Unit 5

Mind and Brain

Objectives

- Acquaint yourselves with the Hypothesis-Test discourse pattern in presenting scientific research;
- Understand why the study of emotions contributes to the psychological wellbeing of the general population;
- Use the results from scientific research to explain the value of positive emotions;
- Develop your skills to describe experiments that test hypotheses;
- Describe the symptoms of depression and explain its consequences;
- Discuss how to cultivate a positive attitude towards life and how to face darkness in life;
- Note down the main points when listening to talks and interviews.

Task 1: Familiarize yourselves with the following new words, set expressions or lexical chunks to prepare for reading the texts in this unit.

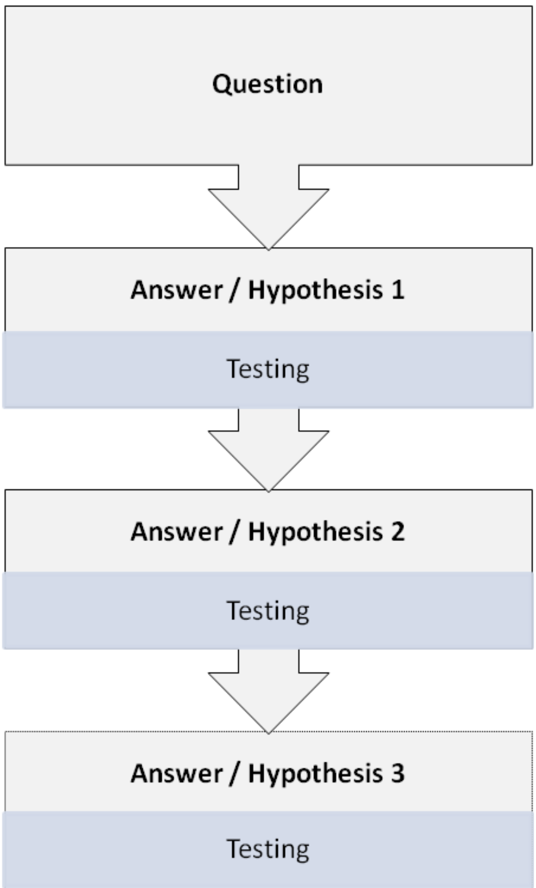
access these benefits	得到这些好处
accrue more personal resources	累积更多的个人资源
affable	友善的
afflict the well-being of humanity	损害人类的利益
be afflicted with	遭受......的折磨
ail this world	使世人遭受痛苦
ailment	病痛
alleviate clinical depression	缓解临床抑郁症
altruistic act	利他行为
Alzheimer's disease	阿尔茨海默病
anchor on initial thoughts or come to premature closure in their diagnosis	锚定在最初的想法上或得出不成熟的诊断结论
antidepressant	抗抑郁剂
autonomic nervous system	自主神经系统，植物性神经系统
balm of hurt minds	治疗心灵创伤的良药
baseline	基线
be diagnosed with depression	被确诊患有抑郁症
brainchild	独创的观念；脑力劳动的产物
broach the subject of depression	谈及抑郁的话题
broaden an individual’s mindset	开阔人的胸怀
buffer the resilient people against depression	使韧性强的人免受抑郁症的伤害
camaraderie	友情

cardiovascular repercussion	对心血管的影响
Carnivore	食肉动物
Catholic nun	天主教修女
cholesterol level	胆固醇水平
clandestinely	秘密地
clog emergency rooms	阻塞急诊室
cohesive, moral, and harmonious social organizations	有凝聚力的、有道德感的、和谐的社会组织
compassionate act	富有同情心的行为
Constituent	选民
Convent	女修道院
cortical neuron	皮层神经元
cultivate positive emotions	培养积极情感
degenerative brain disease	脑退化疾病
depression screening test	抑郁症筛查
despondent	沮丧的
diagnosed with depression	被诊断患有抑郁症
discover integrative solutions	发现综合解决方案
dodge the issue	逃避此问题
downstream effect	下游效应
downtime repair	（细胞）修复时间
edifying event	有益的事情
elapse (of time）	（时光）消逝
elicit joy	诱发喜悦情绪
emotionally evocative	唤起感情的
enzyme	酶
exacerbate heart disease	使心脏病加重
explore the largely uncharted terrain	探索这一在很大程度上是未知的领域
fatal familial insomnia	致死性家族失眠症
free radical	自由基
frivolous pursuit	毫无价值的努力
hailed as a hero	被当成英雄受到欢迎
hallucinogenic side effect	引起幻觉的副作用
have his prescriptions filled	按处方抓药
hedonistic	享乐主义者的
imbue	灌输，渗透
be imbued with	充满
inexorable	不可阻挡的
infuse ordinary events with meaning	使普通的事情具有意义
initiate atherosclerosis	引发动脉粥样硬化
inner walls of arteries	动脉血管内壁
insanity	疯狂，精神失常
irritable	易发火的

irritability	脾气不好
jovial	快乐的，好交际的
knit up the raveled sleeve of care	绕起一团愁思；理清烦乱的思绪
metabolic rate	新陈代谢速度
metabolism	新陈代谢
microwire	微丝
monoamine	一元胺
motoneuron	运动神经元
narrow our thought-action repertoires to	将思维与行为的全部能力集中在
nerve cell	神经细胞
neuron	神经元
neurotransmitter	神经递质
nucleic acid	核酸
onerous	繁重的
opossum	负鼠
over-the-counter hormonal therapy	非处方霍尔蒙疗法
peripheral vasoconstriction	末梢血管收缩
physiological change	生理变化
platypus	鸭嘴兽
precocial animal	早熟动物
proficient at rescuing people from various mental illnesses	善于拯救各种精神疾病患者
proverbial riddle wrapped in a mystery inside an enigma	众所皆知的、谜团中的谜中之谜
psychopharmacology	心理药理学
psychotherapy	精神疗法;心理疗法
puberty	青春期
ravage	蹂躏
reach remission	起到缓解作用
referral	转诊
wife-mandated referrals	在妻子强迫下的就诊
REM sleep	快速眼动睡眠
reptile	爬行动物
resilience	恢复力，韧性
rodent	啮齿类
ruminate over the cases	反复思考那些案件
scientific taxonomies of basic emotions	对基本情感的科学分类
serenity	平静
shed light on their adaptive significance	揭示积极情感的自适应意义
sluggish	行动迟缓的
slumber	睡眠
somnolent state	睡眠状态
specific facial configurations	特有的面部结构

spinal cord	脊髓
spiral down into clinical depression	发展成为临床抑郁症
stigma	污名
sullen	愠怒的
supply nutrients	提供营养素
take stock of	思考
tantalizing question	撩人心扉的问题
tautology	同义反复
thermoregulate	温度调节
tranquilizer	镇静剂
unravel	解释

Task 2: Read the opening section of Text I and identify the sentence which announces the author's communicative purpose. Then skim through the text and complete the following diagram which demonstrates the discourse pattern of the text.



