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An Introduction to Scientific Communication

Учебное пособие

под ред. Л. Н. Выгонской

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Учебное пособие ставит своей задачей формирование навыков научной коммуникации на английском языке с целью оптимизации лингвистического сообщения и предназначено для студентов и аспирантов механико-математического факультета МГУ.

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Предлагаемое учебное пособие, предназначенное для студентов и аспирантов механико-математического факультета МГУ, содержит основные принципы научной коммуникации, обеспечивающие «правильность» построения научного сообщения: последовательное использование функционального стиля научной речи, наличие в тексте внутренних смысловых связей, целостность и связность изложения, точность языкового выражения, а также эффективное построение предложений и абзацев.

Данный курс носит коммуникативно-ориентированный характер и предусматривает обучение различным видам речевой деятельности. Для совершенствования навыков письменной коммуникации в предлагаемый курс включены рекомендации и задания для эффективной организации абзацев, смысловой компрессии текста в виде summary, написания essay (composition) по заданной тематике. Учебное пособие также содержит клишированные научные выражения для построения различных частей научной статьи: постановка задачи, методы исследования, результаты и их интерпретация, области применения, перспективы научного исследования.

Для развития навыков коммуникативного устного высказывания в пособии даны типичные общенаучные выражения, которые помогут высказать свою точку зрения, доказать правильность использованной аргументации, согласиться или опровергнуть высказывание оппонента, подвести итоги дискуссии.

Учебное пособие также предусматривает обучение изучающему чтению на основе анализа текстологической и композиционной организации научного текста.

В качестве материала данного курса были отобраны статьи из *Encyclopaedia Britannica* и журналов *Scientific American, Discover, The Economist* по актуальным проблемам современной науки в основном за период 1997–2002 гг. Тексты не подвергались адаптации или каким-либо другим изменениям, включая правописание и пунктуацию.

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Introductory Unit

Basic Principles of Scientific Communication

Registers of English

"Every time that we write or speak, we are faced with a myriad of choices: not only choice in what we say but in how we say it. The vocabulary and grammar that we use to communicate are influenced by a number of factors such as the reason for communication, the context, the people with whom we are communicating, and whether we are speaking or writing. Taken together, these choices give rise to systematic patterns of use in English.

By **register** (language style) we mean the words, grammar, and style, used by speakers and writers in a paricular situation or in a particular type of writing. There are four main registers, namely conversation, fiction, newspaper language, and academic prose."[1]

A comparison of texts from different registers shows their strik-

[1] Douglas Biber, Stig Johansson, Geoffrey Leech et al, *Grammar of Spoken and Written English*, London, Longman, 1999, p. 4.

ing contextual differences. Let us compare, for example, conversations and science texts. Situationally, all conversational texts are very similar in their production circumstances, primary purposes, and interactiveness. They are spoken (rather than written) and produced spontaneously, with the words and grammatical organization being essembled on the spot as the conversation unfolds. In addition, most conversations are personal, private, and directly interactive. Speakers express their own personal attitudes, feelings, and concerns, and they interact with one another to build a shared discourse jointly.

In contrast to conversations, science texts are written, carefully planned, edited, and revised. Their primary purpose is to present detailed and precise information, explanations, and arguments about scientific topics as opposed to the personal purposes of conversational participants. Science texts are addressed to a large audience of readers (scientists) but they are not interactive. Due to the influence of these contextual factors, the linguistic characteristics of science texts are dramatically different from those of the conversational texts. For instance, sentences of science texts are grammatically complete, as well as relatively long and grammatically complex. None of the reduced or interactive linguistic characteristics common in conversation occur in these texts.

On the contrary, in academic writing sentences often have noun phrases with multiple premodifiers (e. g. *the greatest British theoretical* **physicist,** *hypothesis testing* **process,** *information processing* **activities**). As to noun phrases with multiple postmodifiers, they become in this register especially long and complex. For example, in the following sentence, the postmodifier complex following the head noun **source** includes multiple prepositional phrases, relative clauses, and ing- and ed-participle clauses, together with a split in apposition (marked by the ':'):

> Theoretically it can serve as a **source** *of ideas and insights which are of particular relevance for the formulation of principles: ideas emerging form disciplines devoted to the study of language and learning which might bear upon the definition of language as subject.*

Register Awareness and its Significance for Scientific Communication

The major characteristics of written academic English are the following: it is **formal**, **objective**, and **impersonal**. Thus, for example, written academic English does not normally contain contractions (i. e. *they have discovered* would be used instead of *they've discovered*) and hesitation fillers (e. g. *well, you know, say*) which might be common in the spoken language. Besides, the language of journal article, thesis, report, essay, abstract is objective and neutral in connotation because a researcher/writer is expected to present unbiased information. Moreover, personal pronouns *I, you* tend not to be used in written academic English. Instead an introductory *it* or *there* may begin sentences or even the impersonal pronoun *one*; passive verb tenses may also be used.

Further, **conciseness** is also essential to scientific writing. Although some writers apparently believe that length impresses readers, it is brevity that readers most appreciate. Ability to convey complex and detailed information within a limitied space is a valuable skill for any writer. Using fewer words gives each word increased significance and thus intensifies the tone.

Exactness is another merit of scientific communication that students should aim for. Scientific papers and abstracts must present exact and detailed information. Dates, figures, and names should be specified and the most exact reference feasible in the situation should be made.

Emphasis also plays an important role in writing. As the opening position in sentences and paragraphs is the strongest, this position should be used for important material. To begin with, first words in sentences should be significant which is why sudents should avoid constructions starting with an introductory "It is ... " or "There is ... ". Next, the first sentence in any paragraph is usually the topic sentence which expresses its main idea. Finally, for the paper as a whole, the first (introductory) paragraph is of paramount importance because it introduces the general topic of the article and conveys the most essential information.

Writing is easier to follow if the writer helps the reader stay on track by making the logic as clear on paper as it is in the writer's mind. Making the logic clear means making the relationships between the facts and ideas clear. Writing in which these relationships are expressed with the help of connectives is said to have **coherence** (see p. 15). For example,

addition	**result**	**contrast**
besides	thus	however
further	hence	in contrast
moreover	therefore	on the contrary

Building Effective Paragraphs

A paragraph is a basic unit of a scientific text. It is an indented block of writing that expresses one main idea and consists of a number of sentences that are closely related. A well-constructed paragraph should possess: a) unity, b) logical sequence of thought, and c) variety of length and construction.

By **unity** we mean that one main idea (or topic) is dealt with. This main idea may be either clearly expressed in the topic sentence or understood (implied). The topic sentence is usually the opening sentence of the paragraph because the reader of a paper often skips and his eye normally hits the first paragraph of each section, the first sentences of many paragraphs. If important matter is hidden away in the middle of paragraphs, the hasty reader will miss it. The first sentence of a paragraph, therefore, should either indicate the exact subject of the paragraph, summarize its contents, or be clearly preparatory to the statements that are to follow.

A logical sequence of thought. A paragraph cannot be regarded as satisfactory unless the sentences are arranged in a clear and logical order. Each sentence must lead to the following and all must be linked up. The connection between the sentences should be shown not only by their logical order but also by using special **connectives** (words and phrases that join parts of a sentence or sentences and indicate their logical relationships).

Development of paragraphs

The topic sentence is usually developed by supporting sentences in which the seven conventional rhetorical patterns are used: examples, comparison and contrast, cause and effect, description, narration, definition, and classification.

By using **illustrations and examples** abstract ideas are reduced to particular cases. That is why it is important to select the proper examples to serve as a representative case.

To clarify the ideas **comparison and contrast** can be used. Analogy is a special form of comparison which explains unfamiliar concepts by relating them to familiar ones.

In academic writing, events and actions are frequently linked with their **cause and effect** relationship. In such a paragraph sometimes the cause is named before the effect; sometimes the effect is given first.

In **a descriptive paragraph** details "paint a picture" that conveys the writer's message, whereas **a narrative paragraph** tells a story by carefully choosing details to make a point.

The purpose of a definition paragraph is to set limits or boundaries for the object defined, whereas a good classification paragraph should account for all possible occurrences of the thing being classified.

Varying length and construction. The length of a paragraph is largely determined by its purpose and by the length of the work it is a part of. A preferred length of the paragraph in scientific papers is 75–100 words, thus it would not exceed 5–7 sentences. Variation of paragraph length is as important as variation of sentence length within paragraphs. It creates a sense of rhythm and movement which aids the reading.

Transitional sentences

A paragraph is self-contained but should link logically with the previous and following paragraphs so that the flow and cohesion of writing is maintained. A paragraph can show some reference to other paragraphs, perhaps by introducing a series of ideas or by summing up a collection of statements. This means that a paragraph may have not only a topic sentence but also a transitional sentence which takes up the thread of previous paragraphs or which states the theme to be developed in the next paragraphs (e. g. *Attention should, first of all, be drawn to the topological aspect of the problem.*). Thus, a great deal of the general effectiveness of a text depends on the construction of its paragraphs. Paragraphing is a method of punctuation, it is a signal to the reader that a new step in the development of the subject has been reached.

Writing Correct Sentences

A sentence is a unit of the text which serves to express a complete idea and is constructed in a definite grammatical order. Sentences are divided into simple, compound, and complex. **A simple sentence** is a group of words that makes complete sense, has the subject and the predicate and fits one of the communication conditions: it makes a statement, it is a question or it is a command.

Word order in simple sentences

English word order is rather rigid compared to word order in many other languages. **The subject** most often comes at the beginning of the sentence. It is followed by **the predicate**:

$\underbrace{\textit{The area}}_{subject}$ $\underbrace{\textit{offers}}_{predicate}$ a wealth of recreational possibilities.

When both direct and indirect objects accompany the predicate, there are two possible patterns for most verbs:

Pattern 1: This pattern consists of the predicate (P.) followed by **the direct object (D. O.)**, followed by preposition **to** or **for** and **the indirect object (I. O.)**:

I wrote $\underbrace{\textit{a letter}}_{D.O.}$ $\underbrace{\textit{to my best friend}}_{I.O.}$ last night.

My father bought $\underbrace{\textit{a computer}}_{D.O.}$ $\underbrace{\textit{for me}}_{I.O.}$.

Use **to** with indirect objects after verbs like *bring, give, lend, say, send, write,* and *tell.* Use **for** with indirect objects after verbs like *buy, get*, and *make.*

Pattern 2: This pattern consists of the predicate followed by the indirect object followed by the direct object:

I wrote $\underbrace{\textit{my best friend}}_{I.O.}$ a $\underbrace{\textit{letter}}_{D.O.}$ last night.

My father bought $\underbrace{\textit{me}}_{I.O.}$ a $\underbrace{\textit{computer}}_{D.O.}$.

Exceptions: When the direct object is a pronoun, only Pattern 1 is possible:

He got $\underbrace{\textit{it}}_{D.O.}$ $\underbrace{\textit{for me}}_{I.O.}$ at a discount.

The verbs *explain, recommend,* and *say* take only Pattern 1:

John explained $\underbrace{\textit{his problem}}_{D.O.}$ $\underbrace{\textit{to her}}_{I.O.}$.

Circumstance adverbials in series

The function of circumstance adverbials is to add circumstantial information about the action or state (predicate) described in the sentence. They answer such questions as '**How** (manner), **Where** (place), **When** (time), **Why** (cause), **To what extent** (degree), **For what purpose** (aim), **How often** (frequency),' and mainly occur in the final position in the sentence. The fequency and ordering of circumstance adverbials occuring in series is usually as follows: **manner+place+time**.[2] For example,

The problems of information security, computer viruses as well as encryption system developments will be discussed $\underbrace{\textit{in detail}}_{manner}$ $\underbrace{\textit{at Moscow International Computer Science Conference}}_{place}$

[2]ibid. Circumstance adverbials, pp. 776–810.

$\underbrace{\textit{in December 2002.}}_{time}$ (ACAD)

Grammatically, there is no limit to the number of adverbials that can be used in a series, though, of course, there is a limit to the number, that the reader or addressee can follow. A series of three or more adverbials in conversation tend to be fairly short and concrete, often referring to **place, time, and purpose**. For instance,

I have to be $\underbrace{\textit{at his office}}_{place}$ $\underbrace{\textit{at nine o'clock}}_{time}$ $\underbrace{\textit{tomorrow morning}}_{time}$ $\underbrace{\textit{to discuss this important problem.}}_{purpose}$ (CONV)

Sometimes newspaper language and academic prose have more widely varied series, including both longer adverbials and differing semantic categories and their ordering:

A coaching session for women footballers is to be held $\underbrace{\textit{at the racecourse ground in Wrexham}}_{place}$ $\underbrace{\textit{between 6.30pm and 8pm tomorrow}}_{time(duration)}$ $\underbrace{\textit{as part of a community sports programme.}}_{manner}$ (NEWS)

The level of water rose $\underbrace{\textit{to 2 metres}}_{degree}$ $\underbrace{\textit{in 1990}}_{time}$ $\underbrace{\textit{due to an unusually wet summer.}}_{cause}$ (ACAD)

Compound and complex sentences

A compound sentence consists of two or more independent simple sentences or clauses, connected by the way of **coordination**. The relation between clauses may be different and it is the connective that makes clear what the relation is. For instance, to join two clauses the second of which adds a related thought, use: *and,* *in addition, likewise, moreover, besides, futhermore, also.* To join two clauses the second of which is a consequence of the first, use: *hence, thus, therefore, so, accordingly.*

The parts of a compound sentence may also be joined without any connective. This co-ordination is always marked by a comma (,), a semicolon (;), or a colon (:).

A complex sentence formed by **subordination** consists of one indepenedent (principal) clause and at least one dependent (subordinate) clause. **Subordination** means putting less important details in less conspicuous clauses. Hence the important ideas in a sentence should go into principal clauses. The functions of subordinate clauses are similar to those of the parts of a simple sentence. Accordingly, subordinate clauses are classed as subject, predicative, object, attribute, and adverbial clauses.

Avoid using **a sentence fragment**: it is a part of the sentence which lacks either the subject or the predicate (a phrase) or it does not express a compete thought (i. e. it is a dependent sentence).
Fragment: *In a dispute between kids, parents usually take the side of the younger child. Because that child is weaker and smaller* (a dependent clause).
Correction 1: *In a dispute between kids, parents usually take the side of the younger child because that child is weaker and smaller* (adding the fragment to the independent clause that it logically goes with).
Correction 2: *In a dispute between kids, parents usually take the side of the younger child. They do so because that child is weaker and smaller* (making the fragment an independent sentence). Correction 2 is better when Correction 1 would result in a sentence that is too long.

A run-on sentence runs together two or more thoughts that should properly be expressed in separate sentences. For example:
Run-on: *We want to speak about larger and smaller infinities and so we face a problem of comparing the numbers and we can neither name nor write them down.*
Correct: *If we want to speak about larger and smaller infinities we face a problem of comparing the numbers that we can neither name nor write down.*

Suggestions for correcting run-together sentences

1. If the two independent clauses of run-together sentences are closely related and not too long, they can be separated with **a semicolon**.

   The human genome resembles a teleprinter tape; *it is a linear text without headlines or punctuation marks comprising some* 3,000 *million letters.*

   It is better to separate two longer or unrelated independent clauses with **periods**.

   Anyone who listens to the radio, watches television, and reads books, newspapers, and magazines cannot help but be aware of statistics. *Statistics appear in opinion polls, in cost-of-living indexes, and in reports of business trends.*

2. **A coordinating conjunction** (*and, but, so, nor, for, yet, or*) can be used to join the two independent clauses. Place a comma before the coordinating conjunction.

   Sharks play an important role in oceans as top predators, ***and*** *their depletion can have wide-ranging effects on other marine species.*

3. **A subordinator** (*because, although, since, whereas, so that*) can be used to join the two clauses. If the dependent clause with the subordinator comes first, separate it from the independent clause with a comma.

   Because *the Internet has made national borders invisible, companies in different countries are encountering the same threats to their information's safety.*

   If the dependent clause comes after the independent clause, use no comma.

   Poker is a zero-sum game ***because*** *the combined wealth of the players remains constant.*

4. **A transition word (or a connective)** can be used to join the two independent clauses. Note the use of the semicolon.

   Most companies have anti-virus programs and network monitors as safety precautions; ***however****, they* *focus on technical safety measures rather than organizational ones.*

Using Discourse Connectives

Linking adverbials are words and phrases that join two units of discourse (parts of a sentence or sentences) and indicate their logical relationships. They can express a variety of relationships, including enumeration/addition, summation, apposition, result/inference, contrast/concession, transition, etc. Because they explicitly signal the connections between the passages of the text, linking adverbials are important devices for creating **textual coherence**.

1. **Enumeration, addition, equation**
   a) first(ly), ... second(ly), ... third(ly)
      for one thing, ... for another ...
      first, ... furthermore, ... finally, ...
      to begin with, ... in the second place, ... moreover, ... and to conclude, ...
      next, ... then, ... lastly, ...
   b) in addition, further, besides, moreover, furthermore, again, also, then
   c) similarly, equally, likewise, correspondingly, in the same way
2. **Summation, conclusion**
   a) in sum, to summarize, to sum up, on the whole, in brief, in short
   b) in conclusion, to conclude, all in all
3. **Apposition (reformulation or related references)**
   in other words, which is to say, i. e., that is, viz., namely, or rather, or better, specifically, mainly, chiefly, notably, particularly, in particular
4. **Exemplification**
   for instance, e. g., for example, including, such as, as an illustration
5. **Result, inference (deduction), consequence**

therefore, consequently, thus, hence, so, as a result, for this reason, accordingly

6. **Generalization**

   in general, generally, normally, usually, as usual, on the whole

7. **Contrast, concession**

   a) on the other hand, in contrast, alternatively, however, but, in comparison with, on the contrary, conversely

   b) though, nevertheless, nonetheless, even if/though, at the same time, at any rate, in any case

8. **Transition**

   now, as for, as to, regarding, concerning, with respect/regard to

Summarizing

Summarizing is giving a brief account of the main points of any piece of writing. References must always be given to the sources of the texts you are making use of, otherwise you may be accused of plagiarism.

Suggestions for writing summaries

1. Skim the text (read quickly) to get an overall idea of it.
2. Read the text carefully, identifying the main points. Try to find the topic sentence of each paragraph (perhaps of two or three paragraphs).
3. Make a topic outline (a list of points to be discussed).
4. Mind some of the ways of cutting down the length of the article: remove repetitions, details, illustrative figures, examples, unimportant remarks, generally known facts.
5. Reorganize the ideas in a way that makes your points clear. You do not have to follow the order of the original text.
6. At the beginning of the summary write an introductory paragraph which usually introduces the general statement of the

main idea. If the summary is to serve as a note for possible use in a research paper, it should also include the main supporting ideas.

7. As far as possible condense the points into straightforward statements and rewrite in your own words where possible (paraphrase). Do not add your own view to the summary. Refer to the text under discussion only when you want to make sure of some point.
8. If certain sentences or phrases are important and may be useful to quote in an essay etc, copy them exactly, word for word, and put them in inverted commas (quotation marks). If you intend to abbreviate the quotation by omitting some words, put three dots (...) in place of the words.
9. Write clearly, concisely, logically and coherently paying attention to the correct use of connectives and effective paragraph division.
10. Make the summary short, no more than 25 percent of the original text.
11. Be sure to edit your work. Polish it to make the language flow smoothly.

Writing Argumentative Essay

Introduction and thesis statement. The aim of an argumentative essay is to convince the reader to agree with the author's point of view or opinion. An argumentative essay tries to be very persuasive by appealing to reason and logic. It must introduce and explain the background to the issue of the problem. But, in the thesis statement, the author must take a stand and present his or her point of view strongly and clearly. In addition, an argumentative essay usually suggests a course of action for the future.

Supporting your views. In most good argumentative essays, the writer's point of view is obvious in the first paragraph. But an essay is not a mere opinion. The body of the essay should provide support or reasons for the author's point of view: explanations, factual details, examples.

Refuting opposing points of view. Writing an argumentative essay is like taking one side in a debate, either for or against. The writer must not only show that his or her ideas are correct; he must also show that his opponent's views are wrong. Refuting an opponent's views involves showing why the opponent's arguments are incorrect. To be effective, an argumentative essay must contain a point-by-point refutation of the main arguments of the opposing view.

Concession. If an opponent has a valid point or expresses an idea that is true, the writer must, in all honesty, concede it. It is very rare that the arguments on one side are all bad and on the other all good. After admitting that the opposition may have a good point, the writer can go on to show that, overall, his or her reasons are superior to the opponents' views. The concession should not appear in the conclusion, and it cannot be allowed to change the main idea or divert attention from the thesis statement of the essay.

Conclusion. The conclusion should follow logically from the arguments in the essay. It summarizes the main ideas and reaffirms the thesis. It may also offer suggestions for the future.

Suggestions for writing essays on the topic

Title Write a title for your composition. Make it short, relevant to your topic, and interesting.

Paragraph 1: Introduction Include a sentence that expresses your main idea, or **thesis**. It is often the last sentence of the first paragraph.

The introduction does not need to be long, but it must be more than one sentence. Do not begin your introduction with a pronoun or refer to the title; the introduction, not the title, begins your composition.

Body paragraphs (Paragraphs 2, 3, etc) Each paragraph should be complete and unified, with its own topic sentence that supports the thesis statement in the introduciton. Show the order and priority of the ideas in your writing. Make sure you keep body paragraphs distinct: Each one has its own main idea and does not repeat

information from other body paragraphs.
Last paragraph: Conclusion This can be short, but it should be more than one sentence. Remind your readers of your thesis, or give them something related to think about.[3]

Writing Research Reports

Students often need to write reports on their research; in an extended form these become dissertations or thesis. It should be pointed out that making **an outline**[4] before writing helps organize one's thinking logically by giving ideas order and priority. In this case it will be clear to readers which ideas are main points and which are secondary points. The framework or structure of research reports is as follows.

Preliminaries

1. **The title**
   The fewest words possible that adequately describe the paper.
2. **Acknowledgements**
   Thanking colleagues, supervisors, sponsors, etc for their assistance.
3. **List of contents**
   The sections, in sequence, included in the report.
4. **List of figures/tables**
   The sequence of charts or diagrams that appear in the text.

Introduction

5. **The abstract**
   An extremely concise summary of the contents of the report, including the conclusions. It provides an overview of the whole report for the reader.
6. **Statements of the problem**
   A brief discussion of the nature of the research and the rea-

[3] William R. Smalzer, *Write to be Read*, Cambridge University Press, 1996, p. 93.
[4] An outline is a plan for an article, essay, etc in which each new idea is separately recorded.

sons for undertaking it. A clear declaration of proposals and hypotheses.

Main body

7. **Review of the literature**
   A survey of selective, relevant and appropriate reading, both of primary and secondary source materials. Evidence of original and critical thought applied to books and journals.
8. **Design of the investigation**
   A statement and discussion of the hypotheses, and the theoretical structure in which they will be tested and examined, together with the methods used.
9. **Measurements and techniques used**
   Detailed descriptions and discussion of testing devices used.
10. **Results**
    The presentation in a logical order of information and data on which a decision can be made to accept or reject the hypotheses.

Conclusion

11. **Discussion and conclusion**
    The presentation of principles, relationships, correlations and generalisations shown by the result. The interpretation of the results and their relationship to the research problem and hypotheses. The making of deductions and inferences, and the implications for the research. The making of recommendations.
12. **Summary and conclusions**
    A concise account of the main findings, and the inferences drawn from them.

Extras

13. **Bibliography**
    An accurate listing in strict alphabetical order of all the sources cited in the text.
14. **Appendices**
    A compilation of important data, explanatory and illustrative material, placed outside the main body of the text.

Note:

1 There may be slight variations to the above. For example, the abstract may be separate and appear at the very beginning of the report. In its place there may be a section entitled 'Outline of the research'. 9 may be called 'Methods and procedures'. 11 may include 'Recommendations and suggestions for further research'.

2 In abbreviated form, the traditional structure of a scientific or technical report is **IMRAD**=**I**ntroduction, **M**ethods, **R**esults **a**nd **D**iscussion.[5]

Exploring Language: Correcting Fragments

Task 1. *Identify the fragments in the following groups of items. Decide why it is a fragment: a dependent clause or a phrase which lacks the subject or the predicate or sometimes both of them. Then rewrite the entire item correcting the fragment using Correction 1 or Correction 2 (see p. 13). Add the necessary words to make fragments independent sentences.*

1. Now the voice-recognition software is moving on to conquer a new frontier. Enabling computers to understand and act upon spoken commands, allowing users to vocally launch programs, send e-mail or search the Internet.
2. Mathematical functions that represent continuous events can be graphed by unbroken lines or curves. Or perhaps smooth, gradually changing, surfaces.
3. The theory of fractals is today being applied to many areas of science and technology. To analyze the symmetry of living forms, the turbulence of liquids, the branching of rivers, and price variation in economics.
4. Biological weapons (particularly smallpox and anthrax viruses) now pose a greater threat than nuclear weapons. According to a grim report in today's issue of *Science*.

[5]Based upon Appendix 3 'Research Report', in *Academic Writing Course*, by R. R. Jordan (Longman, 1999).

5. The city had extra time to heighten and extent the level that protects the downstream district. Because it was situated in the lower end of the flood zone.
6. Millions of small fire-blackened stones in Ireland and Scotland are giving support to the theory that northern parts of the British Isles were depopulated almost 3,200 years ago. As a result of a nuclear winter-style disaster.
7. Broadly speaking, a field is an algebraic system consisting of elements that are commonly called numbers, in which the four familiar operations of addition, substraction, multiplication and division are universally defined (except for division of zero). And have all their usual properties.
8. Hackers frequently took advantage of glitches in security. For example, misconfigurations in netware monitors and carelessness of users.

