallow versus Deep Constructivism

"Constructivism" is a term whose vagueness beclouds important distinctions. Knowledge building is clearly a constructive process, but most of what goes on in the name of constructivism is not knowledge building. To clarify, it is helpful to distinguish between shallow and deep forms of constructivism. The shallowest forms engage students in tasks and activities in which ideas have no overt presence but are entirely implicit. Students describe the activities they are engaged in (e.g., planting seeds, measuring shadows) and show little awareness of the underlying principles these tasks are to convey. In the deepest forms of constructivism, people are advancing the frontiers of knowledge in their community. This purpose guides and structures their activity: Overt practices such as identifying problems of understanding, establishing and refining goals based on progress, gathering information, theorizing, designing experiments, answering questions and improving theories, building models, monitoring and evaluating progress, and reporting are all directed by the participants themselves toward knowledge building goals.

Most learner-centered, inquiry-based, learning community, and other approaches labeled ‘‘constructivist’’ are distributed somewhere between these extremes of shallow and deep constructivism. Participants in this middle ground are engaged to a greater or lesser extent with ideas and they have greater or lesser amounts of responsibility for achieving goals, but the over-arching responsibility and means for advancing the frontiers of knowledge are either absent or remain in the hands of the teacher or project designer. The idea of ‘‘guided discovery’’ suggests this middle ground. Middle-level constructivist approaches are best categorized as constructivist learning rather than knowledge building. Knowledge building calls for deep constructivism at all educational levels; it is the key to innovation.

Knowledge Building Environments

In knowledge building, ideas are treated as real things, as objects of inquiry and improvement in their own right. Knowledge building environments enable ideas to get out into the world and onto a path of continual improvement. This means not only preserving them but making them available to the whole community in a form that allows them to be discussed, interconnected, revised, and superseded.

Threaded discourse, which is the predominant Internet technology for idea exchange, has limited value for this purpose. Typically, ideas are lodged within conversational threads, contributions are unmodifiable, and there is no way of linking ideas in different threads or assimilating them into larger wholes. By contrast, CSILE/Knowledge Forum, a technology designed specifically to support knowledge building, has these required provisions and scaffolding supports for idea development, graphical means for viewing and reconstructing ideas from multiple perspectives, means of joining discourses across communities, and a variety of other functions that contribute to collaborative knowledge building. Contributions to a community knowledge base serve to create shared intellectual property, and give ideas a life beyond the transitory nature of conversation and its isolation from other discourses. Thus the environment supports sustained collaborative knowledge work, integral to the day-to-day workings of the community, as opposed to merely providing a discussion forum that serves as an add-on to regular work or study.

A shared workspace for knowledge building enables a self-organizing system of interactions among participants and their ideas and helps to eliminate the need for externally designed organizers of work. Advances within this communal space continually generate further advances, with problems reformulated at more complex levels that bring a wider range of knowledge into consideration. Thus there is a compounding effect, much like the compounding of capital through investment. Supporting such compounding and social responsibility for the collective work is the main challenge in the principled design of knowledge building environments.

In keeping with the belief that the process of knowledge building is fundamentally the same at beginning and advanced levels, and across sectors and cultures, Knowledge Forum is used from grade one to graduate school, and in a variety of knowledge-based organizations in countries around the world.

Social Aspects of Knowledge Building

Educational approaches of all kinds are subject to what is called the ‘‘Matthew effect’’: The rich get richer. The more you know the more you can learn. This is as close to a law of nature as learning research has come. It can be used to justify loading the elementary curriculum with large quantities of content. However, another potent principle is that knowledge needs to be of value to people in their current lives, not merely banked against future needs. This is part of the justification for activity and project-based methods where work is driven by students' own interests. In knowledge building this Deweyean principle is carried a step farther: Advances in understanding produce conceptual tools to achieve further advances in understanding. Thus there is a dynamism to knowledge building that can be a powerful motivator.

The Matthew effect foretells a widening gap between haves and have-nots in education, one that may already be manifesting itself in the widening income gap between the more and the less well-educated. No educational approach can be expected to solve the related equity problems, but knowledge building offers signal advantages. The knowledge building trajectory offers value all along its course, not just at its upper reaches. At all stages people are building authentic knowledge that is immediately useful to themselves and their community in making sense of their world. They are also developing skills and habits of mind conducive to lifelong learning. It is not assumed that everyone will come out equal in the end, but possibilities for continual advancement remain open for all.

From a social standpoint, the ability to connect discourses within and between communities opens new possibilities for barrier-crossing and mutual support. Successful knowledge-building communities establish socio-cognitive norms and values that all participants are aware of and work toward. These include contributing to collective knowledge advances, constructive and considerate criticism, and continual seeking of idea improvements. Grade one students, participants with low-literacy levels, and workers in knowledge-creating organizations can all adopt such norms, which then serve as a basis for cooperation across the developmental trajectory and among culturally diverse groups.

Knowledge building has been shown to yield advantages in literacy, in twenty-first century skills, in core content knowledge, in the ability to learn from text, and in other abilities. However, it is the fact that knowledge building involves students directly in creative and sustained work with ideas that makes it especially promising as the foundation for education in the knowledge age.

(from ***Encyclopedia of Education***)

K. Translate your summary of the text from exercise J into Russian.

L. Answer the following questions to the text from exercise J:

1) What is a developmental trajectory in education?
2) What approaches do you know in the field of knowledge building?
3) How is the “constructivism” defined?
4) What are the knowledge building environments?
5) How is the Matthew effect applied in knowledge building?

M. Read the following text and render it in English:

В.В. Путин: "О развитии образования в Российской Федрации"

Образование — это, безусловно, один из важнейших приоритетов в деятельности государства. Предложенная недавно для реализации дополнительная, по сути, целевая программа, названная приоритетным общенациональным проектом в области образования, — не только средство для решения давно назревших, а иногда и перезревших проблем, а скорее всего, это способ еще раз сосредоточить усилия и внимание государства и общества на проблемах образования, способ побудить всех нас к поиску наиболее эффективных путей развития в этой сфере, способ придать всем нам мужества для принятия необходимых, но выверенных решений.

Сегодня мы говорили о дошкольном воспитании, школьном образовании, специальном профессиональном и высшем образовании. Рабочая группа Госсовета проделала огромную работу. Сергей Леонидович Катанандов начал заниматься этой темой еще несколько лет назад. Считаю, что сформулированные руководителями регионов предложения могут быть положены в основу плана практических действий по совершенствованию системы образования в нашей стране.

Система детских дошкольных учреждений — это отдельная, безусловно, тесно связанная проблемами демографии тема. Она требует отдельного рассмотрения, особого нашего внимания.

Школа, одна из проблем здесь — большое количество малокомплектных школ в России. Очевидно, что здесь существует несколько вопросов, на которые следует обратить внимание рабочей группы.

Первое. Содержание таких школ обходится очень дорого, а образование остается весьма на низком уровне. Вместе с тем согласен с теми, кто считает, что, решая эти сложные вопросы, мы должны руководствоваться особенностями регионов, особенностями территорий и муниципалитетов.

Практически все выступавшие говорили о необходимости применения новых методов и форм организации системы образования. Практически все без исключения выступили с предложением шире внедрять систему нормативно-подушевого финансирования в школах.

Вместе с тем нормативно-подушевое финансирование невозможно без определения так называемой базы подушевого финансирования. Это значит, что ее нужно оценить по объективным критериям. Нужно заранее понять, что будет с этой базой происходить по мере ее внедрения в практику, с тем чтобы она не уменьшалась и не ухудшалась, с тем чтобы мы полностью исключили какие бы то ни было искушения властей по мере внедрения системы постоянно эту базу уменьшать.

Это значит, что заранее нужно определить объемы и источники финансирования муниципалитетов, регионов, конкретных учреждений, переходящих на предлагаемую рабочей группой систему финансирования школ.

Внедрение предлагаемых преобразований должно улучшать систему образования, а не ухудшать ее. Это значит, что действовать нужно очень аккуратно, постепенно расширяя базу эксперимента, расширяя его географию, прежде всего за счет тех регионов, которые хотят внедрять эту систему и которые готовы к ее внедрению.

Мы пока говорим об эксперименте, но, естественно, он должен проходить на легальной основе, а это значит, что все правовые ограничения должны быть устранены.

Наконец, последнее. Принцип бесплатности школьного образования должен быть обеспечен безусловно.

Мы много говорили о вузах и их инновационной деятельности. Это очень важная составляющая вузовского образования. Конечно, государство должно оказывать поддержку прежде всего тем высшим учебным заведениям, которые в состоянии эффективно использовать выделяемые государством на эти цели средства.

На этот год предусмотрено пять миллиардов, на следующих год — пятнадцать миллиардов рублей. И нет необходимости всуе упоминать Стабилизационный фонд Правительства. Нужно сначала освоить предлагаемые ресурсы, а государство, Правительство, Министерство образования и науки должны выработать объективные критерии оценки готовности вузов не по громким названиям и титулам, а исходя из их реальной готовности к инновационной деятельности.

От результатов по использованию предлагаемых и выделяемых ресурсов будет в значительной степени зависеть и их вузовское будущее, их реальный статус в будущем, их привлекательность для абитуриентов и уровень поддержки со стороны государства.

(from ***www.news.kremlin.ru***)

N. Prepare a public speech for 5—8 minutes (in Russian) about the role of knowledge building among students of schools and universities. Make up an abstract (3—5 sentences) of the speech and point out some key words (5—10 words).

O. After presenting your speech give the key words and abstract to other students, who will render your speech in English.

P. Point out the ways to organize knowledge building.

THE PARADOXICAL PROFESSION

Teaching is a paradoxical profession. Of all the jobs that are or aspire to be professions, only teaching is expected to create the human skills and capacities that will enable individuals and organizations to survive and succeed in today's knowledge society. Teachers, more than anyone, are expected to build learning communities, create the knowledge society, and develop the capacities for innovation, flexibility and commitment to change that are essential to economic prosperity. At the same time, teachers are also expected to mitigate and counteract many of the immense problems that knowledge societies create, such as excessive consumerism, loss of community, and widening gaps between rich and poor. Somehow, teachers must try to achieve these seemingly contradictory goals at the same time. This is their professional paradox.

Meanwhile, public expenditure, education, and welfare have been the first casualties of the slimmed-down state that knowledge economies have often required. Teachers' salaries and work conditions have been among the most expensive items at the top of the public-service casualty list.

In the industrial revolution, resources of human labor moved from the country to the city. This mass migration filled the Dickensian factories and dark Satanic mills of the period with labor power. But in the face of overcrowding and urban squalor, this movement also prompted the creation of great institutions of public space and public life such as state education, public libraries, and the great municipal parks. The economic explosion of the industrial revolution was not limitless. It was counterbalanced by acts of civic and philanthropic responsibility that provided learning, schooling, and green urban space that would benefit the people.

The knowledge revolution has been redirecting resources once more, this time from the public purse to private pockets as a way to boost consumer spending and stimulate stock-market investment in a global casino of endless speculation. There is little sign of social compensation or counterbalancing in this second revolution. Indeed, its drain on public spending and its championing of private choice is placing many of our public institutions, including public education, in jeopardy. Just as we are expecting the very most from teachers to prepare children for the knowledge society, their total salary costs, a result of having become a mass profession, have driven many governments to limit or withhold the resources and support their need to be more effective. In damaging the teachers of the next generations, the knowledge economy is eating its young.

The knowledge society finds it difficult to make teaching a true learning profession. It craves higher standards of learning and teaching. Yet it has also subjected teachers to public attacks; eroded their autonomy of judgment and conditions of work; created epidemics of standardization and over-regulation; and provoked tidal waves of resignation and early retirement, crises of recruitment, and shortages of eager and able educational leaders. The very profession that is so often said to be of vital importance for the knowledge economy is the one that too many groups have devalued, more and more people want to leave, less and less want to join, and very few are interested in leading. This is more than a paradox. It is a crisis of disturbing proportions.

Teachers today thus find themselves caught in a triangle of competing interests and imperatives:

- To be *catalysts* of the knowledge society and all the opportunity and prosperity it promises to bring;
- To be *counterpoints* for the knowledge society and its threats to inclusiveness, security and public life;
- To be *casualties* of the knowledge society in a world where escalating expectations for education are being met with standardized solutions provided at minimum cost.

The interactions and effects of the three forces shown in Figure 1.1 are shaping the nature of teaching, what it means to be a teacher, and the very viability of teaching as a profession in the knowledge society.

(from ***Teaching in the Knowledge Society*** by ***Andy Hagreaves)***

Q. Read the following instructions on how to prepare a scientific paper.

A. FRONT MATTER

The front matter precedes the text and pertains more to the bibliographical facts of the paper than to the actual research. Front matter consists of the title page, the abstract, and a list of key words for indexing.

1. Title

- Choose a title that will attract the reader's interest.
- Use the fewest possible words to adequately describe the content of the paper.
- Be specific.
- Avoid abbreviations, except standard ones such as DNA.
- Put important terms at the beginning of the title

2. Authors and Affiliations

- Include only those who have contributed materially to the research project.

- List order depends on each author's role and contribution.
- Write names in western format: Given names followed by family name. Possible exceptions are names of famous people, which should be given in their most recognizable form. This rarely happens in a scientific paper, however.
- List the affiliations of all authors.
- List the corresponding author, the address to which correspondence should be directed, telephone number, facsimile (fax) number, and electronic mail (e-mail) address, if any. Provide the country code for telephone and fax numbers outside of the United States

3. Abstract

- An abstract is usually less than one double-spaced typed page. It begins on a new page and contains up to 150 to 250 words. If possible, avoid citing references in the abstract.
- Objective and scope: informative for research papers and indicative for reviews, conference reports, and so forth
- Methodology: brief unless the research project is about methods
- Summary of results
- Conclusions

4. Key Words

- Provide several words or phrases for the benefit of the indexer.
- Include words that are not part of the title of the paper.

B. TEXT

The text is the main body of the paper. The organization of the text is represented by the acronym IMRAD, which stands for:

Introduction: What problem was the research project addressing?
Materials and Methods: How did you study the problem?
Results: What did you find?
And
Discussion: What do these findings mean?

1. Introduction

The introduction contains information that should be read before the rest of the text. Its purpose is to provide the educated reader with specifics needed to understand the paper. The introduction typically includes:

- Nature and scope of the problem
- Pertinent literature cited
- Methods
- Recent findings and theories
- Principal results

2. Materials and Methods (Experimental Procedures)

This section describes and justifies your approach to the research problem.

- Provide detail sufficient to enable a competent reader to repeat the experiments.
- Do not include results, except in a methodology paper, in which the methods become the results.

- Remember that a good reviewer will read this section to judge the validity of your approach.

3. Results

This section is the meat of a paper, presenting the findings in text, illustrations, and tables. This does not, however, mean that the Results section should be lengthy.

- Do not start the Results section by describing methodology.
- Report significant results only.
- Avoid redundancy: Numerical values that are apparent in illustrations and tables should not be duplicated in the text.
- Cite figures and tables concisely: Do not include the same data in both figures and tables and do not repeat the legend of a figure or the title of a table in the text.
- Bear in mind that text in figures and tables must be legible after reduction by the printer, and some exhibits are costly to reproduce.

4. Discussion

This is usually the most challenging section to write. It is not a recapitulation of results. The value of the discussion lies in your interpretation of the findings and their significance.

New results should not be introduced in this section

- Present the principles, relationships, and generalizations shown by the results
- Point out any exceptions or any lack of correlation, and define unsettled points, but avoid focusing on trivial details
- Show how your results and interpretations agree or disagree with published work
- Discuss the theoretical implications and any possible applications of your findings and interpretations
- State your conclusions
- Summarize your evidence for each conclusion

C. BACK MATTER

The back matter follows the text and lists resources that were not a part of the research project but nonetheless contributed to its execution. These include research contributions, sources of funding, and reference materials.

1. Acknowledgment

The main purpose of this section is to credit those who have made significant research contributions to your project. Another important function of this section is to mention individuals and entities that have provided essential support such as grants and fellowships.

2. References

- Cite only significant published references
- Follow the journal's instructions for documentation, which will be some version of the author-date system, the number system, or a combination of the two.

(from ***An Outline of Scientific Writing*** by ***Jen Tsi Yang)***

R. Read the following descriptions of some notions. How can you amend or modify them?

1) Basics of Knowledge Management	The formulation of knowledge goals is the starting point of knowledge management on an individual as well as on an organizational level. The process of knowledge evaluation can be seen as the end of the knowledge management processes. There is a feedback look from evaluation to goals in that the results of the evaluation may lead to changes in the knowledge goals. A wide range of possible tasks and processes are relevant between goal setting and evaluation. These can be grouped into four kinds of processes that are closely connected and interactive: *knowledge representation, knowledge communication, use of knowledge,* and *development of knowledge.* These categories describe the knowledge management processes on an individual as well as on an organizational level.
2) Knowledge goals	The formulation and identification of knowledge goals is necessary to provide the initial direction for the knowledge management activities. Carefully planned knowledge management processes are the basis of knowledge goals on an individual as well as on an organizational level.
3) Evaluation	Evaluation can be seen as the final stage of the four knowledge management processes. On both an individual as well as on an organizational level it is necessary in evaluation to estimate if the knowledge goals have been reached within this context.
4) Knowledge representation	Knowledge representation describes the process of knowledge identification, preparation, documentation and actualization. The main goal of this category is to transform knowledge into a format which enhances the distribution and exchange of knowledge.
5) Knowledge communication	In knowledge communication, processes are combined which concern the distribution of information and knowledge, the mediation of knowledge, knowledge sharing, and the co-construction of knowledge, as well as knowledge-based cooperation. These activities necessitate two or more people communicating

	directly, indirectly face-to-face, or in a virtual environment.
6) Development of knowledge	The development of knowledge includes not only processes of external knowledge procurement (i.e. through cooperative efforts, consultants, new contacts, etc.) or the creation of specific knowledge resources like research and development departments. The formation of personal and technical knowledge networks are also part of the development of knowledge.
7) Use of knowledge	Use of knowledge focuses on the *de facto* transformation of knowledge to products and services. This category is of special interest because it shows the effectiveness of the preceding actions in the range of the categories such as knowledge representation, knowledge communication and development of knowledge.
8) Knowledge Management in the Organization	With the goal of knowledge management to develop the potential for learning of individuals and organizations by developing, exchanging, and using knowledge, knowledge management can be seen as a prerequisite for innovations in organizations. In this context knowledge management is often regarded as a concept and instrument for the realization of the metaphor of the learning organization. Concepts regarding the learning organization emphasize almost the same goals as knowledge management; but in actuality knowledge management can be regarded as a prerequisite for the creation and maintenance of a learning organization. If an organization (company, school, university etc.) is able to handle its knowledge resources well, it can react to shifts in the marketplace faster and more flexibly. Thus it demonstrates its capability to learn. The learning ability of employees provides a major competitive advantage in the framework of the increasing market pressure. In this context, individual and team-based learning are as important as the documentation and distribution of knowledge within an organization.
	The individual as the initial point of knowledge management has been neglected, especially as knowledge management has become a topic important in the business world. Most companies at first relied on technology-based knowledge management, which has mostly led to the implementation of databases.

9) Knowledge Management and the Individual	On the basis of an intensive analysis of the subject of knowledge management, the conclusion can be drawn that most attempts to manage the resource of knowledge have failed. Today it is clear that knowledge management approaches can only be successful if the individual plays a major role in the process. But it is the individual acting as a member of a community that is critical. Etienne Wenger introduced the idea of communities of practice in the workplace as providing added value to companies. According to Wenger, a *community of practice* is a community in which the members are informally bound by what they do together and by what they have learned through mutual engagement in these activities. Communities are highly self-organized, and it is the responsibility of the members to control the community and distribute the work among its members. Thus self-management, communication skills, the capacity for teamwork and the handling of knowledge are valuable skills for the members of communities. These individual knowledge management competencies are not only important in the range of communities but also for life in a knowledge society. To be able to cope with the new challenges of a knowledge society these skills become core competencies of every individual.
10) Knowledge Management in Formal Education	It is the task of schools and universities to provide students with basic knowledge management skills needed for life in a rapidly changing society. However, the traditional system of schools and universities does not meet the requirements of a knowledge society. Schools and universities should be transformed into learning organizations where knowledge management comes to life. The core aim should be the mediation of deep understanding of topics and the development of individual knowledge management skills. This new orientation requires a holistic change process in schools. In schools the analog of communities of practice is learning communities. Learning communities offer multifaceted possibilities for the integration of knowledge-management processes in schools and universities. Communities can be developed among the learners within the school. Thus long-term and deep engagement with a topic,

	interdisciplinary learning, and the development of social skills can be facilitated. At the same time, the exchange of knowledge between the teachers can be stimulated by implementing communities among teachers. In this context the initiation of a community that reaches out over the school boundaries can further enhance this process of knowledge sharing and mutual learning.
11) Issues in Implemen-	In this context the question arises of how the implementation of knowledge management processes to organizations can be facilitated. Within the field of knowledge management, research activities are still limited primarily to case studies. On the basis of several case studies with focus on small and medium-sized companies, six critical success factors for the implementation of knowledge management processes have been found. These factors can also be applied to different kinds of organizations (companies, schools, universities, etc.). **Corporate culture.** Successful implementation of knowledge management is closely related to the corporate culture. However, these cultural changes need time. In the context of the implementation of knowledge management activities, it is important to know how knowledge management initiatives interact with the culture and to determine how the culture should be changed. **Qualification of employees.** The competencies and motivation of employees strongly influence the success of knowledge management. Thus human resource development and the design of incentive-systems are highly important. **Learning culture.** The implementation of knowledge management can be seen as a step-by-step learning process which has to be nurtured. **Management support.** Knowledge management activities only have the opportunity to be successful if they are supported by the executive board. **Integration of knowledge processes to organization's processes.** It is important to connect knowledge management closely to the organization's processes in order to gain acceptance and for reasons of economical legitimacy. **New information and communication technolo-**

tation	**gies.** The implementation of knowledge management does not necessarily have to be connected to an investment in new information and communication technologies. The potential for such technologies evolves only if the cultural and organizational conditions exist. To confirm and empirically verify these findings further research—basic as well as applied research— is needed in the field of knowledge management. Basic and applied research should be closely connected. Moreover, research questions should be oriented on authentic and current problems. Research initiatives on knowledge management should be designed to be interdisciplinary and extremely precise. Furthermore they should be based on a wide range of methods.

(from ***Encyclopedia of Education***)

S. Read the following text and translate it into Russian:

Innovation systems — three alternative perspectives

We can thus identify at least three different ways of delimiting the innovation system. The first is the innovation system as *rooted in the R&D-system,* the second is the innovation system as *rooted in the production system* and the third is the innovation system as *rooted in the production and human resource development system.* There are several reasons why the last perspective is to be preferred.

Several OECD-countries that are characterised by a low-tech specialisation in production and exports are among the countries in the world with the highest GNP per capita. To focus on the rather small part of the economy engaged in formal R&D-activities would give very limited insights regarding the growth potential for these countries. This is true for most small OECD-countries and for developing countries. It may be argued that the 'made in America' study (Dertoutzos et al, 1989) and the made in France study (Taddei and Coriat 1993) indirectly have demonstrated that this wider perspective has relevance even for the big OECD-countries.

A second reason has to do with the fact that empirical studies especially at the regional level only partially support the original hypothesis in Lundvall (1985) about innovations systems as primarily constituted by inter-firm, user-producer relationships. It is an obvious alternative to broaden the perspective on regional and national systems and to see them as constituted also by a common knowledge base embedded in local institutions and embodied in people living and working in the region.

The final and perhaps the most important reason for taking the broader view has to do with the basic assumption presented above about the present era as dominated by a 'learning economy'. This hypothesis points to the need to give stronger emphasis to the analysis of the development of human and organisational capabilities. In the national education systems people learn specific ways to learn. In labour markets they experience nation-specific incentive systems and norms about what kinds of knowledge are the most valuable. Again this will have an impact on how they learn.

(from ***The Learning Organisations and National Systems of Competence Building and Innovation*** by ***Alice Lam and Bengt-Aake Lundvall***, 2004)

T. Write a short essay (8—15 sentences) about competence building approach in the Russian Federation.

U. Insert the prepositions from the list and read the text aloud. Discuss it with other students.

on (3) with in (2) about (2) of (2) by (2)

Stereotyping

Introduced as a psychological term … US journalist Walter Lippman … 1922 (Lippman, 1922), this rapidly entered everyday language.

Stereotyping is perceiving and treating others as representative … some group to which, … the basis of superficial appearance alone, one assumes they belong, and in the belief that they possess the psychological traits which one believes to characterise members of that group.

'Racial', religious and national stereotypes are numerous and often quite detailed.

If some level … stereotyping is unavoidable in everyday encounters, the danger lies in accepting predominantly negative stereotypes and using them to justify one's behaviour and beliefs.

The greater the social or cultural distance between two people, the more likely they are to perceive and treat the other stereotypically … first encounter.

… some circumstances this may amount to no more than light-heartedly playing a familiar national stereotype role when in another country as the first move in establishing a closer acquaintance … the other.