What is the value of positive emotion?

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Positive emotions promote longevity:

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The sentence which announces the author's communicative purpose:

Text I

The Value of Positive Emotions[13]

The emerging science of positive psychology is coming to understand why it is good to feel good.

Barbara L. Fredrickson

1 Back in the 1930s some young **Catholic nuns** were asked to write short, personal essays about their lives. They described **edifying events** in their childhood, the schools they attended, their religious experiences and the influences that led them to the **convent**. Although the essays may have been initially used to assess each nun's career path, the documents were eventually archived and largely forgotten. More than 60 years later the nuns' writings surfaced again when three psychologists at the University of Kentucky reviewed the essays as part of a larger study on aging and **Alzheimer's disease**. Deborah Danner, David Snowdon and Wallace Friesen read the nun's biographical sketches and scored them for positive emotional content, recording instances of happiness, interest, love and hope. What they found was remarkable: The nuns who expressed the most positive emotions lived up to 10 years longer than those who expressed the fewest. This gain in life expectancy is considerably larger than the gain achieved by those who quit smoking.

2 The nun study is not an isolated case. Several other scientists have found that people who feel good live longer. But why would this be so? Some answers are emerging from the new field of positive psychology. This branch of psychological science surfaced about five years ago, as the **brainchild** of Martin E. P. Seligman, then president of the American Psychological Association (APA). Like many psychologists, Seligman had devoted much of his research career to studying mental illness. He coined the phrase *learned helplessness* to describe how hopelessness and other negative thoughts can **spiral down into clinical depression**.

3 At the start of his term as APA president, Seligman **took stock of** the field of psychology, noting its significant advances in curing ills. In 1947, none of the major mental illnesses were treatable, whereas today 16 are treatable by **psychotherapy**, **psychopharmacology** or both. Although psychology had become **proficient at rescuing people from various mental illnesses**, it had virtually no scientifically sound tools for helping people to reach their higher ground, to thrive and flourish. Seligman aimed to correct this imbalance when he called for a "positive psychology" to investigate "that which makes life worth living."

4 This is how many research psychologists, myself included, were drawn to positive psychology. My own background is in the study of emotions. For more than a dozen years, I've been studying the positive emotions—joy, contentment, gratitude and love—to **shed light on their adaptive significance**. Among scientists who study emotions, this is a rare specialty. Far more emotion researchers have devoted their careers to studying negative emotions, such as anger, anxiety and sadness. The study of optimism and positive emotions was seen by some as a **frivolous pursuit.** But the positive psychology movement is changing that. Many psychologists have now begun to **explore the largely uncharted terrain** of human strengths and the sources of happiness.

5 The new discoveries generated by positive psychology hold the promise of improving individual and collective functioning, psychological well-being and physical health. But to harness the power of positive psychology, we need to understand how and why "goodness" matters. Although the discovery that people who think positively and feel good actually live longer is remarkable, it raises more questions than it answers. Exactly how do positive thinking and pleasant feelings help people live longer? Do pleasant thoughts and feelings help people live better as well? And why are positive emotions a universal part of human nature? My research traces the possible pathways for the life-enhancing effects of positive emotions and attempts to understand why human beings evolved to experience them.

Why So Negative?

6 There are probably a number of reasons why the positive emotions received little attention in the past. There is, of course, the natural tendency to study something that **afflicts the well-being of humanity**—and the expression and experience of negative emotions are responsible for much of what **ails this world**. But it may also be that the positive emotions are a little harder to study. They are comparatively few and relatively undifferentiated—joy, amusement and **serenity** are not easily distinguished from one another. Anger, fear and sadness, on the other hand, are distinctly different experiences.

7 This lack of differentiation is evident in how we think about the emotions. Consider that **scientific taxonomies of basic emotions** typically identify one positive emotion for every three or four negative emotions and that this imbalance is also reflected in the relative numbers of emotion words in the English language.

8 Various physical components of emotional expression similarly reveal a lack of differentiation for the positive emotions. The negative emotions have **specific facial configurations** that **are imbued with** universally recognized signal value. We can readily identify angry, sad or fearful faces. In contrast, facial expressions for positive emotions have no unique signal value: All

share the same smile—in which the corners of the lips are raised and the muscles are contracted around the eyes, which raises the cheeks. A similar distinction is evident in the response of the **autonomic nervous system** to the expression of emotions. About 20 years ago, psychologists Paul Ekman and Wallace Friesen at the University of California, San Francisco, and Robert Levenson at Indiana University showed that anger, fear and sadness each elicited distinct responses in the autonomic nervous system. In contrast, the positive emotions appeared to have no distinguishable autonomic responses.

9 The study of positive emotions has also been hindered because scientists attempted to understand them with models that worked best for negative emotions. Central to many theories of emotion is that they are, by definition, associated with urges to act in particular ways. Anger creates the urge to attack, fear the urge to escape and disgust the urge to expel. Of course, no theorist argues that people invariably act out these urges; rather, people's ideas about possible courses of action narrow in on these specific urges. And these urges are not simply thoughts existing in the mind. They embody specific **physiological changes** that enable the actions called forth. In the case of fear, for example, a greater amount of blood flows to the large muscle groups to facilitate running.

10 The models that emphasize the role of these specific action tendencies typically cast the emotions as evolved adaptations. The negative emotions have an intuitively obvious adaptive value: in an instant, they **narrow our thought-action repertoires to** those that best promoted our ancestors' survival in life-threatening situations. In this view, negative emotions are efficient solutions to recurrent problems that our ancestors faced.

11 Positive emotions, on the other hand, aren't so easily explained. From this evolutionary perspective, joy, serenity and gratitude don't seem as useful as fear, anger or disgust. The bodily changes, urges to act and the facial expressions produced by positive notions aren't as specific or as obviously relevant to survival as those marked by negative emotions. If positive emotions didn't promote our ancestors' survival in life-threatening situations, then what good were they? Do they have any adaptive value at all? Perhaps they merely signaled the absence of threats.

The Broaden-and-Build Theory

12 We gain some insight into the adaptive role of positive emotions if we abandon the framework used to understand the negative emotions. Instead of solving problems of immediate survival, positive emotions solve problems concerning personal growth and development. Experiencing a positive emotion leads to states of mind and to modes of behavior that indirectly prepare an individual for later hard times. In my broaden-and-build theory, I propose that the positive emotions **broaden an individual's mindset**, and

by doing so help to build enduring personal resources. We can test these ideas by exploring the ways that positive emotions change how people think and how they behave.

13 My students and I conducted experiments in which we induced certain emotions in people by having them watch short, **emotionally evocative** film clips. We **elicited joy** by showing a herd of playful penguins waddling and sliding on the ice, we elicited serenity with clips of peaceful nature scenes, we elicited fear with films of people at precarious heights, and we elicited sadness with scenes of deaths and funerals. We also used a neutral “control” film of an old computer screen saver that elicited no emotion at all.