Adding Coherence

Task 2. *Read the following fragment of the text concerning theory of games. Although the methods of paragraph division and development are effective, this extract is challenging for a reader because it lacks coherence. Each action is clear in itself, but the relationship between the sentences is not clear. Insert the necessary connectives from the list of choices given below. Write a summary.*

CLASSIFICATION OF GAMES

1 Games are grouped into several categories according to certain significant features, the most obvious of which is the number of players involved. A game can ... be designated as being one-person, two-person, or n-person (with n larger than two), ... the games in each category have their own distinct natures. A player need not be a single person, ... ; it may be a nation, a corporation, or a team consisting of many people with identical interests relative to the game. In games of perfect information, such as chess, each player knows everything about the game at all times. Poker, ... , is an

example of a game of imperfect information because players do not know the cards the other players are dealt.

2 The extent to which the goals of the players are opposed or coincide is another basis for classifying games. Zero-sum (. . . , more accurately, constant-sum) games are completely competitive. Poker, . . . , is a zero-sum game because the combined wealth of the players remains constant; if one player wins, another must lose because money is neither created nor destroyed. Players in zero-sum games have completely conflicting interests. In nonzero-sum games, . . . , all the players can be winners (or losers). In a labour-management dispute, . . . , the two parties have some conflicting interests . . . both may benefit if a strike is avoided.

3 Nonzero-sum games can be . . . distinguished as being either cooperative or noncooperative. In cooperative games players may communicate and make binding agreements in advance; in non-cooperative games they may not. An automobile salesman and a potential customer are engaged in a cooperative game, as is a business and its employees; participants bidding independently at an auction are playing a noncooperative game.

4 . . . , a game is said to be finite when each player has a finite number of decisions to make and has only a finite number of alternatives for each decision. Chess, checkers, poker, and most parlour games are finite. Infinite games, in which there is either an infinite number of alternatives or an infinite number of decisions, are much subtler and more complicated.

Connectives: for example (2), or, on the other hand, thus, of course, and, finally, yet, further, however.

Writing Summaries

Task 3. *Read and analyze the model summary following the article below. It was taken from Study Skills for Academic Writing.*[6] *Discuss the characteristics of effective summaries and important steps in writing them.*

[6] John Trzeciak, S. E. Mackay, *Study Skills for Academic Writing,* New York, 1995, pp. 36–37.

FIRE STONES SUPPORT CATASTROPHE THEORY

1 Millions of small fire-blackened stones in Ireland and Scotland are giving support to the theory that nothern parts of the British Isles were depopulated by a nuclear winter-style disaster almost 3,200 years ago.

2 Archaeologists believe the disaster was caused by a huge volcanic eruption in Iceland in 1159 BC. An examination by John Barber, of the Scottish Historic Buildings and Monuments Directorate, and other archaeologists, of these piles of burnt stones had led to the conclusion that hunting, as a major part of the prehistoric economy, declined rapidly after the mid twelfth century BC.

3 The stones were used in the cooking of meat and other food. Now normally referred to as "pot-boilers", they were the main method of boiling water when metal cauldrons were rare and pottery not strong enough to withstand great heat.

4 Modern tests have shown that normally it would have taken around three such stones, deposited into the pit of water over a 15-minute period, to bring the water to the boil. Many stones were retrieved, reheated and reused.

5 However, it is the distribution and dating of these fire-blackened mounds of stones which lends support to claims that an environmental catastrophe struck upland areas of the British Isles.

6 The earliest burnt mounds date from 2,100 BC and for most of the second millennium BC can be found in permanent settlement sites and temporary hunting camp sites. But in upland areas, as from the mid twelfth century BC, burnt mound material persists only in settlement sites.

7 Hunting camp sites ceased to occur and archaelogists believe this is linked to the volcanic eruption, which probably destroyed much of upland Britain and led to the demise of many game species and, consequently, to a massive move away from hunting.

8 Research by Dr Michael Baillie and Dr Martin Munro, of the Palaeoecology Centre at Queens University, Belfast, paved the way for the development of the catastrophic depopulation theory. They discovered, through an examination of tree-ring data, that tree growth slowed dramatically at times of major northern hemispheric volcanic eruptions—including that in Iceland.

9 It is thought that the eruption, which spewed at least 12 cubic km of volcanic dust into the atmosphere, and the ensuing environmental problems, reduced the population of northern Britain by as much as 90 per cent.

David Keys, Archaeology Correspondent

SUMMARY

The existence of piles of burnt stones had led archaeologists such as John Barber of the Scottish Historic Buildings and Monuments Directorate to conclude that a volcanic eruption in Iceland in 1159 BC led to the decline of hunting in the northern British Isles. The stones were used to boil water for cooking. After the mid 12th century BC, they were confined to permanent settlement sites and not found in temporary hunting camp sites, suggesting that the eruption had destroyed many game species. This is further evidence for the catastrophic depopulation theory put forward after research on tree-ring data by Baillie and Munro of the Palaeoecology Centre at Queens University, Belfast. Their findings revealed that tree growth declined markedly following major volcanic eruptions in the northern hemisphere, such as one in Iceland.

Unit I

Information Technology

Background

Task 1. *Read the introduction to the report "The Future Social Impacts of Telecommunications" devoted to the development of information technologies. Find the author's thesis and the topic sentences that support it. Analyze the structure of argumentative paragraph 6*[1] *as well as the connectives used in its development.*[2] *Say how the main idea of paragraph 8 is developed. This method of paragraph development is commonly used throughout academic writing.*

TECHNOLOGY AND MODERN SOCIETY

1 Technology has always played an important role in human society. We talk about epochs such as the Stone Age, the Bronze Age, or the Iron Age, illustrating that the most important characteristics of these periods were the materials technologies in use. In modern

[1] See Introductory Unit, pp. 17–18.
[2] ibid. p. 9.

times our reliance on technology is increasing, and it is appropriate to say that today we stand on the threshold of the Information Age.

2 The 20th century has been strongly influenced by three major inventions all conceived around 1870. I am thinking of the Otto engine, which powers our cars, the telephone and electricity generation. Most other products prior to modern electronics are either derivatives of or supplements to these major inventions.

3 It is not unreasonable to assume that the 21st century in the same way will be dominated by technology based on two major inventions made almost exactly 100 years after the invention of the car engine, the telephone and electricity generation. Those two inventions are the semiconductor chip and the optical fiber. The transistor, on which our electronic chips are based, was invented in 1948. It was followed by the first small-scale integrated circuit about 10 years later. The first really large-scale integrated circuit appeared around 1970, at the same time as the optical fiber was invented.

4 Considering that only 30 years have elapsed since these two major microelectronic components appeared, their influence on society has been remarkable. Computers are to be found everywhere, and telecommunications are already reshaping most business activities from banking to retail and industrial manufacturing.

5 Although the title of this report refers to telecommunications alone, it would be impossible to isolate the effects of communications as such from the effects of data processing and storage and other uses of microelectronic technology. The systems we now see evolving are networks where data transfer, storage and processing take place in a distributed manner. Isolating one technology from the other becomes impossible. I will therefore discuss the impact of microelectronics as one single technology.

6 Looking at an industialized country it is tempting to say the Information Age is already here. We already depend on computer networks. It could also be argued that modern society moves and evolves at an accelerating pace. Whereas it took (perhaps) 80 years for the inventions of the 1870s to reach their full societal impact, the inventions of the 1970s only needed 30 years. My hypothesis is that this line of argument is incorrect. First of all, the technologies

as such are not yet sufficiently mature to exert their full influence. Furthermore, once technology reaches its mature stage we need to build up an appropriate infrastructure to make the full use of the technology possible. Finally, even such a mature technology and an established infrastructure, the adaptation of human behavior to totally new possibilities probably takes a generation.

7 Based on these arguments, my projection is that the technology will mature during the first decade of the 21st century. Infrastructures will be built up gradually in the period 2000-2020, and around the year 2050 our descendants will be living in a true Information Age. Even if we have to wait another half century to see the full impact of information technology, the short term effects on society are tremendous.

8 We can already see major effects, for example:

- automation in manufacturing and reduction in the number of people employed in industry;
- improvements in all traditional products thanks to the use of computer-aided design, as well as the use of electronics in the products,
- internationalization of all business activities, attributable in part to easy telecommunications,
- the rapid spread of information world-wide via television and other news media,
- increased speed and volume of capital flow owing to computerized banking,
- credit and charge cards replacing cash,
- fax replacing traditional mail,
- changes in educational needs due to new, emergent technology,
- computerized warfare,
- computer crime,
- advances in medicine as a result of the use of information technology.

9 Important as these effects are, we still live in a society which probably resembles 1960 more than that year resembled 1900. Where will the really great changes take place? Maybe the turbulence we are currently witnessing on the financial markets forebodes some of the things we are going to see in the future. Computerized banking has increased the speed and volume of international capital flows tremendously. Telecommunication and information networks provide financial players with instant round-the-clock information from all the international markets. As a consequence of these developments it appears that only the very largest nations can maintian a finacial and monetary policy of their own. Perhaps we are already past the point of no return where unification of countries into major trading and currency unions such as the European Union and NAFTA will be necessitated regardless of political wishes.

Prof. PETER WEISSGLAS

Task 2. *Below is the list of the main points of the report "Technology and Modern Society" given in a mixed order. Reorganize them so that they follow the logical development of the text. In this way you will make a topic outline.*

- ☐ a. The epoch-making inventions of the semiconductor chip and the optical fiber.
- ☐ b. The role of technology in human society.
- ☐ c. The influence of computers and telecommunications on the life of human society.
- ☐ d. The importance of three major inventions made around 1870.
- ☐ e. The conditions of the full use of the Information Age technology.
- ☐ f. Microelectronics as one single technology.
- ☐ g. Some predictions of building up information technology and infrastructure.
- ☐ h. The short term effects of information technology on society.
- ☐ i. Unification of countries into major trading and currency unions.

Task 3. *Write down your answers to the questions that follow and discuss them in the class.*

1. What are the epoch-making inventions of the 20th century?

2. What other important discoveries and inventions were made in the 20th century?
3. What role does information technology play in modern society?
4. Why does increased telecommunications traffic serve to stimulate global economic growth which in turn stimulates increased telecommunications traffic?
5. Why are telecommunications revolutionizing world trade and the way world traders do business?
6. Is it possible to say that telecommunications (from global calling and the Internet services to satellite communications and videoconferencing) are crucial to the globalization of the world economy? Give some examples.

Task 4. *Write a short summary of the text beginning with one of the following introductory phrases: "The paper deals with ... ", "The text is concerned with ... ", "The article is devoted to ... ".*

Task 5. *Do an Internet search or go to the library and research on one of the topics that follow. Then write an argumentative essay and discuss it in the class.*

1. The role of information technology in modern society.
2. Advances in medicine as a result of the use of information technology.
3. The role of the Internet in reshaping most business and science activities.
4. The results of computerized banking.
5. Globalization of the world economy and business.
6. Computer-aided design systems.
7. The Internet services.
8. The demand for efficient, cost-effective global telecommunications and new markets for US telecommunication equipment.

Exploring Language: Useful Phrases Discussing Ideas and Opinions

Discussion is one of the most common speaking activities in any language. Taking part in a discussion is an art which demands skill and ability.

First of all, you should be able to present your ideas in a concise and clear manner. In making an oral presentation you have a special need to gain and hold the attention and interest of your audience. A useful technique here is to use appropriate openings. You may either focus the attention of the audience on the most interesting aspects of the subject or state in general terms what exactly you intend to speak about. Other helpful techniques are the abilities to create a sense of urgency, suggest alternative actions, attack someone else's opinions and ideas. In other words, you are supposed to be able to persuade people of the importance, necessity or correctness of your own point of view and defend your own position.

Task 6. *Complete the following sentences and memorize active expressions.*

Opening discussion

1. The problem of … is rather compicated/urgent/controversial.
2. I'd like to dwell on the main principles of …
3. I want to start with a few remarks about the present system of …
4. I think it's important to consider the problem of …
5. At present there's no doubt that … play an important role in …
6. When speaking about … we should take into account …
7. I'd like to raise the subject of …
8. As you probably know there're some general grounds to believe that …
9. In connection with what has been said here, I'd like to stress that …
10. I should like to say a few words about …

Making conclusions

1. Thus, it can be concluded that ...
2. Therefore, it may be deduced that ...
3. On this basis, it can be inferred that ...
4. Given this, we can make the following conclusion ...
5. Detailed study of these effects leads to the conclusion that ...
6. It cannot be concluded without testing that ...
7. In short/in brief, the data collected lead us to a general conclusion concerning the influence of ...
8. To sum up, our research makes it possible to conclude that ...
9. We now summarize the main conclusions for this work ...
10. In conclusion, we can say that the method under discussion finds wide use in calculating these values in ...

Reading 1

Task 7. *Read the text concerning computer graphics which has been developing in an impressive way since the early 1960s, when graphics poineer Ivan Sutherland demonstrated a computer system, called Sketchpad, that used a light pen to sketch lines on the computer screen. It was an interactive graphics device which allowed someone to use a computer to create and revise an image as an artist would, instead of programming and reprogramming. Get the main points and analyze the methods of paragraph development. The article was published in Encyclopaedia Britannica.*

COMPUTER GRAPHICS

1 Computer graphics is the field that deals with display and control of images on the computer screen. Applications may be broken down into four major categories: (1) design (computer-aided design [CAD] systems), in which the computer is used as a tool in designing objects ranging from automobiles to bridges to computer chips by providing an interactive drawing tool and an interface to simulation and analysis tools for the engineer; (2) fine arts, in which artists use the computer screen as a medium to create images of impressive beauty, cinematographic special effects, animated cartoons, and television commercials; (3) scientific visualization, in which simulations of scientific events—such as the birth of a star or the development of a tornado—are exhibited pictorially and in motion so as to provide far more insight into the phenomena than would tables of numbers; and (4) human-computer interfaces.

2 Graphics-based computer interfaces, which enable users to communicate with the computer by such simple means as pointing to an icon with a handheld device known as a mouse, have allowed millions of ordinary people to control application programs like spreadsheets and word processors. Graphics technology also supports windows (display boxes) environments on the workstation or personal computer screen, which allow users to work with different applications simultaneously, one in each window. Graphics also provide realistic interfacing to video games, flight simulators, and other simulations of reality or fantasy. The term virtual reality has been coined to refer to interaction with a computer-simulated virtual world.

3 A challenge for computer science has been to develop algorithms for manipulating the myriad lines, triangles, and polygons that make up a computer image. In order for realistic on-screen images to be generated, the problems introduced in approximating objects as a set of planar units must be addressed. Edges of objects are smoothed so that the underlying construction from polygons is not visible, and representations of surfaces are textured. In many applications, still pictures are inadequate, and rapid display of real-time images is required. Both extremely efficient algorithms and state-of-the-art hardware are needed to accomplish such real-time animation. Technical details of graphics displays are discussed in computer graphics.

4 Computer graphics has found widespread use in printing, product design and manufacturing, scientific research, and entertainment since the 1960s. In the business office, computers routinely create graphs and tables to illustrate text information. Computer-aided design systems have replaced drafting boards in the design of a vast array of products ranging from buildings to automotive bodies and aircraft hulls to electrical and electronic devices. Computers are also often used to test various mechanical, electrical, or thermal properties of the component under design. Scientists use computers to simulate the behaviour of complicated natural systems in animated motion-picture sequences. These pictorial visualizations can afford a clearer understanding of the multiple forces or variables at work in such phenomena as nuclear and chemical reactions, large-scale gravitational interactions, hydraulic flow, load deformation, and physiological systems. Computer graphics are nowhere so visible as in the entertainment industry, which uses them to create the interactive animations of video games and the special effects in motion pictures. Computers have also come into increasing use in commercial illustration and in the digitalization of images for use in CD-ROM products, online services, and other electronic media.

Vocabulary for Comprehension

computer graphics *n* information in the form of images which can be stored, changed, or output by a computer. As well as being used in industry, computer graphics are thought by some people to be a modern art form. This term is used to cover a huge range of applications, from a simple color bar graph crated at PC to an aircraft design created at and tested within a supercomputer
simulation *n* a model or a representation of a course of events in business, science, etc, especially by computer calculation to study the effects of possible future changes or decisions
computer modeling *n* the building of a picture of an object on a computer so that it can be looked at from any angle. It is especially used in the planning of such things as cars, buildings etc, and when information collected by other machines, for example in outer space, is needed in a form that people can see
spreadsheet *n* a type of computer program that allows figures (e.g. about sales, taxes, and profits) to be shown in groups on a screen so that quick calculations can be made
virtual reality *n* an environment in which computers create the

effect of a world which seems almost completely real to the people in it

Task 8. *Read the fragment of the text concerning different applications of computer graphics. Find and correct mistakes in the underlined words. There is only one mistake in each sentence.*

1. Computer graphic (1), the visual display of information (2) by computer, has developed (3) in (4) impressive way in 40 years. 2. Today, computer graphics have (1) important applications (2) in business, medicine, science and engineering, and the (3) arts, ranging (4) from the most practical—such as package design—to the most isoteric—such as wind-shear simulation. 3. Engineers, designers, and architects (1) use computer-aided design (CAD) to electronically (2) sketch and test (3) their idea (4). 4. Manufacturers can to convert (1) such (2) computerized designs into instructions for computer-aided manufacturing (CAM) systems; cars, sneakers, even spacecraft (3) have been designed (4) this way. 5. Engineers were the first to harness graphics as a design tool: companies were willing (1) to make the investment in expensive CAD system equipment because such systems shaved times (2) and dollars off (3) product (4) design cycles. 6. An (1) engineer using (2) CAD can easy (3) view an object from any angle, copy it, change dimensions, or perform other (4) manipulations. 7. He can submit the final design to computerized (1) simulations of real-world conditions that might (2) affect the behavior of the part or system, such as simulating of (3) extreme heat and

air-pressure variations on automobile tires.
4

Task 9. *Match a term in A with its definition in B. Remember that the purpose of any definition is to set limits or boundaries for the matter defined, to avoid "double meaning", and to make misinterpretation impossible.*

A	B
window	a small sign shown on a computer screen which, when you point to it with a mouse, makes the computer perform a particular operation
word processor	one of a number of areas into which a computer's screen can be divided, each of which is used to show a particular type of information
icon	a small computer used especialy for ordinary office jobs, such as typing letters and reports, storing information
laptop	the part of a computer program or software package that contains the commands and functions available to the person using the computer
user interface	a computer small enough to be held on one's knees
hacker	a very small piece of silicon containing a set of electronic parts and their connections, which is used in computers and other machines
microchip	someone who secretly uses or changes the information in other people's computer systems

Reading Comprehension

Task 10. *Discuss the following questions in pairs or small groups.*

1. The term *computer graphics* is used to cover a huge range of applications: computer-aided design systems, computer-aided manufacturing systems, business graphics systems, desktop publishing systems, interactive animations of video games,

and special effects in motion pictures, isn't it? Give examples.
2. How can the increase of the sales of CAD/CAM equipment be explained?
3. Graphics-based computer interfaces enable users to communicate with the computer by pointing to an icon rather than by using word command menus. Why is it so important to make icons part of the interfaces in the computers?

Task 11. *Do an Internet search or go to the library and research on one of the topics that follow. Then write an essay and discuss it in the class.*

1. Recent developments in computer graphics.
2. The benefits of computer graphics in business and engineering.
3. The importance of simulation of scientific events.
4. Computer graphics and fine arts (cinematographic special effects, animated cartoons, television commercials).

Exploring Language: Useful Phrases Discussing Ideas and Opinions

When we participate in the discussion we normally need to present a balanced view. We look at the advantages and disadvantages of a particular idea or proposal; we examine the arguments for and against it. Then we try to evaluate the different opinions, comparing and contrasting, and eventually come to the conclusion.

Task 12. *Complete the following sentences.*

Introducing your own point of view

1. One of the main arguments in favour of/against this method is that ...
2. The first thing to be considered here is ...
3. First of all, I'd like to draw your attention to ...
4. I think I ought to say right from the start that ...
5. I want to make it clear that ...
6. There is no doubt that ...

Referring to a previous point

1. I'd like to return to the point made a few minutes ago.
2. I think we should look closer at the issue that we only touched on earlier.
3. I'd like to talk about the method that was mentioned in passing earlier.

Elucidating information

1. What is your position on … ?
2. What I really need to know is …
3. What I'd like to hear is …
4. Can you give me some information about …
5. Could you be a little more specific/precise?
6. I think I've missed some details concerning the method of …

Interrupting

1. Do you mind if I just interrupt?
2. Could I just correct one small detail?
3. May I add something to what has just been said?
4. Excuse me, may I make a point?

Agreeing

1. I agree with the author/speaker when he writes/says that …
2. I completely agree with Mr. Smith when he says that … (emphatic)
3. You may well be right, but … (tentative)
4. I agree with you to a certain extent, but … (tentative)

Disagreeing

1. I disagree with Mr. Black when he says that …
2. I don't agree with you at all on that point.
3. That's not right, I'm afraid.
4. I really must object to that comment, you know.

Reading 2

Task 13. *Read the text devoted to virtual reality which represents the first major effort in three decades to bring about a dramatic evolution in computers. The aim of the second (artificial intelligence)* *was to build systems that could mimic human reasoning, a goal that has yet to be reached. Virtual reality is the antithesis of what AI tries to do. It aims to extend the power of the person and create a computer-generated "reality". Analyze the methods of paragraph developments. The text was taken from Encyclopaedia Britannica.*

VIRTUAL REALITY

1 *As personal computers became faster and more powerful in the late 1980s, software developers discovered that they were able to write programs as large and as sophisticated as those previously run only on mainframes. The massive million-dollar flight simulators on which military and commercial pilots trained were the first real-world simulations to be moved to the personal computer.*

2 Flight simulators are perfect examples of programs that create a virtual reality, or a computer-generated "reality" in which the user does not merely watch but is able to actually participate. The user supplies input to the system by pushing buttons or moving a yoke or joystick, and the computer uses real-world data to determine the results of those actions. For example, if the user pulls back on the flight simulator's yoke, the computer translates the action according to built-in rules derived from the performance of a real airplane. *The monitor will show exactly what an airplane's viewscreen would show as it begins to climb.* If the user continues to climb without increasing the throttle, the "virtual plane" will stall (as would a real plane) and the "pilot" will lose control. Thus the user's physical actions are immediately and realistically reflected on the computer's display. For all intents and purposes, the user is flying—that is, the "plane" obeys the same laws of nature, has the same mechanical capabilities, and responds to the same commands as a real airplane.

3 Virtual reality programs give users three essential capabilities—immersion, navigation, and manipulation. People must be immersed in the alternate reality, not merely feel as if they are viewing it on a screen. *To this end, some programs require people to wear headphones, use special controllers or foot pedals, or wear 3-*

D glasses. The most sophisticated means of immersing users in a virtual reality program is through the use of head-mounted displays, helmets that feed slightly different images to either eye and that actually move the computer image in the direction that the user moves his or her head. Virtual reality programs also create a world that is completely consistent internally. *Thus one can navigate one's way though that world as "realistically" as in the real world.* For example, a street scene will always show the same doors and windows, which, though their perspective may change, is always absolutely consistent internally. The most important aspect of a virtual reality program is its ability to let people manipulate objects in that world. *Pressing a button may fire a gun, holding down a key may increase a plane's speed, clicking a mouse may open a door, or pressing arrow keys may rotate an object.*

4 Many amusement parks now have rides and attractions that use virtual reality principles for creating exciting alternate realities for their audiences—for example, a simulated ride in a spaceship, complete with near collisions and enemy attacks. Acceleration and deceleration are simulated by pitching and moving seats, all computer-controlled and cleverly coordinated with stereo sound effects and wrap-around video displays.

TOOLS TO AMPLIFY THE MIND

Brain

Research into the human brain and behavior is shaping the design of computer-generated worlds. The goal: Present information so it can be absorbed and manipulated more easily and quickly. For instance, scientists know that the human mind is genetically programmed to pick up certain visual cues. This is helping researchers design better computer icons.

Sound

Virtual worlds can include 3-D sound that appears to come from specific locations. Such a system could help those who monitor multiple sound sources. Pilots keeping track of nearby traffic are an example. NASA and Crystal River Engineering Inc. have developed a circuit board that can make sounds seem to originate from specific points and grow louder or fainter.

Vision
Computer-generated worlds need to move with the speed of live action so that viewers perceive what they see as real. Most VR is still too slow, but increased computing power is closing the gap. Today's systems use stereoscopic displays with small screens encased in goggles or helmets. Less intrusive future displays may resemble a pair of glasses. Computer-generated visuals could help with such tasks as repairing machines.

Touch
Today, gloves, or entire body suits, armed with sensors let a participant communicate with the computer and direct objects in virtual space through gestures. In the future, touch-sensitive joysticks and gloves with feedback mechanisms will create the sensation of picking up an object. This ability will make it easier to use such systems to direct equipment remotely.