In others, it may be offensive, provocative, patronising and verging on delusional.

There is something a little paradoxical … condemning all stereotyping outright, since we are all torn between visually signalling the way we wish to be treated, or role we see ourselves as playing, in any given context and wanting to be treated as an individual without others making prior assumptions … us.

Professional roles, from police-person and doctor to night-club bouncer or waitress all rely … eliciting a form of stereotyped response, typically signalled … dress and posture.

Most psychological work, however, has addressed negative stereotyping in the contexts of inter-group relations, racism and various other forms of prejudice involving uncontrollable physical traits, gender or sexual orientation.

Many such stereotypes can be considered as forms of social representation.

(from ***"Psychology — The Key Concepts"*** by ***Graham Richards***)

V. Put the verbs in brackets in the right tense-form and read the text. Discuss it with other students.

12 Principles of Knowledge Management

Understanding knowledge is the first step to managing it effectively. Here are a dozen characteristics of knowledge, and some tools and approaches for making the most of the knowledge **(to asset)** in your organization.

Winston Churchill said, "The empires of the future are the empires of the mind." Tom Peters said, "Heavy lifting is out; brains are in."

Stately or slangy, it's a fact that knowledge **(to be)** edging out buildings and gear as the essential business asset. Even advertising and marketing **(to use)** such words as *knowledge, intelligence,* and *ideas.* When many companies must innovate or die, their ability to learn, adapt, and change becomes a core competency for survival. Most **(to seek)** more knowledge through training, education, and career development. Every business is a knowledge business; every worker (to be) a knowledge worker.

The knowledge economy **(to bring)** new power to workers. Many are "free agents," contingency workers that make up almost a third of the U.S. workforce. Workers own the means of production-their knowledge. They can sell it, trade it, or give it away and still own it. As a result, the ways we manage people **(to undergo)** a dramatic, fundamental shift.

Knowledge is perishable. The shelf life of expertise is limited because new technologies, products, and services continually pour into the marketplace. No one can hoard knowledge. People and companies must constantly renew, replenish, expand, and create more knowledge.

That **(to require)** a radical overhaul of the old knowledge equation: knowledge = power, so hoard it. The new knowledge equation is knowledge = power, so share it and it will multiply. Widespread noncompetitive benchmarking and best-practice sharing show how eagerly we are embracing the concept of knowledge sharing.

Hubert St. Onge, who **(to lead)** the development of the knowledge management approach at Canadian Imperial Bank of Commerce, sees the primary challenge as making an organization's unarticulated or tacit knowledge explicit so that it can be shared and renewed constantly.

"It is important," he says, "to understand how knowledge is formed, and how people and organizations (to learn) to use it wisely."

12 guiding principles

A navigation technique is to look at the stars to tell you where you are. Similarly, we must use a powerful new "knowledge lens" in order to navigate or manage our companies. But we can't manage knowledge in a traditional way. Always changing, knowledge is more organic than mechanical.

Nevertheless, here are 12 fairly steady principles about knowledge.

1. Knowledge is messy. Because knowledge is connected to everything else, you can't isolate the knowledge aspect of anything neatly. In the knowledge universe, you can't pay attention to just one factor.

2. **Knowledge is self-organizing.** The self that knowledge (to organize) around is organizational or group identity and purpose.

3. **Knowledge seeks community.** Knowledge wants to happen, just as life wants to happen. Both **(to want)** to happen as community. Nothing illustrates this principle more than the Internet.

4. **Knowledge travels via language.** Without a language to describe our experience, we can't communicate what we know. Expanding organizational knowledge (to mean) that we must develop the languages we use to describe our work experience.

5. **The more you try to pin knowledge down, the more it slips away.** It's tempting to try to tie up knowledge as codified knowledge-documents, patents, libraries, databases, and so forth. But too much rigidity and formality regarding knowledge lead to the stultification of creativity.

6. **Looser is probably better.** Highly adaptable systems look sloppy. The survival rate of diverse, decentralized systems is higher. That means we can waste resources and energy trying to control knowledge too tightly.

7. **There is no one solution.** Knowledge is always changing. For the moment, the best approach to managing it **(to be)** one that keeps things moving along while keeping options open.

8. **Knowledge doesn't grow forever.** Eventually, some knowledge is lost or **(to die)**, just as things in nature. Unlearning and letting go of old ways of thinking, even retiring whole blocks of knowledge, contribute to the vitality and evolution of knowledge.

9. **No one is in charge.** Knowledge is a social process. That means no person can take responsibility for collective knowledge.

10. **You can't impose rules and systems.** If knowledge is truly self-organizing, the most important way to advance it is to remove the barriers to self-organization. In a supportive environment, knowledge **(to take care of)** itself.

11. **There is no silver bullet.** There is no single leverage point or best practice to advance knowledge. It must be supported at multiple levels and in a variety of ways.

12. **How you define knowledge determines how you manage it.** The "knowledge question" can present itself many ways. For example, concern about the ownership of knowledge leads to acquiring codified knowledge that is protected by copyrights and patents.

A concern about knowledge sharing **(to emphasize)** communication flow and documentation. A focus on knowledge competencies leads to seeking more effective ways to create, adapt, and apply knowledge.

(from ***12 Principles of Knowledge Management*** by ***Verna Alee***)

W. Discuss with your groupmates what competencies all teachers should possess. Give your own reasons.

X. If you were the Minister of Education of the Russian Federation, which priorities in knowledge building would you take? Give your own reasons.

Y. Do you think there is a well-built knowledge management and knowledge quality assurance system in the educational area of Russia? What should be improved and how? Give your own proposals.

Z. Write an essay (15—25 sentences) using the vocabulary of this unit. Choose one of the following topics:
1) Knowledge Has Become More Powerful in the 21st Century
2) Competence is a Basis for One's Future Career
3) Knowledge and Competence as Fundamentals of the Future Prosperity

Unit 4

Perspectives of Science Development

A. Read the following quotations about science and express your own opinion about science and its development or perspectives.

1) The pace of science forces the pace of the technique. Theoretical physics forces atomic energy on us; the successful production of the fission bomb forces upon us the manufacture of the hydrogen bomb. *We* do not choose our problems, we do not choose our products; we are pushed, we are forced—by what? By a system which has no purpose and goal transcending it, and which makes man its appendix. (***Erich Fromm*** from ***The Sane Society***)
2) From the nineteenth century view of science as a god, the twentieth century has begun to see it as a devil. It behooves us now to understand that science is neither the one nor the other. (***Agnes Meyer*** from ***Education for a New Morality***)
3) Science is the only self-correcting human institution, but it also is a process that progresses only by showing itself to be wrong. (***Allan Sandage*** from ***Origins by Alan Lightman and Roberta Brawer***)
4) Science walks hand in hand with human development as its constant benefactor, as the guardian of its peace, in a universe rich to provide happiness and security for all. (***W.F.G. Swann*** from ***Science by D.W. Hill***)
5) When we come to face the problems before us—poverty, pollution, overpopulation, illness—it is to science that we must turn, not to gurus. The arrogance of scientists is not nearly as dangerous as the arrogance that comes from ignorance. (***Lewis Wolpert*** from ***Can Science Save Its Soul? by Mary Midgley in New Scientist***)

B. Write down 5—10 sentences expressing your ideas about perspectives of modern sciences.

C. Read the definitions of "innovation" and choose the one, which suits best to your ideas about science from exercise B.

No.	**Definition**	**Source**
1.	1) the act of innovating; introduction of something new, in customs, rites, etc. 2) a newly formed shoot, or the annually produced addition to the stems of many mosses. 3) a change effected by innovating; a change in customs; something new, and contrary to established customs, manners, or rites	*US Webster's Unabridged Dictionary (1913 edition)*
2.	1) change, introduction of novelty 2) novelty, radically new measure, violent departure from established precedent	*Soule's Dictionary of English Synonyms*

3.	1) a new thing or a new method of doing something 2) the introduction of new ideas, methods, or things	*Collins COBUILD Advanced Learner's English Dictionary, 4th edition*
4.	change; introduction off something new	*GRE Vocabulary*
5.	1) the introduction of something new 2) a new idea, method, or device ; novelty	*Merriam-Webster's Collegiate Dictionary, 11th Edition*
6.	1) a new idea, method, or invention 2) the introduction of new ideas or methods	*Longman Dictionary of Contemporary English, 3rd edition*

D. Read the following text:

WHAT WILL BECOME OF HOMO SAPIENS?

Contrary to popular belief, humans continue to evolve. Our bodies and brains are not the same as our ancestors' were-or as our descendants' will be.

When you ask for opinions about what future humans might look like, you typically get one of two answers. Some people trot out the old science-fiction vision of a big-brained human with a high forehead and higher intellect. Others say humans are no longer evolving physically—that technology has put an end to the brutal logic of natural selection and that evolution is now purely cultural.

The big-brain vision has no real scientific basis. The fossil record of skull sizes over the past several thousand generations shows that our days of rapid increase in brain size are long over. Accordingly, most scientists a few years ago would have taken the view that human physical evolution has ceased. But DNA techniques, which probe genomes both present and past, have unleashed a revolution in studying evolution; they tell a different story. Not only has *Homo sapiens* been doing some major genetic reshuffling since our species formed, but the rate of human evolution may, if anything, have increased. In common with other organisms, we underwent the most dramatic changes to our body shape when our species first appeared, but we continue to show genetically induced changes to our physiology and perhaps to our behavior as well. Until fairly recently in our history, human races in various parts of the world were becoming more rather than less distinct. Even today the conditions of modern life could be driving changes to genes for certain behavioral traits. If giant brains are not in store for us, then what is? Will we become larger or smaller, smarter or dumber? How will the emergence of new diseases and the rise in global temperature shape us? Will a new human species arise one day? Or does the future evolution of humanity lie not within our genes but within our technology, as we augment our brains and bodies with silicon and steel? Are we but the builders of the next dominant intelligence on the earth—the machines?

The Far and Recent Past

Tracking human evolution used to be the province solely of paleontologists, those of us who study fossil bones from the ancient past. The human family, called the Hominidae, goes back at least seven million years to the appearance of a small proto-human called *Sahelanthropus tchadensis.* Since then, our family has had a still disputed, but rather diverse, number of new species in it—as many as nine that we know of and others surely still hidden in the notoriously poor hominid fossil record. Because early human skeletons rarely made it into sedimentary rocks before they were scavenged, this estimate changes from year to year as new discoveries and new interpretations of past bones make their way into print.

Each new species evolved when a small group of hominids somehow became separated from the larger population for many generations and then found itself in novel environmental conditions favoring a different set of adaptations. Cut off from kin, the small population went its own genetic route and eventually its members could no longer successfully reproduce with the parent population.

The fossil record tells us that the oldest member of our own species lived 195,000 years ago in what is now Ethiopia. From there it spread out across the globe. By 10,000 years ago modern humans had successfully colonized each of the continents save Antarctica, and adaptations to these many locales (among other evolutionary forces) led to what we loosely call races. Groups living in different places evidently retained just enough connections with one another to avoid evolving into separate species. With the globe fairly well covered, one might expect that the time for evolving was pretty much finished.

But that turns out not to be the case. In a study published a year ago Henry C. Harpending of the University of Utah, John Hawks of the University of Wisconsin-Madison and their colleagues analyzed data from the international haplotype map of the human genome. They focused on genetic markers in 270 people from four groups: Han Chinese, Japanese, Yoruba and northern Europeans. They found that at least 7 percent of human genes underwent evolution as recently as 5,000 years ago. Much of the change involved adaptations to particular environments, both natural and human-shaped. For example, few people in China and Africa can digest fresh milk into adulthood, whereas almost everyone in Sweden and Denmark can. This ability presumably arose as an adaptation to dairy farming.

Another study by Pardis C. Sabeti of Harvard University and her colleagues used huge data sets of genetic variation to look for signs of natural selection across the human genome. More than 300 regions on the genome showed evidence of recent changes that improved people's chance of surviving and reproducing. Examples included resistance to one of Africa's great scourges, the virus causing Lassa fever; partial resistance to other diseases, such as malaria, among some African populations; changes in skin pigmentation and development of hair follicles among Asians; and the evolution of lighter skin and blue eyes in northern Europe. Harpending and Hawks's team estimated that over the past 10,000 years humans have evolved as much as 100 times faster than at any other time since the split of the earliest hominid from the ancestors of modern chimpanzees. The team attributed the quickening pace to the variety of environments humans moved into and the changes in living conditions brought about by agriculture and cities. It was not farming per se or the changes in the landscape that conversion of wild habitat to tamed fields brought about but the often lethal combination of poor sanitation, novel diet and emerging diseases (from other humans as well as domesticated animals). Although some researchers have expressed reservations about these estimates, the basic point seems clear: humans are first-class evolvers.

Unnatural Selection

During the past century, our species' circumstances have again changed. The geographic isolation of different groups has been broached by the ease of transportation and the dismantling of social barriers that once kept racial groups apart. Never before has the human gene pool had such widespread mixing of what were heretofore entirely separated local populations of our species. In fact, the mobility of humanity might be bringing about the homogenization of our species. At the same time, natural selection in our species is being thwarted by our technology and our medicines. In most parts of the globe, babies no longer die in large numbers. People with genetic damage that was once fatal now live and have children. Natural predators no longer affect the rules of survival.

Steve Jones of University College London has argued that human evolution has essentially ceased. At a Royal Society of Edinburgh debate in 2002 entitled "Is Evolution Over?" he said: "Things have simply stopped getting better, or worse, for our species. If you want to know what Utopia is like, just look around—this is it." Jones suggested that, at least in the developed world, almost everyone has the opportunity to reach reproductive age, and the poor and rich have an equal chance of having children. Inherited disease resistance—say, to HIV—may still confer a survival advantage, but culture, rather than genetic inheritance, is now the deciding factor in whether people live or die. In short, evolution may now be memetic—involving ideas—rather than genetic.

Another point of view is that genetic evolution continues to occur even today, but in reverse. Certain characteristics of modern life may drive evolutionary change that does not make us fitter for survival—or that even makes us less fit. Innumerable college students have noticed one potential way that such "inadaptive" evolution could happen: they put off reproduction while many of their high school classmates who did not make the grade started having babies right away. If less intelligent parents have more kids, then intelligence is a Darwinian liability in today's world, and average intelligence might evolve downward.

Such arguments have a long and contentious history. One of the many counterarguments is that human intelligence is made up of many different abilities encoded by a large number of genes. It thus has a low degree of heritability, the rate at which one generation passes the trait to the next. Natural selection acts only on heritable traits. Researchers actively debate just how heritable intelligence is, but they have found no sign that average intelligence is in fact decreasing.

Even if intelligence is not at risk, some scientists speculate that other, more heritable traits could be accumulating in the human species and that these traits are anything but good for us. For instance, behavior disorders such as Tourette's syndrome and attention-deficit hyperactivity disorder (ADHD) may, unlike intelligence, be encoded by but a few genes, in which case their heritability could be very high. If these disorders increase one's chance of having children, they could become ever more prevalent with each generation. David Comings, a specialist in these two diseases, has argued in scientific papers and a 1996 book that these conditions are more common than they used to be and that evolution might be one reason: women with these syndromes are less likely to attend college and thus tend to have more children than those who do not. But other researchers have brought forward serious concerns about Comings's methodology. It is not clear whether the incidence of Tourette's and ADHD is, in fact, increasing at all. Research into these areas is also made more difficult because of the perceived social stigma that many of these afflictions attach to their carriers.

Although these particular examples do not pass scientific muster, the basic line of reasoning is plausible. We tend to think of evolution as something involving structural modification, yet it can and does affect things invisible from the outside—behavior. Many people carry the genes making them susceptible to alcoholism, drug addiction and other problems. Most do not succumb, because genes are not destiny; their effect depends on our environment. But others do succumb, and their problems may affect whether they survive and how many children they have. These changes in fertility are enough for natural selection to act on. Much of humanity's future evolution may involve new sets of behaviors that spread in response to changing social and environmental conditions. Of course, humans differ from other species in that we do not have to accept this Darwinian logic passively.

Directed Evolution

We have directed the evolution of so many animal and plant species. Why not direct our own? Why wait for natural selection to do the job when we can do it faster and in ways beneficial to ourselves? In the area of human behavior, for example, geneticists are tracking down the genetic components not just of problems and disorders but also of overall <u>disposition</u> and various aspects of sexuality and competitiveness, many of which may be at least partially heritable. Over time, elaborate screening for genetic makeup may become commonplace, and people will be offered drugs based on the results.

The next step will be to actually change people's genes. That could conceivably be done in two ways: by changing genes in the relevant organ only (gene therapy) or by altering the entire genome of an individual (what is known as germ-line therapy). Researchers are still struggling with the limited goal of gene therapy to cure disease. But if they can ever pull off germ-line therapy, it will help not only the individual in question but also his or her children. The major obstacle to genetic engineering in humans will be the sheer complexity of the genome. Genes usually perform more than one function; conversely, functions are usually encoded by more than one gene. Because of this property, known as pleiotropy, tinkering with one gene can have unintended consequences.

Why try at all, then? The pressure to change genes will probably come from parents wanting to guarantee their child is a boy or a girl; to endow their children with beauty, intelligence, musical talent or a sweet nature; or to try to ensure that they are not helplessly disposed to become mean-spirited, depressed, hyperactive or even criminal. The motives are there, and they are very strong. Just as the push by parents to genetically enhance their children could be socially irresistible, so, too, would be an assault on human aging. Many recent studies suggest that aging is not so much a simple wearing down of body parts as it is a programmed decay, much of it genetically controlled. If so, the next century of genetic research could unlock numerous genes controlling many aspects of aging. Those genes could be manipulated.

Assuming that it does become practical to change our genes, how will that affect the future evolution of humanity? Probably a great deal. Suppose parents alter their unborn children to enhance their intelligence, looks and longevity. If the kids are as smart as they are long-lived—an IQ of 150 and a lifespan of 150 years—they could have more children and accumulate more wealth than the rest of us. Socially they will probably be drawn to others of their kind. With some kind of self-imposed geographic or social segregation, their genes might drift and eventually differentiate as a new species. One day, then, we will have it in our power to bring a new human species into this world. Whether we choose to follow such a path is for our descendants to decide.

The Borg Route

Even less predictable than our use of genetic manipulation is our manipulation of machines— or they of us. Is the ultimate evolution of our species one of symbiosis with machines, a human- machine synthesis? Many writers have predicted that we might link our bodies with robots or upload our minds into computers. In fact, we are already dependent on machines. As much as we build them to meet human needs, we have structured our own lives and behavior to meet theirs. As machines become ever more complex and interconnected, we will be forced to try to accommodate them. This view was starkly enunciated by George Dyson in his 1998 book *Darwin among the Machines:* "Everything that human beings are doing to make it easier to operate computer networks is at the same time, but for different reasons, making it easier for computer networks to operate human beings.... Darwinian evolution, in one of those paradoxes with which life abounds, may be a victim of its own success, unable to keep up with non-Darwinian processes that it has spawned."

Our technological prowess threatens to swamp the old ways that evolution works. Consider two different views of the future taken from an essay in 2004 by evolutionary philosopher Nick Bostrom of the University of Oxford. On the optimistic side, he wrote: "The big picture shows an overarching trend towards increasing levels of complexity, knowledge, consciousness, and coordinated goal-directed organization, a trend which, not to put too fine a point on it, we may label 'progress.' What we shall call the Panglossian view maintains that this past record of success gives us good grounds for thinking that evolution (whether biological, memetic or technological) will continue to lead in desirable directions."

Although the reference to "progress" surely causes the late evolutionary biologist Steven Jay Gould to spin in his grave, the point can be made. As Gould argued, fossils, including those from our own ancestors, tell us that evolutionary change is not a continuous thing; rather it occurs in fits and starts, and it is certainly not "progressive" or directional. Organisms get smaller as well as larger. But evolution has indeed shown at least one vector: toward increasing complexity. Perhaps that is the fate of future human evolution: greater complexity through some combination of anatomy, physiology or behavior. If we continue to adapt (and undertake some deft planetary engineering), there is no genetic or evolutionary reason that we could not still be around to watch the sun die. Unlike aging, extinction does not appear to be genetically programmed into any species.

The darker side is all too familiar. Bostrom (who must be a very unsettled man) offered a vision of how uploading our brains into computers could spell our doom. Advanced artificial intelligence could encapsulate the various components of human cognition and reassemble those components into something that is no longer human—and that would render us obsolete. Bostrom predicted the following course of events: "Some human individuals upload and make many copies of themselves. Meanwhile, there is gradual progress in neuroscience and artificial intelligence, and eventually it becomes possible to isolate individual cognitive modules and connect them up to modules from other uploaded minds....Modules that conform to a common standard would be better able to communicate and cooperate with other modules and would therefore be economically more productive, creating a pressure for standardization....There might be no niche for mental architectures of a human kind."

As if technological obsolescence were not disturbing enough, Bostrom concluded with an even more dreary possibility: if machine efficiency became the new measure of evolutionary fitness, much of what we regard as quintessentially human would be weeded out of our lineage. He wrote: "The extravagancies and fun that arguably give human life much of its meaning—humor, love, game-playing, art, sex, dancing, social conversation, philosophy, literature, scientific discovery, food and drink, friendship, parenting, sport—we have preferences and capabilities that make us engage in such activities, and these predispositions were adaptive in our species' evolutionary past; but what ground do we have for being confident that these or similar activities will continue to be adaptive in the future? Perhaps what will maximize fitness in the future will be nothing but nonstop high-intensity drudgery, work of a drab and repetitive nature, aimed at improving the eighth decimal of some economic output measure."

In short, humanity's future could take one of several routes, assuming we do not go extinct:

Stasis. We largely stay as we are now, with minor tweaks, mainly as races merge.

Speciation. A new human species evolves on either this planet or another.

Symbiosis with machines. Integration of machines and human brains produces a collective intelligence that may or may not retain the qualities we now recognize as human.

Quo vadis Homo futuris?

(from ***Scientific American, January 2009*** by ***Peter Ward***)

E. Check your reading comprehension. Choose the best answer (only one variant is possible). What do the underlined words from exercise D mean?

1) ***reshuffling***
(a) making
(b) changing
(c) developing
(d) interfering

2) ***tracking***
(a) looking at
(b) searching for
(c) making from
(d) putting into

3) ***evolvers***
(a) ancestors
(b) creators
(c) extremes
(d) developed

4) ***reverse***
(a) alike
(b) poetic
(c) opposite
(d) same

5) ***disposition***
(a) arrangement
(b) location
(c) critic
(d) negativism

6) ***artificial***
(a) space
(b) man-made
(c) artefactual
(d) creative

F. Match the words in the left column with their definitions in the right column.

1) ***induce***
2) ***dominant***
3) ***sedimentary***
4) ***genome***
5) ***hominid***
6) ***broach***
7) ***thwart***
8) ***memetic***
9) ***doom***
10) ***quintessentially***

a) any member of the primate family Hominidae, including humans and their fossil ancestors
b) to cause or to bring about
c) to mention a subject that may be embarrassing, unpleasant or cause an argument
d) to make someone or something certain to fail, die, be destroyed
e) made of the solid matter that settles at the bottom of the sea, rivers, lakes
f) connected with the study of backgrounds, history, vocabulary, ideas, memes
g) more powerful, successful, influential, or noticeable than other people or things
h) most essentially
i) the total of all the genes that are found in one type of living thing
j) to prevent someone from doing what they are trying to do

G. Fill in the gaps in the sentences below with the words from the list.

threaten modified standard detrimental content pesticide resistant
adequate health forefront supply measures control

1) In the past few weeks, genetically modified organisms (GMOs) have again been at the … of controversy involving contamination of rice and grass varieties.
2) Environmentalists, politicians, and scientists have long feared that the introduction of genetically modified seeds and plants could cause … effects from "genetic pollution," which occurs when an engineered gene enters another species of crop or wild plant through cross-pollination.

3) This contamination may pose public health threats, create superweeds which could require greater amounts of more toxic pesticides to manage, and … extinction for rare plants and their weedy relatives relied upon for crop and plant biodiversity.
4) In 2000, a type of bioengineered corn (Starlink) that produces its own … and was approved only for use in animal feed, contaminated many of our food products, causing a massive recall of tortillas, corn chips and other corn-based products.
5) Again, in 2002, regulators found genetically engineered corn … to produce pharmaceuticals sprouting in a Nebraska soybean field.
6) Yet, despite the continuing reports of contamination from genetically modified organisms, the federal government has refused to take … steps to safeguard our food crops, their relatives, and public health.
7) The recent contaminations involving rice and grass varieties underscore the need for a more stringent … of oversight for genetically modified organisms.
8) On August 18th, the USDA announced that an unapproved genetically engineered variety of long grain rice has contaminated the food … .
9) In response, Japan announced that it would stop importing all U.S. long grain rice, South Korea demanded that there be no genetically engineered … in U.S. rice shipments, and the European Union announced that it will not permit unauthorized GE products to reach its citizens.
10) According to EU Commission spokeswoman Antonia Mochan, "We are preparing … in order to ensure that unauthorized GE products do not reach European consumers."
11) On August 5th, it was reported that genetically engineered herbicide-… bentgrass has been discovered in the wild in Oregon.
12) Norman Ellstrand, UC plant geneticist, said, "such resistance could force land managers and government agencies to switch to nastier herbicides to … grasses and weeds."
13) These ecological impacts resulting from the vast introduction of genetically modified organisms are perhaps the least completely understood, though certainly the most significant, for our sustained … and well-being.