14 We then assessed the participant’s ability to think broadly. Using global-local visual processing tasks, we measured whether they saw the “big picture” of focused on smaller details. The participant’s task is to judge which of two comparison figures is more similar to a “standard” figure. Neither choice is right or wrong, but one comparison figure resembles the standard in global configuration, and the other in local, detailed elements. Using this and similar measures, we found that, compared to those in negative or neutral states, people who experience positive emotions tend to choose the global configuration, suggesting a broadened pattern of thinking.

15 This tendency to promote a broader thought-action repertoire is linked to a variety of **downstream effects** of positive emotions on thinking. Two decades of experiments by Alice Isen of Cornell University and her colleagues have shown that people experiencing positive affect (feelings) think differently. One series of experiments tested creative thinking using such tests as Mednick’s Remote Associates Test, which asks people to think of a word that relates to each of three other words. So, for example, given the words *mower*, *atomic* and *foreign*, the correct answer is *power*. Although this test was originally designed to assess individual differences in the presumably stable trait of creativity, Isen and colleagues showed that people experiencing positive affect perform better on this test than people in neutral states.

16 In other experiments, Isen and colleagues tested the clinical reasoning of physicians. They made some of the physicians feel good by giving them a small bag of candy, then asked all of them to think aloud while they solved a case of a patient with liver disease. Content analyses revealed that physicians who felt good were faster to integrate case information and less likely to become **anchored on initial thoughts or come to premature closure in their diagnosis**. In yet another experiment, Isen and colleagues showed that negotiators induced to feel good were more likely to **discover integrative solutions** in a complex bargaining task. Overall, 20 years of experiments by Isen and her colleagues show that when people feel good, their thinking becomes more creative, integrative, flexible, and open to information.

17 Even though positive emotions and the broadened mindsets they create are themselves short-lived, they can have deep and enduring effect. By momentarily broadening attention and thinking, positive emotions can lead to the discovery of novel ideas, actions and social bonds. For example, joy and playfulness build a variety of resources. Consider children at play in the schoolyard or adults enjoying a game of basketball in the gym. Although their immediate motivations may be simply **hedonistic**—to enjoy the moment—they are at the same time building physical, intellectual, psychological and social resources. The physical activity leads to long term improvements in health, the game-playing strategies develop problem-solving skills, and the **camaraderie** strengthens social bonds that may provide crucial support at some time in the future. Similar links between playfulness and later gains in physical, social and intellectual resources are also evident in non-human animals, such as monkeys, rats and squirrels. In human beings, other positive states of mind and positive actions work along similar lines: **altruistic acts** strengthen social ties and build skills for expressing love and care. These outcomes often endure long after the initial positive emotion has vanished.

18 My students and I recently tested these ideas by surveying a group of people to examine their **resilience** and optimism. The people were originally interviewed in the early months of 2001, and then again in the days after the September 11th terrorist attacks. We asked them to identify the emotions they were feeling, what they had learned from the attacks and how optimistic they were about the future. We learned that after September 11nearly everyone felt sad, angry and somewhat afraid. And more than 70 percent were depressed. Yet the people who were originally identified as being resilient in the early part of 2001 felt positive emotions strongly as well. They were also half as likely to be depressed. Our statistical analyses showed that their tendency to feel more positive emotions **buffered the resilient people against depression**.

19 Gratitude was the most common positive emotion people felt after the September 11th attacks. Feeling grateful was associated both with learning many good things from the crisis and with increased levels of optimism. Resilient people made statements such as, "I learned that most people in the world are inherently good." Put differently, feeling grateful broadened positive learning, which in turn build optimism, just as the broaden-and-build theory suggests.

20 My students and I have recently completed an experimental test of the building effect of positive emotions. After the course of a month-long study of daily experiences, we induced one group of college students to feel more positive emotions by asking them to find the positive meaning and long benefit within their best, worst and seemingly ordinary experiences each day. At the end of the month, compared to others who did not make this daily

effort to find positive meaning, those who did showed increases in psychological resilience.

21 So "feeling good" does far more than signal the absence of threats. It can transform people for the better, making more optimistic, resilient and socially connected. Indeed, this insight might solve the evolutionary mystery of positive emotions: Simply by experiencing positive emotions, our ancestors could have naturally **accrued more personal resources**. And when later faced with threats to life or limb, these greater resources translated into greater odds of survival and greater odds of living long enough to reproduce.

The Undoing Hypothesis

22 We might also ask whether there are other immediate benefits to experiencing positive emotions, aside from the **tautology** that they make us "feel good." One effect relates to how people cope with their negative emotions. If negative emotions narrow people's mindsets and positive emotions broaden them, then perhaps positive emotions undo the lingering effects of negative emotions.

23 Such effects may extend to the physiological realm. The negative emotions have distinct physiological responses associated with them—autonomic activity, including cardiovascular activity, which represents the body's preparation for specific action. A number of studies suggest that the cardiovascular activity associated with stress and negative emotions, especially if prolonged and recurrent, can promote or **exacerbate heart disease.** Experiments on non-human primates reveal that recurrent emotion-related cardiovascular activity also appears to injure the **inner walls of arteries** and **initiate atherosclerosis**. Because the positive emotions broaden people's thought-and-action repertoires, they may also loosen the hold that negative emotions gain on both mind and body, dismantle preparation for specific action and undo the physiological effects of negative emotions.

24 My colleagues and I tested this undoing hypothesis in a series of experiments. We began by inducing a negative emotion: We told participants that they had one minute to prepare a speech that would be videotaped and evaluated by their peers. The speech task induced the subjective feeling of anxiety as well as increases in heart rate, **peripheral vasoconstriction** and blood pressure. We then randomly assigned the participants to view one of four films: two films evoked mild positive emotions (amusement and contentment), a third served as a neutral control condition and a fourth elicited sadness.

25 We then measured the time **elapsed** from the beginning of the randomly assigned film until the cardiovascular reactions induced by the speech task

returned to each participant’s **baseline** levels. The results were consistent: Those individuals who watched the two positive-emotion films recovered to their baseline cardiovascular activity sooner than those who watched the neutral film. Those who watched the sad film showed the most delayed recovery. Positive emotions had a clear and consistent effect of undoing the **cardiovascular repercussions** of negative emotions.

26 At this point the cognitive and physiological mechanisms of the undoing effect are unknown. It may be that broadening one’s cognitive perspective by feeling positive emotions mediates the physiological undoing. Such ideas need further exploration.

Ending on a Positive Note

27 So how do the positive emotions promote longevity? Why did the happy nuns live so long? It seems that positive emotions do more than simply feel good in the present. The undoing effect suggests that positive emotions can reduce the physiological “damage” on the cardiovascular system sustained by feeling negative emotions. But some other research suggests that there’s more to it than that. It appears that experiencing positive emotions increases the likelihood that one will feel good in the future.