Vocabulary for Comprehension

main-frame *n* the largest and most powerful type of computer
simulator *n* an apparatus which allows a person in training to feel what real conditions are like, for example in traffic or in an aircraft, a spacecraft
joy-stick *n* an upright handle moved to control the operation of something, especially the movement of an aircraft
throttle *n* a valve in a pipe that opens and closes to control the flow of liquid, gas, oil etc, into an engine
stall *v* (of an engine or vehicle) to stop because there is not enough power or speed to keep going
immerse *v* to cause (oneself) to enter deeply into an activity
navigate *v* to direct the course of a ship (plane, etc)
manipulate *v* to control, manage, or handle something

Reading Comprehension

Task 14. *Translate the italicized sentences into Russian. Explain the use of the grammatical forms and structures.*

Task 15. *Read the text a second time. Use the questions to go more deeply into the reading. Write short answers to the questions and compare them in pairs or small groups.*

1. How may cyberspace simulations enhance job performance and training?
2. What characteristics distinguish VR world from other computer graphics?
3. Why do some programs require people to wear headphones or use special controllers, or wear 3-D glasses?
4. What are the essential capabilities of virtual reality programs?
5. What is meant by the sentence "Virtual Reality programs create a world that is completely consistent internally"?
6. Artists and entertainment moguls are pioneering new attractions—interactive theater, breath-taking rides and attractions that use virtual reality principles for creating exciting alternate realities for their audiences. Do you know anything about it?
7. Why is virtual reality the antithesis of what AI tries to do?

Reading 3

Task 16. *Read the text from Encyclopaedia Britannica and translate the italicized sentences into Russian. Divide the text into paragraphs*[3] *and give reasons why paragraphs should begin where they do. Express in a brief topic sentence the main idea of each paragraph and then write a summary.*

ARTIFICIAL INTELLIGENCE

the capacity of a digital computer or computer-controlled robot device to perform tasks commonly associated with the higher intellectual processes characteristic of humans, such as the ability to reason, discover meaning, generalize, or learn from past experience.

[3] ibid. p. 8.

The term is also frequently applied to the branch of computer science concerned with the development of systems endowed with such capabilities. Research on artificial intelligence began soon after the development of the modern digital computer in the 1940s. Early investigators quickly recognized the potential of computing devices as a means of automating thought processes. Over the years, it has been demonstrated that computers can be programmed to carry out very complex tasks—as, for example, discovering proofs for theorems or playing chess—with great proficiency. Some computer programs that are used to perform AI tasks are designed to manipulate symbolic information at extremely high speeds, in order to compensate for their partial lack of human knowledge and selectivity. Such programs are usually called "expert systems." *Other programs are designed to simulate human capabilities for problem solving through the use of highly selective search and recognition methods, rather than through superhuman processing speeds.* Both expert systems and programs simulating human methods have attained the performance levels of human experts and professionals in performing certain specific tasks, but by the mid-1990s there were still no programs that could match human flexibility over wider domains or in tasks requiring much everyday knowledge. Knowledge-based expert systems enable computers to make decisions for solving complicated nonnumerical problems. These expert systems consist of hundreds or thousands of "if-then" logic rules formulated with knowledge gleaned from leading authorities in a given field. The MYCIN program, for example, has been used to help physicians diagnose certain forms of bacterial blood infections and to determine suitable treatments. *A computer programmed in MYCIN first makes a plausible guess as to the patient's condition on the basis of observed symptoms, then determines how well that tentative diagnosis fits all known facts about the behaviour of the microorganism thought to be involved. Once the computer has identified the cause of the infection, it reviews the kinds of antibiotics available and recommends one or several alternative forms of therapy.* Programs have also been developed that enable computers to comprehend commands in a natural language—e.g., ordinary English. The software systems of this type that have been produced so far are limited in their vocabulary and knowledge to specific, narrowly defined subject areas. *They contain large amounts of information about the meaning of words pertaining to that subject, as well as information about grammatical rules and common violations of those rules.* The ability to identify graphic patterns or images is associated with artificial intelligence, since it involves both cognition and abstraction. In a system designed with this capability, a device linked to a computer scans, senses, and transforms images into digital patterns, which in turn are compared with patterns stored in the computer's memory. The stored patterns can represent geometric shapes and forms that the computer has been programmed to (or has learned to) identify. *The computer processes the incoming patterns in rapid succession, isolating relevant features, filtering out unwanted signals, and adding to its memory any new patterns that deviate beyond a specified threshold from the old and are thus perceived as new entities.*

Vocabulary for Comprehension

expert systems *n* a computer system which contains information on a particular subject and is intended to find the answers to problems in a similar way to the human brain
cognition *n* the act or experience of knowing, including consciousness of things and judgment about them

Reading Comprehension

Task 17. *Write short answers to the following questions without consulting the text. Discuss them with your classmates.*

1. What are the meanings of the term "artificial intelligence"?
2. Are "expert systems" designed to simulate human capabilities for problem solving through the use of highly selective search and recognition methods or not?
3. What do knowldge-based expert systems enable computers to do?
4. What is the ability to identify graphic patterns associated with?

Exploring Language: Useful Phrases
Periods and Dating

1. *Research an artificial intelligence began* soon after the development of modern digital computer *in the 1940s.* 2. *Over the years, it has been demonstrated* that computers can be programmed *to carry out very complex tasks.* 3. But *by the mid-1990s* there were still no programs that could *match human flexibility over wider domains* or in tasks requiring much everyday knowledge. 4. Computer graphics *has found widespread use* in printing, product design and manufacturing, scientific research and entertainment *since the 1960s.* 5. As personal computers became faster and more powerful *in the late 1980s*, software developers discovered that they were able *to write programs as large and as sophisticated as those* previously run only on mainframes. 6. *The 20th century has been strongly influenced by* three major inventions. 7. The transistor invented in 1948 *was followed by* the first small-scale integrated circuit *about 10 years later.* 8. My projection is that information technology will mature *during the first decade of the 21st century.* 9. Infrastructures will be built up *gradually in the period 2000–2020.* 10. Whereas *it took 80 years for the inventions of the 1870s to reach their full societal impact*, the inventions of the 1970s only needed 30 years. 11. *Back in the 20th century*, *robots were portrayed* in science fiction *as* creaking, groaning metal machines. 12. The stated objective of the RoboCup Federation is to have a team of *autonomous humanoid robot football players* defeating *the human world champions by 2050.* 13. Although *the idea* of programs that could infect computers *dates to the 1970s*, the first well-documented case of a computer virus spreading "in the wild" *occurred in October 1987.*

Reading 4

Task 18. *Read the article published in The Economist (2000) and translate the italicized sentences into Russian. Examine the construction of the paragraphs and the connectives used. Write a* *summary and discuss it in the class.*

ARTIFICIAL MUSCLES—EXPANSIVE THINKING

Robots, and other machines,
may be about to borrow an idea from biology

1 Back in the 20th century, robots were portrayed in science fiction as creaking, groaning metal machines—and the reality, as found on assembly lines, was not much better. But all that may change thanks to a study just published in *Science* by Ron Pelrine and his colleagues at SRI International, a non-profit research institute based in Menlo Park, California. For Dr Pelrine's team has succeeded in making actuators (devices that expand and contract in response to an electrical stimulus) out of plastic. So robots may soon be fitted with plastic muscles instead of metal pistons and electric motors.

2 *Plastic muscles are not entirely novel, but improving their performance to the point where they might be industrially useful has been a long hard slog. Dr Pelrine seems to have done it.* His approach relies on a rule from high-school electrostatics: unlike charges attract; like charges repel.

3 Each actuator consists of a three-layer sandwich. The inner layer is a squishy plastic and the outer layers are electrodes made of grease that has been impregnated with particles of carbon. When a voltage is applied to the electrodes, one of them becomes positive and the other negative. *These unlike charges then attract one another, squashing (and thus extending) the plastic between them.* On top of that, the individual bits of each electrode, being of the same electrical charge, repel each other. Since the electrodes are attached to the plastic, this repulsion serves to stretch and extend it in an additional way.

4 In principle, this idea will work with any soft plastic. But it works better with some than with others. The researchers started with various types of silicone. Using these, they were able to get expansions of over 100%, which is far more than had been achieved before—and better, in fact, than natural muscle. When they moved on to soft acrylics, however, they did better still. Expansions of over

200% became commonplace. *This is easily enough to be turned to industrial advantage.*

Besides robot limbs (which may, in truth, lie some way in the future) the new acrylic actuators could find applications in electric motors, loudspeakers, aeroplane wings (where they would be used to control small flaps, in order to improve an aircraft's trim) and even in a new sort of small, pilotless "ornithopter" that would fly by flapping its wings. Dr Pelrine also envisages using them in reverse, generating electricity by compressing the plastic. Fitted into someone's shoes or clothes, that could take advantage of otherwise wasted energy of movement to run electrical devices such as telephones—giving a whole new meaning to the term "power suit".

Reading Comprehension

Task 19. *Write short answers to the following questions. Do not consult the text.*

1. What is the article under discussion concerned with?
2. What actuators did Dr Pelrine's team make?
3. What is meant by the expression "plastic muscles"?
4. What rule does Dr Pelrine's approach rely on?
5. What is the principle of artificial muscles work?
6. Is the sort of plastic important to be able to get expansions of over 100%?
7. Where can robot limbs find application?

Reading 5

Task 20. *Read the article published in Scientific American (2000) and mark any places in the text that are unclear to you. Then read these passages again to improve your understanding of them. Write a summary.*

MIMICKING MOTHER NATURE

Marrying art and science, Nekton Research has developed an underwater robot inspired by a one-celled organism

1 DURHAM, N.C.—"Right now you're the only person in the world who is holding five submarines in your hand at once," Charles Pell tells me. In my palm are five 70gram robots the size of Havana cigars. Though toylike, they may be the world's smallest autonomous underwater vehicles (AUVs). They can turn on a dime and maintain a set course in open-water tests. Larger versions can cruise at speeds of up to three knots (1.5 meters per second) and maneuver sharply.

2 The bots, called MicroHunters, number among the latest creations hatched by Nekton Research, a technology incubator founded in 1994 to apply emerging ideas from the lab of Stephen A. Wainwright, a leader in the field of biomechanics. Wainwright's Bio-Design Studio was once part of Duke University's zoology department, where scientists and artists collaborated to build numerous three-dimensional working models of various biological organisms.

3 Nekton has been riding a leading wave of biomimetics research, abstracting clues from Mother Nature's designs for use in robotics. Whereas reptiles and insects have inspired other robot designs, MicroHunter borrows from a far simpler creature: the single-celled paramecium. "It has just one single moving part," says Duke zoologist Hugh C. Crenshaw, a Nekton collaborator. Paramecia, he explains, move in a helical pattern, orienting themselves to external stimuli by shifting their rotational velocity. Unlike a car cruising down a highway, a helically traveling object doesn't follow its nose but spirals toward a target by changing its speed along its winding path.

4 Crenshaw deciphered the algorithm of the twisting motion, known as helical klinotaxis, and assisted Nekton's team in applying it to the robots, in essence crafting a new guidance technology. Driven by propellers, MicroHunters navigate in three dimensions by homing in on light sources, depth, pressure or a direction—magnetic north, for example.

5 "Our micro AUVs are changing the way people are thinking about doing oceanography," says Pell, a sculptor and biologist who is Nekton's co-founder and vice president of science and technology. Besides an M.F.A., his resumé includes everything from dissecting tunas to building dinosaur exhibits for the Smithsonian Institution's National Museum of Natural History. The AUVs are "basically platforms waiting for more sensors to be miniaturized," Pell says.

6 When packed with myriad sensors, abundant schools of aquabots will cheaply and efficiently augment data from satellites, ships and buoys. That is the hope, anyway, of Nekton's core creative group of biologists, ocean engineers, roboticists, physicists and mathematical modelers. The tiny submarines, currently rated to depths of 100 meters, will eventually perform 3-D mapping of water-column properties for research, industrial and military applications.

7 In battle arenas the tools, whose development was sponsored by the Defense Advanced Research Projects Agency, could be used to measure effluents from suspected chemical weapons factories, to help clear a harbor of mines, to detect trace plumes of pollutants, to screen water supplies, and even to wander up canals and irrigation ditches for intelligence gathering.

8 Ironically, Nekton was founded to manufacture a bathtub toy called TwiddleFish, basically a piece of rubber fashioned in the shape of a fish that faithfully mimics its swimming motion. Pell stumbled on the design in January 1992 while making more complex 3-D working models of the locomotor systems of mackerel and tuna with Wainwright at the Bio-Design Studio. "It was stunning at first that something so superficially simple worked so well," Pell recalls. He, Wainwright and two business partners incorporated soon thereafter and licensed the discovery. Two versions, a clown fish and a great white shark, soon followed and are available at some museum and aquarium gift shops across the country.

9 Modeling has been central to the privately held company's process of innovation ever since. Nekton researchers build 3-D working models of biosystems by hand, employing kinesthetics (the ability to feel movements of the limbs and body) to aid in uncovering new notions about the way things move. And for Pell, who drew his first paramecium as a toddler, modeling has been a lifelong pursuit. During his years at art schools, his studio looked like an inventor's lab, with as many machine parts, tools and mechanisms lying around as sculptures. "I never saw a difference between the way organisms and machines move, between the activity of making a sculpture and making an aircraft," he says. As Pell sees it, what Nekton does is a blend of art and science.

10 In the case of MicroHunter, the team initially planned to test prototypes in a tank filled with six metric tons of clear silicon goop to approximate the viewpoint of a cruising microorganism. To a paramecium, swimming through water feels the way trudging through chilled molasses would feel to us. Before filling the tank, though, Nekton's engineers decided to try to tweak the algorithm to account for such effects as the inertia of less viscous media, like water, and so they plunged a prototype into a swimming pool. To copy the cell's orientation mechanism, Nekton's engineers also had to copy its feature of not caring which way is up, because the cell itself is not affected much by gravity. "We weren't even sure we could do it," says Jason Janet, Nekton's vice president of research and development.

11 After much tinkering, someone had the idea to switch the power on and off to turn the vehicle. It worked. Eventually the team achieved a pure-science solution in which the sub automatically and continuously tracks an external signal, much the way a paramecium orients itself to light or other signals, such as concentrations of chemicals in a fluid medium. Deliberately turning the propeller on and off at different positions in the helix proved to be a new control option. As a result, MicroHunter steers in two modes: one strictly biomimetic, the other derived from computer modeling of how the sub responds in water when the prop speed is changed. It was the latter mode "that allowed us to understand what was important about the dynamic [computer modeling] system," Pell says, "and to develop a basis for many other things that we've done since with other vehicles."

12 In designing its robots, Nekton tries to distill and program into the machines the essence of a biological organism's motion. In the case of the paramecium, MicroHunter emulates its sheer doggedness and irrepressibility of movement. Underwater, the bots are relentless and hard to detect. In half of six three-minute swimming-pool tests, a former U.S. Navy SEAL, playing underwater goalie, couldn't prevent most oca swarm of them from swimming past him to the beam of light that serves as a target.

13 MicroHunter itself probably will not be armed as a weapon for some time, if ever. For now, it's low on the intelligence scale as AUVs go. Just fitting sensors into the fuselage presents a problem—the control electronics supporting many desired sensors are bigger than the 70-gram platforms.

14 But MicroHunter's orientation effect is scalable, Pell says as he shows off (among others) an eightcentimeter-long, seven-gram test swimmer and a 30centimeter-long, 700-gram version loaded with sensors that measure both acceleration and magnetism and other parameters in all three dimensions. New capabilities, such as remote programming of the robot's swimming instructions, are sure to follow soon. In time, the micro AUVs could be launched individually or in a flotilla to form a moving sensor array.

15 If Nekton's metal creations do succeed in ocean tests and become as capable in the sea as fish, another difficulty may arise: their size means that they might be mistaken as bait. That's a challenge Pell welcomes.

JULIE WAKEFIELD

Reading 6

Task 21. *Read the article concerning speech-based interfaces which was published in Scientific American (1999). Translate the italicized sentences into Russian. Examine all the connectives. Write down the key words and expressions. Make a topic outline and write a summary.*

TALKING WITH YOUR COMPUTER

Speech-based interfaces may soon allow computer users to retrieve data and issue instructions without lifting a finger

1 For decades, science-fiction writers have envisioned a world in which speech is the most commonly used interface between humans and machines. *This is partly a result of our strong desire to make computers behave like human beings. But it is more than that.* Speech is natural—we know how to speak before we know how to read and write. Speech is also efficient—most people can speak about five times faster than they can type and probably 10 times faster than they can write. And speech is flexible—we do not have to touch or see anything to carry on a conversation.

2 The first generation of speech-based interfaces is beginning to emerge, including high-performance systems that can recognize tens of thousands of words. In fact, you can now go to various computer stores and buy speech-recognition software for dictation. Products are offered by IBM, Dragon Systems, Lernout & Hauspie, and Philips. Other systems can accept extemporaneously generated speech over the telephone. AT&T Bell Labs pioneered the use of speech-recognition systems for telephone transactions, and now companies such as Nuance, Philips and SpeechWorks have also entered the field. *The current technology is employed in virtual-assistant services, such as General Magic's Portico service, which allows users to request news and stock quotes and even listen to e-mail over the telephone.* But the Oxygen project will need far more advanced speech-recognition systems.

3 I believe the next generation of speech-based interfaces will enable people to communicate with computers in much the same way that they communicate with other people. Therefore, the notion of conversation is very important. The traditional technology of speech recognition—which converts audible signals to digital symbols—must be augmented by language-understanding software so that the computer can grasp the meaning of spoken words.

4 *On the output side, the machine must be able to verbalize; it has to take documents from the World Wide Web, find the appropriate information and turn it into well-formed sentences.* Throughout this process the machine must be able to engage in a dialogue with the user so that it can clarify mistakes it might have made—for example, by asking questions such as "Did you say Boston, Massachusetts, or Austin, Texas?"

GALAXY SPEAKS

5 We at the M.I.T. Laboratory for Computer Science have spent the past decade working on systems with this kind of conversational interface. Unfortunately, the machines developed so far are not terribly intelligent; they can deal only with limited domains of knowledge, such as weather forecasts and flight schedules. But the information is up-to-date, and you can access it over the telephone. *The machines are capable of communicating in several languages; the three to which we pay the most attention are American English, Spanish and Mandarin Chinese.* These systems can answer queries almost in real-time—that is, just as quickly as in a normal conversation between two people—when the delays in downloading data from the Web are discounted.

6 *The speech-based applications we have produced are founded on an architecture called Galaxy, which our group introduced five years ago.* It is a distributed architecture, which means that all the computing takes place on remote servers. Galaxy can retrieve data from several different domains of knowledge to answer a user's query. The system can handle multiple users simultaneously, and last but not least, it is mobile. You can access Galaxy using only a phone, but if you also have an Internet connection, you can tell the machine to download data to your computer.

7 Galaxy has five main functions: speech recognition, language understanding, information retrieval, language generation and speech synthesis. When you ask Galaxy a question, a server called Summit matches your spoken words to a stored library of phonemes—the irreducible units of sound that make up words in all languages. Then Summit generates a ranked list of candidate sentences—the machine's guesses at what you actually said. To make sense of the best-guess sentence, the Galaxy system uses another server called Tina, which applies basic grammatical rules to parse the sentence into its parts: subject, verb, object and so forth. Tina then formats the question in a semantic frame, a series of commands that the system can understand. For example, if you asked, "Where is the M.I.T. Museum?" Tina would frame the question as the command "Locate the museum named M.I.T. Museum."

8 At this point, Galaxy is ready to search for answers. A third server called Genesis converts the semantic frame into a query formatted for the database where the requested information lies. The system determines which database to search by analyzing the user's question. *Once the information is retrieved, Tina arranges the data into a new semantic frame.* Genesis then converts the frame into a sentence in the user's language: "The M.I.T. Museum is located at 265 Massachusetts Avenue in Cambridge." Finally, a commercial speech synthesizer on yet another server turns the sentence into spoken words.

9 Our laboratory has so far created about half a dozen Galaxy-based applications that can be accessed by telephone. Jupiter offers weather information for 500 cities worldwide. Pegasus provides the schedules of 4,000 commercial airline flights in the U.S. every day, updated every two or three minutes. Voyager is a guide to navigation and traffic in the greater Boston area. To move from one application to another, the user simply says, "I want to talk to Jupiter" or "Connect me to Voyager." Since May 1997 Jupiter has fielded more than 30,000 calls, achieving correct understanding of about 80 percent of the queries from first-time users. The calls are recorded and evaluated to improve the system's performance.

10 *Speech recognition would be an ideal interface for the handheld devices being developed as part of the Oxygen project.* Using speech to give commands would allow much greater mobility—there would be no need to incorporate a bulky keyboard into the portable unit. And spoken language would enable users to communicate with their devices more efficiently. A traveling executive could say to his or her computer, "Let me know when Microsoft stock is above $160." The machine would act much like a human assistant, accomplishing a variety of tasks with minimum instruction.

11 Of course, several research problems still need to be addressed. We must create speech-recognition applications that can handle many complex domains of information. The systems must be able to draw data from different domains—the weather information domain, for example, and the flight information domain—without being specifically instructed to do so. We must also increase the num-

ber of languages that the machines can understand. And finally, to exploit the spoken-language interface fully, the systems must be able to do more than just what I say—they must do what I mean. Ideally, tomorrow's speech-based interfaces will allow machines to grasp their users' intentions and respond in context. Such advanced systems probably will not be available for at least a decade. But once they are perfected, they will become an integral part of the Oxygen infrastructure.

VICTOR ZUE

Reading Comprehension

Task 22. *Answer the following questions based on your understanding of the reading. Write your answers on a separate piece of paper and then discuss them with your partner.*

1. What is meant by the statement that "speech is efficient"? Do you speak faster than you type or write?
2. What is speech-recognition software for dictation?
3. How many words can high-performance systems of the first generation of speech-based interfaces recognize?
4. Are there speech-recognition systems for telephone transactions?
5. What do virtual-assistant services allow users to do?
6. What will the next generation of speech-based interfaces enable people to do?
7. What are the characteristic features of the system with a conversational interface called "Galaxy"?
8. How many servers does the Galaxy system have and what role do they play?
9. How many Galaxy-based applications have been created?

Exploring Language: Useful Phrases Ideas and Achievements

1. Dr Pelrine's team *has succeeded in making actuators* out of plastic. 2. *His approach relies on a rule* from high-school electrostatics. 3. Dr Pelrine also *envisages using actuators in reverse*, generating electricity by compressing the plastic. 4. The lab of Stephen A. Wainwright is *a leader in the field of biomechanics.* 5. *Scientists and artists collaborated to build* numerous three-dimensional working models of various biological organisms. 6. Nekton Research *has been riding a leading wave of biomimetics research.* 7. *The bots*, called MicroHunters, *number among the latest creations* hatched by Nekton. 8. Nekton *abstracts clues from Mother Nature's designs* for use in robotics. 9. In designing its robots, Nekton tries *to distill and program into the machines the essence of* a biological organism's motion. 10. Crenshaw *deciphered the algorithm of* the twisting motion and *assisted Nekton's team in applying it to* the robots, in essence crafting a new guidance technology. 11. *The world's smallest autonomous underwater vehicles* are changing the way people are thinking about doing oceanography. 12. *When packed with myriad sensors*, abundant schools of aquabots will cheaply and efficiently *augment data from satellites, ships and buoys.* 13. *Modeling has been central to the company's process of innovation* ever since. 14. Nekton researchers build 3-D working models of biosystems by hand, employing kinesthetics *to aid in uncovering new motions about the way things move.* 15. *The team achieved a pure-science solution* in which the sub automatically and continuously tracks an external signal. 16. *New capabilities*, such as remote programming of the robot's swimming instructions, *are sure to follow soon.* 17. *Speech-based interfaces* may soon *allow computer users to retrieve data and issue instructions* without lifting a finger. 18. *Von Neumann's extensive knowledge of the subject enabled him to bring* new and interesting insights into every aspect of his work. 19. *The discovery* of black holes in galactic centers *could affect current ideas about* the evolution of the universe.

Unit II

The World Wide Web

Background

Task 1. *Read the introduction to a series of articles in which famous technologists tackle questions concerning the organization of information on the Internet with the aim of making it more genuinely useful. Discuss the problem of the rapid growth of the on-line information volume in cyberspace.*

THE INTERNET: BRINGING ORDER FROM CHAOS

1 The Internet, as everybody with a modem now knows, has fallen victim to its own success. In a few short years, it has gone from being the communications province of scientists and engineers to a primary route of information exchange for everyone from financial analysts to fashion designers. So much clutter and traffic snarl the computer networks that the Clinton administration has announced its intention to build a new, separate system—the Internet II—just so that scientists can get some work done again.

2 Putting the Net to work for the rest of us will be the real challenge in the years ahead. Electronic mail and even videoconferencing are already entrenched, but those applications do not cut to the heart of what the World Wide Web and the rest of the Internet constitute gigantic storehouses of raw information and analysis, the database of all databases. Worries about the future of the Net usually center on the delays and access limitations caused by its overburdened hardware infrastructure. Those may be no more than growing pains, however. The more serious, longer-range obstacle is that much of the information on the Internet is quirky, transient and chaotically "shelved."

3 In the pages that follow, noted technologists tackle questions about how to organize knowledge on the Internet with the aim of making it more genuinely useful. From a variety of standpoints, they consider how to simplify finding the information we desire (yes, there is life beyond today's search engines). They discuss the best ways to format and display data, so that everyone (including the blind) has maximum access to them, in as many ways as can be imagined. The creative technological solutions that they propose may not be the approaches that are finally adopted, but their ideas will certainly provoke further awareness and constructive thinking about the problems.

THE EDITORS

Reading Comprehension

Task 2. *Answer the following questions. Compare your answers in pairs, small groups, or as a class.*

1. What are the consequences of the Internet's rapid growth?
2. What intention has the U.S. administration announced?
3. Why does the Internet constitute a gigantic storehouse of raw information? Why does it lack organization and structure?
4. What causes the delays and access limitations?
5. Is it possible to simplify finding the information we desire so that everyone has maximum access to the Internet?