(from **Genetic Pollution Threatens Trade, Health and the Environment** *by* **Britt Bailey***)*

H. Learn the following words and word combinations with 'perspective' and 'development'.

PERSPECTIVE

- To put something into perspective
- The proper perspective
- The right perspective
- The true perspective
- From a perspective
- In perspective

DEVELOPMENT

- Arrested development
- Economic development
- Historical development
- Intellectual development
- Physical development
- A housing development
- A ribbon development

(Source: ***BBI Combinatory Dictionary of English by M. Benson, E. Benson, & R. Ilson***)

I. What is the difference between the following synonyms:

1) development
2) evolution
3) growth
4) maturity
5) increase
6) advancement
7) enlargement
8) progress
9) improvement
10) expansion

J. Read the following text and make up a summary (10—15 sentences):

Destructive Creativity in Scientific Research

An increasing obsession in modern culture with destruction, and comparatively seldom with creation, is perhaps noteworthy for it can be seen on many fronts, of which there are some quite striking examples in science, medicine and entertainment. There are, however, movements which attempt to raise awareness of these malpractices — if some of the more peripheral groups are unfortunately destructive in themselves.

Scientific experimentation in the laboratory not seldom proceeds by way of 'destroying' something. The atom is split (smashed), the animal is dissected (killed) and the environments are experimentally modified (interfered with)... all in the name of 'creative thought'. Science destroys so as to analyse, or as Tennyson's poem has it, "We murder to dissect". It is a law of nature that virtually all physical destruction leaves more or less toxic waste products, which was long disregarded — or minimised as being of relatively little importance — both in the chemistry and nuclear physics and the industries these have created. Only now that toxic pollution has become a problem of planetary dimensions have scientists reluctantly been turned, largely by public outcry, to recognise more directly the consequences of this "law of destruction", so to speak.

That scientific analyses also have destructive effects far beyond the laboratory is indisputable even if we only consider how its results have been used in the development of overwhelming "weapons of mass destruction". Defence spending has been the chief funding instance in (or somewhere behind) a large amount of the advanced research work in 20th century sciences and it continues to be very considerable. Whatever benefits science may have brought humanity, one cannot but deplore the way practitioners have given it a permit to carry out some of the most 'inhuman' violence to animals, to be financed by and to produce knowledge and technology for every imaginable sort of ghoulish meddling with any processes of human life regardless of social, cultural and religious sensibilities. Public awareness of this increases in certain countries, yet is still virtually nil in other major emerging economies.

The medical industry, which includes as its extension almost all medical institutions and practitioners, is increasingly driven by profit. From the viewpoint of those major interests, illness is profitable, health is not! Medical research into disease and degeneration is far more widespread than into health and regeneration, even today. Medicine has become overly preoccupied with the prevention of impending death at all costs. Though this is understandable, it is hardly very rational. Prevention of illness is obviously related to health, but there are two general types of it: either averting or removing illness.

Any really rational overall health policy must obviously rather have the long-term and preventive view as its keystone and concentrate resources effectively there. This is constructive and creative, being oriented more towards improving life quality and averting illnesses before they arise, rather than having to patch up at far greater expense after the fact (to society, that is). However, from the viewpoint of the medical profession and all those other professions and organisations dependent upon it, a very healthy populace means in general less employment. Large cutbacks in spending are unpopular with all organisations having the inherent tendency to develop and expand, which means almost all of them.

Compared with curative medicine, the preventive field is almost entirely undeveloped. This is patently evident in cancer research in which the destruction of cancer cells has long been the Holy Grail, rather than the many constructive therapies that can prevent cancer, reinforce the patient's immune system and even effect permanent cures (written off by the puzzled doctor as 'spontaneous remissions'). Despite many billions of dollars spent, deaths by cancer have remained largely unaltered. Despite all the propaganda of medical science and its allied industries and charities, in Britain for example, life expectancy from middle age onwards has hardly changed during the entire century! The health benefits and curative powers of proper diet, including system cleansing through fasting, remain wholly unresearched. It can hardly be seriously disputed that fresh and non-polluted foodstuffs are generally better for health than artificially preserved, chemically-treated and less naturally nutritious foods. Despite blanket medical support for most 'industrial foodstuffs', a wide public has already realised the many health advantages of vegetable products grown by 'organic' or other such natural methods. Vegetarian, vegan or fruit diets have long been known by certain minority groups to cure many serious chronic and even some illnesses regarded as terminal by specialists. But science has for over a century ignored all this most blatantly. It is the cheapest kind of health care, and also absolutely the least profitable one to the interests behind medical research, modern drug development and sale, operative and other many other technologised medical techniques. Science has also been instrumental in developing the modern high-intensive, highly polluting agro-industry, towards the interests of which it is largely biased on many issues, from the destruction of nature to the creation of more potent chemical agents with unknown side-effects and long term consequences.

Science directly affects most people's lives through the creation of modern electronic media for leisure. This has a huge potential for influencing the mind, and partly also the mental health and social values of the population. This has at the same time brought home to people the existence of every manner of terrible suffering, traumatic experience, human brutality and fearful prospect that are known or imaginable. The reverse side of the coin is well know, that the constancy of such reports in one's own living room also dulls perception of the meaning of these events and creates a sense of powerlessness. Scientific technology also plays a large part in making possible the form of entertainment that cinema, T.V., video and home computers provide, where the fascination with destructive acts is also widespread in a way that even our recent forbears would have found incomprehensibly dreadful. There seems to be no limit to the amount and value of goods destroyed, from vehicles to buildings for the sake of amusement, in the film, TV and other leisure industries. No limits seem to exist for the extent and degree of devilishness shown in the destruction of lives, human relationships and the perversion of practically all values that have ever been held sacrosanct — both in 'artistic imagination' and, yet stranger than this, in actual fact. On the other hand, portrayal of creative acts cannot be seen to have increased or spread in the media to anything like the same obsessional degree as in the contrary case. The increasing preoccupation with destructivity at all levels of life is apparently another of the unpredicted side-effects of scientific-technological progress.

(from ***Robert Priddy, Oslo, 1999***)

K. Translate your summary to the text from exercise J into Russian.

L. Answer the following questions to the text from exercise J:

1) Does the author criticize science and scientific development?
2) Are all scientific analyses destructive?
3) What is the medical industry, in the author’s opinion, driven by?
4) Is the preventive field well-developed?
5) What is the reverse side of the electronic media development?

M. Read the following text and render it in English:

Технические достижения как гордость нации

«Зато мы делаем ракеты, и покоряем Енисей,
а также в области балета — мы впереди планеты всей»

Крупные достижения в любых областях являются тем цементом, который связывает народ любой страны в единый конгломерат, вызывает чувство гордости за свою родину, позволяет забыть о недостатках и лишениях. Крупные вожди и правители всегда понимали это. В былые времена это были великие походы и завоевания других народов.

Что школьники изучают в истории? Походы Чингизхана, Батыя, Ганнибала, завоевания Европы Наполеоном, Гитлером, Сталиным. В наш ядерный век, завоевания стали невозможны. Единственный способ сплотить нацию (кроме гипертрофированного национализма), вызвать у людей чувство гордости за свою страну, вдохновить их на подвиги — это технические достижения, возможность показать иностранцам то, чего нет ни у кого в мире.

Так Сталин в мирное время заставлял Туполева строить в единственном экземпляре рекордные самолеты для перелетов через Северный полюс в Америку или самый большой в мире самолет (Максим Горький) для парадов.

Я вспоминаю какую радость испытывали многие советские люди, когда Советский Союз первым в мире запустил искусственный спутник Земли. Молодежь без всяких принуждений сверху пришла на Красную площадь, пела и танцевала.

Новые поколения забудут про коммуналки, лишения, голод, массовые репрессии (ведь это было не с ними!), но всегда будут помнить, что их страна первой в мире запустила спутник, человека, женщину, сделала выход в открытый космос. Важно для патриота любой страны сказать: «А у нас самая высокая в мире башня» или «Самый мощный в мире компьютер», «Самый длинный в мире мост». Это и дополнительный доход, ибо всех туристов всегда тянет посмотреть «самое, самое», а тем более чудеса света, которые есть только здесь. Вспомните слова студенческой песни 50-х лет: «Зато мы делаем ракеты, и покоряем Енисей, а также в области балета — мы впереди планеты всей».

Поэтому НАСА уделяет такое огромное внимание пропаганде своих достижений, имеет специальные центры по связям с общественностью, туристические подразделения при каждом своем центре. Министерство обороны США возможно имеет не меньшие технические достижения. Но кто об этом знает? Все только требуют сократить на него расходы.

Мир стоит на пороге огромных технических прорывов. Это не только космос, но и компьютерная техника, искусственный интеллект, сверхпрочные материалы, нанотехнология, генная инженерия, ядерная энергетика. Появилась технические возможности соединять материки и острова дешевыми транспортными системами без мостов и тоннелей (Гибралтар, Сахалин с Россией и Японией, Россию с Америкой через Берингов пролив), быстро и дешево строить газопроводы без стальных труб и вреда для окружающей среды, летать в Космос без ракет, самолетами на большие расстояния при помощи любого двигателя, расположенного на Земле, построить недорогую туристическую надувную башню высотой 3 км. Для многих такие заявления звучат дико. Но когда они знакомятся с предложениями и расчетами, то удивляются, как это люди не додумались до этого раньше.

От правительств, прессы и общественности зависит, насколько они осознают факт новой ситуации, решающую роль научного и технического прогресса, зависит будущее страны и ее народа.

(from ***«Российская и американская науки: их проблемы и пути развития»***,
Александр Болонкин)

N. Prepare a public speech for 5—8 minutes (in Russian) about the perspectives of development of your scientific field. Make up an abstract (3—5 sentences) of the speech and point out some key words (5—10 words).

O. After presenting your speech give the key words and abstract to other students, who will render your speech in English.

P. Learn the tips how to prepare an effective presentation.

1) No-one ever complained of a presentation being too short.

Long presentations can turn off the audience and be boring. Say what you have to say. Stop and shut up.

2) A picture is worth a thousand words.

Use pictures instead of bullet points and your message retention should increase. Research suggests that this could be by a factor of five.

3) Involve the audience.

Happy Computers have made a great success of their coaching business by involving the audience. Their motto seems very apt.

"Tell me and I will forget,
Show me and I will remember,
Involve me and I will understand".

4) Make the presentation interactive — if you can.

5) Produce an unusual statistic.

It could help build some connection with the audience. I love the one by Vic Reeves — 93.7% of statistics are made up on the spot. Radio shows are filled with "strange but almost true" quotations.

6) Live with the fear.

All presenters end up as being very nervous before a presentation — a situation commonly known as "bricking it". We have given literally hundreds and the fear never goes away. It is a combination of adrenaline and testosterone (which affects both men and women). Learn how to harness it, just like an athlete has to.

7) Realize that you will come down.

I love this quotation from the great performer Robert Houdin that I found in the book — Carter beats the Devil by Glen David Gold.

"It is well known that a magician feels no suffering while on the stage; a species of exaltation suspends all feelings foreign to his part, and hunger, thirst, cold, or heat, even illness itself, is forced to retreat in the presence of this excitement, though it takes revenge afterwards"

When the testosterone wears off, you will come down with a low. If you have done well you will have been on a high — sometimes known as that Presentation Sensation. Realize that when this goes, often in the evening — you will feel low or even depressed.

No matter how well the presentation goes — you will come down later — usually in the evening. This is only temporary.

8) Clean your shoes.

You will be on display. Your audience will be looking at how well you are turned out. They will look at your shoes. Make sure that you have cleaned them.

9) The eyes have it.

Maintain good eye contact with the audience. Don't keep contact with only one group of the audience. Spread your attention around the room.

10) Avoid jargon.

People really do play buzzword bingo. Whether it is the "TLA" — Three Letter Abbreviation or the "Paradigm Shift" you don't want the audience to be scoring points at your expense.

11) KISS.

No — not kiss the audience — **K**eep **I**t **S**imple **S**tupid. Reduce your presentation to simple concepts and your audience should be able to follow you. If you go beyond their understanding they will switch off.

12) Don't use PowerPoint sound effects.

It may seem funny to have applause at the end of a slide, or a screeching sound for a new bullet point, but it will turn off the audience.

13) Check out the room before your presentation.

Make sure the room has everything that you need and make sure the presentation works on the screen. If possible go up the day before — or at least an hour beforehand. This will avoid any nasty surprises on the big day.

14) Don't drink the night before — and certainly don't get drunk.

Alcohol recovery or a hangover will be the kiss of death to your presentation. Alcohol will drain all of the enthusiasm from your voice. And if you've had a drink before you go on, your voice will be slightly slurred. Best avoid it, the time for a drink is after, not before.

15) Don't lock your knees.

When you get to the lectern, unlock your knees and act as if you were about to catch a ball. It will relax you and make it all flow much more smoothly.

16) Take a spare tie.

You don't want a gravy spot on your tie before you speak. If you have a meal before you speak take a spare tie with you.

(from ***http://www.presentationmagazine.com/presentation_hints.htm***)

Q. Read the following piece of advice, translate all examples, verbs and adjectives and learn them by heart.

When describing your academic experience or career, you need to sound positive and confident: neither too aggressive, nor overly modest. The following words and phrases are intended as suggestions for thinking about your experience and abilities.

Choose ***ACTIVE VERBS*** that describe your skills, abilities, and accomplishments.

Examples:

I can contribute, enjoy creating, have experience in organizing...

While at the University, I administered, coordinated, directed, participated in....

Below is a list of such verbs:

accomplish; achieve; analyze; adapt; balance; collaborate; coordinate; communicate; compile; conduct; contribute; complete; create; delegate direct; establish; expand; improve; implement; invent; increase; initiate; instruct; lead; organize; participate; perform; present; propose; reorganize; research; set up; supervise; support; train; travel; work (effectively, with others)

Choose ADJECTIVES and NOUNS that describe yourself positively and accurately:

able to; administrative; analytical; (fluently) bilingual; broad scope; capable; communication skills; collaboration; collaborative; consistent; competent; complete; creative; dedicated; diversified; effective; experienced; efficient; extensive; exceptional; flexible; global; handle stress; imaginative; intensive; in-depth; innovative; integrated; able to listen; motivated; multilingual; multi-disciplinary; a negotiator; other cultures; reliable; responsible; a supervisor; teamwork; well- traveled; work well with....

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R. Read the chronological information of the most important discoveries starting from the 20th century. How can you amend or modify them?

1900
Quantum theory proposed / Planck
1901
Discovery of human blood groups / Landsteiner
1905
Wave-particle duality of light / Einstein
1905
Special theory of relativity / Einstein
1906
Existence of vitamins proposed / Hopkins
1906
Evidence that Earth has a core / Oldham
1908
Synthesis of ammonia from its elements / Haber
1909
Idea of genetic disease introduced / Garrod
1909
Boundary between Earth's crust and mantle identified / Mohorovicic
1909
Discovery of Burgess Shale: ancient invertebrate fossils / Walcott
1910
First mapping of a gene to a chromosome / Morgan and others
1911
Discovery of the atomic nucleus / Rutherford
1911
Superconductivity discovered / Onnes
1912
Discovery of cosmic rays / Hess
1912
Idea of continental drift presented / Wegener
1914
First steps in elucidating chemical transmission of nerve impulses: neurotransmitters / Dale; Barger; Loewi
1914
Astronomical theory of climate change / Milankovitch
1915
General theory of relativity / Einstein
1918 onward
Synthesis of genetics with the theory of evolution by natural selection (neodarwinism) / Fisher; Haldane; Wright

1921
Isolation of insulin / Banting & Best
1923
Nature of galaxies discovered / Hubble
1925
Description of *Australopithecus africanus* / Dart
1925—26
Matrix and wave formulations of quantum mechanics / Heisenberg; Schrödinger
1927
Matter is proved to be wavelike / Davisson & Germer
1928
Discovery of penicillin / Fleming
1929
Expansion of the Universe established / Hubble
1929
First suggestion that Earth's magnetic field reverses / Matuyama
1930
First absolute geological timescale / Holmes
1930s
Theory of chemical bonds developed / Pauling
1930s onward
Establishment of the scientific study of animal behavior / von Frisch; Lorenz; Tinbergen
1931
Birth of radioastronomy / Jansky
1931
First electron microscope / Ruska
1932
Discovery of the neutron / Chadwick
1932
Discovery of the positron, first antimatter particle / Anderson
1935
Magnitude scale for earthquakes / Richter
1935
Theory of the nuclear force / Yukawa
1937
Discovery of the citric acid cycle / Krebs
1938
Nuclear reactions in stars / Bethe; von Weizsäcker
1938
First observation of superfluidity / Kapitza
1939
Discovery of nuclear fission / Meitner & Frisch
1943
Mutations in bacteria identified / Luria & Delbrück

1944
Evidence in bacteria that DNA is the genetic material / Avery, MacLeod, and McCarty
1944
Start of Mexican wheat improvement program, leading to the "green revolution" / Borlaug
1945
Formulation of the one-gene, one-enzyme hypothesis / Beadle & Tatum
1946
Radiocarbon dating / Libby
1946
Initial elucidation of the reactions involved in photosynthesis / Calvin
1947
Invention of the transistor / Shockley, Bardeen, and Brattain
1948
Big Bang theory for origin of the Universe / Gamow, Alpher, and Herman
1948
Quantum electrodynamics / Feynman; Schwinger; Tomonaga
1949
Immunological tolerance hypothesis proposed / Burnet
1951
Presentation of the idea of gene transposition: "jumping genes" / McClintock
1952
First polio vaccine / Salk
1952
Theory of nerve-cell excitation announced / Hodgkin & Huxley
1953
Production of amino acids in "early Earth" conditions / Miller & Urey
1953
First determination of the amino-acid sequence of a protein / Sanger *et al.*
1953
Structure of DNA: the double helix / Watson & Crick
1956
Discovery of the neutrino / Cowan & Reines
1957
Superconductivity explained / Bardeen, Cooper, and Schrieffer
1958
Quantum tunneling of electrons in semiconductors / Esaki
1958
First three-dimensional protein structure published / Kendrew *et al.*
1960
First laser / Maiman
1960 onward
Discoveries of fossils of early *Homo* in East Africa / Leakeys and others

1961
Nature of the genetic / triplet code proposed / Crick *et al.*
1963
Deterministic chaos: the butterfly effect / Lorenz
1963
Discovery of quasars / Schmidt
1963
Explanation for magnetic stripes on the sea floor: seafloor spreading / Vine & Matthews
1964
Existence of quarks proposed / Gell-Mann; Zweig
1964
Genetic explanations proposed for animal social behavior / Hamilton
1965
Discovery of cosmic microwave background radiation / Penzias & Wilson
1967
First warning of an anthropogenic "greenhouse effect" / Manabe & Wetherald
1967
Theory of plate tectonics / McKenzie & Parker; Morgan
1967
Electroweak theory, first unification of fundamental forces / Weinberg; Glashow; Salam
1967
Proposal that certain cell organelles are descended from free-living bacteria / Margulis
1968
Pulsars discovered / Hewish *et al.*
1968
Theory of random molecular evolution / the neutral theory proposed / Kimura
1970
Reverse transcriptase discovered / Baltimore; Temin & Mizutani
1973
Gamma-ray bursts from outer space / Klebesadel, Strong, and Olsen
1973
Advent of genetic engineering techniques / Cohen, Boyer, and Berg
1973
Invention of magnetic resonance imaging / Lauterbur
1974
Identification of CFCs as threat to ozone layer / Molina & Rowland
1974
Principles of cell-mediated immunity unveiled / Zinkernagel & Doherty
1974
Discovery of "Lucy," *Australopithecus afarensis* / Johanson & Taieb
1974
First Grand Unified Theory of particle physics / Georgi & Glashow
1975
Monoclonal antibodies created / Köhler & Milstein

1976
Patch-clamp technique for studying single ion channels / Neher & Sakmann
1977
First complete DNA sequence of an organism / Sanger *et al.*
1977
Discovery of deep-sea hydrothermal vents / Corliss *et al.*
1978
Observation of astronomical dark matter / Rubin
1980
Unveiling of genetic controls on animal body-plan development / Nüsslein-Volhard & Wieschaus
1980
First human oncogene / "cancer gene" identified / Weinberg
1980
Impact hypothesis for extinctions at the Cretaceous/Tertiary boundary / Alvarez *et al.*
1981
Superstring theory / Green & Schwarz
1982
Prion hypothesis proposed / Prusiner
1983
AIDS virus identified / Barré-Sinoussi *et al.*
1985
Genetic fingerprinting invented / Jeffreys
1985
Ozone hole discovered / Farman *et al.*
1985
Discovery of buckminsterfullerene / Kroto *et al.*
1986
First high-temperature superconductor / Bednorz & Müller
1987
Formulation of the "Out of Africa" hypothesis of human evolution using molecular data / Cann, Stoneking, and Wilson
1995
Bose-Einstein condensation of trapped atoms / Cornell & Wieman
1995
First extrasolar planet identified / Mayor & Queloz
1997
Dolly the sheep created by cloning / Wilmut *et al.*

2001
Publication of near-complete sequences of the human genome / International Human Genome Sequencing Consortium; Venter *et al.*

(from ***A Century of Nature: Twenty-One Discoveries that Changed Science and the World*** by ***Laura Garwin and Tim Lincoln***)

S. Read the following text and translate it into Russian:

On Unplanned Scientific Advances or Unforeseen Consequences

It is very well-known that there has been tremendous progress in the theoretical explanations, predictive abilities and manipulatory techniques and instrumentation in the natural sciences in recent times. All in all, it seems, knowledge of nature progresses on a broad front, especially in the basal sciences like physics, chemistry and biology. These are the most precise sciences and, since they yield many extremely accurate predictions, are regarded with good reason as producing certain knowledge, or at least the very best next thing.

The number of scientists employed world-wide since WW2 has increased enormously. Later, even since the millennium, the explanatory power of modern physics, astronomy, bio-genetics, neurology, climatology and paleontology, geo- and social history and numerous other disciplines has made huge leaps. Medical science, as distinct from medical practice, is an area where the understanding and control of the human body has made huge strides in many respects in the last few hundred years and very much more so in the 20th century.

This being said, one must insist straight away that the huge advances made in our knowledge of the natural world should not be allowed to obscure the fact that there are very many gaps in that knowledge, many depths yet not fully sounded and also many phenomena of which the sciences have little knowledge, even if they recognise their very existence. A minority of established experts in most major sciences, not least in medical science, still support a variety of traditional prejudices or short-sighted dogmas. Some are under cogent attack even from the public. There is an inertia to scientific opinion, where caution and resistance to change are often stronger than enterprise and where invested prestige and narrowness of intellectual scope is found, particularly by those not actually doing research or who only reproduce the results of others.

Science made possible the demonstration of it's best hypotheses in repeated experiments, the range and intricacy of which — not to mention the cost — are beyond ordinary imagination. Its prestige arose from its explanatory superiority combined with the industrial technology with their advancements in material goods and useful inventions which has gradually provided a far greater control of nature and human security. Emergent European natural science studied nature, the physical environment of man, including the human body. Everyone knows how this has led to the improvement of physical conditions generally, including working conditions, health and human productivity.

At the same time, it is a platitude today to point out that scientific advances have not been without serious costs in terms of many unwanted side-effects on health, the quality of life and the environment. This applies also to a wider and more proper understanding of the human entity. From its breakthrough in the Renaissance, physical science has been supported by those who saw it as an instrument of material and social change through technological knowledge. This accounts for most of the popularity it enjoys. Francis Bacon was referring to the empirical scientific spirit when he proclaimed that "Knowledge is power". It is power indeed, probably beyond Bacon's most far-flung imaginings... both physical, economical and social power, never forgetting military power. These are both reasons for science being supported and invested in by the various leaders in society.

(from ***Science Limited*** by ***Robert Priddy***)

T. Write a short essay (8—15 sentences) about the present-day and the most perspective sciences and technologies in the Russian Federation.

U. Insert the prepositions from the list and read the text aloud. Discuss it with other students.

for of (2) on (2) in (3) at (2) from by

Nanotechnology

Manufactured products are made … atoms. The properties of those products depend … how those atoms are arranged. If we rearrange the atoms … coal we can make diamond. If we rearrange the atoms in sand (and add a few other trace elements) we can make computer chips. If we rearrange the atoms in dirt, water and air we can make potatoes.

Today's manufacturing methods are very crude … the molecular level. Casting, grinding, milling and even lithography move atoms in great thundering statistical herds. It's like trying to make things out … LEGO blocks with boxing gloves … your hands. Yes, you can push the LEGO blocks into great heaps and pile them up, but you can't really snap them together the way you'd like.

In the future, nanotechnology will let us take off the boxing gloves. We'll be able to snap together the fundamental building blocks of nature easily, inexpensively and … most of the ways permitted … the laws of physics. This will be essential if we are to continue the revolution in computer hardware beyond about the next decade, and will also let us fabricate an entire new generation … products that are cleaner, stronger, lighter, and more precise.