28 My colleague Thomas Joiner and I sought to test whether positive affect and broadened thinking mutually enhance each other—so that experiencing one produces the other, which in turn encourages more of the first one, and so on in a mutually reinforcing ascent to greater well-being. We measured positive affect and broadened thinking strategies in 138 college students on two separate occasions, five weeks apart (times T1 and T2), with standard psychological tests. When we compared the students' responses on both occasions we found some very interesting results: Positive affect at T1 predicted increases in both positive affect and broadened thinking at T2; and broadened thinking at T1 predicted increases in both positive affect and broadened thinking at T2. Further statistical analyses revealed that there was indeed a mutually reinforcing effect between positive affect and broadened thinking. These results suggest that people who regularly feel positive emotions are in some respects lifted on an “upward spiral” of continued growth and thriving.

29 But positive emotions don’t just transform individuals. I’ve argued that they may also transform groups of people, within communities and organizations. Community transformation becomes possible because each person’s positive emotion can resound through others. Take helpful, **compassionate acts** as an example. Isen demonstrated that people who experience positive emotions become more helpful to others. Yet being helpful not only springs from positive emotions, it also produces positive emotions. People who give help, for instance, can feel proud of their good deeds and so experience continued good feelings. Plus, people who receive help can feel grateful, and those

who merely witness good deeds can feel elevated. Each of these positive emotions—pride, gratitude and elevation—can in turn broaden people's mindsets and inspire further compassionate acts. So, by creating chains of events that carry positive meaning for others, positive emotions can trigger upward spirals that transform communities into more **cohesive, moral, and harmonious social organizations**.

30 All of this suggests that we need to develop methods to experience more positive emotions more often. Although the use of humor, laughter and other direct attempts to stimulate positive emotions are occasionally suitable, they often seem poor choices, especially in trying times. Based on our recent experiment with college students, my advice would be to **cultivate positive emotions** indirectly by finding positive meaning within current circumstances. Positive meaning can be obtained by finding benefits within adversity, by infusing ordinary events with meaning and by effective problem solving. You can find benefits in a grim world, for instance, by focusing on the newfound strengths and resolve within yourself and others. You can **infuse ordinary events with meaning** by expressing appreciation, love and gratitude, even for simple things. And you can find positive meaning through problem solving by supporting compassionate acts toward people in need. So although the active ingredient within growth and resilience may be positive emotions, the key to **accessing these benefits** is finding positive meaning.

31 So, what good is it to think about the good in the world? The mind can be a powerful ally. As John Milton told us, "The mind is its own place, and in itself can make a heaven of hell, a hell of heaven." The new science of positive psychology is beginning to **unravel** how such transformations can take place. Think about the good in the world, or otherwise find positive meaning, and you seed your own positive emotions. A focus on goodness cannot only change your life and your community, but perhaps also the world, and in time create a heaven on earth.

Task 3: Read the opening section of Text I and answer the following questions.

1) What can we learn from the Catholic nun study?

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2) What was Martin E.P. Seligman's contribution to the study of postivie psychology?

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3) What was the research focus of many psychologists in the past? What change has taken place later?

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4) What discoveries have been made from the research on positive psychology?

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5) What is the importance of studying positive psychology?

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6) What questions need to be investigated?

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Task 4: Answer the following questions based on the information in the "Why So Negative" section of Text I.

1) Why did positive emotions receive little attention in the past?

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2) What is the importance of negative emotions?

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3) How do negative emotions contribute to the evolution of mankind?

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4) What problem arises when we try to explain the value of positive emotions from an evolutionary perspective?

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5) What is the communicative purpose of this section?

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Task 5: Note down the main points of the hypotheses and tests described in the "The Broaden-and-Build Theory" section and then give an oral summary of each test.

1) The broadening effect hypothesis

Test 1:
Researchers：My colleagues and I
Purpose：Assess the participant's ability to think broadly
Subjects/Participants: Group of people (unidentified)
Method: We induced certain emotions in people by having them watch film clips and then assessed the participant's ability to think broadly with global-local visual processing tasks.
Finding: We found that, compared to those in negative or neutral states, people

who experience positive emotions tend to choose the global configuration.

Conclusion: Positive emotions may lead to a broadened pattern of thinking.

Test 2:

Test 3:

Test 4:

2) The building effect hypothesis

Test 1:

Test 2:

Task 6: Describe the experiment to test "the undoing hypothesis".

The Undoing Hypothesis:

Task 7: Identify the other hypotheses about the value of positive emotions in the last section of Text I.

1)

2)

3)

Task 8: Identify hedges (words or expressions used to show the author's cautiousness when making a statement or expressing an idea and to leave room for further exploration) in the last two sections of Text I.

Task 9: Paraphrase John Milton's words "The mind is its own place, and in itself can make a heaven of hell, a hell of heaven."

- ____
- ____
- ____
- ____
- ____
- ____

Task 10: The following are words to express different types of emotions. Work in groups to put them in the right space in the chart.

hatred, lightheartedness, outrage, doubt, resentment, mad, displeasure, impatience, indignation, irritation, aversion, rage, antipathy, distaste, annoyance, loathing, amazement, sorrow, nausea, gloominess, bliss, objection, repugnance, antagonism, optimism, repulsion, sickness, dislike, apprehension, angst, satisfaction, concern, dismay, dread, horror, scare, suspicion, terror, unease, worry, awe, mourning, timidity, contentment, elation, enjoyment, astonishment, enmity, euphoria, anxiety, shock, glee, joy, well-being, bewilderment, ecstasy, distress, fury, felicity, melancholy, exhilaration, hopefulness, jubilation, playfulness, vivacity, depression, anguish, grief, heartache, pleasure, heartbreak, hopelessness, misery, awe, wonder, delight, cheerfulness

Basic emotions	**Secondary emotions**	**Causes**	**Resulting acts**
Anger		Offence	Attack
Disgust		Nasty things	Expel
Fear		Threat or danger	Escape

Happiness		Pleasant things	Smile
Sadness		Loss	Cry
Surprise		Unexpectedness	Jaw drop

Task 11: Write an essay on "How I Benefit from Positive Emotions?" Your essay can include the following points.

- What are the positive emotions you often feel?
- How do you cultivate these positive emotions?
- In what way do you benefit from these positive emotions?

Task 12: Skim through the opening section of Text II and answer the following two questions.

1) What questions are discussed in the text?

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2) Why is it important to study sleep?

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Text II

Why We Sleep[14]

Jerome M. Siegel

1 Birds do it, bees do it, and even fruit flies appear to do it. Humans certainly do it. Shakespeare's Macbeth said it "**knits up the raveled sleeve of care**" and was the "**balm of hurt minds,** great nature's second course, chief nourisher in life's feast." Cervantes's Sancho Panza sang its praises as "the food that cures all hunger, the water that quenches all thirst, the fire that warms the cold, the cold that cools the heart… the balancing weight that levels the shepherd with the king, and the simple with the wise."