Reading 1

Task 3. *Read the article about the development of a new kind of search engine that exploits one of the Web's most valuable resources—its myriad hyperlinks. It was published in Scientific American (1999). Translate the italicized sentences into Russian and then write a summary.*

HYPERSEARCHING THE WEB

With the volume of on-line information in cyberspace growing at a breakneck pace, more effective search tools are desperately needed. A new technique analyzes how Web pages are linked together

1 Every day the World Wide Web grows by roughly a million electronic pages, adding to the hundreds of millions already on-line. This staggering volume of information is loosely held together by more than a billion annotated connections, called hyperlinks. For the first time in history, millions of people have virtually instant access from their homes and offices to the creative output of a significant—and growing—fraction of the planet's population.

2 *But because of the Web's rapid, chaotic growth, the resulting network of information lacks organization and structure.* In fact, the Web has evolved into a global mess of previously unimagined proportions. Web pages can be written in any language, dialect or style by individuals with any background, education, culture, interest and motivation. Each page might range from a few characters to a few hundred thousand, containing truth, falsehood, wisdom, propaganda or sheer nonsense. How, then, can one extract from this digital morass high-quality, relevant pages in response to a specific need for certain information?

3 In the past, people have relied on search engines that hunt for specific words or terms. But such text searches frequently retrieve tens of thousands of pages, many of them useless. How can people quickly locate only the information they need and trust that it is authentic and reliable?

4 We have developed a new kind of search engine that exploits one of the Web's most valuable resources—its myriad hyperlinks. By analyzing these interconnections, our system automatically locates two types of pages: authorities and hubs. *The former are deemed to be the best sources of information on a particular topic; the latter are collections of links to those locations.* Our methodology should enable users to locate much of the information they desire quickly and efficiently.

THE CHALLENGES OF SEARCH ENGINES

5 Computer disks have become increasingly inexpensive, enabling the storage of a large portion of the Web at a single site. At its most basic level, a search engine maintains a list, for every word, of all known Web pages containing that word. Such a collection of lists is known as an index. So if people are interested in learning about acupuncture, they can access the "acupuncture" list to find all Web pages containing that word.

6 *Creating and maintaining this index is highly challenging, and determining what information to return in response to user requests remains daunting.* Consider the unambiguous query for information on "Nepal Airways," the airline company. Of the roughly 100 (at the time of this writing) Web pages containing the phrase, how does a search engine decide which 20 or so are the best? *One difficulty is that there is no exact and mathematically precise measure of "best"; indeed, it lies in the eye of the beholder.*

7 Search engines such as AltaVista, Infoseek, HotBot, Lycos and Excite use heuristics to determine the way in which to order—and thereby prioritize—pages. *These rules of thumb are collectively known as a ranking function, which must apply not only to relatively specific and straightforward queries ("Nepal Airways") but also to much more general requests, such as for "aircraft," a word that appears in more than a million Web pages.* How should a search engine choose just 20 from such a staggering number?

8 Simple heuristics might rank pages by the number of times they contain the query term, or they may favor instances in which that text appears earlier. But such approaches can sometimes fail spectacularly. Tom Wolfe's book *The Kandy-Kolored Tangerine-Flake Streamline Baby* would, if ranked by such heuristics, be deemed very relevant to the query "hernia," because it begins by repeating that word dozens of times. Numerous extensions to these rules of thumb abound, including approaches that give more weight to words that appear in titles, in section headings or in a larger font.

9 *Such strategies are routinely thwarted by many commercial Web sites that design their pages in certain ways specifically to elicit favorable rankings.* Thus, one encounters pages whose titles are "cheap airfares cheap airfares cheap airfares." Some sites write other carefully chosen phrases many times over in colors and fonts that are invisible to human viewers. This practice, called spamming, has become one of the main reasons why it is currently so difficult to maintain an effective search engine.

MEMBERS OF THE CLEVER PROJECT

Vocabulary for Comprehension

search engine *n* a computer program that allows you to search for information on the Internet. To use a search engine, you type a word, name etc, and the program then searches for all the websites that include this word. Well-known search engines include AltaVista and Yahoo
breakneck *adj* dangerous, hazardous
on-line *adj* directly connected to and/or controlled by a computer: an online database(=a store of information on a central computer, to which other computers can be connected in order to use the information); **on-line** *adv*
hyperlinks *n* annotated connections
hub *n* the centre of activity or importance
heuristic *adj* **1** (of education) based on learning by one's own personal discoveries and experiences; **2** helping one in the process of learning or discovery
query *n* a question or doubt
ranking *n, adj:AmE* of highest rank
spam *infml* email messages containing advertisements, which are

sent to large number of people, and are annoying because you do not want to read them

Reading Comprehension

Task 4. *Answer the following questions and discuss them in the class.*

1. Why are more effective search tools for surfing the Internet so desperately needed?
2. Why does the Web lack organization and structure?
3. Why has the Internet evolved into a global mess of previously unimagined proportions?
4. Is it difficult to extract relevant pages in response to a specific need for certain information? What language, dialect or style can Web pages be written in?
5. Have people relied on search engines that hunt for specific words or terms?
6. Why have computer disks enabled the storage of a large portion of the Web at a single site?
7. What is an index?
8. Why is creating and maintaining the index highly challenging?
9. What does the new kind of search engine exploit?
10. How does the new search engine automatically locate two types of pages: authorities and hubs?
11. Can methodology under discussion enable users to locate much of the information they desire quickly and efficiently?

Exploring Language: Generalization, Qualification and Caution

In some academic writing it is necessary to make some general comments or to generalize about the information. The generalizations can be made more precise by qualifying them. In this case we may give our own opinion or interpretation of the information. Besides, we often need to be careful about any claims that we make. Such 'cautious' language can be expressed by using impersonal verb phrases that are often used at the head of the paragraph.

Qualification

Quantity: many/much, most, all/every/each, a lot of, some, a number of, a few/a little, few/little, none/not any
Frequency: always, generally, on the whole, normally, usually, regularly, frequently, occasionally, sometimes, seldom, hardly, ever, never
Probability: undoubtedly, clearly, definitely, certainly, probably, possibly, perhaps, maybe, uncertainly

Caution

Task 5. *Complete the following impersonal verb phrases.*

1. It is generally believed that ...
2. It is commonly thought that ...
3. It is still too often assumed that ...
4. It is sometimes said that ...
5. It is often asserted that ...

6. It must also be realized that ...	**modality**
7. It might be thought that ...	
8. It should be pointed out/stressed/emphasized	
9. It would seem that	
10. It appears that	

Task 6. *Complete the following sentences having the construction **there to be**. It is a very convenient way of presenting objective facts, points, etc.*

1. There can be no doubt that ...	**high degree**
2. There is every reason to claim that ...	**of**
3. There is clear evidence that	**probability;**
4. There is no decisive evidence that ...	**low degree**
5. There is every doubt to think that ...	**of**
6. There may still be no clear reasons ...	**probability**

Reading 2

Task 7. *Read the following article which was published in Scientific American (1997). It deals with computer viruses, the "Trojan horses", and "worms". Translate the italicized sentences into Russian, examine the paragraph division and connectives. Then write a summary and discuss it in the class.*

FIGHTING COMPUTER VIRUSES

Biological metaphors offer insight into many aspects of computer viruses and can inspire defences against them

1 *Computer viruses have pervaded popular culture at least as successfully as they have the world's computer population. Capitalizing on the same fearful fascination with man-made life-forms that Mary Shelley tapped in Frankenstein, viruses have become the subject of widespread urban legends and hoaxes, popular television shows and movies.* Yet they have not received much scientific scrutiny.

2 Much of their popular presence is attributable to an obvious but deep biological analogy: computer viruses replicate by attaching themselves to a host (a program or computer instead of a biological cell) and co-opting the host's resources to make copies of themselves. Symptoms can range from unpleasant to fatal. Computer viruses spread from program to program and computer to computer, much as biological viruses spread within individuals and among individual members of a society. *There are other computer pathogens, such as the "worms" that occasionally afflict networks and the "Trojan horses" that put a deceptively friendly face on malicious programs, but viruses are the most common computer ill by far.*

3 *We and our colleagues at the IBM Thomas J. Watson Research Center have found the biological analogy to be helpful in understanding the propagation of computer viruses on a global scale and inspirational in our development of defenses against them.* Building on decades of research by mathematical epidemiologists, we have obtained some understanding of the factors that govern

how quickly viruses spread. Our efforts to find efficient methods of detecting viruses and the relations among them owe much to pattern-matching techniques developed by computational biologists. Furthermore, we have also drawn inspiration for defenses against pathological software from the vertebrate immune system and its astounding ability to repel or destroy pathogens.

4 *Computer viruses can trace their pedigree to John von Neumann's studies of self-replicating mathematical automata in the 1940s.* Although the idea of programs that could infect computers dates to the 1970s, the first well-documented case of a computer virus spreading "in the wild" occurred in October 1987, when a code snippet known as the "Brain" virus appeared on several dozen diskettes at the University of Delaware. Today viruses afflict at least a million computers every year. Users spend several hundred million dollars annually on antivirus products and services, and this figure is growing rapidly.

5 Most viruses attack personal computers (PCs). More than 10,000 viruses have appeared so far, and unscrupulous programmers generate roughly another six every day. There are three main classes of PC viruses (and the categories for other systems are analogous): file infectors, boot-sector viruses and macro viruses. Roughly 85 percent of all known viruses infect files containing applications such as spreadsheet programs or games. When a user runs an infected application, the virus code executes first and installs itself independently in the computer's memory so that it can copy itself into subsequent applications that the user runs. *Once in place, the virus returns control to the infected application; the user remains unaware of its existence.* Eventually a tainted program will make its way to another computer via a shared diskette or network, and the infection cycle will begin anew.

6 Boot-sector viruses, which account for about 5 percent of known PC virus strains, reside in a special part of a diskette or hard disk that is read into memory and executed when a computer first starts. The boot sector normally contains the program code for loading the rest of a computer's operating system (hence the name, a reference to lifting oneself up by one's own bootstraps). Once loaded, a boot-sector virus can infect any diskette that is placed in the drive. *It also infects the hard disk, so that the virus will be loaded into memory whenever the system is restarted. Boot viruses are highly effective: even though there are fewer strains, they were for a time much more prevalent than file infectors were.*

7 The third category, macro viruses, are independent of operating systems and infect files that are usually regarded as data rather than as programs. Many spreadsheet, database and word-processing programs can execute scripts—prescribed sequences of actions—embedded in a document. Such scripts, or macros, are used to automate actions ranging from typing long words to carrying out complicated sequences of calculations. And virus writers have created scripts that insert copies of themselves in other documents. Macro viruses can spread much more rapidly than other kinds of viruses because many people share "data" files freely—consider several workers swapping drafts of a jointly written report. "Concept," the first macro virus observed in the wild, infected its first Microsoft Word document late in 1995 and is now the most prevalent virus in the world. Today more than 1,000 macro viruses are known.

8 As well as basic replication code, viruses can contain whatever other code the author chooses. Some virus payloads may simply print a message or display an image, but others will damage programs and data. Even those without malicious payloads can cause damage to systems whose configuration differs from what the virus designer expected. For instance, the "Form" virus, which usually produces only a slight clicking noise once a month, overwrites one disk directory sector in a way that is harmless to older PCs but lethal to newer ones that arrange disk information differently.

Jeffrey O. Kephart, Gregory B. Sorkin,
David M. Chess and Steve R. White

Vocabulary for Comprehension

metaphor *n* a figure of speech in which a term or phrase is applied to something to which it is not literally applicable in order to suggest a resemblance, e. g. the sunshine of her smile or The rain came down in buckets. It may consist of a single word or an elaborated idea. The virtue of metaphor is that it permits us to say a great deal in few words

computer virus *n* a program secretly introduced into a computer which makes copies of itself and often damages other programs on the computer, including the operating system. In other words, a computer virus is a piece of software attached to something that in itself is perfectly harmless, but which, when executed on your system, actually affects other things happening on that system. It may delete files, it may otherwise corrupt your system, it spreads itself to other pieces of the software in your system much like a biological virus. In short, the virus hidden inside software currupts data

"Trojan horse" the *n* a program which pretends to interact to the user in the way that the user expects. For instance, you are connecting to a remote machine and you are asked to log in and supply your password. A "Trojan horse" might be a program pretending to be the logging program: something which takes a copy of your password and stashes it away for future reference and then connects you to the machine. The idea of the "Trojan horse" may come from Greek methology but today it is a real device used for stealing secret data. The concept works in software and hardware too. In short, "Trojan horse" impersonates software and steals data

Frankenstein *n* a novel by Mary Shelley, which was published in 1818 and tells the story of a scientist, called Frankenstein, who makes a creature by joining together bits of dead bodies and then brings it to life by passing an electric current through its body. The creature is gentle at first, but later becomes violent and attacks its maker. People sometimes mistakenly call the creature Frankenstein, instead of the scientist who made it. The story is very popular and has been made into many films

Reading Comprehension

Task 8. *Answer the following questions concerning computer viruses and other computer pathogens.*

1. What threats are posed by malicious and damaging software such as viruses and worms?
2. We know that computer viruses can spread from program to program and computer to computer in the Internet. What is the second way of infecting programs?
3. One of the most important aims of creating virus software is to steal important information. Why is this problem so acute nowadays?
4. The second aim of an infected software is to destroy data. Today viruses affict at least a million computers every year. What are the ways of reporting or destroying pathogens?
5. Is the biological analogy helpful in understanding the propagation of computer viruses on a global scale? How can computational biologists help find efficient methods of detecting viruses and the relations among them?
6. Do you understand the expression *the "Trojan horses" in computer networks*? Do you remember one of the Greek myths in which a wooden horse (the Trojan Horse) was used by Greek soldiers to trick their enemies, the Trojans, during the Trojan War. The Greeks hid inside a large wooden model of horse and were taken into Troy by Trojan soldiers, who thought that it was a gift. On the basis of these two examples explain the meaning of this phraseological unit.
7. How many main classes of PC viruses are there? About 85 per cent of all known viruses infect files containing spreadsheet programs and games. Why is it so?
8. Boot-sector viruses infect the first sector of partition and, hence, the whole system is being infected at once and fully controlled by a virus. Recent operating systems (Windows NT, UNIX—the latest versions) protect a boot sector from being rewritten by some usual program and hence there is little possibility of doing this on a usual modern computer. Do you agree with this statement?
9. Macro viruses (script viruses) are independent of operating systems and infect files that are regarded as data rather than programs. The first virus of this type appeared in 1995 and

was quite unexpected since nobody could expect a virus to hide itself in data. Do you know anything about scripts that are some kind of programs written in high-level languages (Visual Basic, Javascript etc) and used as a part of some documents (e. g.Word documents)?

Reading 3

Task 9. *The text you are going to read was taken from Scientific American (1979). It is concerned with the problem of information security in an age of electronic communications. Examine the italicized sentences and translate them into Russian. Analyze the methods of paragraph division and development since good paper writing clearly depends upon a proper construction and relation of its parts.*

THE MATHEMATICS OF PUBLIC-KEY CRYPTOGRAPHY

The search for privacy in an age of electronic communications has given rise to new methods of encryption. These methods are more practical than older ones and are mathematically more interesting

1 The electronic communications systems that are proliferating throughout modern society offer speed, accuracy and ever diminishing cost. They also present serious problems of security. *As the ordinary transactions conducted in person, on the telephone or by written correspondence have come increasingly to be conducted by new kinds of electronic systems the susceptibility of organizations and individuals to eavesdropping and forgery has grown dramatically.* One way to prevent tampering with the new electronic systems and to protect the vast quantities of private information such as the credit records and medical histories now stored in computer data banks is to resort to cryptosystems[1]: methods for encrypting, or transforming, information so that it is unintelligible and therefore useless to those who are not meant to have access to it.

2 Encryption is a special form of computation, and almost all modern cryptosystems depend on difficulty of computation for their security; they effect transformations of data so complicated that it is beyond the economic means of an eavesdropper to reverse the process. (Accounts of intelligence operations during World War II reveal that as recently as 35 years ago systems offering this type of security were not widely available. Since then the cost of computation has dropped by a factor of about a million, so that the equipment necessary for secure encryption is now reasonably priced.) *Given unlimited computing power (an unrealistic assumption) such computationally secure systems could be broken, but in practice they appear to be unbreakable.*

3 At present mathematicians lack the tools for proving systems to be computationally secure, and the history of cryptography demonstrates all too well that supposedly unbreakable systems often have hidden flaws. It is hoped that discoveries in complexity theory, a branch of mathematics that studies the difficulty (or cost) of computation, will eventually provide the tools needed to establish provably secure cryptosystems: computationally secure systems that can be guaranteed to be free of hidden flaws. In the meantime a group of mathematical problems characterized by a certain kind of computational intractability are serving as the basis of a new

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[1] *Cryptographic system* is a mathematical system for encrypting, or transforming, information so that it is unintelligible and therefore useless to those who are not meant to have access to it. The encryption process generally begins with the conversion of the plaintext, or unenciphered message, into a string of numbers by means of a digital "alphabet" such as one of those shown here. In some cryptosystems it is more convenient to work with binary numbers, and so in the rather simple alphabet shown at the top five bits (binary digits) have been allocated to represent each letter, number or punctuation mark in the plaintext. Each bit can take two values (0 or 1), making a total of 25, or 32, characters in this alphabet In other cryptosystems it is simpler to think in terms not of a binary (base-2) number system but a decimal (base-10) one. In alphabet shown at bottom two decimal digits have been allocated for each plaintext symbol, providing total of 10^2, or 100, characters. (Some of these may not be needed.)

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A = 00000 B = 00001 C = 00010 D = 00011 E = 00100 F = 00101 ...
a = 00 b = 01 c = 02 d = 03 e = 04 f = 05 g = 06 h = 07 ...
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class of encryption procedures that are in many ways superior to current techniques. The proposed new systems, which were first put forward by Ralph Merkle, Whitfield Diffie and me at Stanford University, are termed public-key cryptosystems. To understand the significance of the term it is necessary to consider briefly how methods of encryption have developed historically.

4 *Any cryptographic technique, such as the substitution and transposition of symbols, that operates on a message without regard to its linguistic structure is called a cipher and is said to generate a ciphertext.* (Codes, which I shall not discuss here, operate on larger linguistic units such as words or phrases.) More precisely, the basis of any cipher is an invertible function: an operation (performed by the sender of the message) that converts a plaintext, or unenciphered message, into a ciphertext and has an inverse operation (performed by the intended receiver of the message) that recovers the plaintext from the ciphertext.

5 Originally the security of ciphers depended on the secrecy of the entire encryption process, but eventually ciphers were developed for which the algorithm, or sequence of steps, of encryption could be revealed without compromising the security of a particular ciphertext. In such ciphers—the conventional cryptosystems of today—a set of specific parameters, called a key, is supplied along with the plaintext message as an input to the enciphering algorithm and along with the ciphertext message as an input to the deciphering algorithm. In other words, the specific transformations of the plaintext and the ciphertext depend on the key as well as on the enciphering and deciphering algorithms. In fact, the algorithms themselves can be made public, because the security of the ciphertext generated in such a system depends entirely on the secrecy of the key. In the new public-key cryptosystems not only the algorithms but also the key for implementing the enciphering algorithm can be revealed without compromising the security of the ciphertext.

6 To understand the advantages conferred by the public-key arrangement, consider a conventional cryptosystem employed for protecting information transmuted over an insecure communications channel such as radio. A system of this type can be viewed as a mathematical strongbox with a resettable combination lock. After the sender and the receiver agree on a sequence of numbers—the key—to serve as the combination of the lock, the sender places his message in the box, sets the combination and closes the lock. If the strongbox—the cryptosystem—is secure, no third party who intercepts the box while it is en route to the receiver will be able to get into it to read or alter the message. In other words, a conventional cryptosystem prevents eavesdroppers from extracting information from an insecure channel and prevents forgers from modifying information in the channel.

7 Until quite recently the principal users of cryptosystems were the military and diplomatic services of the world. The drawbacks of the conventional systems are particularly troubling, however, to the new commercial users of cryptography. To begin with, before any information can be enciphered and transmitted over an insecure channel the receiver and the sender must agree on a key. Since the security of the system depends exclusively on the secrecy of the key, the key must be transmitted by means of a secure channel such as a trusted courier, a system that is slow and costly. The distribution of keys is a particular problem in those instances when the individuals seeking privacy have had no prior communication or when privacy must be maintained over a large network, two situations that are often encountered in commercial dealings. Indeed, the cost and inconvenience of relying on couriers to distribute the amount of key information that is needed for any broad application of cryptography are virtually prohibitive.

8 The requirement of key distribution is not the only drawback of the conventional cryptosystems currently in service. They also fail to meet fully the requirements of message authentication. Since a single key is shared between the sender and the receiver, there is nothing to prevent the receiver from sending himself messages that appear to come from the sender. Consider the difficulties such forgeries could cause in electronic mail or electronic banking systems. Conventional cryptosystems, then, cannot offer the same insurance against disputes over what message (if any) was sent that the exchange of signed documents can. The public-key systems, however, provide answers to both the problem of distributing keys and the problem of authentication.

9 In a public-key cryptosystem the sender and the receiver rather than agreeing on a single key each generate two distinct keys of their own: an enciphering key E, which serves to implement the system's enciphering algorithm, and a deciphering key D, which serves to implement the system's deciphering algorithm. The keys are related in the sense that they serve to implement inverse operations: operating on a plaintext message first with the transformation specified by E and then with the transformation specified by D reproduces the message, and in some (but not all) systems applying the transformations in the reverse order also reproduces the message. The trick is that it is computationally infeasible to derive D from E: the calculation would require a vast amount of computing time, perhaps thousands or even billions of years on the most powerful computer. Hence each user can publish his enciphering key in a public file such as a telephone book without compromising his deciphering key, which is kept secret. As in a conventional cryptosystem, the general procedures for enciphering and deciphering are public information. Therefore anyone who wants io transmit information to a particular person simply enciphers the information with that person's listed key E and sends the ciphertext over an insecure channel. Only the intended receiver, who knows the corresponding secret key D, will be able to decipher the transmitted message.

10 To return to the strongbox analogy, a public-key system provides a strongbox with a new kind of lock, which has two combinations: one to lock the box and one to unlock it. (The box does not lock automatically when it is closed.) The locking combinations of all such strongboxes are made public, so that anyone can lock information in a particular strongbox, but only the individual who owns the strongbox and has set the two combinations will be able to get the information out. With this kind of system there is obviously no need of a secure channel for the distribution of keys. Moreover, some of the public-key systems allow for the construction of a "digital signature" that prevents the forgery of messages by a receiver as well as by a third party. In other words, these systems make it possible to dispense with the transporting of signed documents and to depend exclusively on the electronic transmission of information.

11 If an eavesdropper had unlimited computing resources, he could break a public-key system and recover a plaintext. The enciphering operation E is public and the number of possible plaintexts is immense but finite, and so E could be applied to each plaintext until the intercepted ciphertext was reproduced. Since such an attack requires an impossibly large amount of computing time, however, the public-key systems can still be computationally secure. There are also similar techniques for deriving the secret deciphering key D from the public enciphering key E, but once again the computational infeasibility of implementing those algorithms provides the systems with practical security. To put it another way, the systems are based on what are called trapdoor one-way functions. A one-way function is an easily computed function for which it is computationally infeasible to compute the inverse function. A trapdoor one-way function is an easily computed function for which it is computationally infeasible to compute the inverse function unless certain specific information that was employed in the design of the function is known. *Hence like a trapdoor in the floor of a motion-picture haunted house, such functions are easy to go through in one direction, but unless one possesses the special trapdoor information (analogous in the haunted house to which brick to pull or which panel to push) the reverse process takes an impossibly long time.*

12 The search for trapdoor one-way functions on which to base public-key cryptosystems led naturally to the class of problems that complexity theory has identified as nondeterministic, polynomial-time problems, or NP problems. *For the purposes of these cryptosystems the most important property of the NP problems is that at present all the algorithms that are known for finding general solutions to them call for rapidly increasing amounts of time, although a proposed solution can be quickly checked.* In other words, as the size n of such a problem increases, the number of computational steps required to solve the problem increases in proportion to, say, an exponential function of n such as 2^n, whereas the number of steps required to check a possible solution increases in proportion

to a polynomial function of n such as n^2. *Exponential functions increase far more rapidly than polynomial ones, so that a method of solution that requires exponentially increasing amounts of computer time is impossible to implement for even moderate-size problems.* For mathematicians concerned with cryptography the appeal of the NP problems resides in the fact that although it might take someone billions of years to find a solution to such a problem, once he found it he could convince the rest of the world of its validity in seconds. As a result these problems lend themselves readily to the construction of one-way functions. And for the NP problems on which public-key cryptosystems have been based it has been possible to build trapdoors into the functions as well.