It's worth pointing out that the word "nanotechnology" has become very popular and is used to describe many types of research where the characteristic dimensions are less than about 1,000 nanometers. For example, continued improvements … lithography have resulted in line widths that are less than one micron: this work is often called "nanotechnology." Sub-micron lithography is clearly very valuable (ask anyone who uses a computer!) but it is equally clear that conventional lithography will not let us build semiconductor devices in which individual dopant atoms are located … specific lattice sites. Many of the exponentially improving trends in computer hardware capability have remained steady … the last 50 years. There is fairly widespread belief that these trends are likely to continue for at least another several years, but then conventional lithography starts to reach its limits.

If we are to continue these trends we will have to develop a new manufacturing technology which will let us inexpensively build computer systems with mole quantities of logic elements that are molecular in both size and precision and are interconnected in complex and highly idiosyncratic patterns. Nanotechnology will let us do this.

(from ***Nanotechnology*** by ***Dr. Ralph Merkle***)

V. Put the verbs in brackets in the right tense-form and voice. Discuss it with other students.

Life-Changing Science Discoveries

Try to imagine life without antibiotics. We wouldn't live nearly as long as we **(to do)** without them. Here's a look at some discoveries that **(to change)** the world. It's impossible to rank their importance, so they **(to list)** in the order they **(to discover)**.

The Copernicum System

In 1543, while on his deathbed, Polish astronomer Nicholas Copernicus **(to publish)** his theory that the Sun is a motionless body at the center of the solar system, with the planets revolving around it. Before the Copernicum system **(to introduce)**, astronomers believed the Earth was at the center of the universe.

Gravity

Isaac Newton, an English mathematician and physicist, **(to consider)** the greatest scientist of all time. Among his many discoveries, the most important **(to be)** probably his law of universal gravitation. In 1664, Newton **(to figure out)** that gravity is the force that draws objects toward each other. It explained why things **(to fall down)** and why the planets **(to orbit)** around the Sun.

Electricity

If electricity **(to make)** life easier for us, you can thank Michael Faraday. He made two big discoveries that **(to change)** our lives. In 1821, he **(to discover)** that when a wire carrying an electric current is placed next to a single magnetic pole, the wire **(to rotate)**. This **(to lead)** to the development of the electric motor. Ten years later, he **(to become)** the first person to produce an electric current by moving a wire through a magnetic field. Faraday's experiment **(to create)** the first generator, the forerunner of the huge generators that produce our electricity.

Evolution

When Charles Darwin, the British naturalist, **(to come up)** with the theory of evolution in 1859, he changed our idea of how life on earth developed. Darwin argued that all organisms evolve, or change, very slowly over time. These changes **(to be)** adaptations that allow a species to survive in its environment. These adaptations **(to happen)** by chance. If a species **(not to adapt)**, it may become extinct. He **(to call)** this process natural selection, but it is often called the survival of the fittest.

Louis Pasteur

Before French chemist Louis Pasteur began experimenting with bacteria in the 1860s, people did not know what **(to cause)** disease. He not only discovered that disease **(to come)** from microorganisms, but he also **(to realize)** that bacteria could **(to kill)** by heat and disinfectant. This idea caused doctors to wash their hands and sterilize their instruments, which **(to save)** millions of lives.

Theory of Relativity

Albert Einstein's theory of special relativity, which he **(to publish)** in 1905, explains the relationships between speed, time and distance. The complicated theory states that the speed of light always **(to remain)** the same—186,000 miles/second (300,000 km/second) regardless of how fast someone or something **(to move)** toward or away from it. This theory became the foundation for much of modern science.

The Big Bang Theory

Nobody knows exactly how the universe **(to come)** into existence, but many scientists **(to believe)** that it **(to happen)** about 13.7 billion years ago with a massive explosion, called the Big Bang. In 1927, Georges Lemaître proposed the Big Bang theory of the universe. The theory says that all the matter in the universe **(to compress)** originally into a tiny dot. In a fraction of a second, the dot expanded, and all the matter instantly **(to fill)** what is now our universe. The event marked the beginning of time. Scientific observations seem to confirm the theory.

Penicillin

Antibiotics are powerful drugs that **(to kill)** dangerous bacteria in our bodies that make us sick. In 1928, Alexander Fleming **(to discover)** the first antibiotic, penicillin, which he **(to grow)** in his lab using mold and fungi. Without antibiotics, infections like strep throat could be deadly.

DNA

On February 28, 1953, James Watson of the United States and Francis Crick of England made one of the greatest scientific discoveries in history. The two scientists **(to**

find) the double-helix structure of DNA. It **(to make up)** of two strands that twist around each other and have an almost endless variety of chemical patterns that **(to create)** instructions for the human body to follow. Our genes **(to make)** of DNA and **(to determine)** how things like what color hair and eyes we'll have. In 1962, they **(to award)** the Nobel Prize for this work. The discovery **(to help)** doctors understand diseases and may someday prevent some illnesses like heart disease and cancer.

Periodic Table

The Periodic Table is based on the 1869 Periodic Law **(to propose)** by Russian chemist Dmitry Mendeleev. He **(to notice)** that, when arranged by atomic weight, the chemical elements lined up to form groups with similar properties. He was able to use this to predict the existence of undiscovered elements and note errors in atomic weights. In 1913, Henry Moseley of England **(to confirm)** that the table could be made more accurate by arranging the elements by atomic number, which is the number of protons in an atom of the element.

X-Rays

Wilhelm Roentgen, a German physicist, discovered X-rays in 1895. X-rays **(to go)** right through some substances, like flesh and wood, but **(to stop)** by others, such as bones and lead. This **(to allow)** them to be used to see broken bones or explosives inside suitcases, which **(to make)** them useful for doctors and security officers. For this discovery, Roentgen **(to award)** the first-ever Nobel Prize in Physics in 1901.

Quantum Theory

Danish physicist Niels Bohr is considered one of the most important figures in modern physics. He **(to win)** a 1922 Nobel Prize in Physics for his research on the structure of an atom and for his work in the development of the quantum theory. Although he **(to help)** develop the atomic bomb, he frequently promoted the use of atomic power for peaceful purposes.

Atomic Bomb

The legacy of the atomic bomb **(to mix)**: it successfully put an end to World War II, but **(to usher)** in the nuclear arms race. Some of the greatest scientists of the time gathered in the early 1940s to figure out how to refine uranium and build an atomic bomb. Their work **(to call)** the Manhattan Project. In 1945, the U.S. **(to drop)** atomic bombs on the Japanese cities of Hiroshima and Nagasaki. Tens of thousands of civilians **(to kill)** instantly, and Japan **(to surrender)**. These remain the only two nuclear bombs ever used in battle. Several of the scientists who worked on the Manhattan Project later **(to urge)** the government to use nuclear power for peaceful purposes only. Nevertheless, many countries **(to continue)** to stockpile nuclear weapons. Some people say the massive devastation that could result from nuclear weapons actually **(to prevent)** countries from using them.

HIV/AIDS

In 1983 and 1984, Luc Montagnier of France and Robert Gallo of the United States **(to discover)** the HIV virus and **(to determine)** that it **(to be)** the cause of AIDS. Scientists since then **(to develop)** tests to determine if a person **(to have)** HIV. People who test positive **(to urge)** to take precautions to prevent the spread of the disease. Drugs are available to keep HIV and AIDS under control. The hope is that further research **(to lead)** to the development of a cure.

(from ***http://www.factmonster.com/***)

W. Look at exercise R. Complete the list with the discoveries from your field of science. Which discoveries can be made in the near future in your science?

X. Look at exercise V. Describe any important discovery in your science in the way it is done in the exercise.

Y. Do you consider your science perspective? What grounds do you have to consider it perspective? Discuss it with other students.

Z. Write an essay (15—25 sentences) using the vocabulary of this unit. Choose one of the following topics:

1) The Advances of Science in the 21st Century
2) Science Will Never End
3) The Discovery I Am Proud of

Unit 5

Science in Our Everyday Life

A. Read the following quotations about science in our everyday life and express your own opinion about use of scientific discoveries and inventions in our daily life.

1) Today, there is no other influence comparable with science in changing the foundations, indeed the very character of our lives. Science and its products determine our economy, dominate our industry, affect our health and welfare, alter our relations to all other nations, and determine the conditions of war and peace. Everyone who breathes is affected, and cannot remain impervious to them. (***Laurence M. Gould*** from ***UNESCO Courier***)
7) However far modern science and technics have fallen short of their inherent possibilities, they have taught mankind at least one lesson: Nothing is impossible. (***Lewis Mumford*** from ***Technics and Civilization***)
8) Science does its duty, not in telling us the causes of spots in the sun, but in explaining to us the laws of our own life, and the consequences of their violation. (***John Ruskin*** from ***Thought of Ruskin by Henry Attwell***)
9) Science, like everything else that man has created, exists, of course, to gratify certain human needs and desires. The fact that it has been steadily pursued for so many centuries, that it has attracted an ever-wider extent of attention, and that it is now the dominant intellectual interest of mankind, shows that it appeals to a very powerful and persistent group of appetites. (***J.W.N. Sullivan*** from ***The Limitations of Science***)
10) It is hardly necessary to argue, these days, that science is essential to the public. It is becoming equally true, as the support of science moves more and more to state and national sources, that the public is essential to science. The lack of general comprehension of science is thus dangerous both to science and the public, these being interlocked aspects of the common danger that scientists will not be given the freedom, the understanding, and the support that are necessary for vigorous and imaginative development. (***Warren Weaver*** from ***A Guide to Science Reading by Hilary J. Deason***)

B. Write down 5—10 sentences expressing your ideas about implementation and piloting of science and inventions in our everyday life.

C. Read the definitions of "application" and choose the one, which suits best to your ideas about use of science from exercise B.

No.	Definition	Source
1.	1) the use to which something is put 2) the process of putting something on something else 3) the act of applying adhesives	*DICTIONARY OF AUTOMOTIVE TERMS*

2.	1) An application for something such as a job or membership of an organization is a formal written request for it 2) The application of a rule or piece of knowledge is the use of it in a particular situation 3) In computing, an application is a piece of software designed to carry out a particular task 4) Application is hard work and concentration on what you are doing over a period of time 5) The application of something to a surface is the act or process of putting it on or rubbing it into the surface	*Collins COBUILD Advanced Learner's English Dictionary, 4th edition*
3.	1) the act of applying, esp. medicinal ointment to the skin 2) a formal request, usu. in writing, for employment, membership, etc. 3) a. relevance. b. the use to which something can or should be put 4) sustained or concentrated effort; diligence	*Oxford English Reference*
4.	1) an act of putting to use 2) a use to which something is put 3) a. a program (as a word processor or a spreadsheet) that performs one of the major tasks for which a computer is used b. an act of administering or superposing c. assiduous attention	*Merriam-Webster's Collegiate Dictionary, 11th Edition*
5.	1) usually written, request for something such as a job, place at university, or permission to do something 2) practical purpose for which a machine, idea etc can be used, or the act of using it for this 3) the act of putting something such as paint, liquid, medicine, etc. onto a surface 4) attention or effort over a long period of time 5) a piece of software 6) the way in which something can affect or be used on something else	*Longman Dictionary of Contemporary English, 3rd edition*

D. Read the following text:

How Research in Chemistry Has Improved Daily Life

The field of chemistry has always been involved in every aspect of our daily lives. Research in chemistry has lead to life changing discoveries, allowed us to progress as a society, has made our lives safer, and even allowed us to live longer. Without chemistry, we would not have nearly all of the products that we wear, eat, and use daily. It not only has improved our daily lives, but has made a significant impact on how our society has evolved and flourished.

Chemical research and development has resulted in improvements in the production of food and water. Without it, there would be much less safe foods to eat and clean water to drink. One of the most important chemical contributions to society is the development of chemical polymers. Plastics, Nylon, PVC, silicone, polyester, and polycarbonate, can be found in every part of out lives such as in our homes, schools, buildings, and work place. Developments from chemical research affect where and how we eat and play and it allows us to have many hobbies and interests. As well, paper, wood products, and metals such as steel and aluminum, are essential items developed from chemical research.

Without chemistry, we would not have access to the variety foods and food ingredients we see in the grocery stores. In the field of medicine, we would not have such drugs as antibiotics, pain relief medications, and medications for illnesses such as asthma, heart disease, and diabetes, etc. The remarkable surgeries performed today saves millions of lives. Without chemicals used to develop products to allow surgeries to be performed, we would not have access to life saving health care. Such surgical items include: anesthetics, latex gloves, sterilization equipment and solutions, etc.

When it comes to sustaining life on the planet, without chemical research, we would not have essential products as fertilizers, and herbicides and pesticides needed for the agricultural industry. We would also not have the ability to have sewage treatment plants which reduces dangerous illnesses.

Everything we find in our homes is the result of research in chemistry. Chemical processes have resulted in a broad variety of products and materials needed for an ever evolving modern society. For instance, soap, toothpaste, deodorant, shampoo, toothbrushes, shaving supplies, make up, and other personal care products have all been created from chemical research. Kitchen items such as pots, pans, silverware, plates, and cups were created with the help of chemistry. Almost all of the cleaning products found in a home are the result chemical developments. As well, without chemistry, we would not have such items as synthetic fabric, Styrofoam, computers, CDs, DVDs, iPods, fuel for vehicles, oil to heat our homes, refrigeration units, radios, televisions, radios, batteries, and so much more.

For centuries, chemical research and discovery has played a fundamental role in improving the quality and extension of life. Research in chemistry is essential to understanding life and the environment. Wherever we are, some part of research in chemistry is touching our lives. Without it, we would not have the remarkable items that we now take for granted. It is a remarkable field with a bright future.

(by ***Adriana Noton***)

E. Check your reading comprehension. Choose the best answer (only one variant is possible). What do the underlined words from exercise D mean?

1) ***progress***
(a) move
(b) run
(c) advance
(d) manage

2) ***flourish***
(a) develop
(b) blossom
(c) enrich
(d) make better

3) ***item***
(a) speech
(b) unit
(c) range
(d) article

4) ***surgery***
(a) military position
(b) medical operation
(c) urgent task
(d) foodstuff

5) ***sustain***
(a) delay
(b) support
(c) suspend
(d) deteriorate

11) ***variety***
(a) amount
(b) performance
(c) variant
(d) diversity

F. Match the words in the left column with their definitions in the right column.

1) ***safe***
2) ***impact***
3) ***contribution***
4) ***polymer***
5) ***ingredient***
6) ***anesthetic***
7) ***silverware***
8) ***iPod***
9) ***fundamental***
10) ***take for granted***

a) any of a class of natural or synthetic substances composed of macromolecules
b) a drug, such as ether, that produces loss of sensibility
c) a combination portable digital media player and hard drive from Apple Computer
d) an effect or influence, esp. when strong
e) all the things in a house that are made of silver, especially the cutlery and dishes
f) affecting, or serving as a base or foundation, essential
g) the act of giving for a common purpose
h) a component, part or element in a recipe, mixture, or combination
i) assume something is a certain way or is correct
j) free of danger or injury

G. Fill in the gaps in the sentences below with the words from the list.

displays propagate flow experimented completely tower plastic
absorbed experience visible internal escape challenge mirror transmitting phone conductor reach direction

1) The door of a microwave oven is carefully designed to reflect microwaves so that they can't … from the oven.
2) That mesh that you see in the door isn't … , it's metal.
3) Metal surfaces reflect microwaves and, even though the mesh has holes in it to allow you to observe the food, it acts as a perfect … for the microwaves.
4) Basically, the holes are so much smaller than the 12.2-cm wavelength of the 2.45-GHz microwave that the microwave cannot … through the holes.
5) Electric currents flow through the metal mesh as the microwave hits it and those currents re-radiate the microwave in the reflected … .
6) Since the holes aren't big enough to disrupt that current … , the mesh reflects the microwaves as effectively as a solid metal surface would.
7) As for how your cell phone and the cell tower can communicate for miles despite all the intervening stuff, it's actually a … .
8) The microwaves from your phone and the tower are partly … and partly reflected each time they encounter something in your environment, so they end up bouncing their way through an urban landscape.
9) That's why cell towers have multiple antennas and extraordinarily sophisticated … and receiving equipment.
10) They are working like crazy to direct their microwaves at your phone as effectively as possible and to receive the microwaves from your phone even though those waves are very weak and arrive in bits and pieces due to all the scattering events they … during their passage.
11) Indoor cell phone reception is typically pretty poor unless the building has its own … repeaters or microcells.
12) There are times when you don't get any reception because the microwaves from the cell phone and tower are almost … absorbed or reflected.
13) For example, if you were to stand in a metalized box, the microwaves from your cell phone would be trapped in the box and would not … the cell tower.
14) Similarly, the microwaves from the cell … would not reach you.
15) Moreover, the box doesn't have to be fully metalized; a metal mesh or a transparent … is enough to reflect the microwaves.
16) Transparent conductors are materials that conduct relatively low-frequency currents but don't conduct currents at the higher frequencies associated with … light.
17) They're used in electronic … (e.g., computer monitors and digital watches) and in energy-conserving low-E windows.

18) I haven't … with cell phone reception near low-E windows, but I'm eager to give it a try.
19) I suspect that a room entirely walled by low-E windows will have lousy cell … reception.

(**from** *http://www.howeverythingworks.org/*)

H. Learn the following words and word combinations with 'application' and 'implementation'.

APPLICATION	• To file an application • To make an application • To put in an application • To send in an application • To submit an application • To screen applications • To reject an application • To turn down an application • To withdraw an application • A fellowship application • A membership application • A formal application • A written application • An application for (an application for admission to a university) • An application to (an application to be admitted to the intensive course) • By application • On application • Application to (the application of theory to practice) • Application to (the application of ice to the forehead)
IMPLEMENTATION	• Implementation plan • Implementation report • Implementation of a study • Design and implementation of projects

(Source: ***BBI Combinatory Dictionary of English by M. Benson, E. Benson, & R. Ilson***)

I. What is the difference between the following synonyms:

1) application	6) effort
2) relevance	7) commitment
3) reference	8) appeal
4) use	9) request
5) practice	10) pertinence

J. Read the following text and make up a summary (10—15 sentences):

Destructive Creativity in Scientific Research

At all times the rich phenomena of nature have fascinated humankind, which has always been driven by inherent curiosity to get a deeper understanding of the underlying laws and mechanisms. This is the basis of science which has become an essential element of culture. At present it satisfies not only our thirst for knowledge but also leads to many benefits in our daily lives. Specifically, this is true for Nuclear Physics aiming at the study of the properties and interactions of the basic building blocks of matter. Despite the fact that most nuclear phenomena are far beyond our daily experience, there is a great variety of related techniques and applications with great impact on society. However, in many cases even scientists are not aware of the benefits associated with the widespread use of nuclear techniques.

There are many problems of modern society where nuclear science can contribute to their solution. The nuclear physics community should address the challenges of the demands of society related to the field and should take its responsibility in the search for solutions. At present the provision of energy and the management of high-level nuclear waste is of major concern for mankind. Whatever the future of nuclear energy will be, nuclear physicists must play a role in finding innovative solutions, help decision makers to identify valid options and contribute to rational discussions of this issue in public. From the present viewpoint, strong support for applied research associated with the development of new concepts such as hybrid reactors for the transmutation of nuclear wastes (e.g. accelerator-driven systems (ADS)) appears necessary. A preliminary design study for such an ADS is an important step and should be considered in the forthcoming European framework programmes.

The contribution of nuclear physics to medical sciences, biology and radiobiology is now well recognised and is an excellent example of a specific know-how applied to another field. Indeed nuclear techniques applied to life sciences play a major role. They have contributed essentially to recent progress via use of radioactive tracers, accelerator mass spectroscopy (AMS), employment of nuclear imaging techniques of various types (SPECT, PET, NMR, MicroPET), study of radiation effects on biological material, and development of dedicated accelerators and high-quality beams for proton and hadron therapy. In this context, increased formation of interdisciplinary collaborations is strongly needed and the activities of combined teams must be encouraged. Specifically, nuclear physicists should help, jointly with the medical doctors, in the promotion and the development of techniques associated with proton and ion-beam therapy.

Even when dealing with basic problems, the interaction with other communities could be of mutual benefit as different fields very often share concepts, models and techniques. We may present a very nice illustration of the cross-fertilisation that may exist between nuclear science and atomic and condensed-matter physics. Good examples are the use and development of ion sources and atomic traps. These communities are, next to nuclear physicists, important users of the large infrastructures oriented towards nuclear physics. Collaborations must be encouraged and further developed.

Spin-offs of nuclear technology, namely accelerators and detectors are of major importance and are quite often the link with other fields for basic research. These technological developments should be strongly supported and the discussion on future tools for nuclear science should systematically include the multidisciplinary aspects of the projects. The importance of technological developments has been recognised through many RTD contracts financed within the 5th European framework programme. However, a general assessment and better planning should be envisaged at the European level for an improved co-ordination of such developments.

The widespread applications of nuclear techniques and their strong impact on society require an education of the general public in the concept of elementary nuclear phenomena. This is needed to promote effective and balanced discussions of nuclear science issues that are of importance for society at large. Enhancing nuclear physics knowledge will help the understanding of science in general.

(from the report ***Nuclear Physics in Europe: Impact, Applications, Interactions*** by ***the Nuclear Physics European Collaboration Committee***)

K. Translate your summary of the text from exercise J into Russian.

L. Answer the following questions to the text from exercise J:

1) How can you define the basis of science?
2) Which problems of modern society can nuclear science solve?
3) Which sciences has nuclear physics contributed to?
4) Which technological developments are to be supported?
5) What do the widespread applications of nuclear techniques require?

M. Read the following text and render it in English:

Инновационное образование: вызовы и решения

В настоящее время образование во всем мире претерпевает значительные изменения. Это связано, прежде всего, с процессом глобализации, частью которой являются мощнейшие интегративные процессы, несущие в себе огромные преимущества, но, одновременно, таящие в себе невиданные ранее опасности подавления национальных культур и традиций. Поэтому здесь особая роль принадлежит образованию как фактору, позволяющему, с одной стороны, вписаться в указанные интегративные тенденции, идти в ногу со временем, не отстать от развитых стран, а с другой стороны — не растерять национальных особенностей своей культуры.

Другой причиной изменения выступают процессы экономизации образования, то есть рассмотрение последнего как важнейшего фактора экономического развития страны. Образование все больше рассматривается не как образование ради образования, ради получения «чистого знания», а именно как мощный факт развития, позволяющий странам выйти на новые инновационные технологические рубежи. То есть, образование рассматривается в целом как главный фактор социально-экономического прогресса и обеспечения устойчивости социальной системы.

Сегодня уровень образования населения является важнейшим фактором устойчивого развития любой страны. Как отмечают специалисты Организации экономического сотрудничества и развития (ОЭСР), «темпы базового долгосрочного роста экономики в странах ОЭСР зависят от поддержания и расширения базы знаний… Во многих странах ОЭСР реальный рост добавленной стоимости в отраслях, основанных на знаниях, в минувшие два десятилетия устойчиво превышал темпы общего экономического роста. Процесс глобализации ускоряет эти тенденции… .

В настоящее время высшее образование в России характеризуется резким увеличением численности выпускников высших учебных заведений.

Одной из проблем современного образования в нашей стране является нахождение оптимального механизма финансирования образования.

Современное образование должно достаточно быстро реагировать на запросы рыночной экономики. Это невозможно осуществить без прямых инвестиций в образование, которые нацелены на получение определенного результата и необходимого качества. Однако довольно быстро стало ясным, что прямые инвестиции как бюджетного, так и частного капитала в образование таят в себе и целый ряд опасностей, связанных с потерей единой государственной стратегии в данной сфере. Если инвестиции соотносить лишь с требованиями рынка, то можно разрушить систему подготовки специалистов, которые на сегодняшний момент могут быть не затребованы рынком, но необходимы для развития государства и общества. Прямые частные инвестиции в большей степени ориентируются на индивидуальные траектории образования, как на уровне потребителя, так и на уровне работодателя, что может не совпадать с общими задачами государства. Стало ясным, что, учитывая высокий уровень необходимых инвестиций в современное образование, от 4 до 6 процентов валового внутреннего продукта (ВВП), в котором «расходы на высшую школу, как правило, составляют от 15 до 20 процентов всех расходов на государственное образование», частных инвестиций будет заведомо недостаточно. Кроме того, преимущественная ориентация в образовании на запросы рынка имеет неоднозначные последствия. Организация высшего образования только на основе частных инвестиций не может обеспечить оптимальные объемы и структуры его производства, поскольку на уровне индивидов невозможно уловить и воспользоваться всеми выгодами образования. Образование приносит выгоду для общества в целом, а не только для отдельных его членов.

Таким образом, все более понятной становится особая роль, которая должна принадлежать в образовании государству и государственной политике в области образования. Для нормального функционирования образование необходима поддержка государства, особенно в области фундаментальных наук, так как именно они обеспечивают будущие инновационные технологии, которые, в свою очередь способны значительно повысить производительность труда в масштабах всего общества, а значит качество жизни и, как следствие, снизить имеющуюся социальную напряженность.