2 The simple and the wise have long contemplated two related questions: What is sleep, and why do we need it? An obvious answer to the latter is that adequate sleep is necessary to stay alert and awake. That response, however, **dodges the issue** and is the equivalent of saying that you eat to keep from being hungry or breathe to ward off feelings of suffocation. The real function of eating is to **supply nutrients**, and the function of breathing is to take in oxygen and expel carbon dioxide. But we have no comparably straightforward explanation for sleep. That said, sleep research—less than a century old as a focused field of scientific inquiry—has generated enough insights for investigators to at least make reasonable proposals about the function of the **somnolent state** that consumes one third of our lives.

What is sleep?

3 Despite the difficulty in strictly defining sleep, an observer can usually tell when a subject is sleeping: the sleeper ordinarily exhibits relative inattention to the environment and is usually immobile. (Dolphins and other marine mammals swim while sleeping, however, and some birds may sleep through long migrations.)

4 In 1953 sleep research pioneer Nathaniel Kleitman and his student Eugene Aserinsky of the University of Chicago decisively overthrew the commonly held belief that sleep was simply a cessation of most brain activity. They discovered that sleep was marked by periods of rapid eye movement, commonly now known as **REM sleep**. And its existence implied that something active occurred during sleep. All terrestrial mammals that have been examined exhibit REM sleep, which alternates with non-REM sleep, also called quiet sleep, in a regular cycle.

5 More recently, the field has made its greatest progress in characterizing the nature of sleep at the level of **nerve cells** (**neurons**) in the brain. In the past 20 years, scientists have mastered techniques for guiding fine **microwires** into various brain regions. Such wires produce no pain once implanted and have been used in humans as well as in a wide range of laboratory animals while they went about their normal activities, including sleep. These studies showed, as might be expected, that most brain neurons are at or near their maximum levels of activity while the subject is awake. But neuronal doings during sleep are surprisingly variable. Despite the similar posture and

inattention to the environment that a sleeper shows during both REM and non-REM sleep, the brain behaves completely differently in the two states.

6 During non-REM sleep, cells in different brain regions do very different things. Most neurons in the brain stem, immediately above the **spinal cord**, reduce or stop firing, whereas most neurons in the cerebral cortex and adjacent forebrain regions reduce their activity by only a small amount. What changes most dramatically is their overall pattern of activity. During the awake state, a neuron more or less goes about its own individual business. During non-REM sleep, in contrast, adjacent **cortical neurons** fire synchronously, with a relatively low frequency rhythm. (Seemingly paradoxically, this synchronous electrical activity generates higher-voltage brain waves than waking does. Yet just as in an idling automobile, less energy is consumed when the brain "idles" in this way.) Breathing and heart rate tend to be quite regular during non-REM sleep, and reports of vivid dreams during this state are rare.

7 A very small group of brain cells (perhaps totaling just 100,000 in humans) at the base of the forebrain is maximally active only during non-REM sleep. These cells have been called sleep-on neurons and appear to be responsible for inducing sleep. The precise signals that activate the sleep-on neurons are not yet completely understood, but increased body heat while an individual is awake clearly activates some of these cells, which may explain the drowsiness that so often accompanies a hot bath or a summer day at the beach.

8 On the other hand, brain activity during REM sleep resembles that during waking. Brain waves remain at low voltage, because neurons are behaving individually. And most brain cells in both the forebrain and brain stem regions are quite active, signaling other nerve cells at rates as high as—or higher than—rates seen in the waking state. The brain's overall consumption of energy during REM sleep is also as high as while awake. The greatest neuronal activity accompanies the familiar twitches and eye motion that give REM sleep its name. Specialized cells located in the brain stem, called REM sleep-on cells, become especially active during REM sleep and, in fact appear to be responsible for generating this state.

9 Our most vivid dreams occur during REM sleep, and dreaming is accompanied by frequent activation of the brain's motor systems, which otherwise operate only during waking movement. Fortunately, most movement during REM sleep is inhibited by two complementary biochemical actions involving **neurotransmitters**, the chemicals that physically carry signals from one neuron to another at the synapse (the contact point between two neurons). The brain stops releasing neurotransmitters that would otherwise activate motoneurons, and it dispatches other neurotransmitters that actively shut down those motoneurons. These mechanisms, however, do not affect the motoneurons

that control the muscles that move the eyes, allowing the rapid eye movements that give the REM sleep stage its name.

10 REM sleep also profoundly affects brain systems that control the body's internal organs. For example, heart rate and breathing become irregular during REM sleep, just as they are during active waking. Also, body temperature becomes less finely regulated and drifts, like that of a **reptile**, toward the environmental temperature.

11 This brief description of sleep at the neuronal levels is both accurate and as unsatisfying as being awakened before the completion of a good night's **slumber**. The **tantalizing question** persists: What is sleep for?

The Function of Sleep

12 At a recent sleep conference, an attendee commented that the function of sleep remains a mystery. The chair of the session argued vehemently against that position—she did not, however, provide a concrete description of exactly why sleep's function was no longer mysterious. But based on the currently available evidence, I can put forth what many of us feel are some reasonable hypotheses.

13 One approach to investigating the function of sleep is to see what physiological and behavioral changes result from a lack of it. More than a decade ago it was found that total sleep deprivation in rats leads to death. These animals show weight loss despite greatly increased food consumption, suggesting excessive heat loss. The animals die, for reasons yet to be explained, within 10 to 20 days, faster than if they were totally deprived of food but slept normally.

14 In humans, a very rare **degenerative brain disease** called **fatal familial insomnia** leads to death after several months. Whether the sleep loss itself is fatal or other aspects of the brain damage are to blame is not clear. Sleep deprivation studies in humans have found that sleepiness increases with even small reductions in nightly sleep times. Being sleepy while driving or during other activities that require continuous vigilance is as dangerous as consuming alcohol prior to those tasks. But existing evidence indicates that "helping" people to increase sleep time with long-term use of sleeping pills produces no clear-cut health benefit and may actually shorten life span. (About seven reported hours of sleep a night correlates with longer life spans in humans.) So **inexorable** is the drive to sleep that achieving total sleep deprivation requires repeated and intense stimulation. Researchers employing sleep deprivation to study sleep are therefore quickly confronted with the difficulty of distinguishing the effects of stress from those of sleep loss.

15 Researchers also study the natural sleep habits of a variety of organisms. An important clue about the function of sleep is the huge variation in the amount that different species need. For example, the **opossum** sleeps for 18 hours a

day, whereas the elephant gets by with only three or four. Closely related species that have genetic, physiological and behavioral similarities might also be expected to have similar sleep habits. Yet studies of laboratory, zoo and wild animals have revealed that sleep times are unrelated to the animals' taxonomic classification: the range of sleep times of different primates extensively overlaps that of **rodents**, which overlaps that of **carnivores**, and so on across many orders of mammals. If evolutionary relatedness does not determine sleep time, then what does?