Martin E. Hellman

Vocabulary for Comprehension

cryptography *n* the study of secret writing and codes
cryptographic system *n* a mathematical system for **encrypting**, or transforming, information so that it is unintelligible and therefore useless to those who are not meant to have access to it
security *n* a protection against lawbreaking, enemy acts; stealing information, cracking passwords, breaking computationally secure systems
privacy *n* secrecy
cipher, cypher *n* a system of secret writing; code
code *n* a system of words, letters, numbers etc used instead of ordinary writing, especially to keep messages secret
code also **encode** *fml v* to translate into a code; opposite **decode**
transact *v* carry through affairs, business, etc to a conclusion or settlement
eavesdrop *v* listen secretly to other people's conversation
forge *v* to make a copy of something in order to deceive
tamper with smth *phr v* to touch or make changes in something without permission, especially so as to cause damage
complexity theory *n* a branch of mathematics that studies the difficulty (or cost) of computation

strongbox *n* a strongly-made lockable usually metal box for keeping valuable things in, such as jewels
public-key system *n* a system which provides a strongbox with a new kind of lock, which has two combinations: one to lock the box and one to unlock it (the strongbox analogy). In other words, the system generates two distinct keys of their own: an enciphering key E (a public key) which serves to implement the system's enciphering algorithm, and a deciphering key D (personal private key), which serves to implement the system's deciphering algorithm

Reading Comprehension

Task 10. *Write down your answers to the questions that follow and discuss them with your partner.*

1. What is cryptography concerned with?
2. Why do the electronic communications systems present serious problems of security?
3. What is encryption? How can information be transformed in different cryptosystems?
4. Why has security become priority for computer designers since 1988?
5. What is a cipher and a ciphertext? What is the basis of any cipher?
6. Did the history of cryptography demonstrate that supposedly unbreakable systems had hidden flaws? Why was it so important to decode Enigma machine messages during World War II?
7. When did the security of ciphers depend on the secrecy of the entire encryption process?
8. In which cryptosystem could the algorithm of encryption be revealed without compromising the security of a particular ciphertext? What does the security of the ciphertext depend on in such a system?
9. What are the advantages of a public-key cryptosystem?
10. Can the public-key systems be computationally secure?
11. What are trapdoor one-way functions?

Task 11. *Make a topic outline and then write a summary.*

Task 12. *Do an Internet search or go to the library and research on one of the topics that follow. Then write an essay and discuss it in the class.*

1. The use of anti-virus programs and network monitors as safety precautions.
2. Security violations in U.S. companies. Type of incident: unsanctioned employee access, theft of commercial info, wiretapping, fraud, viruses, notebook theft, system break-ins, sabotage.
3. Cases of security violations in Russian companies: virus attacks, attacks intended to disrupt services, external hacking, theft of laptop computers, violation of data and/or network integrity, fraud, theft of commercial information.
4. Technical measures taken to ensure safety of Russian companies: firewalls (76%), encryption (35%), virtual private network (30%), anti-virus programs (96%), intrusion detection systems (38%).

Exploring Language: Transitional Sentences in Scientific Communication

In addition to typical connectives, impersonal verb phrases and the construction ‘there to be’ which help join paragraphs in the flow of ideas, there exists the second kind of relation among paragraphs: *the relation which exists between any one paragraph and the entire piece of writing in which it appears.* The succeeding paragraph may turn to an entirely new thought, relevant to, but not consequent on, need be labelled to show their exact positions in the structure of the whole, but at certain kinds of critical points, special transitional sentences can be helpful.

1. Objectiveness of information can be achieved by using sentences with **passive voice forms of the verb**:
   One more point should be mentioned in connection with the

problem in question.
Two more aspects of categorisation must be touched upon.
A few words can be added here regarding new developments in this field of science.
Another feature of spectrograms must be briefly described.
One crucial aspect for this project can be made clear.

2. To express **the transition** from one part of a piece of writing to another the following verbs can be very helpful:
approach, begin (with), come (to), continue (with), get away (from), go (to), go back (to), go on, pass on (to), proceed, return (to), start (with), turn (to). E. g.:
We shall now go back and say a few words about ...
We shall begin this chapter by starting ...
We shall now proceed to explain ...
We shall begin by adducing examples ...

3. The verbs expressing '**acquiring and passing on**' knowledge are often used in this function:
add, analyze, characterize, compare, deal (with), demonstrate, describe, discuss, draw attention (to), dwell (upon), exemplify, explain, formulate, give, illustrate, interpret, introduce, mention, present, point out, reiterate, show, sum up. E. g.:
We primarily need to explain ...
We would now like to sum up ...
We must also take into consideration ...
We shall now draw attention to ...
We may illustrate the method by analyzing ...
We may show one of these methods by assuming that ...
We ought therefore to mention what we mean when ...
One may note, in passing, two other properties ...
One ought to bear in mind the implications of ...
One ought to mention the importance of ...

Useful Phrases
Methods and Techniques

1. *The search for* privacy *has given rise to* new methods of ... 2. These methods are *more practical than older ones.* 3. At present mathematicians *lack the tools for* proving systems to be computationally secure. 4. It is hoped that *discoveries* in complexity theory will eventually *provide the tools needed to* establish ... 5. *To understand the advantages* conferred by the public-key arrangement, *consider* ... 6. *The drawbacks of the conventional systems* are particularly troubling to the new users of ... 7. *The method* described above *is most efficient in calculating* ... 8. We can conclude that *the method is applicable to the investigation of* ... 9. *A clear and detailed description of this method has been provided by* ... 10. The ideas developed *represent extensions and elaborations of a similar technique* described in ... 11. The researchers are at present looking at *the adaptation of this method to* more difficult problems. 12. *Applications of this method to* a restricted class of problems in ... *have recently been presented.* 13. *This method exhibits many advantages over* conventional techniques due to ... 14. *The method finds wide use in calculating* these values in ... 15. *The method provides good fit of* theoretical data and experimental values. 16. To overcome the difficulties *a slightly modified approach was suggested.* 17. *Another approach consists in developing* ... 18. *The application of this method is not without* its difficulties and questions. 19. Unfortunately, *the method* developed in our institute *suffers from two disadvantages* ... 20. *This method is unlikely to be successful for the solution of* ... 21. *This technique fails to give* satisfactory results for the solution of the problems connected with ... 22. *This method opens up broad perspectives for* fruitful interaction between the synchronic and diachronic approaches to language. 23. *Taking different but complementary approaches*, we have examined the flights of many insects and discovered some general principles. 24. *The oldest and most successful techniques* of knot theory *employ* topological transformations. 25. Searching databases is not that tough once you master a few basic techniques.

Unit III

The Bioinformatics Gold Rush

Background

Task 1. *Read the fragment from the report "Ethical Controversies of Future Biotechnology" which deals with the problem of increased "biologization" of modern science and society. Suggest the title for each paragraph and write a summary of the text in 3 sentences.*

THE EVOLUTION OF SCIENCE

1 Science in its modern sense is a young branch on the tree of civilization. After the period of romantic enlightenment, science began to emerge as a hypothetico-deductive enterprise, first in physics and chemistry and then in biology and medicine. The industrial-technical revolution began in the 19th century and more recently accelerated developments have originated in advances in electronics and computer science.

2 During the last five decades, we have been witnessing a biological revolution. Interestingly, this revolution brought with it an important new quality which was not associated with preceding

physico-chemical developments. This qualitative difference derives from the fact that only biology reflects an evolutionary process. The dramatic development of the branch of biology that we call molecular genetics dates back only to the discovery of the double helical structure ot DNA by Watson and Crick in 1953. Since then, we have come a long way in our understanding of the structure and expression of generic material. The gradual accumulation of knowledge of the structures of the genomes (the sum of the genetic material) of ever more complex live entities, with the eventual characterization of the whole human genome in the HUGO project, will provide radically new perspectives on functional homologies and evolutionary relationships.

3 According to the Finnish philosopher von Wright, we live in a period of increased "biologization" of modern science and society. This development may according to von Wright pose some inherent problems, since as he proposes, modern science in general has relinquished its claim to be a source of values. This view is arguable, at least with respect to the biological sciences. We are, in fact, by the use of modern genetic techniques obtaining an insight into the evolution of life itself. Not only does this insight fill us with awe and admiration, but it also emphasizes the interdependence of different species. The importance of generic plurality and the intricate ecological balance in nature are starting to be highlighted on a molecular level. The results of our analyses will by necessity have a major impact on our value orientation.

Prof. Erling Norrby

Reading Comprehension

Task 2. *Working in pairs, discuss the following questions.*

1. Do you agree with the statement "During the last five decades, we have been witnessing a biological revolution"? Support your ideas with some examples.
2. What discovery does the dramatic development of molecular genetics date back to? Can you show that this branch of biol-

ogy has come a long way in our understanding the structure and expression of genetic material?

3. Is it possible to obtain an insight into the evolution of life itself by using modern genetic techniques? Why are the ideas of genetic plurality and the intricate ecological balance in nature so important?

Reading 1

Task 3. *Read the fragment from the report concerning the human GENOME-project. In July 2000 the scientists announced that the first draft of the human genome sequence (figuring out the order of the letters in our genetic alphabet) had been completed. The next stage of the project is deciphering the meaning of the genetic instruction book. Description compises everything that can be known about a gene: where it works, what it does and how it interacts with fellow genes. Write an argumentative essay.*

THE HUMAN GENOME PROJECT—PROMISE OR THREAT?

1 By the year 2005, the human genome is expected to be characterized in all its details. This grand scientific enterprise is called the human GENOME-project or the HUGO-project (HUGO=HUman Genome Organisation). The results will provide a blueprint of the human body and they will be of immense importance for all future biomedical research.

2 Mapping the human genome is not new science. The mapping of human genes started in the 1960s when the first methods for gene localization were disclosed. Gene mappers have in the past been working on their favourite genes and knowledge about our genome has accumulated incrementally. In fact the human genome would be mapped and sequenced even without the GENOME-project. The new idea is to co-ordinate a worldwide effort, to increase the pace and to ascertain that the work is completed, using state-of-the-art methods.

3 The human genome resembles a teleprinter tape; it is a linear text without headlines or punctuation marks comprising some 3,000 million letters (nucleotides, represented by the letters A, C, G, and T). The text is subdivided into a number of smaller 'volumes' which the geneticists call *chromosomes.* The purpose of the human GENOME-project is to map each chromosome and eventually to determine the identity of all the 3,000 million letters that comprise the whole human genome. To accomplish the goal of having everything sequenced by year 2005 the collective world wide sequencing effort must on the average generate about 1 million nucleotides per working day. By today's standards this is an astonishing accomplishment. To grasp the width of the undertaking an historical comparison might be appropriate. The first nucleic acid to be fully sequenced was a small molecule comprising some 80 letters. This sequencing task took one team several years to complete and it rendered the person responsible for the project a Nobel prize in 1968.

4 To facilitate the mapping, landmarks ('markers') are first identified along each chromosome with an average spacing of some million letters (nucleotides). This is accomplished by constructing a so-called genetic map utilizing what are known as markers (a marker is a position in the genome where chromosomes from different individuals exhibit differences). This first goal has been reached—a crude genetic map has already been presented with markers spaced less than 10 million nucleotides apart in most chromosomal regions and denser maps are being constructed with new sets of markers, which will soon reach a spacing of one marker per 100,000–1,000,000 base pairs. The work has recently been speeded up by the discovery of highly informative so-called microsatellite markers, that is, markers representing regions in the genome which exhibit an exceptionally high degree of variability among individuals.

Prof. Ulf Pettersson

Vocabulary for Comprehension

Human Genome Progect, the an international scientific project that started in 1988. Its aim is to find and describe every gene in every chromosome in the human body, and to find out what each gene's purpose is, especially in order to discover which ones cause particular diseases
gene *n* any of several small parts of the material at nucleus (=centre) of a cell, that control the development of all the qualities in a living thing which have been passed on from its parents
chromosome *n* a threadlike object found in all living cells, which passes on and controls the nature, character etc of a young plant, animal, or cell. **Y chromosome** *n* a type of chromosome which exists only in male cells, and which makes someone a male rather than a female. **X chromosome** *n* a type of chromosome that exists in pairs in female cells
heredity *n* the fact that living things have the ability to pass on their own qualities from parent to child in the cells of the body
genetics *n* the study of how living things develop according to the effects of those substances passed on in the cells from the parents
DNA *n abbrev.* deoxyribonucleic acid; the acid which contains genetic information in a cell. DNA is responsible for all the features of a plant, animal, or human that are passed from the parent to the child, and it is sometimes called the 'building block' (=most basic substances) of life. Its structure was discovered by the scientists Francis Crick and James Watson
clone *n* the descendant of a single plant or animal, produced non-sexually from any one cell, and with exactly the same form as the parent
cloning *n* the production of genetically identical individuals

Reading Comprehension

Task 4. *Based on what you have read about the human genome, discuss the following questions with your partner.*

1. What does the human genome resemble?

2. What is a linear text of the human genome subdivided into?
3. What is the purpose of the human GENOME-project?
4. Which project won a Nobel prize in the field of biology in 1968?
5. Has the first goal of the project (a crude genetic map) been reached?

Exploring Language: Useful Phrases Setting a Goal

1. *The purpose of* the human GENOME-project *is to map* … 2. *This* first *goal has been reached.* 3. *The* second *main objective of our paper (research, study, analysis, discussion) is to* … 4. *To accomplish the goal of* having everything sequenced by 2005 … 5. *This task took one team several years to complete.* 6. *The* new *idea is to co-ordinate* a worldwide effort and to increase the pace. 7. To grasp the width of the undertaking *a historical comparison might be appropriate.* 8. *The work has* recently *been speeded up by* the discovery of … 9. *The results will be of immense importance for* all future biomedical research.

Reading 2

Task 5. *Read the article published in Scientific American (2000) and translate the italicized sentences into Russian. Explain the grammatical forms and structures. Pay attention to a large number of quotations used in the text. Write a summary.*

THE BIOINFORMATICS GOLD RUSH

A $300-million industry has emerged around turning raw genome data into knowledge for making new drugs

1 "Plastics." When a family friend whispered this word to Dustin Hoffman's character in the 1967 film *The Graduate,* he was advocating not just a novel career choice but an entirely different way of life. *If that movie were made today, in the age of the deciphering of the human genome, the magic word might well be "bioinformatics."*

2 Corporate and government-led scientists have already compiled the three gigabytes of paired A's, C's, T's and G's that spell out the human genetic code—a quantity of information that could fill more than 2,000 standard computer diskettes. *But that is just the initial trickle of the flood of information to be tapped from the human genome. Researchers are generating gigantic databases containing the details of when and in which tissues of the body various genes are turned on, the shapes of the proteins the genes encode, how the proteins interact with one another and the role those interactions play in disease. Add to the mix the data pouring in about the genomes of so-called model organisms such as fruit flies and mice, and you have what Gene Myers, Jr., vice president of informatics research at Celera Genomics in Rockville, Md., calls "a tsunami of information."* The new discipline of bioinformatics—a marriage between computer science and biology—seeks to make sense of it all. *In so doing, it is destined to change the face of biomedicine.*

3 "For the next two to three years, the amount of information will be phenomenal, and everyone will be overwhelmed by it," Myers predicts. "The race and competition will be who can mine it best. There will be such a wealth of riches."

4 A whole host of companies are vying for their share of the gold. Jason Reed of the investment banking firm Oscar Gruss & Son in New York City estimates that bioinformatics could be a $2-billion business within five years. He has compiled information on more than 50 private and publicly traded companies that offer bioinformatics products and services. These companies plug into the effort at various points: collecting and storing data, searching databases, and interpreting the data. Most sell access to their information to pharmaceutical and biotechnology companies for a hefty subscription price that can run into the millions of dollars.

5 *The reason drug companies are so willing to line up and pay for such services—or to develop their own expensive resources in-house—is that bioinformatics offers the prospect of finding better drug targets earlier in the drug development process.* This efficiency could trim the number of potential therapeutics moving through a

company's clinical testing pipeline, significantly decreasing overall costs. It could also create extra profits for drug companies by whittling the time it takes to research and develop a drug, thus lengthening the time a drug is on the market before its patent expires.

6 "Assume I'm a pharmaceutical company and somebody can get [my] drug to the market one year sooner," explains Stelios Papadopoulos, managing director of health care at the New York investment banking firm SG Cowen. *"It could mean you could grab maybe $500 million in sales you would not have recovered."*

7 *Before any financial windfalls can occur, however, bioinformatics companies must contend with the current plethora of genomic data while constantly refining their technology, research approaches and business models. They must also focus on the real challenge and opportunity—finding out how all the shards of information relate to one another and making sense of the big picture.*

8 *"Methods have evolved to the point that you can generate lots of information," comments Michael R. Fannon, vice president and chief information officer of Human Genome Sciences, also in Rockville.* "But we don't know how important that information is."

9 *Divining that importance is the job of bioinformatics.* The field got its start in the early 1980s with a database called GenBank, which was originated by the U.S. Department of Energy to hold the short stretches of DNA sequence that scientists were just beginning to obtain from a range of organisms. In the early days of GenBank a roomful of technicians sat at keyboards consisting of only the four letters A, C, T and G, tediously entering the DNA-sequence information published in academic journals. As the years went on, new protocols enabled researchers to dial up GenBank and dump in their sequence data directly, and the administration of GenBank was transferred to the National Institutes of Health's National Center for Biotechnology Information (NCBI). After the advent of the World Wide Web, researchers could access the data in GenBank for free from around the globe.

10 *Once the Human Genome Project (HGP) officially got off the ground in 1990, the volume of DNA-sequence data in GenBank began to grow exponentially.* With the introduction in the 1990s

of high-throughput sequencing—an approach using robotics, automated DNA-sequencing machines and computers—additions to GenBank skyrocketed. GenBank held the sequence data on more than seven billion units of DNA as this issue of Scientific American went to press.

11 Around the time the HGP was taking off, private companies started parallel sequencing projects and established huge proprietary databases of their own. Today companies such as Incyte Genomics in Palo Alto, Calif., can determine the sequence of approximately 20 million DNA base pairs in just one day. *And Celera Genomics—the sequencing powerhouse that announced in April that it had completed a rough draft of the human genome—says that it has 50 terabytes of data storage.* That's equivalent to roughly 80,000 compact discs, which in their plastic cases would take up almost half a mile of shelf space.

12 But GenBank and its corporate cousins are only part of the bioinformatics picture. Other public and private databases contain information on gene expression (when and where genes are turned on), tiny genetic differences among individuals called single-nucleotide polymorphisms (SNPs), the structures of various proteins, and maps of how proteins interact.

Ken Howard

Reading Comprehension

Task 6. *Read the article again to answer the following questions.*

1. What does Gene Myers, Jr., vice president of informatics research at Celera Genomics in Rockville, Md., call "a tsunami of informaition"?
2. Why can the new discipline of bioinformatics be called a marriage between computer science and biology?
3. How can the developments in bioinformatics change the face of biomedicine?
4. Find the paragraph in which the exrpession "Gold Rush" is used in regard to bioinformatics. When was the expression

coined and why?

5. What bioinformatics products and services do more than 50 companies offer?
6. Whom do they sell access to their information to?
7. Does bioinformatics offer the prospect of finding better drug target earlier in the drug development process? Prove this idea.
8. Why should bioinformatics companies constantly refine their technology, research approaches and business models?
9. What is the job of bioinfomatics nowadays when there is "a tsunami of information" concerning the human genetic code?
10. When did bioinfomatics get its start with a database called GenBank? What were the next steps in the development of this field, especially after the advent of the World Wide Web?
11. Why did additions of information to GenBank skyrocket in the 1990s?
12. Celera Genomics in Rockville, Md. announced in April 2000 that it had completed a rough draft of the human genome. Is it a great breakthrough, in your opinion?

Task 7. *Find the introductory paragraph in the following newspaper article and then arrange the other paragraphs in a logical order. Write a short summary and discuss it in the class.*

U.S. TO RE-EXAMINE BIOTECH SAFETY

Washington—The Food and Drug Administration's decision to hold public hearings on GM foods came amid concern by foreign consumers that not enough is known about the long-term effects of products made from bioengineered corn, soy-beans, potatoes and other crops.

A growing number of nations are requiring labels on GM foods to give consumers more information, an option that the U. S. administration previously rejected as unnecessary for foods deemed safe by the FDA.

Faced with a growing consumer backlash in Europe and Asia against genetically modified, or GM, foods, a U. S. government agency said Monday it would re-examine the safety of the foods and whether special labels may be needed.

Current FDA rules require companies to add special labels to bioengineered food products only if they are changed significantly or introduce a potential allergen from another food.

"We are thinking broader than just traditional labeling," said Joseph Levitt, head of the FDA's Center for Food Safety and Applied Nutrition. Regulators would "look at alternative and creative ways like web sites" for consumers to obtain information about foods made from GM crops, he added.

"Although people have enthusiastically accepted new drugs made from biotechnology, some consumers have concerns about the use of this technology in foods," said Health and Human Services Secretary Donna Shalala. "We need to ask why those concerns exist and how we can address them."

To gauge the American public's views about GM foods, the FDA said it would hold public meetings.

Labels are also opposed by U. S. food industry groups, which contend there is no reason to slap a special label on food that the FDA judges as safe.

A Gallup poll published earlier this month found that 27 percent of Americans surveyed believed biotechnology posed a serious health hazard, while 53 percent did not think it was a hazard. The remaining 20 percent said they were unsure if GM foods were dangerous.

Julie Vorman

Reading 3

Task 8. *Read the article from Scientific American (2000) and get its main points. Translate the italicized sentences into Russian. Write a summary.*

THE POTENTIAL MEDICAL BENEFITS OF ANIMAL CLONING

1 Cloning is typically thought of as the production of genetically identical individuals. *The primary biomedical benefits of cloning stem more from the use of this technology in the genetic modification of animals rather than from making identical copies, however.* The idea behind the cloning technique is that each of the cells in an individual contains the same set of genes and, under the right conditions, should be capable of directing the development of a new genetically identical copy of the original animal.

2 For genetic modification of an animal, the important point is to have a cell type that can be grown easily in culture. One example of this kind of cell is the fibroblast. *Fibroblasts are present in many different organs and tissues in the body and are responsible for, among other things, building up and tearing down the extracellular matrix that holds the cells in a tissue together.* Fibroblasts can be prepared readily by placing a sliver of skin in a dish containing the correct culture media and waiting for them to grow out and attach to the bottom of the dish. Because fibroblasts are so simple to grow in culture, it is possible to use the large-scale but inefficient methods of inserting genes into cells and selecting the cells with the correctly inserted gene. Only about one out of a million cells will correctly incorporate a foreign gene using the most common versions of this technique. Inserting a gene into a specific site, which is important for several biomedical uses, therefore requires about 100 million to one billion cells for a single success. *Therefore, one of the most important breakthroughs with current work is not cloning itself but the ability to turn a genetically modified cell into a fully developed animal.*

3 One biomedical application of the cloning technique is genetically modifying animals so that their cells and organs can be transplanted into humans. Normally, cells or organs from one individual (even one of the same species) will be rejected by another; the host recognizes the graft as foreign because of differences in surface molecules on the cells. *The graft is then rejected by the body's defense mechanisms and destroyed, just as if it were a disease-*

causing organism. Genetic modification can be used to disguise animal's cells and organs and thereby reduce or even eliminate rejection of the graft. Thousands of people die every year because of the unavailability of human organs for transplantation. Genetically modified animal organs could begin to fill this need.

4 Many other diseases could be treated by the transplantation of genetically altered cells. For example, Parkinson's, Alzheimer's and Huntington's diseases are caused by the death of specific cells in the brain. Preliminary research has shown that it is possible to alleviate the symptoms of Parkinson's disease by transplanting fetal pig brain cells into patient's brains. A related technique may be applied to diabetes, another widespread disorder. Currently diabetics rely on insulin therapy, which is far from being an ideal treatment and is certainly not a cure. The transplantation of genetically modified animal pancreatic islet cells—which could secrete insulin in response to the body's varying glucose levels, just as the cells in a healthy individual do—could effectively cure the disease. There are numerous other examples, so transplantation therapy could potentially relieve suffering in many thousands or even millions of patients.

5 Another important application of cloning technology (through both the genetic modification of animals and the creation of identical copies) lies in the potential to produce therapeutic proteins. Recently, researchers have demonstrated how to make such proteins in the milk of genetically modified animals. The mammary gland is a magnificent protein-manufacturing organ, and it also provides a convenient delivery system. The great value of the mammary gland is that it can synthesize the very large quantities of complex proteins, such as antibodies, that are needed for therapeutic or diagnostic purposes. *These proteins are easily isolated from milk and can be administered in pure form by injection.* In the future, we may drink altered milk to ward off diseases such as gastric ulcers or to treat autoimmune diseases such as some forms of arthritis.

6 *The discovery of a drug for the treatment of, or vaccination against, a disease is greatly facilitated if there is an animal model (an animal that mimics the behavior or responses of the human body) for testing the effectiveness of the drug.* But animals are generally not susceptible to the diseases that afflict humans. *AIDS is a good example.* HIV, the virus that causes AIDS, either does not infect or does not cause the same disease symptoms in laboratory animals that it does in humans. It is therefore difficult to test vaccines or therapies for their potential to alleviate the symptoms of the disease. Cloning technology may be utilized to produce useful genetically modified animal models, which would greatly facilitate the development of treatments or innoculations for many diseases. Scientists are already at work developing a genetically modified rabbit model that expresses the human receptor for the virus and is susceptible to infection.

James Robl

Reading Comprehension

Task 9. *Answer the following questions.*

1. What is cloning?
2. What are the primary biomedical benefits of the use of this technology?
3. What idea is behind the cloning technique?
4. What are fibroblasts responsible for? Are they present in many different organs in the body?
5. What is one of the most important biomedical applications of the cloning technique?
6. What is the aim of genetic modification of animal's cells and organs? Can genetically modified animal organs be transplanted into humans?
7. What diseases could be treated by the transplantation of genetically altered cells?
8. Is insulin therapy a cure or an ideal treatment of such a desease as diabetes?
9. Could the transplantation of genetically modified animal pancreatic islet cells effectively cure this disease?
10. Are animals generally susceptible to the diseases that afflict humans? May cloning technology be utilized to produce use-

ful genetically modified animal models for testing the effectiveness of new drugs?