Последние 1—2 года в этой области происходят позитивные изменения, которые, в частности, связаны с реализацией инновационного образовательного гранта. Финансирование образования через поддержку инновационных проектов позволяет синтезировать, с одной стороны, проведение государственной политики в сфере образования, ориентирующегося на цели и задачи развития страны в целом, а с другой — повысить эффективность вкладываемых финансовых средств в образовательные проекты. Это более гибкая форма финансирования, позволяющая реагировать, в том числе, и на запросы рынка, оперативно менять векторы развития образования за счет перераспределения средств, выделяя доминирующие на данный момент секторы образования.

Инновации в образовании связаны с изменениями в содержании образования, в структуре образовательных институтов, в технологии учебно-воспитательных процессов, методах и средствах обучения и воспитания. Инновации необходимым образом касаются и механизма управления образованием. В современных условиях инновационная деятельность является важнейшим инструментом повышения качества и конкурентоспособности образования.

Инновационное образование предполагает обучение в процессе создания новых знаний, в результате активного взаимодействия образования с наукой. Переход российского образования на инновационный путь развития может быть достигнут за счет интеграции фундаментальной науки, непосредственно учебного процесса и производства. В образовательную практику все в большей степени вовлекаются интеллектуальные ресурсы. Научные исследования и разработки являются основанием и условием инновационного образования. Развитие науки и образования, таким образом, представляет собой единство, имеющее целью освоить и распространить инновации.

Инновационность выступает важнейшей парадигмой современного образования, которая в условиях процесса глобальной трансформации культуры требует переориентации системы образования, прежде всего профессионального, на инновационный путь развития. Это должно выражаться в пересмотре и обновлении программ обучения в сторону стимулирования творческой деятельности студентов, реального их участия в выполнении научно-исследовательских работ, переходе к новым формам связи науки, профессионального образования и экономики. Переход на многоуровневую систему подготовки кадров сопровождается пересмотром соотношения в образовательном процессе учебной и научно-исследовательской деятельности обучающихся. Так, государственный образовательный стандарт подготовки магистров предполагает в качестве обязательного элемента профессиональной подготовки научно-исследовательскую работу студента-магистранта и подготовку магистерской диссертации, которая является обязательным видом итоговой государственной аттестации. Проблема, возникающая при реализации модели многоуровневой подготовки кадров, связана с определением соотношения выпускников, ориентированных на исследовательскую деятельность и владение навыками деятельности в конкретной предметной области. Какие механизмы (государственный заказ специалистов, система финансирования, возможности построения индивидуальных образовательных траекторий и прочее) обеспечат такое распределение? Инновационное образование в идеальном варианте требует подготовки всех выпускников на основании стандартов, обеспечивающих единство науки и образования.

Новая формирующаяся парадигма образования основана уже не на воспроизводстве готового знания, а на готовности индивида к действию в разнообразных ситуациях. В сфере подготовки кадров внимание уделяется формированию таких навыков, как умение действовать в условиях интенсивного информационного обмена, использовать информацию для обоснования решений и планирования деятельности. Нельзя не заметить, что знание при этом теряет свою стабилизирующую роль основания интеллектуальной жизни, и, тем самым, общества в целом. Образование ориентируется на подготовку людей к неопределенному и, в значительной степени, непредсказуемому будущему. От прежней системы образования сохраняется стремление научить алгоритму, но теперь уже не «алгоритму знания» — применению готовых знаний, а «алгоритму действия» — поступку в различных ситуациях.

В современной культурной ситуации приобретение знания уже не рассматривается как абсолютная, самодостаточная ценность, безотносительная к утилитарному применению результатов образования. Знание объявляется ценным только при наличии возможности его практического использования. Данная ориентация отчетливо проявилась в проектах Государственных образовательных стандартов высшего профессионального образования третьего поколения, где утвердился компетентностный подход. В проект стандартов заложена идея того, что прогностическую функцию, определяя желаемые результаты и средства их достижения в профессиональном образовании, выполняет заказчик обучения — работодатель. Однако при этом необходимо учитывать, что работодателем выступают не просто представители различных областей современной экономики и производства, но и государство как таковое, а в некоторых случаях, преимущественно государство. Поэтому нужна не прямая подготовка по запросам работодателей, ориентированная на приспособление к настоящему, а выработка самой стратегии достижения желаемого состояния, основанной на готовности индивида к получению новых знаний и обучению в течение всей жизни. То есть, образование, основанное на постоянном обновлении знаний, рассматривается как ценность, необходимая для достижения жизненного успеха.

(from **«Инновационное образование: вызовы и решения»**, ***В.В. Миронов, МГУ им. М.В. Ломоносова***)

N. Prepare a public speech for 5—8 minutes (in Russian) about applications of the science you are interested in. Make up an abstract (3—5 sentences) of the speech and point out some key words (5—10 words).

O. After presenting your speech give the key words and abstract to other students, who will render your speech in English.

P. Learn the tips about defending a thesis.

Points about Defending a Ph.D. Thesis or Dissertation

A thesis defense! Everybody seems diffident of taking an oral examination. But how can you not be intimidated? After all, you are defending a topic in front of experts! In this situation, fear is more of a natural response than exception.

It turns out that the outcome of your thesis defense is largely dependent on how you manage your fears! Believe it or not, no matter the amount of stuff you know and your arduous rehash, you are bound to fail if you are not psychologically conditioned to face your challenge. Hence, focus on this aspect and put in mind its relative significance to your preparations: Actual preparations (30%) and execution (70%). At the onset, there might be a need to defend this percentage allocation.

Recall what a custom written thesis or dissertation means. It is usual for institutions to refer to the word thesis as some kind of an involved research work, usually done by an undergraduate student or a graduate pursuing a master's degree. Certainly, a master's thesis is relatively more comprehensive in scope and normally defended in front of an examining panel or a committee. A custom dissertation is a research paper or a thesis usually done by a candidate to a doctoral degree. However, it has become customary for many institutions to refer to a dissertation as a doctoral thesis. At any rate, a baccalaureate, master’s, or especially the doctoral thesis is a serious piece of original research work that requires considerable time to complete under the guidance of an advisor, usually a professor or expert in the field that the student is working on. Therefore, mastery of the thesis or its subject content is one that cannot be expected of a student simply in a matter of weeks; in fact, mastery is developed from the time of thesis conception to reproduction! This is just to say that understanding the subject matter during the relatively short time allotted to the preparation for a defense is too late a preparation — and, certainly, this is not leading to any mastery of subject matter. Currently, this is not what is meant also by preparations.

Accordingly, preparations for a thesis defense rest on one crucial assumption or requirement: Mastery of the topic and those matters relevant to it. Precisely, you must have built some considerable confidence on your knowledge about your subject matter through the years that you were working on it. Otherwise, there is no point scheduling for a defense- simply, you are not ready!

Suppose that you do have the required knowledge and confidence about it. Here are down-to-earth pointers that may help you through a successful defense, stated in suggested order of execution:

1. The Planning

Call it a "game plan," but there is nothing more assuring at the back of your mind than a well laid out plan. Begin by setting aside a comfortable amount of time for your preparation, say, a month or so. Make sure that the rest of the tasks that you must do must fit in this allotted time, plus some allowances. Yes, assume contingencies in your plan and strategize how to manage them. For instance, remember that you will need help from other people (classmates, colleagues, professors, etc.); hence, give leeway for their busy schedules.

2. Visitations

Visiting classmates, colleagues and members of your committee must be first in your plan. Ask about the business of defending a thesis. Some students are so organized and conscientious that they logged questions and responses of old examinations for the succeeding examinees to use. Take a preview, and try to comprehend the underlying scope and limitations. Further, it is likely that you will get a characteristic profile of your examining committee from older students. Use all these information to probe further: Visit your committee members. Thoughtful visitations, at the least, will help impress them of your seriousness. Most of the time, a good professor will not resist a curious, dedicated and thoughtful learner.

3. Refine Your Plan

Nobody says that you cannot go back to the drawing board and make changes to your plan in case of difficulties with your dissertation. In fact, you must do this as often as necessary. Were the advices by other students inaccurate? What imminent changes are possible? The end result must be a strategy for a defense that is most comfortable for you. Besides, you can only feel comfortable once you know you have already a fair handle of the situation.

4. Defense Materials

It is quite alright to bring important visual aids or extracts from your thesis (charts, drawings, quotations, tables, etc.) to help you elaborate on your responses to questions. It is not necessary to carry a heavy baggage inside the examination room, but it is certainly assuring to have with you "everything" that you might think will be helpful. Remember, as always, "pictures speak louder than words," and, when short of articulation, one visual aid may be ready for the rescue. Really, you may not have to say, "As you know" if I have only brought with me that particular diagram, you might know exactly what I mean." Do not underestimate the value of simple tools like colored pens. You might actually be asked to demonstrate certain details on a blank transparency, to support your arguments. Likewise, you may not have to say, "Is there a pen somewhere? I wish I can write it all out for you." Certainly, a lack of simple tools during your defense can be misinterpreted as some lack of seriousness or mastery on your part.

5. Practice

The old adage "Practice makes perfect" still holds. Gather some friends and classmates to do the "mock orals" for you. Allow any of them to depict the questioning style of your committee members, and do the practice as realistically as possible. Your final hints to your potential performance can be gauge from here. When permissible, request for two or three sessions and consider the suggestions and key improvements each time. To a large extent, your own group can best decide on whether or not you will eventually succeed.

From this point onward, you are on your own. After all, the decision to succeed or not still is your own. Now, it is the right time to work out on you psychological conditioning. The following pointers may serve as your inspiration to manage any remaining fear and ensure a smooth defense:

A. Do you have any reason to expect what can possibly go wrong? You had years of studying your subject. You have addressed many issues and queries along the way. And, you know you are still in command of your thesis. What then can be more assuring on your part?

B. Did you complete your preparations from planning to "mock orals"? Did you receive a final nod from your friends and classmates? Was your main advisor happy about this? If so, do you have further reasons to harbor any fear?

C. Remember what failure means. Your years of stay in school have been expensive. You will not like paying for the same real estate twice. You would rather like a job that earns you a better livelihood or push you to a higher degree or accomplishment. Simply, you cannot afford to be ruined by mere fear of one examination!

D. Finally, all humans fear- yes, your committee members included! At least you are a normal human being. Understand what is meant by failure- it is not the end of everything! Knowing this fall back position and your strong drive to succeed is your final defense against fear.

On your examination day, these are the remaining final preparations:

- **Do not overdress yourself.** You are up to a rough ride; come on a presentable (formal) yet comfortable attire.
- **Try to act natural and well composed**. Without being presumptuous, look ready to take up any question.
- **Understand each question well** and/or clarify before making any response.
- **Don't ever bluff!** You are in front of respectable and knowledgeable people. It is alright to say "I cannot have the explanation offhand," "I can't seem to remember a good explanation," or "I don't believe that I have an answer to that." Yes, honesty matters to your committee next to mastery.

In sum, your prime pointer to defending your thesis is largely on your defense against irrational fears. Strive to manage these fears through strong psychological conditioning backed by your ready mastery of your thesis and some systematic preparations. "No guts, no glory." Remember: If gamblers can exploit courage to win by pure luck, certainly, you can succeed because you have the tangible ingredients to success.

(by ***Rex Balena, PhD***)

Q. Read the following text about the structure of a thesis abroad. Compare it with the requirements in the Russian Federation. Describe the structure of your own thesis.

A suggested thesis structure

The list of contents and chapter headings below is appropriate for some theses. In some cases, one or two of them may be irrelevant. Results and Discussion are usually combined in several chapters of a thesis. Think about the plan of chapters and decide what is best to report your work. Then make a list, in point form, of what will go in each chapter. Try to make this rather detailed, so that you end up with a list of points that corresponds to subsections or even to the paragraphs of your thesis. At this stage, think hard about the logic of the presentation: within chapters, it is often possible to present the ideas in different order, and not all arrangements will be equally easy to follow. If you make a plan of each chapter and section before you sit down to write, the result will probably be clearer and easier to read. It will also be easier to write.

Copyright waiver

Your institution may have a form for this. In any case, this standard page gives the university library the right to publish the work, possibly by microfilm or other medium.

Declaration

Check the wording required by your institution, and whether there is a standard form. Many universities require something like: "I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text. (signature/name/date)"

Title page

This may vary among institutions, but as an example: Title/author/"A thesis submitted for the degree of Doctor of Philosophy in the Faculty of Science/The University of New South Wales"/date.

Abstract

Of all your thesis, this part will be the most widely published and most read because it will be published in Dissertation Abstracts International. It is best written towards the end, but not at the very last minute because you will probably need several drafts. It should be a distillation of the thesis: a concise description of the problem(s) addressed, your method of solving it/them, your results and conclusions. An abstract must be self-contained. Usually they do not contain references. When a reference is necessary, its details should be included in the text of the abstract. Check the word limit. Remember: even though it appears at the beginning, an abstract is *not* an introduction. It is a résumé of your thesis.

Acknowledgments

Most thesis authors put in a page of thanks to those who have helped them in matters scientific, and also indirectly by providing such essentials as food, education, genes, money, help, advice, friendship etc. *If any of your work is collaborative, you should make it quite clear who did which sections.*

Table of contents

The introduction starts on page 1, the earlier pages should have roman numerals. It helps to have the subheadings of each chapter, as well as the chapter titles. Remember that the thesis may be used as a reference in the lab, so it helps to be able to find things easily.

Introduction

What is the topic and why is it important? State the problem(s) as simply as you can. Remember that you have been working on this project for a few years, so you will be very close to it. Try to step back mentally and take a broader view of the problem. How does it fit into the broader world of your discipline?

Especially in the introduction, do not overestimate the reader's familiarity with your topic. You are writing for researchers in the general area, but not all of them need be specialists in your particular topic. It may help to imagine such a person—-think of some researcher whom you might have met at a conference for your subject, but who was working in a different area. S/he is intelligent, has the same general background, but knows little of the literature or tricks that apply to your particular topic.

The introduction should be interesting. If you bore the reader here, then you are unlikely to revive his/her interest in the materials and methods section. For the first paragraph or two, tradition permits prose that is less dry than the scientific norm. If want to wax lyrical about your topic, here is the place to do it. Try to make the reader want to read the heavy bundle that has arrived uninvited on his/her desk. Go to the library and read several thesis introductions. Did any make you want to read on? Which ones were boring?

This section might go through several drafts to make it read well and logically, while keeping it short. For this section, I think that it is a good idea to ask someone who is not a specialist to read it and to comment. Is it an adequate introduction? Is it easy to follow? There is an argument for writing this section—-or least making a major revision of it—-towards the end of the thesis writing. Your introduction should tell where the thesis is going, and this may become clearer during the writing.

Literature review

Where did the problem come from? What is already known about this problem? What other methods have been tried to solve it?

Ideally, you will already have much of the hard work done, if you have been keeping up with the literature as you vowed to do three years ago, and if you have made notes about important papers over the years. If you have summarised those papers, then you have some good starting points for the review.

If you didn't keep your literature notes up to date, you can still do something useful: pass on the following advice to any beginning PhD students in your lab and tell them how useful this would have been to you. When you start reading about a topic, you should open a spread sheet file, or at least a word processor file, for your literature review. Of course you write down the title, authors, year, volume and pages. But you also write a summary (anything from a couple of sentences to a couple of pages, depending on the relevance). In other columns of the spread sheet, you can add key words (your own and theirs) and comments about its importance, relevance to you and its quality.

How many papers? How relevant do they have to be before you include them? Well, that is a matter of judgment. On the order of a hundred is reasonable, but it will depend on the field. You are the world expert on the (narrow) topic of your thesis: you must demonstrate this.

A political point: make sure that you do not omit relevant papers by researchers who are like to be your examiners, or by potential employers to whom you might be sending the thesis in the next year or two.

Middle chapters

In some theses, the middle chapters are the journal articles of which the student was major author. There are several disadvantages to this format.

One is that a thesis is both allowed and expected to have more detail than a journal article. For journal articles, one usually has to reduce the number of figures. In many cases, all of the interesting and relevant data can go in the thesis, and not just those which appeared in the journal. The degree of experimental detail is usually greater in a thesis. Relatively often a researcher requests a thesis in order to obtain more detail about how a study was performed.

Another disadvantage is that your journal articles may have some common material in the introduction and the "Materials and Methods" sections.

The exact structure in the middle chapters will vary among theses. In some theses, it is necessary to establish some theory, to describe the experimental techniques, then to report what was done on several different problems or different stages of the problem, and then finally to present a model or a new theory based on the new work. For such a thesis, the chapter headings might be: Theory, Materials and Methods, {first problem}, {second problem}, {third problem}, {proposed theory/model} and then the conclusion chapter. For other theses, it might be appropriate to discuss different techniques in different chapters, rather than to have a single Materials and Methods chapter.

Here follow some comments on the elements Materials and Methods, Theory, Results and discussion which may or may not correspond to thesis chapters.

Materials and Methods

This varies enormously from thesis to thesis, and may be absent in theoretical theses. It should be possible for a competent researcher to reproduce exactly what you have done by following your description. There is a good chance that this test will be applied: sometime after you have left, another researcher will want to do a similar experiment either with your gear, or on a new set-up in a foreign country. Please write for the benefit of that researcher.

In some theses, particularly multi-disciplinary or developmental ones, there may be more than one such chapter. In this case, the different disciplines should be indicated in the chapter titles.

Theory

When you are reporting theoretical work that is not original, you will usually need to include sufficient material to allow the reader to understand the arguments used and their physical bases. Sometimes you will be able to present the theory *ab initio,* but you should not reproduce two pages of algebra that the reader could find in a standard text. Do not include theory that you are not going to relate to the work you have done.

When writing this section, concentrate at least as much on the physical arguments as on the equations. What do the equations mean? What are the important cases?

When you are reporting your own theoretical work, you must include rather more detail, but you should consider moving lengthy derivations to appendices. Think too about the order and style of presentation: the order in which you did the work may not be the clearest presentation.

Suspense is not necessary in reporting science: you should tell the reader where you are going before you start.

Results and discussion

The results and discussion are very often combined in theses. This is sensible because of the length of a thesis: you may have several chapters of results and, if you wait till they are all presented before you begin discussion, the reader may have difficulty remembering what you are talking about. The division of Results and Discussion material into chapters is usually best done according to subject matter.

Make sure that you have described the conditions which obtained for each set of results. What was held constant? What were the other relevant parameters? Make sure too that you have used appropriate statistical analyses. Where applicable, show measurement errors and standard errors on the graphs. Use appropriate statistical tests.

Take care plotting graphs. The origin and intercepts are often important so, unless the ranges of your data make it impractical, the zeros of one or both scales should usually appear on the graph. You should show error bars on the data, unless the errors are very small. For single measurements, the bars should be your best estimate of the experimental errors in each coordinate. For multiple measurements these should include the standard error in the data. The errors in different data are often different, so, where this is the case, regressions and fits should be weighted (i.e. they should minimize the sum of squares of the differences weighted inversely as the size of the errors.)

In most cases, your results need discussion. What do they mean? How do they fit into the existing body of knowledge? Are they consistent with current theories? Do they give new insights? Do they suggest new theories or mechanisms?

Try to distance yourself from your usual perspective and look at your work. Do not just ask yourself what it means in terms of the orthodoxy of your own research group, but also how other people in the field might see it. Does it have any implications that do not relate to the questions that you set out to answer?

Final chapter, references and appendices

Conclusions and suggestions for further work

Your abstract should include your conclusions in very brief form, because it must also include some other material. A summary of conclusions is usually longer than the final section of the abstract, and you have the space to be more explicit and more careful with qualifications. You might find it helpful to put your conclusions in point form.

It is often the case with scientific investigations that more questions than answers are produced. Does your work suggest any interesting further avenues? Are there ways in which your work could be improved by future workers? What are the practical implications of your work?

This chapter should usually be reasonably short—-a few pages perhaps. As with the introduction, I think that it is a good idea to ask someone who is not a specialist to read this section and to comment.

References (See also under literature review)

It is tempting to omit the titles of the articles cited, and the university allows this, but think of all the times when you have seen a reference in a paper and gone to look it up only to find that it was not helpful after all.

Should you reference web sites and, if so, how? If you cite a journal article or book, the reader can go to a library and check that the cited document and check whether or not it says what you say it did. A web site may disappear, and it may have been updated or changed completely. So references to the web are usually less satisfactory. Nevertheless, there are some very useful and authoritative sources. So, *if the rules of your institution permit it*, it may be appropriate to cite web sites. (Be cautious, and don't overuse such citations. In particular, don't use a web citation where you could reasonably use a "hard" citation. Remember that your examiners are likely to be older and more conservative.) You should give the URL and also the date you downloaded it. If there is a date on the site itself (last updated on .....) you should included that, too.

Appendices

If there is material that should be in the thesis but which would break up the flow or bore the reader unbearably, include it as an appendix. Some things which are typically included in appendices are: important and original computer programs, data files that are too large to be represented simply in the results chapters, pictures or diagrams of results which are not important enough to keep in the main text.

(by ***Joe Wolfe, School of Physics, University of New South Wales, Australia***)

R. Read the text about the most widely discussed scientific progress — nanotechnology. What can you say about applications of it?

Applications of Nanotechnology

There are numerous applications of nanotechnology. Most of the applications come as a surprise to your average person.

However, once it's explained, it makes perfect sense. Many everyday products are the direct result of nanotechnology applications.

The manipulation of particles that are smaller than most people can imagine is able to create products that enrich our everyday lives.

Nanotechnology involves the creation of material derived from the manipulation of particles as smaller than atoms. Manipulations of these microscopic particles allow scientists create all kinds of products that we use on a regular basis.

Nanoemulsion is one form of nanotechnology that produces liquid products like cleaners and disinfectants for swimming pools that are not harmful to humans. Liquids that kill the bacteria in pools are mixed with drops that are about a million times smaller than the head of a pin in order to spread toward the bacteria.

This means that nanotechnology has produced highly effective pool antibacterial liquids that require a lesser amount of chemical in the water. This product makes swimming pools safer for people on two levels. Bacteria is controlled more effectively and exposure to harsh chemicals that have the potential to cause health problems.

Over the counter bandages are effective at killing germs and protecting cuts thanks to nanotechnology. Originally bandages and antibiotic ointment were sold separately because the technology to blend the two didn't exist. However, nanoparticles of silver ions are now added to the bandages in order to create an inhospitable environment for bacteria.

The ions literally smother or suffocate the bacteria. The infusion with bandages is simple technology when compared to the technology that prevents infection around cuts and abrasions.

Sports benefit from the products of nanotechnology as well. Tennis rackets now come with the strength of steel buildings but weigh less than the tennis ball in some cases. A carbon nanotube infused graphite has been compounded in order to produce the lightest possible tennis racket.

The tennis rackets created with this type of nanotechnology are stronger than the steel used to build weatherproof buildings. The tennis balls benefit as well as one of the applications of nanotechnology.

To make the core of the tennis ball stronger scientists have created a coating of nanoparticles of clay which means that air can not escape from the core of the ball. This helps the ball maintain its bounce and thus does not have to be replaced as often.

Technological applications of nanotechnology include the creation of nano— batteries, tiny capacitors, and nearly microscopic microprocessors. This type of nanotechnology brings smaller computers with heartier capabilities.

This will help decrease the replacement rate for the world’s smallest computers that are sent into space, down to the depths of the sea, and those we plop on our laps on a daily basis.

Nanotechnology has additionally produced a digital screen that can be flexed and bent without losing resolution. As an application of nanotechnology there is a while host of practical applications that can be thought up using a flexible high resolution screen.

With these smaller, flexible screens humanitarians will be able to take outreach projects to the jungles with more efficiency, human safety will increase by reducing household accidents, and of course we can have a lot more fun on long road trips with take anywhere flexible screens for our electronic devices.

There is a company using the application of nanotechnology to create something known as “self cleaning glass.” The nanoparticles used in the process are photocatalytic, which means that the sun engages the nanoparticles.

Additional nanoparticles are used to make the glass hydrophilic, which means that the rainwater that touches the glass will spread out evenly. Thus, self cleaning glass uses nanotechnology to encourage the sun to loosen the dirt particles and the rain to wash it away.

There are many additional applications of nanotechnology. It is the heart of things that we surround ourselves with everyday. Our wrinkle free fabrics which we pull from the dryer on our way out the door, LCD screens that make our entertainment clearer, and skin care products that provide deep penetration to help keep skin cells healthy are all part of the applications of nanotechnology that make our lives better.

(from ***http://nanogloss.com/nanotechnology/applications-of-nanotechnology/***)

S. Read the following text and translate it into Russian:

Scientists warn US Congress of cancer risk for cell phone use

The potential link between mobile telephones and brain cancer could be similar to the link between lung cancer and smoking — something tobacco companies took 50 years to recognize, according to US scientists' warning.

Scientists are currently split on the level of danger the biological effects of the magnetic field emitted by cellular telephones poses to humans.