16 The extraordinary answer is that size is the major determinant: bigger animals simply need less sleep. Elephants, giraffes and large primates (such as humans) require relatively little sleep; rats, cats, voles and other small animals spend most of their time sleeping. The reason is apparently related to the fact that small animals have higher **metabolic rates** and higher brain and body temperatures than large animals do. And metabolism is a messy business that generates **free radicals**—extremely reactive chemicals that damage and even kill cells. High metabolic rates thus lead to increased injury to cells and the **nucleic acids**, proteins and fats within them.

17 Free-radical damage in many body tissues can be dealt with by replacing compromised cells with new ones, produced by cell division; however, most brain regions do not produce significant numbers of new brain cells after birth. The lower metabolic rate and brain temperature occurring during non-REM sleep seem to provide an opportunity to deal with the damage done during waking. For example, **enzymes** may more efficiently repair cells during periods of inactivity. Or old enzymes, themselves altered by free radicals, may be replaced by newly synthesized ones that are structurally sound.

18 Last year my group at the University of California at Los Angeles observed what we believe to be the first evidence for brain cell damage in rats, occurring as a direct result of sleep deprivation. This finding supports the idea that non-REM sleep wards off metabolic harm.

19 REM sleep, however, is the **proverbial riddle wrapped in a mystery inside an enigma**. The cell-repair hypothesis could explain non-REM sleep, but it fails to account for REM sleep. After all, **downtime repair** cannot be taking place in most brain cells during REM sleep, when these cells are at least as active as during waking. But a specific group of brain cells that goes against this trend is of special interest in the search for a purpose of REM sleep.

20 Recall that the release of some neurotransmitters ceases during REM sleep, thereby disabling body movement and reducing awareness of the environment. The key neurotransmitters affected are termed **monoamines**, because they each contain a chemical entity called an amine group. Brain cells that make these monoamines are maximally and continuously active in

waking. But Dennis McGinty and Ronald Harper of D.C.L.A. discovered in 1973 that these cells stop discharging completely during REM sleep.

21 In 1988 Michael Rogawski of the National Institutes of Health and I hypothesized that the cessation of neurotransmitter release is vital for the proper function of these neurons and of their receptors (the molecules on recipient cells that relay neurotransmitters' signals in that cell). Various studies indicate that constant release of monoamines can desensitize the neurotransmitters' receptors. The interruption of monoamine release during REM sleep thus may allow the receptor systems to "rest" and regain full sensitivity. And this restored sensitivity may be crucial during waking for mood regulation, which depends on the efficient collaboration of neurotransmitters and their receptors.

Other Possibilities

22 What else might REM sleep do? Researchers such as Frederick Snyder and Thomas Wehr of the National Institutes of Health and Robert Vertes of Florida Atlantic university have proposed that the elevated activity during REM sleep of brain cells that are not involved in monoamine production enables mammals to be more prepared than reptiles to cope with dangerous surroundings. When waking in a cold environment, reptiles are **sluggish** and require an external heat source to become active and responsive. But even though mammals do not **thermoregulate** during REM sleep, the intense neuronal activity during this phase can raise brain metabolic rate, helping mammals to monitor and react more quickly to a given situation on waking. The observation that humans are much more alert when awakened during REM sleep than during non-REM periods supports this idea.

23 Sleep deprivation studies indicate, however, that REM sleep must do more than prime the brain for waking experience. These studies show that animals made to go without REM sleep will undergo more than the usual amount when they are finally given the opportunity. They apparently seek to make up the "debt" —yet another clue that REM sleep is important.

24 Old ideas that REM sleep deprivation led to **insanity** have been convincingly disproved (although studies show that depriving someone of sleep, for example by prodding him or her awake repeatedly, can definitely cause **irritability**). In fact, REM sleep deprivation can actually **alleviate clinical depression**. The mechanism for this phenomenon is unclear.

25 Some researchers are pursuing the idea that REM sleep might have a role in memory consolidation, but as I examined in detail in a 2001 article in *Science* the evidence for that function is weak and contradictory. The findings that argue against memory consolidation include the demonstration that people who have brain damage that prevents REM sleep, or who have a drug-induced blockade of REM sleep, have normal—or even improved—memory. And although sleep deprivation before a task disturbs

concentration and performance—sleepy students do not learn or think well—REM deprivation after a period of alert learning does not appear to interfere with retaining the new information. In addition dolphins experience little or no REM sleep yet exhibit impressive reasoning and learning ability.

26 In fact, learning ability across species does not appear to be related to total REM sleep duration. Humans do not have particularly long REM sleep times—90 to 120 minutes each night—compared with other mammals. (And humans with higher IQs or school performance do not have more, or less, REM sleep than those with lower IQs.) The amount of time spent in REM does change over an individual's life, however, in all animals studied, the portion of each day devoted to REM sleep is highest early in the subject's life and falls gradually to a steady, lower level in adulthood, An additional, fascinating fact emerges from comparing numerous species: the best predictor of the amount of REM sleep time for an adult in a given species is how immature the offspring of that species are at birth.

27 In 1999 Jack Pettigrew and Paul Manger of the University of Queensland in Australia and I were able to study an unusual research subject, the **platypus**. This evolutionarily earliest of extant mammals surprised us by revealing itself to be the champion REM sleeper: about eight hours a day. The platypus is born completely defenseless and blind, cannot thermoregulate or find food on its own, and stays attached to its mother for weeks after birth. At the other extreme, the newborn dolphin can and must thermoregulate, swim, follow its mother and avoid predators. And adult dolphins, as previously noted, do almost no REM sleeping.

28 Michel Jouvet, the pioneering sleep researcher who discovered four decades ago that the brain stem generates REM sleep, has a provocative suggestion for the large amounts of REM in immature animals. REM sleep's intense neuronal activity and energy expenditure, Jouvet believes, have a role early in life in establishing the genetically programmed neuronal connections that make so-called instinctive behavior possible. Before birth, or in animals that have delayed sensory development, REM sleep may act as a substitute for the external stimulation that prompts neuronal development in creatures that are mature at birth. Work by Howard Roffwarg, director of the Sleep Disorders Center at the University of Mississippi Medical Center, and his colleagues support this idea. Roffwarg found that preventing REM sleep in cats during this early period can lead to abnormalities in the development of the visual system.