Exploring Laguage: Useful Phrases Prospects and Applications

1. One of the most important *breakthroughs with current work* is ... 2. The most significat *innovation of the research* is that ... 3. The results obtained *highlight the potential of the method* ... 4. *These findings* ... *may be of* considerable practical *value.* 5. Scientists *are* already *at work developing* ... 6. *The theory* ... *proved useful in* solving problems concerning ... 7. *The technique* under discussion *can be applied in* combination with ... 8. *The primary* biomedical *benefits* of cloning *stem from* ... 9. *The idea behind* the cloning *technique* is that ... 10. *The method* of animal cloning *needs careful explanation* because ... 11. *This point requires justification (should be examined in detail).* 12. Cloning *technology may be utilized to* produce ... 13. *Another* important *application* of cloning technology *lies in* the potential to bring about improvements in ... 14. *Further experiments* in this field *may yield revolutionary results.* 15. *Further study* concerning this problem *may shed light on* ... 16. *The application* of the technique ... *will improve our understanding of* ... 17. Cloning has become *a worldwide problem* (*a hot topic of* debates).

Task 10. *Do an Internet search or go to the library and research on one of the topics that follow. Then write an argumentative essay.*

1. The potential medical benefits of animal cloning.
2. The new discipline of bioinformatics—a marriage between computer science and biology.
3. New developments in genetic modifications of animals and plants.
4. Biotech safety of genetically modified (GM) foods.
5. Ethical controversies of future biothechnology.

Reading 4

Task 11. *Read the newspaper article and analyze its paragraph division, the use of quotations and other characteristic features typical of newspaper style. Write a summary and discuss it in the class.*

IBM IS SEEKING BIOLOGY'S 'HOLY GRAIL'

New York—IBM is seeking to unlock the secrets of the human body with a supercomputer 1,000 times more powerful than the chess-playing Deep Blue.

IBM said Monday it will build a computer called Blue Gene to solve the mysteries of how proteins, the workhorse molecules and building blocks of the body, get their shape.

Paul Horn, senior vice president of research at IBM, said such a computer could provide crucial understanding of severe diseases like hepatitis and AIDS.

"With this project we have a chance not only to change the future of computing, but also the future of health care," Horn said.

IBM expects it will take up to five years and $100 million to build the computer, which will be a million times faster than the average desktop computer. It will perform 1 million billion mathematical operations per second, 500 times more than the fastest computer today.

Stan Burt, a researcher in computational biology at the National Cancer Institute in Fredrick, Maryland, said the problem of analyzing proteins is "one of the Holy Grails of biology."

"Many diseases can be traced back to problems involving proteins," he said, naming high blood pressure and the common cold as examples.

Knowing the structure of the proteins involved could allow scientist to tailor drugs to lock on to the proteins and block them, or change their function, he said.

Proteins are strings that fold into complex shapes. The shape largely determines how the protein works in the body, whether it transports oxygen in the blood, like hemoglobin, or breaks up molecules of fat to digest food.

The problem for scientists is that the way a protein goes from a string to a functional shape is very complicated. Each protein "chain" can be made up of more than a thousand links, and each link can have 10 different configurations.

"There are more pathways for the folding of a single protein ... than there are atoms in the universe," Horn said.

Proteins fold in a fraction of second in the human body, yet IBM estimates that even Blue Gene will take a year to compute the folding process for a single protein with 300 links in the chain.

To accomplish its tasks, Blue Gene will have 1 million processors—the central computing engines of computers—working together.

With these many parts, the computer has to be able to "heal" itself by detecting failing components, sealing them off, and directing the work elsewhere.

Henry Dietz, a computer engineer at the University of Kentucky in Lexington, said IBM's proposed design seemed sound, but was not a radical step forward.

"The system software is going to be very tough. There have been a lot of attempts to make self-healing software and hardware systems. It's been very difficult to make it really work," he said.

In 1997, IBM's Deep Blue supercomputer defeated the world's greatest chess player, Garry Kasparov, in a highly publicized tournament.

Armonk, New York-based IBM credits the technological advances and the media attention generated by the Deep Blue project with helping it become the largest supplier of supercomputers in the world, with a market share of one third.

The new Blue Gene computer will be built and operated at IBM's Watson Research Center in Yorktown Heights, New York.

Peter Svensson

Reading Comprehension

Task 12. *Discuss the following questions.*

1. What problems does computational biology deal with?
2. What can you tell about the role of proteins in the human body?
3. Why is it so important to solve the mysteries of how proteins get their shape?
4. What do you think of IBM's ambitious project of changing the future of health care?
5. What are the difficulties on the way of making self-healing software and hardware systems?
6. Can the Deep Blue project help IBM become the largest supplier of supercomputers in the world?
7. Where will the new Blue Gene computer be built?

Task 13. *Support or challenge the following statements.*

1. The problem of analyzing proteins is one of the Holy Grails of Biology.
2. By launching the Deep Blue project American scientists have a chance to change the future of computing.
3. Main tasks of computational biology as a science are very complicated and time-consuming.
4. The role of proteins as workhorse molecules and building blocks of the human body has defied scientists for years.
5. IBM's Deep Blue supercomputer did not defeat the world's greatest chess player, Garry Kasparov.

Exploring Language: Useful Expressions Proposals for Further Research

1. A researcher in computational biology considers the problem of analyzing proteins *to be "one of the Holy Grails*[1] *of* biology".

[1] the Holy Grail—something that people try very hard to find or achieve, even though this is almost impossible.

2. *Knowing the structure of* the proteins involved *could allow scientist to* ... 3. IBM will build a computer *to solve the mysteries of* ... 4. A supercomputer could *provide crucial understanding of* ... 5. *With this project we have a chance to* ... 6. *To accomplish its tasks*, a supercomputer will have 1 million processors working together. 7. The understanding of the exact mechanism of ... *deserves further investigation.* 8. In this field of study *much research remains to be done.* 9. It is necessary *to have an accurate theoretical knowledge of* ... 10. *Understanding* the formation of ... *can lead to new thinking about* ...

Reading 5

Task 14. *Read the article concerning brain-imaging technologies and then answer the questions based on the reading. Write an argumentative essay.*

SCIENTISTS IMAGE BRAINS TO TEST FREUD'S THEORY

New York—Sigmund Freud might concede that sometimes a cigar is just a cigar. But on the larger issue he was adamant—a dream is never just a dream.

Then what is a dream? The question has divided students of the mind for a century.

Freud said dreams are windows into an otherwise inaccessible mind, "the royal road to the unconscious." But others say they are merely the random firings of a dormant brain.

A century ago, a dream was a will-o'-the-wisp, a tantalizing glimpse into a spirit world where truths were revealed and events foretold. But Freud changed all that with a book.

"The Interpretation of Dreams," published Nov. 4, 1899, recreated dreams as a powerful probe of the unconscious mind. Suddenly, they were messages from an unknown landscape entirely within us.

"Before Freud, you would say that dreams were considered as spirits, as otherworldly things, messages from the other world," says psychoanalyst Leon Hoffman. "Through his study, he came to the idea that the mind worked outside of our awareness and that dreams had meaning."

Science is putting Freud to the test. Brain-imaging technologies allow researchers to see which parts of the brain are active during a dream.

Freud said dreams are a person's most deeply held wishes, expressed in symbolic form. Their purpose was to keep the unconscious drives that constantly pop up from waking us in the night.

Few psychoanalysts today believe dreams' function is to protect sleep. But Freud's more basic idea, that dreams are messages from a part of the mind beyond our conscious control, is stronger than ever.

Imaging technologies have shown what parts of the brain are most active during dreaming. Allen Braun of the National Institute on Deafness and other Communication Disorders studies sleeping people with a technology called positron emission tomography scanning. His findings test some of Freud's ideas.

For example, during dreaming, the parts of the brain involved in emotions and emotional memories are active. That explains why dreams can feel so intense and powerful. The areas involved in recognizing objects and processing images are also active: however, the areas that Braun calls the "executive regions of the brain" are deactivated. That might help explain why dreams are often illogical. All of those observations are roughly consistent with Freud's idea of dreams as messages from the unconscious mind. But contrary to what Freud might have predicted, the part of the brain involved in processing symbols is relatively quiet during dreaming. Freud believed dreams were full of symbols that had to be decoded to reveal the innermost workings of the mind.

"Dreams may be meaningful, but they're not meaningful in the way Freud thought," Braun says.

He and several of his colleagues believe that the meaning of dreams is right on the surface. In other words, a cigar is always just a cigar.

MATT CRENSON

Reading Comprehension

Task 15. *Below is the list of expressions you have come across in the text. Be sure you understand their meanings. If necessary consult a dictionary and give their Russian equivalents:*

students of the mind; an otherwise inaccessible mind; the royal road to the unconscious; the random firings; a will-o'-the-wisp; a spirit world; otherworldly things; brain-imaging technologies; outside of our awareness; communication disorders; positron emission tomography scanning; the innermost workings of the mind

Task 16. *Answer the following questions without looking at the text.*

1. When was a dream considered to be a tantalizing glimpse into a spirit world where events were foretold?
2. Who said that dreams were merely the random firings of a dormant brain?
3. How do you understand the expression "dreams are the royal road to the unconscious"?
4. What ideas did Sigmund Freud come to in his book "The Interpretation of Dreams"?
5. What processes do brain-imaging technologies allow researchers to see?
6. Do many psychoanalysts today believe that dreams' function is to protect sleep?
7. What is positron emission tomography scanning?
8. Which parts of the brain are active during dreaming?

Task 17. *Support or challenge the following statements.*

1. New observations are roughly consistent with Freud's idea of dreams.
2. Many people think that dreams are messages from the other world.
3. During dreaming the parts of the brain involved in emotional memories are deactivated.
4. The part of the brain involved in processing symbols is active during dreaming.
5. Dreams may be meaningful.

Exploring Language: References, Quotations and Abbreviations

After the last page of your article proper, and on a separate page or pages, place the references which consist of all the books and articles that you have read and made use of in writing your paper. The references are arranged in alphabetical order of the author's surname or the name of the organization. If more than one reference is given by the same author, then the earlier dated reference will appear first. References to one author are normally listed before those of joint authorship of the same author.

References to books: Author's surname, initials, date (in brackets), title (in italics or underlined), place of publication, publisher. E.g.:
Beard, R. M. and J. Hartley (1984: 4th ed.). *Teaching and Learning in Higher Education.* London: Harper and Row.

References to articles in journals: Author's surname, initials, date (in brackets), title of article, name of journal (in italics or underlined), volume number, issue number, sometimes season or month, sometimes page numbers. E.g.:
Mestel, R. (1999). Drugs from the Sea. *Discover*, Vol. 20, No. 3: 1/5–6/5.

The main uses of quotations in writing:

1) introduction of a viewpoint:
   According to R.F. Cohen, '... '
2) explanation of a point:
   As R. West suggested/observed '... '
3) exemplification of the point being made:
   Thus, for example, '... '
4) support for an argument:
   Recent research made by A. Bell shows that '... '
5) conclusion of a discussion:
   Therefore L.E. Fraenkel concludes '... '

Common English abbreviations

Ed./Eds.	Editor(s); edited by; edition
ff.	and the following pages, lines
l./ll.	line(s)
ms./mss.	manuscript(s)
no./nos.	number(s)
p./pp.	page(s)
para./paras.	paragraph(s)
ref./refs.	reference(s)
vol./vols.	volume(s)

Latin abbreviations and English equivalents

c./ca.	circa	about, approximately
cf.	confer	compare with
e.g.	exempli gratia	for example
et al	et alii	and others
etc.	et cetera	and so on, and all others
et seq.	et sequens	and the following pages
ibid.	ibidem	in the same place
i.e.	id est	that is, in other words
N.B.	nota bene	take special note of
viz.	videlicet	namely, that it to say

Unit IV

Marine Ecosystems

Pre-reading task

Task 1. *Discuss the following questions with a partner.*

1. What is deep-water archaeology concerned with?
2. Where did explorer Robert Ballard discover the Titanic in 1985?
3. What do you know about a unique ecosystem of the Black Sea?

Reading 1

Task 2. *The newspaper article you are supposed to read is devoted to the most ambitious project ever undertaken in the emerging field of deep-water archaeology. The scientists hope that the marine survey of the unique ecosystem of the Black Sea will enable them to have a complete chronicle of human history. Read the text and describe the characteristic features of newspaper style. Write a summary.*

ARCHAEOLOGISTS TO PLUMB BLACK SEA FOR SECRETS

1 As the story is told in the Old Testament, the great flood lasted for 40 days and 40 nights, and submerged every living thing on Earth beneath 7 meters of water, sparing only Noah, his family and the pairs of animals he protected on his ark.

2 Scientists have never found Noah or his ark, but they believe in his flood. It happened about 7,600 years ago, when the Mediterranean Sea, swollen by melted glaciers, breached a natural dam separating it from the freshwater lake known today as the Black Sea.

3 It was an apocalyptic event, in many respects much worse than anything described in Genesis. Every day for two years, 42 cubic kilometers of sea water cut through the narrow channel now known as the Bosporus, and plunged into the lake—more than 200 times the flow over Niagara Falls. Every day the lake level rose 15 centimeters.

4 And every day the water marched another kilometer inland, forcing people and animals to flee or drown, killing freshwater fish and plants by the ton, inundating forests, villages and entire cities and spreading pestilence and death for kilometers.

5 But as the deluge filled the lake and transformed it into a sea, it also created an ecosystem unique in the world—an oxygenless abyss where shipwrecks could rest for thousands of years in chill, inert darkness uncorrupted by living creatures.

6 The possible presence of old ships in near-mint condition on the Black Sea floor has made Noah's flood the starting point for perhaps the most ambitious project ever undertaken in the emerging field of deep-water archaeology.

7 Since explorer Robert Ballard discovered the Titanic 3,750 meters beneath the North Atlantic in 1985, deep-sea experts have used ever more sophisticated robots and submersibles to plumb the world's seas for both science and profit. Secrets that have withstood prying eyes for hundreds or even thousands of years are being unlocked in a new age of discovery reminiscent of the early days of space travel.

8 In 1988, commercial salvagers found perhaps $1 billion in gold in the 19th century paddle wheeler Central America, sunk in deep water off the North Carolina coast. In 1998, Tampa-based salvagers found a 2,500-year Phoenician cargo ship off Gibraltar. In 1989, Ballard found the German battleship Bismarck, sunk by the British in 4,680 meters of water during World War II, and this summer he found two ships nearly 3,000 years old lying more than 300 meters below the surface of the Eastern Mediterranean.

9 But the "Black Sea Project," with Ballard as lead oceanographer, has far more audacious goals than the discovery of a single ship. The project hopes to prove that literally thousands of years of history may lie intact in the shipwrecks that are blanketed by the sterile waters of Noah's flood.

10 "It's very much like a bathtub, but without a drain," Ballard said. "The Bosporus acts like an overflow valve, but the trapped water can't circulate, so it went anoxic [lost its oxygen] long ago. Such conditions exist nowhere else in the world."

11 In the past five years, project researchers trying to determine the Black Sea trade routes of antiquity have studied scientific literature, history and classical texts such as the myth of Jason, whose quest for the Golden Fleece is believed to have made him the first of the ancient Greeks to enter the Black Sea.

12 At project headquarters in the Turkish city of Synope, archaeologists mapped a seaport that acted as a major trading center during the Bronze Age, 5,000 years ago, and maybe even earlier. Artifacts have linked Synope to Black Sea sites north in the Crimea and west in Bulgaria, as well as to Troy, the fabled Aegean city that guarded the entrance to the Black Sea.

13 Rather than hugging the coast, the research suggests, sailors were willing to save time and money by traveling point-to-point over waters reaching depths close to 2,000 meters.

14 "Once an ancient mariner got into water beyond visual depth, he didn't know how deep it was," Ballard said. "Here you've got a trade route that can be documented as far back as any."

15 And just this summer, the project's underwater surveyors found an ancient coastline at a depth of 135 meters, just above the anoxic dead zone: "I'm not sure whether it's Noah's flood, or not Noah's

flood," said David Mindell, a Massachusetts Institute of Technology professor leading the marine survey. "But I do buy that there was a flood."

16 The theory of the Black Sea's Neolithic catastrophe was developed by Columbia University marine geologists William Ryan and Walter Pitman over three decades of research and published this year in their book "Noah's Flood."

17 The authors describe how the sea level worldwide began to rise as glaciers melted at the end of the last ice age 15,000 years ago. When the melt began, the Black Sea was a freshwater lake fed by rivers, among them those known today as the Danube, the Dnepr and the Don.

18 On the lake's southern edge, a 108-meter natural dam held back the waters of what is now the Mediterranean Sea. By 7,600 years ago, sea level probably had risen to within 5 meters of the lip of the Bosporus. And then it flooded.

19 "It probably started as a trickle when it pierced the Bosporus valley," Pitman said in an interview. "But when it got to the Black Sea, it gouged out a channel, and within 60 days it began to flood with a rush."

20 It was a one-of-a-kind event, and it had a unique result. The incoming salt water, denser than the fresh water it displaced, plunged straight to the bottom of the lake bed. As the seawater rose, the fresh water floated on top, and, being less dense, stayed on top, flowing in from the northern rivers and out via the Bosporus.

21 This bathtub phenomenon repressed the natural heat exchange that causes water to circulate and reoxygenate in seas and lakes throughout the world. Trapped on the bottom, the creatures that lived in the original floodwater used up the original oxygen, then died.

22 Today, the top 135 meters of the Black Sea are constantly renewed and support a vigorous marine life. But the abyss, leached of oxygen long ago, lies like a cold blanket hundreds of meters deep covering the sea floor and its secrets.

23 If there is no oxygen, then there should be none of the wood-boring mollusks that consume wooden ships at almost any depth. Marine archaeologists learned long ago that in ordinary circum-

stances, an old wooden wreck will appear as nothing more than a jumble of amphorae or other cargo on the sea bottom. Part of the hull may be intact if it has sunk into the mud, but exposed wood will have been eaten.

24 But in the Black Sea, anything on the bottom should be intact—including ancient wooden ships. And because the Black Sea lies within shouting distance of the Fertile Crescent and served as a commercial waterway for civilizations from ancient Greece to Byzantium and the Ottoman Empire, the possibilities are dazzling: "One should have a complete chronicle of human history," Ballard said.

25 This was the pitch he made in 1994 to archaeologist Fredrik Hiebert, a specialist in ancient trade along the "silk road" linking central Asia with the West. If Hiebert could find a trade route across the Black Sea, Ballard said, then deep water archaeology could find the wrecks: "This was the most incredible thing I had ever heard," Hiebert said. "The only problem was that the Black Sea is huge."

26 Hiebert agreed to oversee a series of library studies to determine what trade existed and found solid evidence that the ancient peoples on all sides of the waterway had a brisk interchange of goods.

27 Along the coast, whether in Synope or modern Ukraine or Russia, artifacts showed remarkable similarities. Roof tiles in the line-break Crimea were stamped with the Greek word "Synope," and studies of ocean currents and winds showed that sailors could travel the 280-kilometer south-north route across the sea from Synope to the Crimea, and probably did. But it was dangerous, Hiebert said: "Roman historians wrote about it."

28 Funded by the University of Pennsylvania and the National Geographic Society, Hiebert, a Penn archaeologist, and Ballard began work on the project. Hiebert, in charge of dry land archaeology, mapped the land site, while Mindell managed the marine survey.

29 "We were already up and running because of the anoxic water and the shipwrecks," Mindell recalled, but then "Noah's Flood" was published, with its suggestion that entire cultures may lie submerged below the ancient floodwaters.

30 The group expanded its mandate to include a search along the old coastline. Next year, Hiebert will spot likely locations for ancient settlements, and Mindell will look for them.

31 Meanwhile, Ballard will use the government's robot, a remotedly operated vehicle named "Jason," to begin scouting the old trade route, aided by a narrow-beam sonar developed by Mindell that can spot a wreck through up to 4 meters of sediment. Perhaps then, Ballard said, the team will be able to answer its most important question: Have the wood-borers figured out a way to work in the Black Sea abyss, "or do the wrecks have sails?"

GUY GUGLIOTTA

Task 3. *The article you have read can be divided into six parts:*

1. The story of the Old Testament (paragraphs 1–4).
2. A unique ecosystem in the world (paragraphs 5–6).
3. Discoveries of deep-water archaeology (paragraphs 7–8).
4. "The Black Sea Project" (paragraphs 9–15).
5. The theory of the Black Sea's Neolithic catastrophe (paragraphs 16–21).
6. The possibilities of having a complete chronicle of human history (paragraphs 22–31).

Write a topic sentence outline on the basis of the topic outline which has been done for you. You can also write your own topic outline.

Reading Comprehension

Task 4. *Answer the following questions and discuss them in the class.*

1. How do the authors of the book "Noah's Flood" describe the Black Sea's Neolithic catastrophe?
2. What is the goal of the "Black Sea Project"?
3. What is the cause of the bathtub phenomenon in the Black Sea?
4. Can you explain why the Black Sea is an oxygenless abyss where shipwrecks can rest for thousands of years in chill?

5. What equipment will be used in the marine survey of the Black Sea?
6. Why are the possibilities of having a complete chronicle of human history dazzling?

Exploring Language: Expressing Cause and Effect

The cause-and-effect structures reveal the connection between the reason for an event or a situation (the cause) and the influence this event or situation has on people, places, or things (the result, or the effect):

back in time or sequence				forward in time or sequence
cause reason	←	event action problem idea situation	→	result consequence solution effect

Task 5. *Complete the following sentences having cause-effect relationships.*

1. The transformation of the lake into a sea *led to (resulted in, caused)* ... (noun).
2. *Because (since, as)* glaciers melted at the end of the last ice age ... (clause).
3. The sea level worldwide began to rise; *therefore (so, thus, hence, as a result, as a consequence, accordingly, consequently, because of this)* ... (clause).
4. *The cause (reason)* of the ecosystem uniqueness is ... (noun).
5. The possibilities of having a complete chronicle of human history are dazzling *because of (as a result of, owing to, on account of)* ... (noun).
6. The bathtub phenomenon of the Black Sea is caused by (due to, because of) ... (noun).
7. *When (if)* the melt began, *then* ... (clause).

Task 6. *Write four sentences using patterns with* ***because/since*** *and* ***consequently/therefore/thus/so****.*

Cause: Stating a reason with adverb clauses that begin with *because* and *since*
Because/Since the Black Sea served as a commercial waterway for civilizations from ancient Greece to Byzantium and the Ottoman Empire, the possibilities of having a complete chronicle of human history are dazzling.

The possibilities of having a complete chronicle of human history are dazzling because/since Black Sea served as a commercial waterway for civilizations from ancient Greece to Byzantium and the Ottoman Empire.

Note: When the adverb clause beginning with *because* or *since* comes at the beginning of a sentence, a comma separates the clause from the result.

Effect: Stating a result with the discourse connectives *consequently/thus/therefore/so*
The fresh water lake was transformed into a sea whose depth supported no life; *consequently/thus/therefore shipwrecks could rest for thousands of years in chill, inert darkness uncorrupted by living creatures.*

Note: When using discourse connectives, you may write one sentence and join the two clauses as above with a semicolon (*consequently/thus/theerfore*) or a comma (*so*).

Pre-reading task

Task 7. *Answer the questions that follow and discuss them with a partner.*

1. Where are the world's coral reefs located?
2. What is symbiosis?
3. What is photosynthesis?

Reading 2

Task 8. *Read the article published in The Economist (2000). It discusses the results of the ninth international coral reef symposium concerning a clearer understanding of the mechanism of "coral bleaching". Identify the main points and write a summary of the text.*

LIFE'S A BLEACH, AND THEN YOU DIE

1 In 1998, 16% of the world's coral reefs, in a swathe stretching from Brazil to the Indian Ocean, were severely damaged by what is known as "coral bleaching". One of the results of the ninth international coral reef symposium was a clearer understanding of the mechanism of bleaching.

2 Bleaching happens when the animals that form the coral (creatures known as anthozoans, which look like miniature sea anemones) expel the algae that normally live symbiotically in their cells. Besides providing the colour that makes reefs so attractive to the eye, these algae act as the coral's solar panels. They capture light energy photosynthetically, and use it to produce organic chemicals, some of which are passed on to their hosts.

3 Around 90% of coral's sugars and amino acids arrive in this way. Only 10% are captured, in the form of small animals, by its stinging tentacles. In return for their services, the algae receive essential nutrients. But if they become a burden, they are summarily ejected, causing the coral to go white—hence the term bleaching.

4 Ove Hoegh-Guldberg of the University of Queensland, who has been studying coral bleaching since the early 1980s, presented new work to the conference on what exactly it is that causes the algae to become burdensome. He found that when coral is heated, the algae lose their ability to process light. They then have nowhere to put all the light energy they are absorbing, and the resulting breakdown of biochemical pathways creates toxic oxygen-containing molecules known as free radicals. Rather than suffer the effects of these, the anthozoans prefer to show their guests the door.

5 Bleaching is not necessarily a death sentence. Anthozoans can go into “starvation mode” for some months, waiting for conditions to ameliorate. If they do, the animals can acquire new algae and return to normal. But if the temperature does not drop in time, they will die.

6 The mass bleaching of 1998 was caused by climatic events which stopped wind and currents in the Indian Ocean—causing the waters to fall into a dead calm. As the sun beat down, the water's temperature increased until it was, in some places, 5°C above normal, an effect felt as much as 50 metres below the surface. Four weeks after the peak summer temperatures, the coral bleaching started.

7 For those who suspect that global temperatures are rising because of the increased amount of carbon dioxide, a “greenhouse gas”, in the atmosphere, Dr Hoegh-Guidberg's explanation is worrying. It suggests that bleaching will get more common.