However, society "must not repeat the situation we had with the relationship between smoking and lung cancer where we ... waited until every 'i' was dotted and 't' was crossed before warnings were issued," said David Carpenter, director of the Institute of Health and Environment at the University of Albany, in testimony before a subcommittee of the US House of Representatives Committee on Oversight and Reform.

"Precaution is warranted even in the absence of absolutely final evidence concerning the magnitude of the risk" — especially for children, said Carpenter.

Ronald Herberman, director of the University of Pittsburgh Cancer Institute — one of the top US cancer research centers — said that most studies "claiming that there is no link between cell phones and brain tumors are outdated, had methodological concerns and did not include sufficient numbers of long-term cell phone users."

Many studies denying a link defined regular cell phone use as "once a week," he said.

"Recalling the 70 years that it took to remove lead from paint and gasoline and the 50 years that it took to convincingly establish the link between smoking and lung cancer, I argue that we must learn from our past to do a better job of interpreting evidence of potential risk," said Herberman.

A brain tumor can take dozens of years to develop, the scientists said.

Carpenter and Herberman both told the committee the brain cancer risk from cell phone use is far greater for children than for adults.

Herberman held up a model for lawmakers showing how radiation from a cell phone penetrates far deeper into the brain of a five-year-old than that of an adult.

The committee were shown several European studies, particularly surveys from Scandinavia — where the cell phone was first developed — which show that the radiation emitted by cell phones have definite biological consequences.

For example, a 2008 study by Swedish cancer specialist Lennart Hardell found that frequent cell phone users are twice as likely to develop a benign tumor on the auditory nerves of the ear most used with the handset, compared to the other ear.

A separate study in Israel determined that heavy cell phone users had a 50 percent increased likelihood in developing a salivary gland tumor.

In addition, a paper published this month by the Royal Society in London found that adolescents who start using cell phones before the age of 20 were five times more likely to develop brain cancer at the age of 29 than those who didn't use a cell phone.

"It's only on the side of the head where you use the cell phone," Carpenter said.

"Every child is using cell phones all of the time, and there are three billion cell phone users in the world," said Herberman.

He added that, like the messages that warn of health risks on cigarette packs, cell phones "need a precautionary message."

Carpenter described the situation as "a critical public health issue," and called on the US government to support further research and for the Federal Communications

Commission (FCC), in charge of monitoring the use of the radio spectrum, "to review their standards."

Also testifying was Julius Knapp, who heads the FCC office of engineering and technology — responsible for setting limits for human exposure to radio frequency (RF) energy from electronic devices like telephones that they approve, to prevent it from heating up live tissue.

"It is important to understand that we rely on guidance from US health, safety and environmental agencies in setting those limits," Knapp said.

He added: "The FCC staff is not sufficiently qualified to speak with authority to the science of health effects of RF absorption in the body."

(from ***AP, 26.09.2008***)

T. Write a short essay (8—15 sentences) about implementation of various scientific projects in Russia.

U. Insert the prepositions from the list and read the text aloud. Discuss it with other students.

to for (2) of (3) on (2) in (3) at (1) by before about

Modern Education and Critical Thinking

The demand in modern or post-modern education theory (constructivism) … problem solving and critical thinking are undermined … course design changes which do not require drill and practice … arithmetic, so that arithmetic provides repeatable and reproducible results, and to the point that students are taught or shown that care, patience and self-discipline is required to mastery multistep methods. Allowing students to skip that care, patience and self-discipline needed to obtain repeatable and reproducible results leads to wishful and suspect critical thinking and problem solving abilities. The use and combination … rules and patterns one … a time and then one after another represents the start of deductive reason and deductive connection, construction and Euclidean codification of skills and concepts. For very critical thinking and problem solving skills demanded, students need the ability and self-discipline to follow rules and patterns … a repeatable, reproducible and thus verifiable or objective manner. But they also need the knowledge that rules and patterns, even those with seemingly repeatable, reproducible and therefore verifiable results need not be reliable. Again, that is where critical thinking appears. Further in problem solving, students should meet or be given solutions to problems previously met, so that there is not continuing need to re-invent solutions, and so that students can repeat or develop further what others have done. Students need the ability to recognize and solve open problems, but that stand … a knowledge of what has been done … and a deliberate coverage of the benefits, origins and limits … rule and pattern based processes in thought and deed. A balance is needed.

Past practices should not be pushed aside. Students should learn … them, their benefits, origins and limitations, while learning to go beyond when needed.

Critical thinking … science is based … statements that can be tested and the empirical accumulation … practices that work in some measure if not completely. Therein lies an behavioral approach … learning and teaching in science, mathematics included. Modern cognitive theory which says teachers and schools should not test students because (i) whatever a student thinks is valid … him or her; (ii) because rule and pattern based skills and concepts are not real learning; and because (iii) student success on one test is no guarantee of success on further tests, do so in opposition to empirical perspective of mathematics and science.

(from ***http://whyslopes.com/mathematics_education_essays/***)

V. Put the verbs in brackets in the right tense-form and voice. Discuss it with other students.

The Magical Number Seven, Plus or Minus Two

It (to say) sometimes human beings are nothing more than a collection of memories. Memories for people, events, places, sounds and sights. Our whole world is funnelled in through our memories. In fact, they may be our most prized possessions. The study of memory (to be) always central to psychology — this text describes one of its most influential findings.

The title of this text is the same given to a 1956 article by the psychologist George A. Miller in which he (to describe) the capacity of human memory. The article's opening (to become) famous amongst historians of psychology:

"My problem is that I have been persecuted by an integer. For seven years this number (to follow) me around, (to intrude) in my most private data, and (to assault) me from the pages of our most public journals. This number (to assume) a variety of disguises, being sometimes a little larger and sometimes a little smaller than usual, but never changing so much as to be unrecognizable." (Miller, 1956, p. 81).

It's not just Miller who (to persecute) by this number though, it's all of us. What this magical number (to represent) — 7 plus or minus 2 — is the number of items we can hold in our short-term memory.

So while most people can generally hold around seven numbers in mind for a short period, almost everyone (to find) it difficult to hold ten digits in mind.

Remember that memory is a slippery concept: short-term memory for psychologists (to refer) to things that are currently being used by your brain right now. For example as you (to read) this text the words you've read go into short-term memory for a very short period, you extract some meaning (hopefully) and then the meaning either (to store) or (to discard). You'll probably still have some faint memory of this article tomorrow, but won't be able to remember most of the actual words.

All sorts of experiments and theories (to follow) disputing the 7 items approach to memory. More recent studies, for example, (to show) how we put items together in order to 'chunk' data. Still, the basic concept that our immediate short-term memory is relatively limited is still valid.

If you think seven isn't much then be thankful you're not a six month old infant. Recent research (to suggest) they can only hold one thing in short-term memory (Kaldy & Leslie, 2005). Poor little chaps. Perhaps babies are the new goldfish?

(from ***http://www.spring.org.uk/***)

W. Look at exercise S. Think of other inventions and scientific applications that can cause harm. How can modern sciences mitigate risks of harmful effects?

X. Look at exercise V. Is it still a relevant topic for modern psychology? Can you mention any new trends in social sciences?

Y. What will be the result of your thesis? Can it be applied anywhere? Discuss it with other students.

Z. Write an essay (15—25 sentences) using the vocabulary of this unit. Choose one of the following topics:

1) Application of … *(field of science)* in Our Everyday Life
2) I Cannot Imagine My Life without It
3) The Scientist I Am Proud of

Supplementary Reading

Text 1
Science: From Avocation to Profession

What is science? Science is first and foremost a social institution (Merton 1973, Hull 1988, Longino 1990). Like other social institutions, science depends on the cooperation and coordination of different people to achieve common goals within a larger social environment. Science is a society that operates within society. Many different aspects of scientific research require the cooperation and coordination of different people, such as experimentation, testing, data analysis, writing research papers and grant proposals, refereeing papers and proposals, staffing research projects, and educating future scientists (Grinnell 1992). Many parts of research also bring scientists into direct contact with society at large, such as reporting results to the media, expert testimony, research on human and animals subjects, government funding of research, and so on.

But science is more than a social institution; it is also a profession (Fuchs 1992, Shrader-Frechette 1994). Not every social institution is a profession. Since a social institution is roughly any cooperative, social activity that generates obligations and social roles, social institutions include activities as diverse as baseball, the Stock Market, the US Marines, and marriage. There are many criteria that distinguish professions from other social institutions, but I will discuss only seven central ones below. These criteria should not be viewed as necessary and sufficient conditions for being a profession: that is, we might regard an institution as a profession even if it does not meet all of these criteria, and an institution might meet all of these criteria and yet not be regarded as a profession. Nevertheless, the criteria are useful in describing some common characteristics of professions. I shall now discuss how these criteria pertain to science.

(1) Professions generally enable people to obtain socially valued goals (or goods and services) and professionals have obligations to insure that thesegoals are obtained (Bayles 1988, Jennings *et al.* 1987). Science helps peopleobtain a variety of socially valued goals, such as knowledge and power.

(2) Professions have implicit or explicit standards of competence and conduct that govern professional activities, which help to insure that professionals perform as expected and that the entire profession maintains quality and integrity (Bayles 1988). Incompetent or unethical members of a profession betray the public's trust and deliver goods and services of questionable quality, and when professionals produce goods and services of poor quality, people can be harmed. Bad science can produce adverse social consequences, and science has its own standards of competence and conduct.

(3) Professionals usually go through a long period of formal and informal education and training before being admitted into the profession (Fuchs 1992). The

education and training is necessary to insure that people meet the standards of the profession. Scientists go through a long period of education and training which includes undergraduate and graduate education as well as postdoctoral work (Fuchs 1992). Although scientists do not have to pass professional examinations, it is virtually impossible to be employed as a scientist without mastering a wide body of knowledge as well as various techniques and methods. Most research scientists also have advanced degrees, such as a Ph. D. or MD.

(4) Professions have governing bodies for insuring that professional standards are upheld. Although science's governing bodies are not as powerful or formal as the governing bodies one finds in the other professions, science has its own, informal governing bodies, such as the NSF, NIH, AAAS, NAS, and other scientific organizations (Fuchs 1992). The editorial staffs of various scientific journals can also function as governing bodies insofar as they administer and enforce standards of competence and conduct (LaFollette 1992).

(5) Professions are careers (or vocations). People who occupy professional roles earn money for doing what they do, but a career is more than a way to earn a living: people who have a career usually identify with the goals of that career and draw self-esteem from their vocation. Although science may have been nothing more than a hobby or avocation at one time, it is now a career (PSRCR 1992, Grinnell 1992). Indeed, some writers have argued that the rampant careerism we find in science today is at least partly responsible for some of the unethical conduct that occurs in science (Broad and Wade 1993, PSRCR 1992).

(6) Professionals are granted certain privileges in order to provide their goods and services. With these privileges also come responsibilities and trust: people grant professionals certain privileges because they trust that professionals will provide their goods and services in a responsible, ethical way (Bayles 1988). Scientists are also granted certain privileges. For instance, archeologists are allowed to explore construction sites, psychologists are allowed to have access to controlled substances, and physicists are allowed access to plutonium and other fissionable materials. Special privileges also imply responsibilities and trust: we trust that scientists who receive government funding will not waste it, that psychologists who study the effects of cocaine on rats will not sell this drug on the black market, and so forth.

(7) Professionals are often recognized as intellectual authorities within their domain of expertise (Bayles 1988). Just as lawyers are regarded as having special knowledge, judgment, and expertise about the law, scientists are viewed as having special knowledge, judgment, and expertise about thephenomena they study (Shrader-Frechette 1994). In today's society,intellectual authorities provide us with most of the knowledge we learn inschool and they play a key role in shaping public policy (Hardwig 1994).

Should science be viewed as a profession, given what I have said about professions in general? I believe it should, though I recognize that some people may disagree with this claim. Science has not always been a profession, but it has become more like a profession since the Renaissance (Fuchs 1992). Many of the great figures in the history of science were not what we would call professional scientists, of course. According to the criteria listed above, we should view Aristotle, Copernicus, and Galileo as amateur scientists not because they were incompetent but because science was not a profession during their eras. However, by the time Darwin published his *Origin of Species,* science was clearly a profession and not merely a social institution. What important events happened between 1450 and 1850 that led to the professionalization of science? Although I cannot discuss them all here, some important events include: the development of a scientific method, the establishment of scientific societies and scientific journals, the growth of universities and university-based research, the emphasis of science education at all levels, the employment of scientists in industrial and military research, the technological applications of science, and public recognition of science's power, authority, and prestige (Meadows 1992, Fuchs 1992). However, science is less professional than some other social institutions, such as medicine or law. For instance, science does not have licensing boards and many sciences lack formal codes of conduct.

In my discussion of science as a profession I should note that the phrase "scientific profession" is an abstract, general expression I use to refer to the many different scientific professions, such as molecular biology, developmental psychology, immunology, biochemistry, astronomy, entomology, etc. Although there are important differences between various scientific professions, there are also some important similarities. These similarities consist, in part, of professional standards and goals common to many different sciences. While it is important to be aware of differences, we must not lose sight of the similarities. This book will focus on the similarities, and I will therefore often use the term "science" to refer to that which is common to all scientific professions.

Many scientists may object to my portrayal of science as a profession on the grounds that this view of science does not reflect the importance of amateur science, creativity, freedom, collegiality, and other aspects of science that do not fit the professional model. Moreover, many would argue that science could suffer irreparable damage if it becomes even more like a profession than it already is. The most serious threat posed by the professionalization of science, one might argue, would be harm to scientific creativity and freedom. Making science into a profession could reduce scientists to technocrats and place too many restrictions on how science is practiced. Science should not be governed by rigid rules, licensing boards, and other control mechanisms that we find in professions like medicine or law (Feyerabend 1975).

In response to these objections, I do not claim that science fits the professional model perfectly; I only claim that it fits the model well enough for us to regard it as a profession, and that it fits the model better now than it did a few centuries ago. I am also concerned about the potential damage to science that could result from further professionalization. However, given science's tremendous impact on society and its social responsibilities, completely unprofessionalized science poses grave risks for social values

(Shrader-Frechette 1994). We need some standards of quality control for scientific research, and virtually any standards will take science down the road toward professionalism. Perhaps we can reach some reasonable compromise concerning the degree of professionalization that science ought to achieve by reminding ourselves of the importance of creativity and intellectual freedom in science.

(from ***The Ethics of Science*** by ***David B. Resnik***)

Text 2

True Colours

Most definitions of nanotechnology focus on the control of matter, not light, but research in nanophotonics is thriving in areas as diverse as quantum optics and biological imaging.

The wavelength of visible light (~400—700 nm) is considerably longer than the upper limit of 100 nm or so that is generally used to define the nanoscale. This disparity — and the fact that the diffraction limit prevents light from being focused to dimensions of less than half a wavelength or so — is a challenge that must be overcome when we try to use light to, say, fabricate semiconductor structures or image objects with nanoscale features. Electron microscopes succeed where their optical counterparts fail by exploiting the very short de Broglie wavelengths of electrons to image objects with a resolution that far exceeds what is possible with light. Likewise, scanning probe microscopes (SPMs) rely on atomically sharp tips to image surfaces with atomic resolution, although lasers also play an integral part in SPMs.

However, if we look at the matter again, from the bottom up this time, we start to see the overlap between optics and nanotechnology. First, it is rather obvious that many materials emit and absorb photons at the level of individual atoms and molecules as electrons move up and down between different energy levels. Indeed, at the most fundamental level, all optical phenomena are due to interactions between photons and electrons. Second, there is not a simple relationship between size and wavelength: the size of an atom (or molecule) does not dictate the wavelengths of light that it can emit or absorb; rather, these wavelengths depend on the electronic structure of the atom, and emission and absorption can occur at many different wavelengths, all of them much longer than the size of the atom.

In the nanoworld, the size of a quantum dot or nanoparticle (and also its chemical composition) determines the energy level structure, which in turn determines the emission and absorption wavelengths — hence the phrase 'artificial atom'. For instance, a gold nanoparticle with a diameter of about 100 nm appears purple-pink and has an absorption peak at 575 nm, but the colour shifts to red for particles with diameters around 20 nm, and then to brown-yellow (with an absorption peak at 420 nm) when the diameter reaches about 1 nm.

It is clear that visible light goes hand-in-hand with nanostructured materials, and the fact that there are lots of non-optical methods for controlling matter on the nanoscale — and that the resulting nanostructures can have useful optical properties — is driving research into nanophotonics. Arto Nurmikko and colleagues describe the possibilities offered by combining organic and inorganic materials to produce nanocomposites with improved optical performance. In this case the effective absorption cross-section of semiconductor quantum dots is increased tenfold by the presence of a polymer. Teri Odom and co-workers show how interference lithography — an optical technique that uses ultraviolet light — can be combined with soft lithography (which is a sort of printing process) to produce plasmonic metamaterials that are patterned on a range of length scales from the nanoscale upwards. Surface plasmons — collective excitations of free electrons in a metal — play a central role in this work, and also in many areas of nanophotonics, including the SERS (surface enhanced Raman spectroscopy) technique that is widely used in analytical chemistry and biology.

Metamaterials and plasmonics are also the subject of intense research in physics, where phenomena such as negative refraction and subwavelength focusing are causing the textbooks to be rewritten and, at the same time, are opening up new possibilities for devices. Other areas of interest include nanowire lasers, combinations of photonic crystals and quantum dots, and re-runs of many of the classic experiments of quantum optics in artificial atoms. And elsewhere a variety of clever optical techniques with colourful names such as PALM and STORM are being exploited to look inside cells at the nanoscale. There would appear to be no limit on what nanophotonics might do.

(from ***Nature Nanotechnology, Vol. 2, No. 9, September 2007***)

Text 3
Preserving Internet

An archive of the Internet may prove to be a vital record for historians, businesses and governments

Manuscripts from the library of Alexandria in ancient Egypt disappeared in a fire. The early printed books decayed into unrecognizable shreds. Many of the oldest cinematic films were recycled for their silver content. Unfortunately, history may repeat itself in the evolution of the Internet— and its World Wide Web.

No one has tried to capture a comprehensive record of the text and images contained in the documents that appear on the Web. The history of print and film is a story of loss and partial reconstruction. But this scenario need not be repeated for the Web, which has increasingly evolved into a storehouse of valuable scientific, cultural and historical information.

The dropping costs of digital storage mean that a permanent record of the Web and the rest of the Internet can be preserved by a small group of technical professionals equipped with a modest complement of computer workstations and data storage devices. A year ago I and a few others set out to realize this vision as part of a venture known as the Internet Archive.

By the time this article is published, we will have taken a snapshot of all parts of the Web freely and technically accessible to us. This collection of data will measure perhaps as much as two trillion bytes (two terabytes) of data, ranging from text to video to audio recording. In comparison, the Library of Congress contains about 20 terabytes of text information. In the coming months, our computers and storage media will make records of other areas of the Internet, including the Gopher information system and the Usenet bulletin boards. The material gathered so far has already proved a useful resource to historians. In the future, it may provide the raw material for a carefully indexed, searchable library.

The logistics of taking a snapshot of the Web are relatively simple. Our Internet Archive operates with a staff of 10 people from offices located in a converted military base—the Presidio—in downtown San Francisco; it also runs an information-gathering computer in the San Diego Supercomputer Center at the University of California at San Diego.

The software on our computers "crawls" the Net—downloading documents, called pages, from one site after another. Once a page is captured, the software looks for cross references, or links, to other pages. It uses the Web's hyperlinks—addresses embedded within a document page—to move to other pages. The software then makes copies again and seeks additional links contained in the new pages. The crawler avoids downloading duplicate copies of pages by checking the identification names, called uniform resource locators (URLs), against a database. Programs such as Digital Equipment Corporation's AltaVista also employ crawler software for indexing Web sites.

What makes this experiment possible is the dropping cost of data storage. The price of a gigabyte (a billion bytes) of hard-disk space is $200, whereas tape storage using an automated mounting device costs $20 a gigabyte. We chose hard-disk storage for a small amount of data that users of the archive are likely to access frequently and a robotic device that mounts and reads tapes automatically for less used information. A disk drive accesses data in an average of 15 milliseconds, whereas tapes require four minutes. Frequently accessed information might be historical documents or a set of URLs no longer in use.

We plan to update the information gathered at least every few months. The first full record required nearly a year to compile. In future passes through the Web, we will be able to update only the information that has changed since our last perusal.

The text, graphics, audio clips and other data collected from the Web will never be comprehensive, because the crawler software cannot gain access to many of the hundreds of thousands of sites. Publishers restrict access to data or store documents in a format inaccessible to simple crawler programs. Still, the archive gives a feel of what the Web looks like during a given period of time even though it does not constitute a full record.

After gathering and storing the public contents of the Internet, what services will the archive provide? We possess the capability of supplying documents that are no longer available from the original publisher, an important function if the Web's hypertext system is to become a medium for scholarly publishing. Such a service could also prove worthwhile for business research. And the archival data might serve as a "copy of record" for the government or other institutions with publicly available documents. So, over time, the archive would come to resemble a digital library.

Keeping Missing Links

Historians have already found the material useful. David Allison of the Smithsonian Institution has tapped into the archive for a presidential election Web site exhibit at the museum, a project he compares to saving videotapes of early television campaign advertisements. Many of the links for these Web sites, such as those for Texas Senator Phil Gramm's campaign, have already disappeared from the Internet.

Creating an archive touches on an array of issues, from privacy to copyright. What if a college student created a Web page that had pictures of her then current boyfriend? What if she later wanted to "tear them up," so to speak, yet they lived on in the archive? Should she have the right to remove them? In contrast, should a public figure—a U.S. senator, for instance—be able to erase data posted from his or her college years? Does collecting information made available to the public violate the "fair use" provisions of the copyright law? The issues are not easily resolved.

To address these worries, we let authors exclude their works from the archive. We are also considering allowing researchers to obtain broad censuses of the archive data instead of individual documents—one could count the total number of references to pachyderms on the Web, for instance, but not look at a specific elephant home page. These measures, we hope, will suffice to allay immediate concerns about privacy and intellectual-property rights. Over time, the issues addressed in setting up the Internet Archive might help resolve the larger policy debates on intellectual property and privacy by testing concepts such as fair use on the Internet.

The Internet Archive complements other projects intended to ensure the longevity of information on the Internet. The Commission on Preservation and Access in Washington, D.C., researches how to ensure that data are not lost as the standard formats for digital storage media change over the years. In another effort, the Internet Engineering Task Force and other groups have labored on technical standards that give a unique identification name to digital documents. These uniform resource names (URNs), as they are called, could supplement the URLs that currently access Web documents. Giving a document a URN attempts to ensure that it can be traced after a link disappears, because estimates put the average lifetime for a URL at 44 days. The URN would be able to locate other URLs that still provided access to the desired documents.

Other, more limited attempts to archive parts of the Internet have also begun. DejaNews keeps a record of messages on the Usenet bulletin boards, and InReference archives Internet mailing lists. Both support themselves with revenue from advertisers, a possible funding source for the Internet Archive as well. Until now, I have funded the project with money I received from the sale of an Internet software and services company. Major computer companies have also donated equipment.

It will take many years before an infrastructure that assures Internet preservation becomes well established—and for questions involving intellectual-property issues to resolve themselves. For our part, we feel that it is important to proceed with the collection of the archival material because it can never be recovered in the future. And the opportunity to capture a record of the birth of a new medium will then be lost.

(from ***Scientific American*** by ***Brewster Kahle***)

Text 4
The Metamorphosis of Andrei Sakharov

The inventor of the Soviet hydrogen bomb
became an advocate of peace and human rights.
What led him to his fateful decision?

The cloud turned gray, quickly separated from the ground and swirled upward, shimmering with gleams of orange....The shock wave blasted my ears and struck a sharp blow to my entire body; then there was a prolonged, ominous rumble that slowly died away after thirty seconds or so.... The cloud, which now filled half the sky, turned a sinister blue-black color."

It was August 12, 1953, and Andrei Dmitrievich Sakharov had just become father of the Soviet hydrogen bomb. Along with a few officials, he donned a dustproof jumpsuit and drove into the blast range. The car stopped beside an eagle that was trying to get off the ground; its wings had been badly burned. "I have been told that thousands of birds are destroyed during every test," Sakharov was later to write in his memoirs. "They take wing at the flash, but then fall to earth, burned and blinded."

The innocent victims of nuclear testing were to become a deepening concern, and ultimately an obsession, for this extraordinary man. While he continued to design ever more efficient bombs, he also agonized over how many human lives the fallout from each blast would cost. Sakharov's many fruitless attempts to stop unnecessary tests at last led to his realizing how little control he had over the weapons he had created.

Numerous tales have been invented to account for Sakharov's transformation to an advocate for human rights. After his death in 1989, the Russian state archives released many secret documents relating to his life and work, which are now to be found in the Sakharov Archives in Moscow. These papers, as well as Sakharov's own writings, show that his metamorphosis derived directly from his involvement in the weapons project. For years, Sakharov genuinely believed that nuclear—and thermonuclear—weapons were vital to maintaining military parity with and preventing aggression by the U.S. His transformation came not from a newfound morality but from his rather oldfashioned one, coupled with his accumulating experience with weapons and in the politics of weaponry.