29 Animals that engage in a lot of REM sleep shortly after birth continue to experience relatively large amounts when mature. What is it about immaturity at birth that causes REM sleep duration to be high later in life? In simple evolutionary terms, animals that have low REM time should need less fuel and leave more descendants than animals that experience long periods of high energy consumption. From that perspective, it is most likely

that animals that still have high REM times must have evolved a use for REM sleep that is not found in **precocial animals**. But that function remains to be identified. Sleep researchers are confident that progress in identifying the brain regions that control REM and non-REM sleep will soon lead to a more comprehensive and satisfying understanding of sleep and its functions. As we further study the mechanisms and evolution of sleep, we will probably gain insights into exactly what is repaired and rested, why these processes are best done in sleep, and why knitting up Shakespeare's raveled sleeve of care ultimately helps us to stay awake.

Task 13: Read the opening section and "What is Sleep?" section to find out how the following writers describe "sleep".

What is sleep?

Shakespeare:

____

____

____

Cervantes:

____

____

____

Kleitman & Aserinsky:

____

____

____

The author:

____

State	Brain neurons	Physical features
Waking		
Non-REM sleep		

REM sleep		

Task 14: Read "The Function of Sleep" and "Other Possibilities" sections and complete the following chart. Give an oral summary with the help of the information in the chart.

What is sleep for?

Researchers	Hypotheses	Related studies	Types of sleep
		.	

Task 15: Read the article entitled "Facing Darkness" in Text III and note down the main points as outlined below. Then discuss effective ways of coping with negative emotions such as depression, anger, sadness, depression, etc. You may use the information in Text III.

1) The reasons why many men try to hide their depression

- Bob Antonioni kept his depression from the people around him, because he ____

  ____

  When he openly talked about his depression, the response ____________

  ____

- Men often suffer silently instead of seeking help, because in American traditional culture, men often ____________________________________

  ____

- Men often fail to recognize symptoms of depression.
- The image of successful men in American culture is __________________

  ____

  ____

2) The consequences of depression

   ____

   ____

   ____

   ____

3) New understanding of depression
   - Depression affects the behavior of men and women differently.
   - Depressed women often _____________________________________

     ____;

     depressed men ____

     ____

   - David Feherty's symptoms are ________________________________

     When David Feherty was diagnosed with depression, he felt ______

     ____

   - Researchers have developed depression-screening tests which help

     ____

     ____

   - New research found that the cause of depression is __________________

     ____

     ____

4) Treatment of depression
   - Medications that block the production of excess stress chemicals, hoping to reduce damage to otherwise healthy nerve cells.
   - ____

- ____
- ____
- ____

5) Attitude towards depression and the right definition of a man

____

____

Text III

Facing Darkness [15]

Julie Scelfo

1 For nearly a decade, while serving as an elected official and working as an attorney, Massachusetts state Senator Bob Antonioni struggled with depression, although he didn't know it. Most days, he attended Senate meetings and appeared on behalf of clients at the courthouse. But privately, he was **irritable** and short-tempered, **ruminating** endlessly over his cases and becoming easily frustrated by small things, like deciding which TV show to watch with his girlfriend. After a morning at the state house, he'd be so exhausted by noon that he'd drive home and collapse on the couch, unable to move for the rest of the day.

2 When his younger brother, who was similarly moody, killed himself in 1999, Antonioni, then 40, decided to seek help. For three years, he **clandestinely** saw a therapist, paying in cash so there would be no record. He took **antidepressants**, but **had his prescriptions filled** at a pharmacy 20 miles away. His depression was his burden, and his secret. He couldn't bear for his image to be any less than what he thought it should be. "I didn't want to sound like I couldn't take care of myself, that I wasn't a man," says Antonioni.

3 Then, in 2002, his chief of staff discovered him on the floor of his state-house office, unable to stop crying. Antonioni, now 48, decided he had to open up to his friends and family. A few months later, invited to speak at a mental-health vigil, he found the courage to talk publicly about his problem. Soon after, a local reporter wrote about Antonioni's ongoing struggle with the disease. Instead of being greeted with jeers, he was **hailed as a hero**, and inundated with cards and letters from his **constituents**. "The response was universally positive. I was astounded."

4 Six million American men will be **diagnosed with depression** this year. But millions more suffer silently, unaware that their problem has a name or unwilling to seek treatment. In a confessional culture in which Americans are increasingly obsessed with their health, it may seem clichéd—men are from Mars, women from Venus, and all that—to say that men tend not to take care of themselves and are reluctant to own up to mental illness. But the facts suggest that although depression is emotionally crippling and has numerous medical implications—some of them deadly—many men fail to recognize the symptoms. Instead of talking about their feelings, men may mask them with alcohol, drug abuse, gambling, anger or by becoming workaholics. And even when they do realize they have a problem, men often view asking for help as an admission of weakness, a betrayal of their male identities.

5 The result is a hidden epidemic of despair that is destroying marriages, disrupting careers, filling jail cells, **clogging emergency rooms** and costing society billions of dollars in lost productivity and medical bills. It is also creating a cohort of children who carry the burden of their fathers' pain for the rest of their lives. The Gary Cooper model of manhood—what Tony Soprano called "the strong, silent type" to his psychiatrist, Dr. Melfi—is so deeply embedded in our social psyche that some men would rather kill themselves than confront the fact that they feel **despondent**, inadequate or helpless. "Our definition of a successful man in this culture does not include being depressed, down or sad," says Michael Addis, chair of psychology at Clark University in Massachusetts. "In many ways it's the exact opposite. A successful man is always up, positive, in charge and in control of his emotions."

6 As awareness of the problem grows—among the public and medical professionals alike—the **stigma** surrounding male depression is beginning to lift. New tools for diagnosing the disease—which ranges from the chronic inability to feel good, to major depression, to bipolar disorder—and new approaches to treating it, offer hope for millions. And as scientists gain insight into how depression occurs in the brain, their findings are spurring research into an array of new treatments including faster-acting, more-effective drugs that could benefit those who struggle with what Winston Churchill called his "black dog."

7 For decades, psychologists believed that men experienced depression at only a fraction of the rate of women. But this overly rosy view, doctors now recognize, was due to the fact that men were better at hiding their feelings. Depressed women often weep and talk about feeling bad; depressed men are more likely to get into bar fights, scream at their wives, have affairs or become enraged by small inconveniences like lousy service at a restaurant. "Men's irritability is usually seen as a character flaw," says Harvard Medical School's William Pollack, "not as a sign of depression." In many cases, however, that's exactly what it is: depression.

8 If modern psychologists were slow to understand how men's emotions affect their behaviors, it's only because their predecessors long ago decided that having a uterus was the main risk factor for mental illness. During the last two centuries, depression was largely viewed as a female problem, an outgrowth of hormonal fluctuations stemming from **puberty**, childbirth and menopause. Even the most skilled psychologists and psychiatrists missed their male patients' mood disorders, believing that depressed men, like depressed women, would talk openly about feeling blue. "I misdiagnosed male depression for years and years," says psychologist Archibald Hart, author of "Unmasking Male Depression."