8 But even if the temperature is not going up, there is still cause for concern. Geological history shows that anthozoans secrete their calcium carbonate skeletons more slowly during periods when there is a lot of carbon dioxide in the atmosphere. Indeed, there is evidence that increased concentrations of carbon dioxide in seawater are slowing the growth of the world's corals already. Time to buy a mask and a snorkel, and see it while it is still there.

NUSA DUA

Vocabulary for Comprehension

bleach *v* to cause to become white or pale, especially by means of chemicals or by the action of sunlight

coral reefs a mass of limestone (=a type of hard rock) formed by coral and/or other living things in warm shallow sea water known for its beautiful colours

sea anemone *n* a simple sea animal with a jelly-like body and brightly-coloured flower-like parts that can often sting

algae *n* very simple, usually very small plants that live in or near water

photosynthesis *n* the production of special sugar-like substances that keep plants alive, caused by the action of sunlight on chlorophyll (=the green matter in leaves); the way green plants make their own food

symbiosis *n tech* the condition of two different living things which depend on each other for certain advantages, often with one living on the other's body

nutrient *n tech* a chemical (or food) providing what is needed for life and growth

ameliorate *v fml* to make or become better or less bad; improve

carbon dioxide *n* the gas produced when animals breathe out, when carbon is burned in air, or when animal or vegetable matter decays. Carbon dioxide is a greenhouse gas

greenhouse gas *n* a gas, especially carbon dioxide or methane, which is thought to trap heat above the Earth and cause the greenhouse effect

greenhouse effect, the *n* the gradual slight warming of the air surrounding the Earth because heat cannot escape through its upper levels, said to be caused by pollution in the air

Reading Comprehension

Task 9. *Answer the questions that follow, then discuss them in the class.*

1. What was the subject of the ninth international coral reef symposium, which was held in 1998?
2. What conditions cause the coral to go white?
3. How are toxic oxygen-containing molecules created?
4. Is bleaching necessarily a death sentence?
5. What is "starvation mode"?
6. Is coral's bleaching connected with the increased amount of carbon dioxide?
7. Is there evidence that increased concentrations of a "greenhouse gas" in seawater are slowing the growth of the world's corals already?

Exploring Language: Useful Phrases Results and their Interpretation

1. One of the results of *the ninth international coral reef symposium* was *a clearer understanding of* ... 2. A marine expert *presented new work to the conference on* ... 3. He *found* that when coral *is heated* ... 4. *The results obtained suggest* that there is a relationship between ... and ... 5. *There is evidence* that increased concentrations of carbon dioxide *leads to (results in)* ... 6. *His explanation is worrying* because ... 7. *The analysis suggests* that bleaching will get more common ... 8. *The key to explaining the mechanism of* ... may lie in ... 9. In this report I would like *to present the data concerning* ... 10. *These estimates* of the process *were derived from* ... 11. *The data* used for this study *are available from* measurements ... 12. Before *we proceed to evaluate* ..., *it is informative to determine* ... 13. *Our arguments are based on* materials obtained in tests ... 14. *Computer simulations reveal* that ... is irrelevant here. 15. *The information* obtained *is crucial for understanding* ... 16. *The researchers furnish strong evidence* that ... 17. This model can *help find a solution by establishing* ... 18. The use of the technique *enables to predict* ...

Pre-reading task

Task 10. *Answer the questions that follow and discuss them in the class.*

1. Is it right to say that the glory days of antibiotics are over?
2. Do doctors have drugs to attack cancer, AIDS, asthma, hemophilia and many other diseases?
3. What drugs from the sea do you know?

Reading 3

Task 11. *The article you are going to read was published in Discover (1999). It is concerned with the attempts to find new supermedicines for the next millennium. Read the article and write a summary. Then discuss it in the class.*

DRUGS FROM THE SEA

There's only one place left to find the next wave of supermedicines. Fortunately, it's where we should have been looking all along

1 Outside the Scripps Institution of Oceanography in La Jolla, California, the sights, sounds, and smells are all of a seaside paradise—salty breezes, crashing blue green waves, picturesque piers, even people fighting gulls from their burgers as the wind whips napkins away. Inside, in biologist William Fenical's lab, it's goodbye to the sea's charms and hello to the smelly and slimy, the creepy and crawly, the disgusting and fascinating world of creatures scooped from that ocean outside, ground up, and thrown at every frightening disease he can think of.

2 This is the medicine chest of the next millennium. Fenical's quest may be critical to the future of medicine. We need new drugs. The glory days of antibiotics are over. Bacterium after bacterium is gaining resistance to our arsenal. Doctors are desperate for compounds to attack cancer, Alzheimer's, AIDS, and a long list of other diseases for which there are limited treatments and no cures. Since that momentous day in 1928 when Alexander Fleming first noticed that a common mold blown in through an open window stopped staphylococcus bacteria from growing in a petri dish—his discovery of penicillin—researchers have been looking in increasingly exotic locations for the next strain of antibiotics. The search has intensified in landfills, septic tanks, swamps, chemical dumps, and trash piles.

3 But the returns are dwindling fast. "In the old days you could wander around a cornfield or up in a forest, take little dirt samples, bring them back to the lab—and what do you know? You'd found microorganisms that produce streptomycin, or actinomycin, or vancomycin," says Fenical, who is the director of the Scripps Center for Marine Biotechnology and Biomedicine. "Today when you do that you find streptomycin, actinomycin, or vancomycin—the same things. Of everything you find, 98 percent turns out to be something you've found before. It's costly; it's inefficient. And when you look at a graph and you see disease resistance going up and drug discovery going down, it's also downright frightening."

4 Fenical's lab of weird concoctions may be proof of his conviction that drug hunters need to look in new places. His answer is surprisingly simple: search the sea. Since the 1980s he has been plunging into the ocean to find the next wave of medicines. Already he and his colleagues have dredged up some promising candidates: chemicals that soothe swelling, from lovely tropical organisms called sea feathers; a compound from a bulbous yellow soft coral that disrupts cell division in cancer cells, like taxol, the breast cancer drug derived from yew trees; and virus-killing proteins from ocean molds that live in sea grasses.

5 Fenical is not alone in this effort. Just a few doors down from his lab, chemist John Faulkner has been in the business even longer, dragging molecules from sponges that might fight cancer, kill viruses, or help scientists better understand how cells in our bodies grow and divide. In labs around the world, the search on this new frontier has intensified. Today the list of novel potential anticancer drugs at the National Cancer Institute's Natural Products Branch includes more candidates from the ocean than from the land. Several promising drugs from the sea that might be used to treat leukemia—including one from a creature called Bugula, which clings to the bottoms of boats—are involved in human trials.

Rosie Mestel

Vocabulary for Comprehension

all along **1** all the time **2** continuously
Scripps, Edward Wyllis *n* 1854–1926, U. S. newspaper publisher
Alzheimer's disease *n* an illness that attacks and gradually destroys parts of the brain, especially in older people, so that they

forget things and lose their ability to take care of themselves
weird *adj* very strange, unnatural, mysterious
concoction *n* something concocted, made by mixing or combining parts

Reading Comprehension

Task 12. *Answer the following questions and discuss them with a partner.*

1. Why has the search of new drugs intensified?
2. What can you tell about the glory days of antibiotics?
3. Why was Fleming's discovery of penicillin so important?
4. Why do drug hunters need to look for medicines in new places?
5. What has an American biologist William Fenical been trying to find since the 1980s?
6. Has he succeeded in finding any promising candidates, for example, a compound that disrupts cell division in cancer cells, virus-killing proteins from ocean molds? What other drugs have been discovered?
7. Why is the ocean a unique place for finding the next wave of supermedicines?
8. Why is finding new compounds a laborious process of trial and error?

Task 13. *Do an Internet search or go to the library and research on one of the topics that follow. Write an essay.*

1. The next wave of supermedicines.
2. The biggest natural disasters.
3. Tasks of deep-water archaeology.
4. Characteristic features of global warming.

Writing Topics

Choose one of the topics on this page and write a well-organized response agreeing or disagreeing with the opinion expressed. Be sure to support your point of view with explanations and examples. Include a refutation of the main ideas of your opponents and one concession. Use the vocabulary you have studied and make sure the verb tenses are appropriate.

1. **Opinion:** Our society deeply believes in the beauty and benevolence of technology, and regards it as the essential foundation for success and happiness. Yet we also know it has dangerous downsides, accidents and misuses.

   Write an argumentative essay agreeing or disagreeing with this opinion statement. Provide support or reasons for your point of view.
2. **Opinion:** We know that the sophisticated technologies developed in just the past few decades—chemical, mechanical, biological, digital, nuclear—have created a manifold environmental crisis that includes a depleted ozone layer, global-warming, pollution, deforestation, overfishing and species extinctions—enough to lead 1,600 world scientists to sign the 1992 Union of Concerned Scientists' warning that present rates of degradation will leave the planet "irretrievably mutilated." Yet not one of the technological processes that have led to this crisis has been forsaken, and indeed they tend rather to become more rapid, more extensive and more powerful—and presumably more destructive.

   Do you agree or disagree with this statement? Make a topic outline and write an argumentative essay containing either a point-by-point support or a refutation of the main arguments of the opposing view. Make concession if necessary. You may also suggest a course of action for the future.
3. **Opinion:** Psychologists call it cognitive dissonance: the anxiety caused by holding opposite beliefs at the same time. In fact, there is one particular difficulty that living with cognitive dissonance entails. It is the psychological and ultimately social strain of living with contradictory concepts. Surely much of the sense of unease and uncertainty in industrial societies everywhere is a result of having our deep faith in the

wonders of technology and the virtue of science challenged by our increasing doubts about where it all is leading and at what price (nuclear energy, bioterror, manifold environmental crisis).

Do you agree with the opinion that when a discovery becomes known nowadays, the first question is not "Will it be useful to mankind," as in earlier times, but "What damage will it cause, and will it diminish our well-being and health?"

KIRKPATRICK SALE

Exploring Language: Useful Phrases Comments on the Contents

1. *This article gives a general systematic analysis of* the notions of ... in the context of ... 2. *The book includes some of the latest research on* the use of ... in the consideration of ... 3. *The paper deals with the problem of* ... and *offers the latest results on* various aspects of the theory of ... 4. *The monograph serves as a fundamental resource on* the theories and applications of ... 5. *The book covers developments and applications* in the field of ... 6. *The present paper describes recent progress in* the study of ... 7. *The book* under discussion *provides a unique approach to* ... 8. *Chapter I is an introduction to the study of* ... and provides insight into recent applications to ... 9. *The article* in question *covers all the major areas of* ... in a readable, mathematically precise form. 10. *Several chapters deal with especially active areas of research* and give the reader a quick introduction and overview of the basic results in the area. 11. *The present paper is concerned with the application of* the concept of ... *to the solution of* a wide range of problems in ... 12. *The book is devoted to the basic problems of* ... which have great theoretical and practical significance in the present-day technology. 13. In the present article *we restrict our attention to* ... 14. *Readers are introduced to advanced mathematical procedures*, including ... 15. *Readers will find* in this textbook *a truly extensive and modern approach to* ...

Unit V

Space Exploration

Background

Today it is easy to believe that no unexplored worlds remain—that we have seen everything, in person, on television, or in photographs. But a new era of exploration is under way. This exploration, which uses everything from space probes to hairlike fibers to go where the human body cannot, may help answer one of humanity's most enduring questions: What is life's place in the universe?

Reading 1

Task 1. *Read the article concerning the Mars exploration robotic program. Translate the italicized sentences into Russian. Write an argumentative essay and then discuss it in the class. The article was published in The Economist (2001).*

MARTIAN CHRONICLES

The more scientists know about the place, the less they understand it

1 Fascination with Mars started many centuries ago. Its fiery colour and erratic movement across the night sky terrified the ancient Greeks and Romans, causing them to name the planet after their gods of war. Giovanni Schiaperelli, an Italian astronomer, created a detailed gazetteer of the planet in the 19th century, using such beguiling names as Olympus and Elysium for the features he saw through his telescope. In 1877, Schiaperelli thought he saw streaks on the Martian surface, and referred to them in his publications as *canali,* the Italian word for channels. That word was, however, mistranslated into English as "canals", and theories of an inhabited Mars irrigated by melt-waters from the polar ice caps began to flourish. Soon, a mere mention of the planet inspired visions of foreign worlds and fears of alien invasion, and it has since been the subject of countless science-fiction tales.

2 *So it was to everybody's disappointment that Mariner 4, the first space probe to fly past Mars (in 1965), revealed a place with a surface that appeared to have been static for billions of years.* The atmosphere was thin, dry and made mostly of carbon dioxide. There were no canals, no little green men, no signs of life whatsoever. But a later mission, *Mariner 9*, showed in 1971 that the surface had extensive sand dunes, massive craters and huge lava flows. It was also prone to dust storms. *Best of all, the probe found that, although Schiaperelli's original canali were indeed an artefact of his telescope, the planet did have canyons and what appeared to be networks of valleys that seemed to have been carved by water flows aeons ago.*

3 That evidence of water was exciting, for with it came the possibility of life. But it was also puzzling. The Martian atmosphere is so thin, and the planet's temperature so low (averaging $-60^{o}\,C$), that liquid water could not exist there. If it ever did in the past, conditions must have been very different. If that was the case, what became of the water when those conditions changed? It is clearly not in the atmosphere. *Nor is it frozen at the poles (these are made largely of solid carbon dioxide; the amount of water-ice they contain could not possibly have carved the valleys that are visible). It could be underground, in a so-called "cryosphere", but checking that idea would require extensive exploration below the surface.*

4 In any case, if there was water on Mars, it was a long time in the past; perhaps as much as 4 billion years ago. The picture *Mariner 9* painted of modern Mars was of a static desert, with none of the jostling of tectonic plates that makes life interesting for geologists by throwing up island chains and mountain ranges, and opening deep basins for oceans to form in. *Yet many areologists, as students of Mars are sometimes known, could not let go of the idea that the object of their affections was once an active world like the earth. Nor could they quite convince themselves that life—even if it was only bacterial life—had never dwelt there.*

5 With the *Viking* missions in the 1970s—which included two orbiting probes and two landing craft—areologists got more details of Martian topography. But they also got a disappointment. One of the landers contained a small reactor designed to encourage the growth of micro-organisms. A sample of Martian soil was put into it, but nothing interesting happened.

6 *The Viking missions were followed by a 20-year drought.* Three spacecraft (two Russian and one American) were sent in the planet's direction, but all fell victim to the Great Galactic Ghoul that some researchers jokingly suggest protects Mars from human prying. In 1996, however, a craft got past the ghoul. *Mars Pathfinder* landed in a region dubbed Ares Vallis, amid all the hoopla that NASA excels in. Shortly afterwards, *Mars Global Surveyor* arrived, and the modern era of Martian exploration began. *Global Surveyor*, which has mapped the whole Martian surface, some of it down to a resolution of 1.5 metres, has shown that those areologists who kept the faith were right. Mars is not a static world after all. It is a dynamic planet whose surface is in constant flux.

7 *Global Surveyor*, which is still contentedly zipping around the place, is equipped with four instruments. A high-resolution camera provides the pictures. A laser altimeter (the Mars Orbiter Laser Altimeter, or MOLA) measures the height of landscape features. A thermal-emission spectrometer (TES) similar to the one on *Odyssey* looks at the minerals. And a magnetometer measures the planet's magnetic field.

8 *All four instruments have sent back data that have turned the science of Mars on its head.* The camera has produced images of re-

cently formed water-carved structures, and MOLA, which works by bouncing beams of light off the planet's surface, has found mountains twice as high as Everest, a crater ten kilometres deep, and huge valleys carved by more water than scientists believed had ever existed on Mars. *Yet TES has detected minerals which seem to indicate that water could not possibly have created those valleys. And the magnetometer has found a distinctive magnetic signature which, some claim, suggests that Mars, too, may once have had tectonic plates.*

9 *The surprises seem endless.* Last June, the scientific community was stunned by the announcement that there were signs of liquid water on modern Mars after all. Mike Malin and Ken Edgett work for Malin Space Science Systems, a company contracted by NASA to build the camera on board *Global Surveyor* and to analyse some of the photographs. *They found gullies that, had they been seen in aerial photographs of the earth, would unhesitatingly have been identified as water-carved.* By Martian standards, these gullies appear to be young, since some of them have eroded features such as meteoritic craters that are known to have formed relatively recently. Dr Malin and Dr Edgett suggest that the gullies are being created by water that is either seeping slowly to the surface or building up behind barriers of ice and occasionally bursting through.

10 Unfortunately, the data from TES show no evidence of the sorts of minerals, such as clays and carbonates, that tend to form (at least on Earth) in the presence of water. Even more disconcerting was the discovery of a substantial quantity (about $2\frac{1}{2}$ m square kilometres) of rock made of a mineral called olivine. This substance (an iron-magnesium silicate whose greenish colour is reminiscent of olives) weathers rapidly in the presence of water. Its abundance on Mars suggests that the planet has been cold and dry throughout most of its history.

11 *Any water rushing through the Martian valleys would therefore have to have vanished before the olivine was deposited.* According to Michael Carr, a geologist who works for the US Geological Survey, the data are very puzzling. All the chemical and mineralogical evidence suggests that there have been no warm and wet periods in Martian history. The topographical evidence, on the other hand,

shows that there has been water all over the place.

12 Or, at least, it shows there has been liquid. One way out of the dilemma was suggested last August by Nick Hoffman, a geologist at La Trobe University in Melbourne. Dr Hoffman's theory, which has become known as "white Mars", is that the canyons on the planet are, indeed, the result of floods. Those floods, though, were not of liquid water but of liquid carbon dioxide.

13 That hypothesis opens up another explanation for the gullies. *A paper in this week's Geophysical Research Letters, written by Donald Musselwhite and his colleagues at the University of Arizona, suggests that those features could have been caused by the rapid vaporisation of liquid carbon dioxide. This would create a fluid that, although a gas, would have a similar density and cutting power to that of water.*

Reading Comprehension

Task 2. *Answer the following questions without looking at the text.*

1. Why did the ancient Greeks and Romans name the Red Planet after their gods of war?
2. What theories began to flourish after the Italian astronomer Schiaperelli had discovered *canali*?
3. Why were the results of the first successful space probe to fly past Mars disappointing to everybody?
4. Did the results of *Mariner 9* agree with those obtained by *Mariner 4*?
5. What details of Martian topography did areologists get with the *Viking* missions in the 1970s?
6. When did the modern era of Martian exploration begin?
7. What kind of data obtained by *Global Surveyor's* instruments turned the science of Mars on its head?
8. Are there any signs of liquid water on modern Mars?
9. What does all the chemical and mineralogical evidence suggest?

10. How does Dr Hoffman's theory explain the existence of the canyons on the planet?

Reading 2

Task 3. *The article published in Scientific American (2000) examines the main goal of human and robotic missions to Mars: looking for life. Read the article and identify its main points. Translate the italicized sentences from English into Russian. Write an argumentative essay.*

WHY GO TO MARS?

1 *For centuries, explorers have risked their lives venturing into the unknown for reasons that were to varying degrees economic and nationalistic.* Christopher Columbus went west to look for better trade routes to the Orient and to promote the greater glory of Spain. Lewis and Clark journeyed into the American wilderness to find out what the U. S. had acquired in the Louisiana Purchase, and the Apollo astronauts rocketed to the moon in a dramatic flexing of technological muscle during the cold war. *Although their missions blended commercial and political-military imperatives, the explorers involved all accomplished some significant science simply by going where no scientists had gone before.* The Lewis and Clark team brought back samples, descriptions and drawings of the flora and fauna of the western U. S., much of it new to the colonizers and the culture they represented. The Apollo program, too, eventually gushed good data. "Our fundamental understanding of the overall geological history of the moon is largely derived from the last three Apollo missions," says Paul D. Spudis, a geologist and staff scientist at the Lunar and Planetary Institute in Houston.

2 *Today Mars looms as humanity's next great terra incognita. And with dubious prospects for a short-term financial return, with the cold war a rapidly receding memory and amid a growing emphasis on international cooperation in large space ventures, it is clear that imperatives other than profits or nationalism will have to compel*

human beings to leave their tracks on the planet's ruddy surface. Could it be that science, which has long been a bit player in exploration, is at last destined to take a leading role?

3 The question naturally invites a couple of others: Are there experiments that only humans could do on Mars? Could those experiments provide insights profound enough to justify the expense of sending people across interplanetary space?

4 *With Mars the scientific stakes are arguably higher than they have ever been. The issue of whether life ever existed on the planet, and whether it persists to this day, has been highlighted by mounting evidence that the Red Planet once had abundant stable, liquid water and by the continuing controversy over suggestions that bacterial fossils rode to Earth on a meteorite from Mars.* A conclusive answer about life on Mars, past or present, would give researchers invaluable data about the range of conditions under which a planet can generate the complex chemistry that leads to life. If it could be established that life arose independently on Mars and on Earth, the finding would provide the first concrete clues in one of the deepest mysteries in all of science: the prevalence of life in the universe.

5 "If you find any life at all, what you'll have proven is that the processes that lead to the development of life are general," author and astronautical engineer Robert Zubrin said last fall in a speech at a conference at the Massachusetts Institute of Technology. *"It's a question of vast philosophical importance, and Mars is the Rosetta stone for answering it."*

SOLID EVIDENCE FOR LIQUID WATER

6 One of the reasons why the idea of sending people to Mars captivates at least a segment of the public is that it is already possible—the U. S. has the money and the fundamental technologies needed to do it. More important, recent discoveries about the planet's environment in the distant past have presented a clear and compelling scientific incentive for sending people: to search for evidence of life.

7 *The theory that liquid water was once stable on Mars has been bolstered by the Mars Global Surveyor probe, which photographed a channel last year that appeared to have been deeply incised by*

water flowing for hundreds if not thousands of years. Global Surveyor's important findings followed the successful Mars Pathfinder lander, which touched down on the planet in July 1997 and was among the first fruits of the National Aeronautics and Space Administration's "cheaper, faster, better" paradigm for robotic space exploration. Under this strategy, the agency has been undertaking more frequent, less expensive and less ambitious space missions.

8 *Pathfinder was hailed as a vindication of the paradigm, but the affirmation was short-lived.* The back-to-back failures of the next two spacecraft, the $125-million Mars Climate Orbiter and the $165-million Mars Polar Lander, were reminders of how much can go wrong even on relatively straightforward robotic missions.

9 The failures will almost certainly mean a longer wait before people are sent to the planet. Although NASA does not now have any official mandate to send people to Mars, some of its planned robotic probes were to perform experiments specifically designed to help prepare for human missions. After the success of Pathfinder there had even been informal talk within NASA of a human mission around 2020. Such a timetable now seems optimistic.

FOSSIL HUNTING ON MARS

10 *Rather than dwell on the recent setbacks, proponents of human exploration are using the controversial meteorite findings and the stunning Surveyor results to deliberate on discoveries and advances that experts could make on Mars.* Zubrin, for example, says that "if we are serious about resolving the question of life on Mars—and not just whether it's there but also how far it may have evolved in the past—humans are required." *To buttress his claim he notes that hunting for fossil evidence of ancient life would involve "traveling long distances through unimproved terrain, digging with pickaxes, breaking open rocks, carefully peeling away layers of fossil shales and lightly brushing away dirt.* This stuff is way beyond the capabilities of robotic rovers."

11 *A thorough hunt for any Martian life that might be hanging on—despite the present harsh conditions—would also have to be undertaken by humans, according to some experts.* Such life will

be hidden and probably microscopic, says Pascal Lee, a research associate at the NASA Ames Research Center. *"Finding it will require surveying vast tracts of territory," he explains.* "It will take a high degree of mobility and adaptability." Robots might be up to the task sometime in the distant future, Lee concedes. But relying on them to survey Mars completely for life would take an unrealistically long time—"decades if not centuries," he believes.

12 To accomplish the same scientific goals as a series of human missions, far more robotic missions—and therefore launches—would be required. The greater number of launches would mean that the robotic program would take much longer, because opportunities to travel from Earth to Mars are rather limited. They occur only once every 26 Earth-months, when the planets are positioned so that the trip takes less than a year. Some doubt whether a program lasting many decades would sustain the interest of the public and their elected officials. "Who's going to support a series of Mars missions that come up with negative results all the time?" Spudis asks.

13 Another reason why humans may have to be on site to conduct a thorough search for life stems from the fact that if any such life exists it is probably deep underground. Mars's atmosphere contains trace quantities of a strong oxidizing agent, possibly hydrogen peroxide. As a result, the upper layers of the soil are devoid of organic matter. So most strategies for microbe hunting involve digging down to depths where life or organic matter would be shielded from the oxidizing agent as well as from searingly high levels of ultraviolet light.

14 Upcoming probes will be equipped with robotic assemblies that can bore several centimeters into rocks or dig a few meters down into the soil. *But barring any discoveries at those shallow depths, researchers will have to bring up samples from hundreds of meters below the surface, maybe even one or two kilometers down, before they can declare Mars dead or alive.* Drilling for samples at such depths "most likely will require humans," says Charles Elachi, director of the Space and Earth Sciences Program at the Jet Propulsion Laboratory in Pasadena, Calif.

15 *Few if any researchers argue that a human mission to Mars would not advance planetary science. The points of contention,* *predictably, have to do with the cost-effectiveness of human missions in comparison with robotic ones.* The problem is that so little is known about several key factors that any analysis must depend on some largely arbitrary assumptions.

16 Then, too, it is difficult to predict the capabilities of robots even five or 10 years from now. *Today the kind of robotic technology that can be delivered to another planet under NASA's "cheaper, faster, better" paradigm is not really up to the demands of a game of croquet, let alone those of fossil hunting in a frigid, unstructured environment.* The kind of rover system that NASA has demonstrated on Mars is pitifully limited: the small Sojourner rover delivered by Pathfinder traveled just 106 meters around the landing site before Pathfinder stopped relaying its communications. And the best mobile-robot controllers are not even an intellectual match for a cockroach.