A Sugary Layered Roll

Sakharov was born in 1921 to a family of Moscow intelligentsia. His father was a teacher of physics and a writer of popular science books, as well as a humane and forthright man. After graduating from high school, Andrei enrolled in Moscow University in 1938. When war broke out with Germany, his weak heart prevented him from being drafted. Graduating with honors in 1942, he refused to go on to higher studies: he wanted to contribute to the war effort. Accordingly, he became an engineer in a military ammunition plant in Ulyanovsk, where he invented a magnetic device to test the cores of the bullets that were being manufactured.

At the factory he met Klavdia Vikhireva, whom he married at the age of 22. In those years he also dreamed up and solved some small problems in physics, which found their way through his father to Igor Tamm, the leading theoretical physicist at the P. N. Lebedev Physical Institute in Moscow. In early 1945 Sakharov was officially invited to Moscow to conduct graduate studies under Tamm's supervision.

One morning in August he saw in a newspaper that an atomic bomb had exploded over Hiroshima. He realized that "my fate and the fate of many others, perhaps of the entire world, had changed overnight."

Sakharov was clearly very able as a scientist and soon came up with a theory of sound propagation in a bubbly liquid, of importance in detecting submarines with sonar. He also calculated how fusion, the merging of two nuclei into one, might be catalyzed by a light, electronlike particle known as a muon. (Atoms that contain muons in place of electrons are much smaller and therefore would require less compression to be fused.)

Exhilarated by pure physics, he twice declined invitations from senior officials to join the Soviet atomic weapons project. An atomic bomb involves the fission of a heavy nucleus such as uranium 235 into two roughly equal parts, accompanied by the release of energy. But one day in 1948 Tamm announced that he and some selected associates, including Sakharov, had been assigned to investigate the possibility of a hydrogen bomb. This kind of bomb is based on the fusion of light nuclei, most commonly the two forms of hydrogen called deuterium and tritium, emitting greater amounts of energy than a fission bomb does.

Yakov Zel'dovich, a brilliant physicist who headed theoretical research for the nuclear weapons program, handed Tamm a tentative design for the hydrogen bomb. Fusion requires two positively charged nuclei to be brought close enough, despite their mutual repulsion, to touch; such conditions can arise only from the tremendous energy generated by a preceding fission reaction. The idea was to use fission to ignite fusion—otherwise known as a thermonuclear reaction— at one end of a tube of deuterium and somehow make the fusion propagate through the tube. This plan for a "superbomb," devised by American scientists, was given to Soviet intelligence authorities, most likely by physicist and spy Klaus Fuchs in 1945.

Sakharov turned out to be exceedingly adept at the combination of theoretical physics and engineering that was required in making a hydrogen bomb. Despite his junior status, he soon proposed a radically different design, called the *sloika,* or "layered roll": a spherical configuration with an atom bomb in the center, surrounded by shells of deuterium alternating with heavy elements such as natural uranium. The electrons released by the initial atomic explosion generated tremendous pressure within the uranium shell, forcing the fusion of deuterium. The Soviets called the process "sakharization"—literally, "sugaring" (the Russian *sakhar* translates to "sugar"). The fusion in turn released neutrons that enabled the fission of uranium.

The concept, enhanced by an idea from Vitaly Ginzburg—that lithium deuteride replace deuterium as a fuel— allowed the Soviet program to catch up with the American one. It was not until 1950 that American scientists realized that their superbomb design was a dud. But Stanislaw Ulam and Edward Teller of Los Alamos National Laboratory in New Mexico soon invented another design, and the thermonuclear arms race had taken off.

Although Sakharov was fascinated with the physics of fusion, his zeal in pursuing the bomb derived also from patriotism. He believed in concepts such as "strategic parity" and "nuclear deterrence," which suggested that nuclear war was impossible. His emotional investment in the project was immense: "The monstrous destructive force, the scale of our enterprise and the price paid for it by our poor, hungry, war-torn country ... all these things inflamed our sense of drama and inspired us to make a maximum effort so that the sacrifices—which we accepted as inevitable—would not be in vain. We were possessed by a true war psychology."

Yet when Sakharov received an invitation to join the Communist Party, he refused because of its past crimes. He had no choice, however, when in March 1950 he and Tamm were assigned exclusively to bomb work at a secret city where weapons designers lived and worked. Sakharov learned that this military facility had been built by prison labor in the old monastery town of Sarov, situated about 500 kilometers from Moscow. The entire city was surrounded by rows of barbed wire and erased from all maps. It was known to insiders by various code names, at the time Arzamas—16.

In a Secret City

Zel'dovich was already at Arzamas—16. The physicists spent much of the day ironing out details of bomb design. Nevertheless, Sakharov found time to conceive an idea for confining a plasma, gas so hot that electrons have been stripped from the atoms, leaving bare nuclei. The plasma would destroy any material walls but could be confined and even induced to fuse by means of magnetic fields. This principle, the basis of the tokamak reactor, is still the most promising design for producing energy from sustained fusion. ("Tokamak" is derived from the Russian phrase for a doughnut-shaped chamber with a magnetic coil.)

In November 1952 the U.S. had detonated a thermonuclear device. And by August 1953 Soviet scientists were ready to test the *sloika.* At the last minute, however, Viktor Gavrilov, a physicist trained as a meteorologist, pointed out that the radioactive fallout from the explosion would spread far beyond the test site and affect neighboring populations. Somehow no one had thought of this problem. Using an American manual on the effects of test explosions, the physicists quickly worked out the fallout pattern and realized that thousands of people would have to be moved. The recommendation was followed (although, as one official informed an anxious Sakharov, such maneuvers typically cause 20 or 30 deaths).

The *sloika* was successfully tested, yielding an energy about 20 times that of the Hiroshima bomb. In a few months Sakharov was elected a member of the Soviet Academy of Sciences— at 32 its youngest physicist ever. He also received the Stalin Prize and was decorated with the title Hero of Socialist Labor. The Soviet leadership had great hopes for Sakharov: not only was he brilliant, he was also non-Jewish (unlike Zel'dovich and Ginzburg) and politically clean (unlike Tamm).

The *sloika* was, however, limited in scope—its yield could not be increased indefinitely—and soon Sakharov and Zel'dovich came up with a new design. The idea was to use the radiation (photons) generated by an initial atomic explosion to compress a tube, thereby igniting fusion within it. The design, similar to the Ulam-Teller one, had potentially unlimited yield because the length of the tube could be increased as required.

Life at Arzamas—16 was unusual in more than one way. The researchers discussed politics quite freely. Moreover, they had access to Western journals, including the *Bulletin of the Atomic Scientists,* which concerned itself mainly with the social dimensions of nuclear energy and demonstrated how scientists on the other side of the Iron Curtain sought to influence public affairs. One inspiring figure was Leo Szilard, who had discovered the "chain reaction" that makes atomic bombs possible but who turned into a vocal critic of nuclear weapons. Sakharov was also aware of the political writings of Albert Einstein, Niels Bohr and Albert Schweitzer, who doubtless influenced him as well.

A memo written by the administrative director of Arzamas—16 in 1955 noted that although Sakharov was an able scientist, he had substantial defects in the realm of politics. He had, for instance, declined an offer to be elected to the Council of People's Deputies, a legislative body at Arzamas. The "defects" were to get worse.

In November 1955 the Soviets tested the unlimited hydrogen bomb. This time the shock wave from the blast collapsed a distant trench, killing a soldier, and crumbled a building, killing a toddler. These events weighed heavily on Sakharov. When asked to propose a toast at the celebratory banquet that night, he announced, "May all our devices explode as successfully as today's, but always over test sites and never over cities." Marshal Mitrofan Nedelin replied with an obscene joke, whose point was that scientists should just make the bombs and let military men decide where they should explode. It was designed to put Sakharov in his place.

As variations of the basic thermonuclear devices continued to be tested, Sakharov became increasingly concerned about the unidentifiable victims of each blast. He taught himself enough genetics to calculate how many persons worldwide would be affected by cancers and other mutations as a result of nuclear testing.

In 1957 the U.S. press reported the development of a "clean bomb," a fusion bomb that used almost no fissionable material and seemingly produced no radioactive fallout. Sakharov found, however, on the basis of available biological data that a one-megaton (equivalent to a million tons of TNT) clean bomb would result in 6,600 deaths worldwide over a period of 8,000 years because of the proliferation of radioactive carbon 14 (produced when neutrons from the explosion interacted with atmospheric nitrogen). He published his results in 1958 in the Soviet journal *Atomic Energy,* concluding that the atmospheric testing of any hydrogen bomb—"clean" or not—is harmful to humans.

The Chips Fly

Soviet premier Nikita S. Khrushchev himself endorsed the publication of this article. It suited his purposes: in March of 1958 he had suddenly announced a unilateral cessation of nuclear tests. Sakharov was not, however, playing political games. His figures revealed, as he saw it, that "to the suffering and death already existing in the world there would be added hundreds of thousands of additional victims, including people living in neutral countries as well as in future generations." He was also troubled that "this crime is committed with complete impunity, since it is impossible to prove that a particular death was caused by radiation."

In the same year Teller published a book, *Our Nuclear Future,* laying out the majority view of both American and Soviet hydrogen-bomb experts—who did not share Sakharov's concern. Teller estimated the radiation dose from testing as roughly 100th of that from other sources (such as cosmic rays and medical x-ray examinations). He also noted that radiation from testing reduced life expectancy by about two days, whereas a pack of cigarettes a day or a sedentary job reduced it by 1,000 times more. "It has been claimed," he concluded, "that it is wrong to endanger any human life. Is it not more realistic and in fact more in keeping with the ideals of human-itarianism to strive toward a better life for all mankind?" To Sakharov, that statement sounded a lot like the Soviet slogan "when you chop wood, chips fly." He felt personally responsible for any deaths from the fallout of testing.

Meanwhile the U.S. and Britain continued testing, and after six months, a furious Khrushchev ordered that testing be resumed. Deeply concerned—because of the deaths he was convinced would ensue—Sakharov persuaded Igor Kurcha-tov, the scientific head of the atomic project, to visit Khrushchev and explain how computers, limited experiments and other kinds of modeling could make testing unnecessary. Khrushchev did not agree, nor did he welcome the advice. Sakharov repeated his efforts in 1961, when after a de facto moratorium the premier again announced new tests. Khrushchev angrily told him to leave politics to those who understood it.

In 1962 Sakharov learned that tests of two very similar designs of hydrogen bombs were going to be carried out. He tried his best to stop the duplicate test. He pulled all the strings he could, pleaded with Khrushchev, enraged his colleagues and bosses—all to no avail. When the second bomb was exploded, he put his face down on his desk and wept.

To his surprise, however, he was soon able to solve the larger problem. In 1963 his suggestion of a ban on the most harmful—atmospheric—testing was well received by the authorities and resulted in the signing of the Limited Test Ban Treaty in Moscow that same year. Sakharov was justifiably proud of his contribution. After atmospheric testing was stopped, its harmful effects ceased to worry him.

His concerns, however, had induced him to take two major steps: from science to the sphere of morals and finally to politics. The bomb program did not really need him anymore, but Sakharov was starting to feel that his presence would be essential to his retaining influence over the politics of weapons.

In these years Sakharov also found time to return to his first love, pure science. A problem that continues to plague scientists is the excess of matter over antimatter in the universe. He laid out the conditions that could allow such an imbalance to arise, his most important contribution in theoretical physics. Vladimir Kartsev, a young physicist who asked Sakharov to write a preface for his popular science book, recalls that he looked very happy, full of creative energy and ideas about physics.

In 1966 Sakharov signed a collective letter to Soviet leaders against an ominous tendency to rehabilitate Stalin. Most tellingly, in December of that year he accepted an anonymous invitation to participate in a silent demonstration in support of human rights. But when he wrote to the Soviet government in support of dissidents, his salary was slashed, and he lost one of his administrative positions. The events, however, put him in increasing and ultimately fateful contact with activists in Moscow.

Sakharov's worldview was becoming increasingly radical, and it demanded an outlet. In July 1967 he sent via secret mail a letter to the government. He argued that a moratorium proposed by the U.S. on antiballistic-missile systems was to the benefit of the Soviet Union, because an arms race in this new technology would make a nuclear war much more probable. This nine-page memo, with two technical appendices, is now to be found in the Sakharov Archives. Among other things, the letter sought permission for publishing an accompanying 10-page manuscript in a Soviet newspaper to help "American scientists to curb their hawks." The article's style shows that Sakharov still considered himself a technical expert devoted to the "essential interests of Soviet policy."

Nevertheless, permission was refused. The rejection was yet another confirmation to the physicist that those who mattered were oblivious to the danger to which they were subjecting the world.

Early in 1968 Sakharov started working on a massive essay, entitled "Reflections on Progress, Peaceful Coexistence and Intellectual Freedom." He made no effort to hide this manuscript—the secretary at Arzamas—16 retyped it, automatically handing a copy to the KGB. (This carbon copy is now in the president's archives in Moscow.) The article described the grave danger of thermonuclear war and went on to discuss other issues, such as pollution of the environment, overpopulation and the cold war. It argued that intellectual freedom—and more generally, human rights—is the only true basis for international security and called for the convergence of socialism and capitalism toward a system that combined the best aspects of both.

The Die Is Cast

By the end of April Sakharov had released to the samizdat, or underground press, this radical essay. In June he sent it to Leonid I. Brezhnev (who had already seen it, courtesy of the KGB), and in July its contents were described by the British Broadcasting Corporation and published in the New York Times. Sakharov recalled listening to the BBC broadcast with profound satisfaction: "The die was cast."

Sakharov was ordered to stay in Moscow and restricted from visiting Arzamas—16. He had spent 18 years of his life in the secret city. He was not, however, fired from the bomb project until the next year: deciding the fate of a Hero of Socialist Labor three times over, who, moreover, knows the nation's most sensitive secrets, can be tricky. Shortly after, his wife died of cancer, leaving him with three children, the youngest aged only 11. Grief-stricken, Sakharov donated all his savings to a cancer hospital and the Soviet Red Cross.

For Sakharov, a lifetime had ended, and another was about to begin. He had 20 years of life left. He was to meet Elena Bonner, the friend and love of his life, to be awarded the Nobel Prize in Peace in 1975, to pass seven years in exile at Gorki and, unbelievably, to spend his last seven months as an elected member of the Soviet parliament.

Perhaps the best person to explain Sakharov is Sakharov. "If I feel myself free," he once mused, "it is specifically because I am guided to action by my concrete moral evaluation, and I don't think I am bound by anything else." He always did exactly what he believed in, led by a clear, unwavering inner morality. In the 1970s one of his colleagues, Vladimir Ritus, asked him why he had taken the steps he did, thereby putting himself in such grave danger. Sakharov's reply was, "If not me, who?" It was not that he considered himself chosen in any way. He simply knew that fate, and his work on the hydrogen bomb, had uniquely placed him to make choices. And he felt compelled to make them.

(from ***Scientific American*** by ***Gennady Gorelik*****)**

Text 5

The New Age of Wireless

Technologies that turn broadcasting "bugs" into features that open radio spectrum to novel uses will be a boon for consumers

Before 1968 no one in the U.S. could connect anything to the AT&T telephone system unless Western Electric, AT&T's manufacturing arm, provided it. The Federal Communication Commission's landmark "Carterfone" decision erased that policy and ignited an explosion of communications innovations, including faxes, fast modems, PBXs, burglar alarms, answering machines and phone mobility. Although AT&T no longer owned the whole pie, the slice that it kept became part of a far larger industry.

That same explosive growth is beginning in wireless mobile. Microprocessors are now so fast that they can synthesize and handle directly both sound-and-image data and radio signals. Meanwhile the emergence of agile, end-to-end networks is creating unprecedented opportunities in what for 100 years have been staid communications structures. No matter what you think of the wireless devices you have today, you ain't seen nothing yet. Radio is just getting interesting.

Mobile phones will become programs loaded into whatever physical "engine" is convenient or perhaps into many at once. Instead of a "family" phone service plan, you might someday have a "molecular" account that makes accessible any radio-accessible thing or data that you choose. You could decide whether to put your dog's view of the world online, whether to monitor your blood sugar level from afar or whether to talk to someone through your eyeglasses. Broadband will become the province of a person rather than a wire to a home.

The broadcast radio spectrum, which has typically been regarded as limited and interference-plagued, will become open and accessible everywhere by anything. Of course, some broadcasters and registered networks will still rely on keeping certain airwaves empty and silent, and they will be used by legacy devices that we are loath to discard, such as cell phones and AM radios. But grander possibilities await radios that cooperatively sense one another's proximity, use one another to economize on radiated energy and battery life, and turn ever more remote regions of the spectrum into fertile territory for personal use.

Disparate demonstrations paint this new picture of wireless communications. For example, the multipath phenomenon, in which buildings and walls bounce multiple copies of a signal to a receiver, was once just the source of ghosts in television pictures. But in essence, those reflectors are also sending additional energy that would have been lost. Thus, they can also be regarded as independent transmitters. Multiple-input, multiple-output radios built to take advantage of that effect can improve communications.

Other work has built ad hoc networks of mobile radios that at each moment dynamically select for intermediate relays requiring the least energetic connections. One radio might momentarily be in a dead spot, but another will be in a hot spot for passing on a communication. As radios become cheaper than their batteries, adding transmitters becomes more efficient than adding power to make reliable systems. Even more important, the dichotomy between broadcasting and point-to-point connectivity disappears; the two work together by design.

A new discipline called network coding uses broadcasting to save bandwidth by coding and then relaying bits for more than one receiver. Decoding involves combining several transmissions, including your own. Using this principle, we have built a demonstration telephone system in which the default is that everyone can hear anyone—a wireless party line. We call it "push to listen" because you decide how loudly and in which ear you would like to place any speaker's voice. Stock traders, emergency workers and perhaps conference callers might find it particularly useful.

The broadcast nature of wireless is thus a feature rather than a bug: it can save energy, increase efficiency and nurture new ideas. And spectrum need not be regarded as a fixed and finite resource to be divided among users. Instead it can support more communication as more communicators use it. The theory has been in place for a few years, but now it is becoming real. The pie will soon start to grow, and there will be enough slices for all.

(from ***Scientific American*** by ***Andrew Lippman***)

Appendix I

List of Sciences

Name of Science	Definition
• acarology	⇒ study of mites
• accidence	⇒ grammar book; science of inflections in grammar
• aceology	⇒ therapeutics
• acology	⇒ study of medical remedies
• acoustics	⇒ science of sound
• adenology	⇒ study of glands
• aedoeology	⇒ science of generative organs
• aerobiology	⇒ study of airborne organisms
• aerodonetics	⇒ science or study of gliding
• aerodynamics	⇒ dynamics of gases; science of movement in a flow of air or gas
• aerolithology	⇒ study of aerolites; meteorites
• aerology	⇒ study of the atmosphere
• aeronautics	⇒ study of navigation through air or space
• aerophilately	⇒ collecting of air-mail stamps
• aerostatics	⇒ science of air pressure; art of ballooning
• agonistics	⇒ art and theory of prize-fighting
• agriology	⇒ the comparative study of primitive peoples
• agrobiology	⇒ study of plant nutrition; soil yields
• agrology	⇒ study of agricultural soils
• agronomics	⇒ study of productivity of land
• agrostology	⇒ science or study of grasses
• alethiology	⇒ study of truth
• algedonics	⇒ science of pleasure and pain
• algology	⇒ study of algae
• anaesthesiology	⇒ study of anaesthetics
• anaglyptics	⇒ art of carving in bas-relief
• anagraphy	⇒ art of constructing catalogues
• anatomy	⇒ study of the structure of the body

- andragogy ⇒ science of teaching adults
- anemology ⇒ study of winds
- angelology ⇒ study of angels
- angiology ⇒ study of blood flow and lymphatic system
- anthropobiology ⇒ study of human biology
- anthropology ⇒ study of human cultures
- aphnology ⇒ science of wealth
- apiology ⇒ study of bees
- arachnology ⇒ study of spiders
- archaeology ⇒ study of human material remains
- archelogy ⇒ the study of first principles
- archology ⇒ science of the origins of government
- arctophily ⇒ study of teddy bears
- areology ⇒ study of Mars
- aretaics ⇒ the science of virtue
- aristology ⇒ the science or art of dining
- arthrology ⇒ study of joints
- astacology ⇒ the science of crayfish
- astheniology ⇒ study of diseases of weakening and aging
- astrogeology ⇒ study of extraterrestrial geology
- astrology ⇒ study of influence of stars on people
- astrometeorology ⇒ study of effect of stars on climate
- astronomy ⇒ study of celestial bodies
- astrophysics ⇒ study of behaviour of interstellar matter
- astroseismology ⇒ study of star oscillations
- atmology ⇒ the science of aqueous vapour
- audiology ⇒ study of hearing
- autecology ⇒ study of ecology of one species
- autology ⇒ scientific study of oneself
- auxology ⇒ science of growth
- avionics ⇒ the science of electronic devices for aircraft
- axiology ⇒ the science of the ultimate nature of values
- bacteriology ⇒ study of bacteria

- balneology ⇒ the science of the therapeutic use of baths
- barodynamics ⇒ science of the support and mechanics of bridges
- barology ⇒ study of gravitation
- batology ⇒ the study of brambles
- bibliology ⇒ study of books
- bibliotics ⇒ study of documents to determine authenticity
- bioecology ⇒ study of interaction of life in the environment
- biology ⇒ study of life
- biometrics ⇒ study of biological measurement
- bionomics ⇒ study of organisms interacting in their environments
- botany ⇒ study of plants
- bromatology ⇒ study of food
- brontology ⇒ scientific study of thunder
- bryology ⇒ the study of mosses and liverworts
- cacogenics ⇒ study of racial degeneration
- caliology ⇒ study of bird's nests
- calorifics ⇒ study of heat
- cambistry ⇒ science of international exchange
- campanology ⇒ the art of bell ringing
- carcinology ⇒ study of crabs and other crustaceans
- cardiology ⇒ study of the heart
- caricology ⇒ study of sedges
- carpology ⇒ study of fruit
- cartography ⇒ the science of making maps and globes
- cartophily ⇒ the hobby of collecting cigarette cards
- castrametation ⇒ the art of designing a camp
- catacoustics ⇒ science of echoes or reflected sounds
- catalactics ⇒ science of commercial exchange
- catechectics ⇒ the art of teaching by question and answer
- cetology ⇒ study of whales and dolphins

• chalcography	⇒ the art of engraving on copper or brass
• chalcotriptics	⇒ art of taking rubbings from ornamental brasses
• chaology	⇒ the study of chaos or chaos theory
• characterology	⇒ study of development of character
• chemistry	⇒ study of properties of substances
• chirocosmetics	⇒ beautifying the hands; art of manicure
• chirography	⇒ study of handwriting or penmanship
• chirology	⇒ study of the hands
• chiropody	⇒ medical science of feet
• chorology	⇒ science of the geographic description of anything
• chrematistics	⇒ the study of wealth; political economy
• chronobiology	⇒ study of biological rhythms
• chrysology	⇒ study of precious metals
• ciselure	⇒ the art of chasing metal
• climatology	⇒ study of climate
• clinology	⇒ study of aging or individual decline after maturity
• codicology	⇒ study of manuscripts
• coleopterology	⇒ study of beetles and weevils
• cometology	⇒ study of comets
• conchology	⇒ study of shells
• coprology	⇒ study of pornography
• cosmetology	⇒ study of cosmetics
• cosmology	⇒ study of the universe
• craniology	⇒ study of the skull
• criminology	⇒ study of crime; criminals
• cryobiology	⇒ study of life under cold conditions
• cryptology	⇒ study of codes
• cryptozoology	⇒ study of animals for whose existence there is no conclusive proof
• ctetology	⇒ study of the inheritance of acquired characteristics