Glenn Zorpette

Reading Comprehension

Task 4. *Based on what you have read, answer the questions that follow.*

1. Why can we say that "Today Mars looms as humanity's next great terra incognita"?
2. What is the main goal of human space missions to Mars?
3. What important findings supported the theory that liquid water was once stable on Mars?
4. What are the aims of NASA's "cheaper, faster, better" program for robotic space explorations?
5. Why will a thorough hunt for any Martian life have to be undertaken by humans?
6. What is the role of robotic missions in searching for evidence of life?
7. Why is it so important to obtain data about the range of conditions under which a planet can generate the complex chemistry that leads to life?

8. What findings could provide the first concrete clues in one of the deepest mysteries of science: the prevalence of life in the universe?

Task 5. *Complete the following sentences and memorize useful phrases.*

1. *Our fundamental understanding of* the overall geological history of the moon *is* largely *derived from* ...
2. *The question naturally invites* a couple of others ...
3. A conclusive answer about life on Mars would *give researchers invaluable data about* ...
4. If *it could be established* that life arose independently on Mars and on Earth ...
5. It is *a question of vast philosophical importance* and ...
6. *Recent discoveries about* the planet's environment in the distant past *have presented* ...
7. Under the strategy "cheaper, faster, better", *the agency (NASA) has been undetaking* ...
8. *To accomplish the same scientific goals* as a series of human missions ...
9. *Most strategies* for microbe hunting *involve* ...
10. The problem is that *so little is known about several key factors* that any analysis ...

Reading 3

Task 6. *The article you are going to read was published in Scientific American (2000). It is concerned with the gravity-assist cycler approach to sending humans to Mars. It is shown that gravity-assist trajectories between Earth and Mars would reduce the cost of shuttling human crews and their equipment. Identify the main points of the text and make a topic sentence outline.*

A BUS BETWEEN THE PLANETS

Gravity-assist trajectories between Earth and Mars would reduce the cost of shuttling human crews and their equipment

1 Chemical rockets have served humankind well in its first, tentative steps into space. Having ridden atop them to the moon and back, one of us (Aldrin) can vouch for the technology's merits. Nevertheless, for trips beyond our nearest neighbor in space, chemical rockets alone leave much to be desired.

2 Even Mars, the next logical destination in space, would be a stretch for chemical rockets. To deliver a human crew to the planet would require so much fuel that essentially all scenarios for such a voyage involve producing, on the planet's surface, large amounts of fuel for the return trip. That requirement adds another element of risk and complexity to the proposed mission. Much more powerful plasma rockets, on the other hand, are still probably a decade away from use on a human-piloted spacecraft.

BOING!

3 A gravity-assist maneuver can be likened to a rubber ball bouncing off a wall. In this analogy, the spacecraft is like the rubber ball, and the planet is like the wall. As the ball bounces off the wall, the bounce-off velocity will be higher or lower if the wall is moving toward or away from the ball as they meet. The mathematical relation is described by a fundamental principle of Newtonian physics: conservation of momentum. The change in the ball's momentum is balanced by an inverse change in the wall's momentum.

4 In a gravity assist, the spacecraft "collides" elastically with the planet's gravitational field. If the planet is moving into the arc of the spacecraft's trajectory as the craft flies by the planet, the "rebound" speed of the vehicle will be higher than its approach speed. As with the ball bouncing off the wall, momentum is conserved: the planet's momentum changes as much as the spacecraft's. Because of the immense difference in their masses, though, the planet's velocity change is not significant.

5 The more massive the planet, the more sharply it can alter the spacecraft's trajectory. Jupiter, the most massive planet in the solar system by far, can effect a change as great as 160 degrees in a vehicle's direction relative to the planet. Not only can mission controllers change the spacecraft's speed and direction within the orbital plane, they can also put the craft in a new orbital plane quite different from that of the planet's orbit around the sun.

6 How can gravity assist help transport people to Mars? The answer is that it would be used to make critical adjustments to the trajectories of "cycler" spacecraft. These would use the gravity of Earth and Mars as the primary shaper of their trajectories as they cruised back and forth repeatedly, like buses on a scheduled route, shuttling crews and supplies between the two planets. Typically the cycler would not have to be decelerated into orbit around Mars, and it would never have to blast off the planet's surface for the return to Earth. The basic concept goes back more than three decades but continues to produce novel mission strategies, ones that we believe merit more attention than they generally receive in discussions of human missions to Mars.

7 The gravity-assist cycler approach is attractive because it would minimize the need for propulsive maneuvers. Because of the massive life-support equipment that would be required to sustain humans on an interplanetary voyage, huge quantities of rocket fuel would be required for each such maneuver.

CASTLES IN THE FIRMAMENT

8 The cycler concept goes back to the early 1980s. Alan L. Friedlander and John C. Niehoff, both then with Science Applications International, described a system in which several long-lived space habitats (which they called castles) would be placed in solar orbits that would periodically approach Earth and Mars. Human crews would occupy these castles during the interplanetary cruise, which would last two or more years. Then, during the encounters with Mars or Earth, the travelers would make use of more spartan vehicles ("taxis") to go back and forth between a castle and a planet. The castles would be resupplied using propulsion technologies, such as ion drive, that are highly efficient but too slow for human passengers. The trip on board the taxi between a castle and a planet would take about a week or less.

9 As originally conceived, the castles would orbit the sun in such a way that they would encounter Earth about once every five years and Mars every 3.75 years. In a second proposal the habitats would encounter Earth every three years and Mars every 7.5 years. Neither of these orbits would have been significantly modified by the planetary encounters. Thus, gravity assist was not a factor in these early concepts.

10 In 1985 Aldrin proposed a cycling habitat orbit that would make crucial use of gravity assist during each Earth flyby. These castles would also circle the sun, but the strategy would speed up the interplanetary transit time by exploiting orbits whose farthest point from the star (or aphelion) would be well beyond Mars. A major advantage of this scheme is that the habitats would encounter each planet every 2.7 years, and the planet-to-planet transit time would be as little as six months. A drawback would be that periodic propulsion maneuvers would be needed to keep the cycling habitat in this advantageous orbit. Because these maneuvers would not be time-critical, however, they could be performed by high-efficiency, low-thrust propulsion systems.

James Oberg and Buzz Aldrin

Reading Comprehension

Task 7. *Answer the following questions.*

1. Can chemical rockets be used for trips beyond our nearest neighbor in space?
2. When will it be possible to use much more powerful plasma rockets on a human-piloted spacecraft?
3. How can the modest propulsive power of chemical rockets be augmented?
4. When did mission controllers begin using gravity assists?
5. What is the analogy between a gravity-assist maneuver and a rubber ball bouncing off a wall?

6. How can gravity assist help transport people to Mars?
7. What are the advantages of the gravity-assist cycler aproach?
8. Who described a system in which several long-lived space habitats would be placed in solar orbits that would periodically approach Earth and Mars?
9. What is the drawback of periodic propulsion maneuvers?

Exploring Language: Useful Phrases Making Experiments

1. *A conclusve answer about* life on Mars, past or present, *would give researchers invaluable data about* the range of conditions under which a planet can *generate the complex chemistry* that leads to life. 2. *If it could be established* that life arose independently on Mars and on Earth, *the finding would provide the first concrete clues* in one of the deepest mysteries *in all of science.* 3. *The issue of whether life ever existed* on the planet, and whether it persists to this day, *has been highlighted by mounting evidence* that … 4. *The theory* that liquid water was once stable on Mars *has been bolstered by* the Mars Global Surveyor probe. 5. *Recent discoveries about* the planet's environment in the distant past *have presented a clear and compelling scientific incentive for* sending people to Mars. 6. There are experiments that *only humans could do* on Mars. 7. Those experiments could *provide insights profound enough to justify* … 8. Mars Pathfinder lander was among *the first fruits of NASA's "cheaper, faster, better" paradigm* for robotic space exploration. 9. *Under this strategy, the agency has been undertaking* more frequent, less expensive and less ambitious *space missions.* 10. Some of NASA's planned robotic probes were to *perform experiments specially designed to help* prepare for human missions. 11. *Most strategies for microbe hunting involve* … 12. *Upcoming probes will be equipped with* robotic essemblies that … 13. *Few if any researchers argue* that a human mission to Mars would not *advance planetary science.* 14. *The points of contention have to do with* the cost-effectiveness of human missions *in comparison with robotic ones.*

Unit VI

Chaos Theory

Task 1. *Before you read the article concerning chaos theory, the scientific debutante of the 1980s, answer the following questions.*

1. Has science long been based on the notion that law and order rule the universe?
2. What is a scientific law?
3. What do Kepler's laws concerning the motion of the planets along elliptical orbits state?
4. What is the role of Newton's discovery of the law of gravitation that applies to any object in the universe?
5. Do you remember any other law of mechanics or physics?

Reading 1

Task 2. *Read the article published in Discover (2000). Translate the italicized sentences into Russian and explain to your partner what grammatical forms and constructions are used. Examine the connectives which indicate the logical relationships in the text. Write an argumentative essay.*

DOES CHAOS RULE THE COSMOS?

Chaos surrounds us, and yet so do orderly patterns. Scientists are now trying to discover how they can coexist

1 Science has long been based on the notion that law and order rule the universe. When primitive people looked at the sky, they could make sense of what they saw only by attributing it to the whims of powerful gods. But in the sixteenth century the German astronomer Johannes Kepler reduced the motion of the planets to three simple laws that guided them along elliptical orbits. His work led Isaac Newton to discover a law of gravitation that applied to any object in the universe.

2 The universe, scientists subsequently assumed, is a predictable, clockwork system. Some parts are more complex than others—the workings of a swirling galaxy, for example, are rather more intricate than those of a pendulum—but directing even the most complex part is the same rule of order, though it may be imperceptible to our limited brain power. Simple causes always produce simple effects, the reasoning went, and complexity must result either from complicated rules or from the interaction of large numbers of things. Thus the simple geometric shape of a planet's orbit—an ellipse—was seen as a direct consequence of the simplicity of the law of gravity, while the complexity of the DNA molecule was considered a consequence of the huge number of ways in which its atoms could be arranged.

3 *Imagine Newton's and Kepler's dismay if they could have read the July 3 issue of the journal Science this year. In it Gerald Sussman and Jack Wisdom, a computer scientist and an astronomer, respectively, at MIT, announced that the entire solar system is unpredictable.* Without an infinitely precise knowledge of the location and velocity of the planets at any given moment, our Newtonian calculations will be completely wrong after a mere 4 million years.

4 Such startling findings about the changeable nature of the universe are appearing more and more frequently at the frontiers of today's mathematics. *We now know that rigid, predetermined, simple laws can lead not only to predictable, everlasting pattern but also to behavior so complex and irregular that it appears to all intents* *and purposes random.* This phenomenon is called chaos.

5 Chaos raises some fundamental questions about the universe: *Since order can generate chaos as well as pattern, what is the role of natural law? Is it chaos, not order, that rules the universe?* And where do nature's complex patterns come from, if not from simple laws?

6 At the moment scientists have only begun to ask these questions, and so answers are a long way off. For now they must be content to try to investigate chaos in many different phenomena. Ecologists, biologists, astronomers, chemists, economists, physicists—all have found chaos in their own disciplines. *In each case chaos seems to be pointing toward a new understanding of how complexity and patterns arise.* Chaos may help explain the evolution of life on Earth. It may shed light on the age-old question of time's arrow. *It may even let us unlock the baffling mystery of subatomic physics.* And at some point, all these individual efforts may come back together into a single science of change.

7 Chaos was first uncovered in the field of dynamics, which grew out of Newton's laws of motion and gravitation. Dynamics studies how systems change over time. (A system, by definition, is a group of bodies that are all subject to the same forces.) Traditionally researchers approached dynamics quantitatively. The state of the system—say, the positions of the planets and their orbiting speed and direction—was given in numerical values, and the job of the dynamicist was to calculate how those numbers change over time. Now, however, the approach has become qualitative—researchers are looking to say things about the general features of the system. Thus Sussman and Wisdom, instead of saying, "Pluto will be at location X in 10 million years," were essentially saying, "The solar system exhibits chaos."

8 Their approach succeeds thanks to an old trick invented by René Descartes, one that they've stolen and run backward. Descartes discovered how to turn geometry into numbers by assigning coordinates to points in space. *Thus a square can be said to be the area inside the points* $(0,0)$*,* $(1,0)$*,* $(1,1)$*, and* $(0,1)$ *on a two-dimensional graph.* Today we do the reverse: we turn numbers into geometry by pretending that they are coordinates in an imaginary space called

phase space. *Thus the interaction between a population of foxes and the population of rabbits they prey on might be represented by a dynamic system whose two variables are the number of foxes and the number of rabbits.*

9 If we think of those two numbers as coordinates on a two-dimensional graph, we can use them to draw pictures of how the two populations vary. Add a third variable to this ecological model—say, the juniper bushes the rabbits feed on—and you need three dimensions to draw the picture. A more complicated ecological model, with seven different species interacting, similarly determines a seven-dimensional phase space, and so on. Over time the populations of foxes and rabbits rise and fall, and so the point that represents them in phase space moves around. In this way, dynamics changes from long lists of numbers to the motion of points flowing through an appropriate phase space.

10 Often points at great distances from one another all home in on particular regions of the phase space. These regions turn out to have structured geometric forms, and since they attract points, they're called attractors. Attractors embody the long-term qualitative behavior of a system. If a system changes in simple ways, its attractor is a simple geometric object. For example, a system that does nothing at all is represented as a single fixed point. A system that repeats the same behavior periodically traces a closed loop, since it always comes back to the same place in phase space.

11 *Surprisingly, however, a system built on simple processes—three objects floating around each other in space, for instance—can also generate far more complex forms, which dynamicists call strange attractors.* And they are indeed strange: often they look like milk swirling around on the top of a cup of coffee. *They are so convoluted, twisted, and folded in on themselves that a point traveling along one of them seems to be moving completely randomly.* But it is important to remember that both traditional attractors and strange attractors are generated by simple processes. They are equally common, and given the right kinds of nudges, most dynamic systems can be persuaded to exhibit order or chaos.

12 *Chaos, being ubiquitous, strikes at the heart of what we think of as "nature's laws," with their safe, predictable consequences.*

Though simple rules may govern individual atoms, nevertheless the behavior prescribed by those rules may well be chaotic. That implies that nature's laws can't be responsible for the simplicity and order you encounter in your daily life. Chairs, dogs, houses—these are simple in the sense that we recognize them as entities and have a good idea how they will behave and how we should relate to them. But a dog is made from an inordinately large number of atoms. How does a complex system of atoms know about the big simplicities of wagging tails and chasing cats? How can organized large-scale structures function when the atoms that make them up are swimming in an ocean of chaos? How can stable patterns of behavior arise in a fundamentally chaotic world?

13 To understand how chaos—and the questions chaos raises—affects your everyday life, consider the seemingly simple matter of your heart. *Traditional science treats it as if it were a pump beating like clockwork, whose complicated cycles can be broken down into a number of simple waves of standard shapes. Real hearts are far more puzzling.* Your heartbeat is triggered by signals from your brain, but the actual rhythmic contractions are the result of a democratic vote by millions of muscle fibers, all agreeing to contract in synchrony. Such a system is obviously far from clockwork. The rhythm of your heartbeat continually varies by tiny but measurable amounts. It's not a variability imposed from the outside; even when your body is at rest, your heartbeat fluctuates. It is caused by chaotic internal dynamics.

IAN STEWART

Vocabulary for Comprehension

cosmos [ˊkɔzmɔs] *n* the world or universe as an embodiment of order and harmony (as distinguished from chaos)
order [ˊɔ:də] *n* a state in which the units of a whole are arranged, form a pattern or sequence, or are associated according to one or more definite rules. The pattern or sequence can be either in space or in time
disorder [dɪsˊɔ:də] *n* a lack of order in a system or an arrangement. Disorder can exist in varying degrees, e. g. 1) in the liquid state

ions or molecules display less order than in the corresponding solid state, so the ions and molecules display a limited disorder; 2) if some names in an alphabetical list are out of order, then a certain degree of disorder exists in the list

chaos [ˈkeɪɔs] *n* a state in which there is no order at all, and no connection between any units of a whole; it is the extreme form of disorder, e. g. in the gaseous state ions and molecules display no order at all; they are in a state of chaos

random [ˈrændəm] *adj* describes an action, event, process or state which follows no rule, exhibits no order, e. g. when two dice are thrown the result is random, i. e. no combination has a greater chance of appearing than any other combination. A random event cannot be predicted

pattern [ˈpætən] *n* a repeated or regular arrangement of objects, events, properties, behaviour or characteristics. The recurrent configurations (repeated arrangements in space) form a static pattern, i. e. a pattern which is standing still and can be seen all at once. A pattern of recurrent events or processes is a dynamic pattern, i. e. a pattern which appears at regular intervals of time, e. g. the distribution of mosquitoes spreading malaria in Ceylon depends on the rainfall; during the rainy season many people suffer from malaria (a dynamic pattern of processes with a time interval related to the climate of the country)

law [lɔ:] *n* a law is an empirical generalization, either affirmative or conditional, that is accepted as true, e. g. 1) the extension of a spring is proportional to the load (Hooke's law)—affirmative statement; 2) for a given mass of gas **if** the temperature remains constant, **then** the volume of the gas is inversely proportional to the pressure (Boyle's Law)—conditional statement

DNA [ˌdɪ: en ˈeɪ] *n abbrev.* for deoxyribonucleic acid; the acid which contains genetic information in a cell. DNA is responsible for all the features of a plant, animal, or human that are passed from the parent to the child, and it is sometimes called the 'building block' (most basic substance) of life. Its structure was discovered by the scientists Francis Crick and James Watson

MIT *abbrev.* for Massachusetts Institute of Technology; an important and respected US university, especially known for its research work in scientific subjects such as mathematics and computer science

Reading Comprehension

Task 3. *Answer the following questions.*

1. What scientific laws have led to the idea that order rules the universe?
2. What does complexity result form?
3. What facts concerning the behavior of the solar system have been discovered?
4. Do simple laws always lead to a simple motion (or pattern) from a modern point of view?
5. How do scientists describe the behavior of dynamic systems geometrically?
6. What is an attractor?
7. How can a chaotic behavior be described in terms of attractors?
8. What are the examples of an ordered predictable motion which arises on the chaotic basis?
9. Is human heartbeat quite similar to clockwork?
10. Have astronomers, biologists, chemists, economists, ecologists found chaos in their own disciplines?

Reading 2

Task 4. *Read the article published in Scientific American (1998). Translate the italicized sentences into Russian. Examine the connectives which express the logical relationships in the text.*

COMPUTING WITH CHAOS

In the heart of a new machine lies the flakiness of nature

1 *It is a sure sign that a physical science has reached maturity when it yields a new kind of computer.* Charles Babbage's brass-geared difference engine crowned 19th-century mechanics, ENIAC's vacuum tubes put atomic theory to a tough test, and microchips proved the power of early materials science. *More recently, geneticists have coaxed DNA to do math, and physicists have dodged the uncertainty principle to build simple quantum computers.*

2 *Now it appears that chaos theory, the scientific debutante of the 1980s, has grown up as well.* In September, William L. Ditto of the Georgia Institute of Technology and Sudeshna Sinha of the Institute of Mathematical Science in Madras, India, published the first design for a chaotic computer. *Their novel species of machine would exploit the very instabilities that other kinds of computers do their utmost to squelch.*

3 So far the machines have been only simulated mathematically; it will take several months to actually build one. *Daniel J. Gauthier, a chaos researcher at Duke University, says the design is "very interesting" nonetheless because chaotic machines appear able to add and multiply numbers, handle Boolean logic and even perform more specialized calculations.* Together, Ditto says, such operations provide the bare necessities needed to make a general-purpose machine. *Whereas quantum computers and DNA seem suited to only certain problems, such as code breaking or complex mathematics, chaotic computers might be able to do nearly everything current computers do and more.*

4 *Whether they can do so better is an open question. "Better means faster or cheaper, and semiconductors have a huge head start," Gauthier points out.* But devices with a heart of chaos will certainly be different.

5 They will come in many forms. The first machines will probably be assembled out of lasers or analog electronic circuits. But in principle, Ditto says, chaotic computers could be made by connecting a bunch of almost any devices that slip easily into chaos—not randomness, but cyclic behavior that cannot be predicted very far in advance because it is so sensitive to tiny perturbations. The "processors" could theoretically be something as simple as dripping faucets.

6 *Building a computer out of leaky spigots is easier than you might think, and it illustrates well how a chaotic computer would work.* If a faucet is very leaky, its drips fall in a chaotic rhythm that varies wildly depending on the water pressure. Slightly leaky faucets, however, drip steadily. So the tap handle can control both the rate of dripping and whether it is regular or chaotic.

7 *To add three numbers—x, y and z—simply place a funnel under three faucets, adjust them to drip x, y and z times a minute, respectively, and then measure how many drops of water leave the funnel after a minute.* Boolean logic, the foundation of all digital computing, is only slightly harder. *The trick is to set the water pressure and handle position to just the right point at which the spigot drips exactly once per minute if left alone but not at all if a single extra drop of water is added to the pipe behind it.* Almost all chaotic systems will have such critical points, and chaos theory tells you how to find them. By arranging many faucets on a wall so that the drips of higher taps start or stop lower faucets leaking, one can program with plumbing.

8 Of course, Ditto and his colleagues plan to use considerably faster components: advanced lasers that, instead of dripping, send out femtosecond pulses, trillions of which can fit comfortably into one second. "Coupling them together, so that each leaks light into the next, might allow us to perform billions or trillions of calculations per second," he says, giddy at the prospect.

9 "We're also working on using silicon chips to control living neurons," which behave chaotically, Ditto reports. A web of such cybercells could work on many different parts of a problem at the same time. "This really is a whole new paradigm for computers," Ditto says.

10 New computing paradigms are claimed entirely too often and too cavalierly. But now that chaos theory has matured from naive science to fulsome technology, perhaps this particular spinster is worth a long, thoughtful look.

W. Wayt Gibbs

Reading Comprehension

Task 5. *Answer the following questions.*

1. Have chaotic computers been simulated mathematically?
2. What principles will chaotic machines exploit?
3. Might chaotic computers be able to do nearly everything current computes do and more?
4. How could the first devices with a heart of chaos be made?
5. Why is it possible to say that "chaos theory has matured from naive science to fulsome technology"?
6. Paraphrase the expression "perhaps this particular spinster is worth a long, thoughtful look".

Exploring Language: Useful Phrases New Problems

1. Such startling *findings about* ... *are appearing* more and more frequently *at the frontiers of today's mathematics.* 2. Chaos *raises some fundamental questions about* ... 3. At the moment scientists *have only begun to ask these questions* ... 4. Answers are *a long way off* because ... 5. We *face the problem of finding an explanation for* ... 6. *The factors underlying these results* ... remain unclear. 7. Here *a certain clarification is necessary* since ... 8. *This point requires some justification* because ... 9. The most logical explanation for ... *is based on the concept of* ... 10. *The data* obtained in the field of ... *need careful study.* 11. This technique *has not become a widely used tool* in the field of ... 12. By making explicit these properties, ... I hope *to provide an explanation for* ... 13. It seems impossible *to tackle the problem successfully* using ... 14. At present we cannot *explain the discrepancy between* ... and ... 15. *What is less easy to explain is* how ... can induce ... 16. While our analysis *leaves many questions open*, it *serves to provide a unified explanation for* a number of ... 17. *It is not at all clear* how to determine ... 18. *The confusion arises* because of ... 19. Modeling this phenomenon *poses many problems connected with* ...

Resumé

1. *The present monograph focuses on* the problems of technology for sustainable development. 2. *The book covers the fundamental problems of* the industrial ecology of the 21st century. 3. *The article develops and illustrates* an innovative theory called … 4. *This book bridges the gap between … and …* ; it is a source book for those researching and teaching computing. 5. *This research monograph provides a perspective on the foundations of* algebra. 6. *The article* under consideration *offers a solution to the problem of …* 7. *This book* is a collection of articles on … which *brings together evidence concerning* … 8. *This book is written for* Earth specialists. 9. *Part 1 deals with theoretical considerations.* 10. *Part 2 presents analyses of data*, both from a theoretical and from an applied point of view. Topics include … 11. *Part 3 centers around analyses of data* and *covers contemporary theories.* 12. *A final chapter offers clear and practical guide-lines on* methods of data collection. 13. *This paper provides a solid grounding* to enable the student to understand … 14. *The article is aimed at those requiring* an introduction to logic. 15. *This book is extremely comprehensive and deals with* a very complex subject. 16. *This book raises many intriguing problems* and will be a stimulus for a great deal of *productive theoretical and descriptive research* on the phenomena. 17. *The paper is concerned with* the problem of … and *demonstrates some of the limitations of* contemporary theory. 18. *This collection of articles captures some of the newest developments* in the field of … 19. *The paper develops and illustrates an innovative theory* called … , and applies it to representative phenomena. 20. *The book includes a full bibliography and suggestions for further reading* and is supplemented with more than 1.000 photographs. 21. *The novel statistical methods* employed by the authors *lead to the identification of* … , which *sheds fresh light on* the relationship between … and … 22. *The introductory sketch provides a general outline of* the problem. 23. *These approaches are examined and synthesized to produce* a comprehensive methodology that can be used for an analysis of … 24. *The central part of the work provides* information for …

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