- cynology ⇒ scientific study of dogs
- cytology ⇒ study of living cells
- dactyliology ⇒ study of rings
- dactylography ⇒ the study of fingerprints
- dactylology ⇒ study of sign language
- deltiology ⇒ the collection and study of picture postcards
- demology ⇒ study of human behaviour
- demonology ⇒ study of demons
- dendrochronology ⇒ study of tree rings
- dendrology ⇒ study of trees
- deontology ⇒ the theory or study of moral obligation
- dermatoglyphics ⇒ the study of skin patterns and fingerprints
- dermatology ⇒ study of skin
- desmology ⇒ study of ligaments
- diabology ⇒ study of devils
- diagraphics ⇒ art of making diagrams or drawings
- dialectology ⇒ study of dialects
- dioptrics ⇒ study of light refraction
- diplomatics ⇒ science of deciphering ancient writings and texts
- diplomatology ⇒ study of diplomats
- docimology ⇒ the art of assaying
- dosiology ⇒ the study of doses
- dramaturgy ⇒ art of producing and staging dramatic works
- dysgenics ⇒ the study of racial degeneration
- dysteleology ⇒ study of purposeless organs
- ecclesiology ⇒ study of church affairs
- eccrinology ⇒ study of excretion
- ecology ⇒ study of environment
- economics ⇒ study of material wealth
- edaphology ⇒ study of soils
- Egyptology ⇒ study of ancient Egypt
- ekistics ⇒ study of human settlement

electrochemistry	⇒ study of relations between electricity and chemicals
electrology	⇒ study of electricity
electrostatics	⇒ study of static electricity
embryology	⇒ study of embryos
emetology	⇒ study of vomiting
emmenology	⇒ the study of menstruation
endemiology	⇒ study of local diseases
endocrinology	⇒ study of glands
enigmatology	⇒ study of enigmas
entomology	⇒ study of insects
entozoology	⇒ study of parasites that live inside larger organisms
enzymology	⇒ study of enzymes
ephebiatrics	⇒ branch of medicine dealing with adolescence
epidemiology	⇒ study of diseases; epidemics
epileptology	⇒ study of epilepsy
epistemology	⇒ study of grounds of knowledge
eremology	⇒ study of deserts
ergology	⇒ study of effects of work on humans
ergonomics	⇒ study of people at work
escapology	⇒ study of freeing oneself from constraints
eschatology	⇒ study of death; final matters
ethnogeny	⇒ study of origins of races or ethnic groups
ethnology	⇒ study of cultures
ethnomethodology	⇒ study of everyday communication
ethnomusicology	⇒ study of comparative musical systems
ethology	⇒ study of natural or biological character
ethonomics	⇒ study of economic and ethical principles of a society
etiology	⇒ the science of causes; especially of disease
etymology	⇒ study of origins of words
euthenics	⇒ science concerned with improving living

	conditions
exobiology	⇒ study of extraterrestrial life
floristry	⇒ the art of cultivating and selling flowers
fluviology	⇒ study of watercourses
folkloristics	⇒ study of folklore and fables
futurology	⇒ study of future
garbology	⇒ study of garbage
gastroenterology	⇒ study of stomach; intestines
gastronomy	⇒ study of fine dining
gemmology	⇒ study of gems and jewels
genealogy	⇒ study of descent of families
genesiology	⇒ study of reproduction and heredity
genethlialogy	⇒ the art of casting horoscopes
geochemistry	⇒ study of chemistry of the earth's crust
geochronology	⇒ study of measuring geological time
geogeny	⇒ science of the formation of the earth's crust
geogony	⇒ study of formation of the earth
geography	⇒ study of surface of the earth and its inhabitants
geology	⇒ study of earth's crust
geomorphogeny	⇒ study of the origins of land forms
geoponics	⇒ study of agriculture
geotechnics	⇒ study of increasing habitability of the earth
geratology	⇒ study of decadence and decay
gerocomy	⇒ study of old age
gerontology	⇒ study of the elderly; aging
gigantology	⇒ study of giants
glaciology	⇒ study of ice ages and glaciation
glossology	⇒ study of language; study of the tongue
glyptography	⇒ the art of engraving on gems
glyptology	⇒ study of gem engravings
gnomonics	⇒ the art of measuring time using sundials
gnosiology	⇒ study of knowledge; philosophy of knowledge

gnotobiology	⇒ study of life in germ-free conditions
graminology	⇒ study of grasses
grammatology	⇒ study of systems of writing
graphemics	⇒ study of systems of representing speech in writing
graphology	⇒ study of handwriting
gromatics	⇒ science of surveying
gynaecology	⇒ study of women’s physiology
gyrostatics	⇒ the study of rotating bodies
haemataulics	⇒ study of movement of blood through blood vessels
hagiology	⇒ study of saints
halieutics	⇒ study of fishing
hamartiology	⇒ study of sin
harmonics	⇒ study of musical acoustics
hedonics	⇒ part of ethics or psychology dealing with pleasure
helcology	⇒ study of ulcers
heliology	⇒ science of the sun
helioseismology	⇒ study of sun's interior by observing its surface oscillations
helminthology	⇒ study of worms
hematology	⇒ study of blood
heortology	⇒ study of religious feasts
hepatology	⇒ study of liver
heraldry	⇒ study of coats of arms
heresiology	⇒ study of heresies
herpetology	⇒ study of reptiles and amphibians
hierology	⇒ science of sacred matters
hippiatrics	⇒ study of diseases of horses
hippology	⇒ the study of horses
histology	⇒ study of the tissues of organisms
histopathology	⇒ study of changes in tissue due to disease
historiography	⇒ study of writing history

• historiology	⇒ study of history
• homiletics	⇒ the art of preaching
• hoplology	⇒ the study of weapons
• horography	⇒ art of constructing sundials or clocks
• horology	⇒ science of time measurement
• horticulture	⇒ study of gardening
• hydrobiology	⇒ study of aquatic organisms
• hydrodynamics	⇒ study of movement in liquids
• hydrogeology	⇒ study of ground water
• hydrography	⇒ study of investigating bodies of water
• hydrokinetics	⇒ study of motion of fluids
• hydrology	⇒ study of water resources
• hydrometeorology	⇒ study of atmospheric moisture
• hydropathy	⇒ study of treating diseases with water
• hyetology	⇒ science of rainfall
• hygiastics	⇒ science of health and hygiene
• hygienics	⇒ study of sanitation; health
• hygiology	⇒ hygienics; study of cleanliness
• hygrology	⇒ study of humidity
• hygrometry	⇒ science of humidity
• hymnography	⇒ study of writing hymns
• hymnology	⇒ study of hymns
• hypnology	⇒ study of sleep; study of hypnosis
• hypsography	⇒ science of measuring heights
• iamatology	⇒ study of remedies
• iatrology	⇒ treatise or text on medical topics; study of medicine
• iatromathematics	⇒ archaic practice of medicine in conjunction with astrology
• ichnography	⇒ art of drawing ground plans; a ground plan
• ichnology	⇒ science of fossilized footprints
• ichthyology	⇒ study of fish
• iconography	⇒ study of drawing symbols
• iconology	⇒ study of icons; symbols

ideogeny	⇒ study of origins of ideas
ideology	⇒ science of ideas; system of ideas used to justify behaviour
idiomology	⇒ study of idiom, jargon or dialect
idiopsychology	⇒ psychology of one's own mind
immunogenetics	⇒ study of genetic characteristics of immunity
immunology	⇒ study of immunity
immunopathology	⇒ study of immunity to disease
insectology	⇒ study of insects
irenology	⇒ the study of peace
iridology	⇒ study of the iris; diagnosis of disease based on the iris of the eye
kalology	⇒ study of beauty
karyology	⇒ study of cell nuclei
kidology	⇒ study of kidding
kinematics	⇒ study of motion
kinesics	⇒ study of gestural communication
kinesiology	⇒ study of human movement and posture
kinetics	⇒ study of forces producing or changing motion
koniology	⇒ study of atmospheric pollutants and dust
ktenology	⇒ science of putting people to death
kymatology	⇒ study of wave motion
labeorphily	⇒ collection and study of beer bottle labels
larithmics	⇒ study of population statistics
laryngology	⇒ study of larynx
lepidopterology	⇒ study of butterflies and moths
leprology	⇒ study of leprosy
lexicology	⇒ study of words and their meanings
lexigraphy	⇒ art of definition of words
lichenology	⇒ study of lichens
limacology	⇒ study of slugs
limnobiology	⇒ study of freshwater ecosystems
limnology	⇒ study of bodies of fresh water

• linguistics	⇒ study of language
• lithology	⇒ study of rocks
• liturgiology	⇒ study of liturgical forms and church rituals
• loimology	⇒ study of plagues and epidemics
• loxodromy	⇒ study of sailing along rhumb-lines
• magirics	⇒ art of cookery
• magnanerie	⇒ art of raising silkworms
• magnetics	⇒ study of magnetism
• malacology	⇒ study of molluscs
• malariology	⇒ study of malaria
• mammalogy	⇒ study of mammals
• manиge	⇒ the art of horsemanship
• Mariology	⇒ study of the Virgin Mary
• martyrology	⇒ study of martyrs
• mastology	⇒ study of mammals
• mathematics	⇒ study of magnitude, number, and forms
• mazology	⇒ mammalogy; study of mammals
• mechanics	⇒ study of action of force on bodies
• meconology	⇒ study of or treatise concerning opium
• melittology	⇒ study of bees
• mereology	⇒ study of part-whole relationships
• mesology	⇒ ecology
• metallogeny	⇒ study of the origin and distribution of metal deposits
• metallography	⇒ study of the structure and constitution of metals
• metallurgy	⇒ study of alloying and treating metals
• metaphysics	⇒ study of principles of nature and thought
• metapolitics	⇒ study of politics in theory or abstract
• metapsychology	⇒ study of nature of the mind
• meteoritics	⇒ the study of meteors
• meteorology	⇒ study of weather
• metrics	⇒ study of versification
• metrology	⇒ science of weights and measures

microanatomy	⇒ study of microscopic tissues
microbiology	⇒ study of microscopic organisms
microclimatology	⇒ study of local climates
micrology	⇒ study or discussion of trivialities
micropalaeontology	⇒ study of microscopic fossils
microphytology	⇒ study of very small plant life
microscopy	⇒ study of minute objects
mineralogy	⇒ study of minerals
molinology	⇒ study of mills and milling
momilogy	⇒ study of mummies
morphology	⇒ study of forms and the development of structures
muscology	⇒ the study of mosses
museology	⇒ the study of museums
musicology	⇒ study of music
mycology	⇒ study of funguses
myology	⇒ study of muscles
myrmecology	⇒ study of ants
mythology	⇒ study of myths; fables; tales
naology	⇒ study of church or temple architecture
nasology	⇒ study of the nose
nautics	⇒ art of navigation
nematology	⇒ the study of nematodes
neonatology	⇒ study of newborn babies
neossology	⇒ study of nestling birds
nephology	⇒ study of clouds
nephrology	⇒ study of the kidneys
neurobiology	⇒ study of anatomy of the nervous system
neurology	⇒ study of nervous system
neuropsychology	⇒ study of relation between brain and behaviour
neurypnology	⇒ study of hypnotism
neutrosophy	⇒ study of the origin and nature of philosophical neutralities

- nidology ⇒ study of nests
- nomology ⇒ the science of the laws; especially of the mind
- noology ⇒ science of the intellect
- nosology ⇒ study of diseases
- nostology ⇒ study of senility
- notaphily ⇒ collecting of bank-notes and cheques
- numerology ⇒ study of numbers
- numismatics ⇒ study of coins
- nymphology ⇒ study of nymphs
- obstetrics ⇒ study of midwifery
- oceanography ⇒ study of oceans
- oceanology ⇒ study of oceans
- odology ⇒ science of the hypothetical mystical force of od
- odontology ⇒ study of teeth
- oenology ⇒ study of wines
- oikology ⇒ science of housekeeping
- olfactology ⇒ study of the sense of smell
- ombrology ⇒ study of rain
- oncology ⇒ study of tumours
- oneirology ⇒ study of dreams
- onomasiology ⇒ study of nomenclature
- onomastics ⇒ study of proper names
- ontology ⇒ science of pure being; the nature of things
- oology ⇒ study of eggs
- ophiology ⇒ study of snakes
- ophthalmology ⇒ study of eye diseases
- optics ⇒ study of light
- optology ⇒ study of sight
- optometry ⇒ science of examining the eyes
- orchidology ⇒ study of orchids
- ornithology ⇒ study of birds
- orology ⇒ study of mountains

• orthoepy	⇒ study of correct pronunciation
• orthography	⇒ study of spelling
• orthopterology	⇒ study of cockroaches
• oryctology	⇒ mineralogy or paleontology
• osmics	⇒ scientific study of smells
• osmology	⇒ study of smells and olfactory processes
• osphresiology	⇒ study of the sense of smell
• osteology	⇒ study of bones
• otology	⇒ study of the ear
• otorhinolaryngology	⇒ study of ear, nose and throat
• paedology	⇒ study of children
• paedotrophy	⇒ art of rearing children
• paidonosology	⇒ study of children's diseases; pediatrics
• palaeoanthropology	⇒ study of early humans
• palaeobiology	⇒ study of fossil plants and animals
• palaeoclimatology	⇒ study of ancient climates
• palaeolimnology	⇒ study of ancient fish
• palaeolimnology	⇒ study of ancient lakes
• palaeontology	⇒ study of fossils
• palaeopedology	⇒ study of early soils
• paleobotany	⇒ study of ancient plants
• paleo-osteology	⇒ study of ancient bones
• palynology	⇒ study of pollen
• papyrology	⇒ study of paper
• parapsychology	⇒ study of unexplained mental phenomena
• parasitology	⇒ study of parasites
• paroemiology	⇒ study of proverbs
• parthenology	⇒ study of virgins
• pataphysics	⇒ the science of imaginary solutions
• pathology	⇒ study of disease
• patrology	⇒ study of early Christianity
• pedagogics	⇒ study of teaching
• pedology	⇒ study of soils

• pelology	⇒ study of mud
• penology	⇒ study of crime and punishment
• periodontics	⇒ study of gums
• peristerophily	⇒ pigeon-collecting
• pestology	⇒ science of pests
• petrology	⇒ study of rocks
• pharmacognosy	⇒ study of drugs of animal and plant origin
• pharmacology	⇒ study of drugs
• pharology	⇒ study of lighthouses
• pharyngology	⇒ study of the throat
• phenology	⇒ study of organisms as affected by climate
• phenomenology	⇒ study of phenomena
• philately	⇒ study of postage stamps
• philematology	⇒ the act or study of kissing
• phillumeny	⇒ collecting of matchbox labels
• philology	⇒ study of ancient texts; historical linguistics
• philosophy	⇒ science of knowledge or wisdom
• phoniatrics	⇒ study and correction of speech defects
• phonology	⇒ study of speech sounds
• photobiology	⇒ study of effects of light on organisms
• phraseology	⇒ study of phrases
• phrenology	⇒ study of bumps on the head
• phycology	⇒ study of algae and seaweeds
• physics	⇒ study of properties of matter and energy
• physiology	⇒ study of processes of life
• phytology	⇒ study of plants; botany
• piscatology	⇒ study of fishes
• pisteology	⇒ science or study of faith
• planetology	⇒ study of planets
• plutology	⇒ political economy; study of wealth
• pneumatics	⇒ study of mechanics of gases
• podiatry	⇒ study and treatment of disorders of the foot; chiropody
• podology	⇒ study of the feet

• polemology	⇒ study of war
• pomology	⇒ study of fruit-growing
• posology	⇒ science of quantity or dosage
• potamology	⇒ study of rivers
• praxeology	⇒ study of practical or efficient activity; science of efficient action
• primatology	⇒ study of primates
• proctology	⇒ study of rectum
• prosody	⇒ study of versification
• protistology	⇒ study of protists
• proxemics	⇒ study of man’s need for personal space
• psalligraphy	⇒ the art of paper-cutting to make pictures
• psephology	⇒ study of election results and voting trends
• pseudology	⇒ art or science of lying
• pseudoptics	⇒ study of optical illusions
• psychobiology	⇒ study of biology of the mind
• psychogenetics	⇒ study of internal or mental states
• psychognosy	⇒ study of mentality, personality or character
• psychology	⇒ study of mind
• psychopathology	⇒ study of mental illness
• psychophysics	⇒ study of link between mental and physical processes
• pteridology	⇒ study of ferns
• pterylology	⇒ study of distribution of feathers on birds
• pyretology	⇒ study of fevers
• pyrgology	⇒ study of towers
• pyroballogy	⇒ study of artillery
• pyrography	⇒ study of woodburning
• quinology	⇒ study of quinine
• raciology	⇒ study of racial differences
• radiology	⇒ study of X-rays and their medical applications
• reflexology	⇒ study of reflexes
• rhabdology	⇒ knowledge or learning concerning divining

	rods
rhabdology	⇒ art of calculating using numbering rods
rheology	⇒ science of the deformation or flow of matter
rheumatology	⇒ study of rheumatism
rhinology	⇒ study of the nose
rhochrematics	⇒ science of inventory management and the movement of products
runology	⇒ study of runes
sarcology	⇒ study of fleshy parts of the body
satanology	⇒ study of the devil
scatology	⇒ study of excrement or obscene literature
schematonics	⇒ art of using gesture to express tones
sciagraphy	⇒ art of shading
scripophily	⇒ collection of bond and share certificates
sedimentology	⇒ study of sediment
seismology	⇒ study of earthquakes
selenodesy	⇒ study of the shape and features of the moon
selenology	⇒ study of the moon
semantics	⇒ study of meaning
semantology	⇒ science of meanings of words
semasiology	⇒ study of meaning; semantics
semiology	⇒ study of signs and signals
semiotics	⇒ study of signs and symbols
serology	⇒ study of serums
sexology	⇒ study of sexual behaviour
siderography	⇒ art of engraving on steel
sigillography	⇒ study of seals
significs	⇒ science of meaning
silvics	⇒ study of tree's life
sindonology	⇒ study of the shroud of Turin
Sinology	⇒ study of China
sitology	⇒ dietetics
sociobiology	⇒ study of biological basis of human behaviour

- sociology ⇒ study of society
- somatology ⇒ science of the properties of matter
- sophiology ⇒ science of ideas
- soteriology ⇒ study of theological salvation
- spectrology ⇒ study of ghosts
- spectroscopy ⇒ study of spectra
- speleology ⇒ study and exploration of caves
- spermology ⇒ study of seeds
- sphagnology ⇒ study of peat moss
- sphragistics ⇒ study of seals and signets
- sphygmology ⇒ study of the pulse
- splanchnology ⇒ study of the entrails or viscera
- spongology ⇒ study of sponges
- stasiology ⇒ study of political parties
- statics ⇒ study of bodies and forces in equilibrium
- stemmatology ⇒ study of relationships between texts
- stoichiology ⇒ science of elements of animal tissues
- stomatology ⇒ study of the mouth
- storiology ⇒ study of folk tales
- stratigraphy ⇒ study of geological layers or strata
- stratography ⇒ art of leading an army
- stylometry ⇒ studying literature by means of statistical analysis
- suicidology ⇒ study of suicide
- symbology ⇒ study of symbols
- symptomatology ⇒ study of symptoms of illness
- synecology ⇒ study of ecological communities
- synectics ⇒ study of processes of invention
- syntax ⇒ study of sentence structure
- syphilology ⇒ study of syphilis
- systematology ⇒ study of systems
- taxidermy ⇒ art of curing and stuffing animals
- tectonics ⇒ science of structure of objects, buildings and landforms

tegestology	⇒ study and collecting of beer mats
teleology	⇒ study of final causes; analysis in terms of purpose
telmatology	⇒ study of swamps
teratology	⇒ study of monsters, freaks, abnormal growths or malformations
teuthology	⇒ study of cephalopods
textology	⇒ study of the production of texts
thalassography	⇒ science of the sea
thanatology	⇒ study of death and its customs
thaumatology	⇒ study of miracles
theology	⇒ study of religion; religious doctrine
theriatrics	⇒ veterinary medicine
theriogenology	⇒ study of animals' reproductive systems
thermodynamics	⇒ study of relation of heat to motion
thermokinematics	⇒ study of motion of heat
thermology	⇒ study of heat
therology	⇒ study of wild mammals
thremmatology	⇒ science of breeding domestic animals and plants
threpsology	⇒ science of nutrition
tidology	⇒ study of tides
timbrology	⇒ study of postage stamps
tocology	⇒ obstetrics; midwifery
tonetics	⇒ study of pronunciation
topology	⇒ study of places and their natural features
toponymics	⇒ study of place-names
toreutics	⇒ study of artistic work in metal
toxicology	⇒ study of poisons
toxophily	⇒ love of archery; archery; study of archery
traumatology	⇒ study of wounds and their effects
tribology	⇒ study of friction and wear between surfaces
trichology	⇒ study of hair and its disorders
trophology	⇒ study of nutrition

- tsiganology ⇒ study of gypsies
- turnery ⇒ art of turning in a lathe
- typhlology ⇒ study of blindness and the blind
- typography ⇒ art of printing or using type
- typology ⇒ study of types of things
- ufology ⇒ study of alien spacecraft
- uranography ⇒ descriptive astronomy and mapping
- uranology ⇒ study of the heavens; astronomy
- urbanology ⇒ study of cities
- urenology ⇒ study of rust molds
- urology ⇒ study of urine; urinary tract
- venereology ⇒ study of venereal disease
- vermeology ⇒ study of worms
- vexillology ⇒ study of flags
- victimology ⇒ study of victims
- vinology ⇒ scientific study of vines and winemaking
- virology ⇒ study of viruses
- vitrics ⇒ glassy materials; glassware; study of glassware
- volcanology ⇒ study of volcanoes
- vulcanology ⇒ study of volcanoes
- xylography ⇒ art of engraving on wood
- xylology ⇒ study of wood
- zenography ⇒ study of the planet Jupiter
- zoiatrics ⇒ veterinary surgery
- zooarchaeology ⇒ study of animal remains of archaeological sites
- zoochemistry ⇒ chemistry of animals
- zoogeography ⇒ study of geographic distribution of animals
- zoogeology ⇒ study of fossil animal remains
- zoology ⇒ study of animals
- zoonomy ⇒ animal physiology
- zoonosology ⇒ study of animal diseases
- zoopathology ⇒ study of animal diseases

zoophysics	⇒ physics of animal bodies
zoophysiology	⇒ study of physiology of animals
zoophytology	⇒ study of plant-like animals
zoosemiotics	⇒ study of animal communication
zootaxy	⇒ science of classifying animals
zootechnics	⇒ science of breeding animals
zygology	⇒ science of joining and fastening
zymology	⇒ science of fermentation
zymurgy	⇒ branch of chemistry dealing with brewing and distilling

Appendix II

List of Abbreviations for College Degrees

A.A.
Associate of Arts: A two-year degree in any specific liberal art or a general degree covering a mix of courses in liberal arts and sciences. It is acceptable to use the A.A. abbreviation in place of the full degree name. For example: Alfred earned an A.A. at the local community college.

A.A.S.
Associate of Applied Science: A two year degree in a technical or a science field. Example: Dorothy earned an A.A.S. in culinary arts after she earned her high school degree.

A.B.D.
All But Dissertation: This refers to a student who has completed all the requirements for a Ph.D. except for the dissertation. It is used primarily in reference to doctoral candidates whose dissertation is in progress, to state that the candidate is eligible to apply for positions that require a Ph.D. The abbreviation is acceptable in place of the full expression.

A.F.A.
Associate of Fine Arts: A two-year degree in a field of creative art such as painting, sculpting, photography, theater, and fashion design. The abbreviation is acceptable in all but very formal writing.

B.A.
Bachelor of Arts: An undergraduate, four-year degree in a liberal arts or sciences. The abbreviation is acceptable in all but very formal writing.

B.F.A.
Bachelor of Fine Arts: A four-year, undergraduate degree in a field of creative art. The abbreviation is acceptable in all but very formal writing.

B.S.
Bachelor of Science: A four-year, undergraduate degree in a science. The abbreviation is acceptable in all but very formal writing.
Note: Students enter college for the first time as *undergraduates* pursuing either a two-year (associate's) or a four-year (bachelor's) degree. Many universities have a separate

college within called a *graduate* school, where students may choose to continue their education to pursue a higher degree.

M.A.
Master of Arts: The master's degree is a degree earned in graduate school. The M.A. is a master's degree in one of the liberal arts awarded to students who study one or two years after earning a bachelor's degree.

M.Ed.
Master of Education: The master's degree awarded to a student pursuing an advanced degree in the field of education.

M.S.
Master of Science: The master's degree awarded to a student pursuing an advanced degree in science or technology.

Appendix III

List of Abbreviations for Titles

Dr.

Doctor: When referring to a college professor, the title usually refers to a Doctor of Philosophy, the highest degree in many fields. (In some fields of study the master's degree is the highest possible degree.) It is generally acceptable (preferable) to abbreviate this title when addressing professors in writing and when conducting academic and nonacademic writing.

Esq.

Esquire: Historically, the abbreviation Esq. has been used as a title of courtesy and respect. In the United States, the title is generally used as a title for lawyers, after the full name.

- Example: John Hendrik, Esq.

It is appropriate to use the abbreviation Esq. in formal and academic writing.

Prof.

Professor: When referring to a professor in nonacademic and informal writing, it is acceptable to abbreviate when you use the full name. It is best to use the full title before a surname alone. Example:

- I'll invite Prof. Johnson to appear as a speaker at our next meeting.
- Professor Mark Johnson is speaking at our next meeting.

Mr. and Mrs.

The abbreviations Mr. and Mrs. are shortened versions of mister and mistress. Both terms, when spelled out, are considered antiquated and outdated when it comes to academic writing. However, the term mister is still used in very formal writing (formal invitations) and military writing. Do not use mister or mistress when addressing a teacher, a professor, or a potential employer.

Ph.D.

Doctor of Philosophy: As a title, the Ph.D. comes after the name of a professor who has earned the highest degree awarded by a graduate school. The degree may be called a doctoral degree or a doctorate.

- Example: Sara Edwards, Ph.D.

You would address a person who signs correspondence as "Sara Edwards, Ph.D." as Dr. Edwards.

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Вдовичев Алексей Владимирович
Оловникова Наталья Глебовна

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ООО «ФЛИНТА», 117342, г. Москва, ул. Бутлерова, д. 17-Б, комн. 324.
Тел./факс: (495) 334-82-65; тел. (495) 336-03-11.
E-mail: flinta@mail.ru; WebSite: www.flinta.ru