9 Some of the symptoms of depression are so severe, like gambling addiction or alcoholism, they are often mistaken for the problem. David Feherty, the **affable** CBS golf commentator and former golf pro, began drinking at such a young age it became part of his personality. "I drank a bottle of whisky in order to get ready to start drinking," he jokes. By his 40s, he routinely consumed two bottles of whisky a day, and was in such physical pain, he thought he suffered from "some kind of degenerative muscle disease." During that period, he maintained a **jovial** front, and kept up a steady stream of on-air wisecracks during golf tournaments. "It was a problem that just, I don't know, ate itself up and got bigger and bigger and then, one day, bang, I disappeared." When he finally learned in 2005 that he suffered from depression, he felt a combination of shock and relief. "That was the most stunning thing. I just thought I was a lousy husband and miserable bastard and a drunk," says Feherty, now 48. "A mental illness? Me? I had no idea."

10 The widespread failure to recognize depression in men has enormous medical and financial consequences. Depression has been linked to heart disease, heart attacks and strokes, problems that affect men at a higher rate and an earlier age than women. Men with depression and heart disease are two or three times more likely to die than men with heart disease who are not depressed. Lost productivity due to adult depression is estimated at $83 billion a year. Over the past 50 years, American men of all ages have killed themselves at four or more times the rate of women, depending on the specific age range.

11 A general practitioner is usually the first—and often, the only—medical professional a depressed man encounters. In 1990, when Mark Totten began sleeping a lot, refusing food and acting **sullen**, his sister, Julie, suggested he see a doctor, but never for a moment did she think it was life threatening. "I didn't know anything about depression back then," says Julie. In November of that year, Mark, 24, lay down on an Iowa train track and ended his life. Totten learned afterward that her brother had indeed visited his primary-care physician but complained only of stomachaches, headaches and just generally "not feeling so great," she says. The doctor didn't make the connection.

12 Confronted with a patient making vague medical complaints who is unwilling (or unable) to talk about his feelings, the hurried primary-care physician often finds it difficult if not impossible to assess a patient's emotional state. To help clear that hurdle, researchers developed a simple screening test for doctors to use: Over the last two weeks, have you been bothered by either of the following problems: (a) little interest or pleasure in doing things? or (b) feeling down, depressed or hopeless? If a patient responds "yes," seven more questions can be administered, which result in a 0 to 27 rating. Score in hand, many physicians feel more comfortable **broaching the subject of depression**, and men seem more willing to discuss it. "It's a way of making it more concrete," says Indiana University's Dr. Kurt Kroenke, who helped design the questionnaires. "Patients can see how severe their scores are, just like if you showed them blood-sugar or **cholesterol levels**."

13 Depression-screening tests are so effective at early detection and may prevent so many future problems (and expenses) that the U.S. Army is rolling out a new, enhanced screening program for soldiers returning from Iraq. College health-center Web sites nationwide provide the service to their students, and even the San Francisco Giants organization offers these tests to its employees.

14 At Clark University in Massachusetts, where Sigmund Freud introduced his theories to America, researchers are developing new clinical strategies to encourage men to seek help. The Men's Coping Project, led by Michael Addis, recruits men for interviews and discussion groups that focus not on depression but on how they deal with "the stresses of living." At a recent staff meeting, the team reviewed the file of a middle-aged local man who described himself as stressed, angry and isolated, but vehemently denied that he was depressed. In a questionnaire, the man indicated that he preferred "to just suck it up" rather than dwell on his problems and that he believed part of being a man was "being in control." Researchers decided that rather than say "you have a problem" or "you need help," they would praise his self-reliance and emotional discipline, and suggest that meeting with a counselor might be the most effective way for him to "take charge of the situation." So far, Addis and his team have met with 50 men, some of whom said they would seek counseling, and they plan to interview another 50 before the program concludes next year.

15 For decades, scientists believed the main cause of depression was low levels of the neurotransmitters serotonin and norepinephrine. Newer research, however, focuses on the nerve cells themselves and how the brain's circuitry can be permanently damaged by hyperactive stress responses, brought on by genetic predisposition, prolonged exposure to stress or even a single traumatic event. "When the stress responses are stuck in the 'on' position, that has a negative effect on mood regulation overall," says Dr. Michael C. Miller, editor of the Harvard Mental Health Letter. A depressed brain is not

necessarily underproducing something, says Dr. Thomas Insel, head of the National Institute of Mental Health—it's doing too much.

16 These discoveries have opened up broad new possibilities for treatment. Instead of focusing on boosting neurotransmitters (the function of antidepressants in the popular SSRI category such as Prozac and Zoloft), scientists are developing medications that block the production of excess stress chemicals, hoping to reduce damage to otherwise healthy nerve cells. They are also looking at hormones. In a recent study, DHEA, an **over-the-counter hormonal therapy**, was shown to be effective in treating major and minor midlife-onset depression. And Canadian scientists have had success with deep brain stimulation—a procedure in which two thin electrodes are implanted in the brain to send a continuous electrical current to Area 25, a tiny, almond-shaped node thought to play a role in controlling emotions. In recent trials involving patients who got no relief from other forms of treatment, all the subjects reported mood improvements within six months and, remarkably, most said they were completely cured of depression.

17 Researchers at the NIMH are also experimenting with the idea of fast-acting antidepressants that would relieve symptoms in a few hours instead of the eight weeks or more needed for most antidepressants to take effect. In clinical trials, scientists found that a single, IV-administered dose of ketamine, an animal **tranquilizer**, reduced the symptoms of depression in just two to three hours and had long-lasting effects. Because of its **hallucinogenic side effects**, ketamine can never be used out of controlled environments. But the success of the trial is giving scientists new ideas about drugs and methods of administering them.

18 The most effective remedy remains a combination of medication and therapy, but finding the right drug and dosage is still more art than science. The nation's largest depression-treatment study, STAR*D, a three-year NIMH-funded project, found that 67 percent of patients who complete from one to four treatment steps, such as trying a different medication or seeking counseling, can **reach remission**. The process can be **onerous** and frustrating, and the potential side effects, including a low libido, can be hard to take—especially for men. Stephen Akinduro, 35, an unemployed phone operator in Georgia whose mother had committed suicide, tried two different drugs over a three-year period, but both resulted in weight gain, fatigue and a diminished sexual performance. "When that happened I was, like, 'What is going on here?' " says Akinduro. Frustrated, he gave up on antidepressants. Today he gets free counseling through his church and a local support group. Twelve years after his diagnosis, he is still struggling.

19 Often the person who seeks treatment isn't the depressed man, but his fed-up wife. Terrence Real, author of "I Don't Want to Talk About It: Overcoming

the Secret Legacy of Male Depression," says most men in counseling are what he calls "**wife-mandated referrals**." When depression left Phil Aronson unable to get out of bed, feed himself or even pick up the phone, his wife, Emme, the well-known model, physically helped him into the shower, found doctors and therapists, and drove him to appointments, even escorting him inside. At one point, when Phil became suicidal, doctors told Emme it was her job to make sure he continued taking his medication and keep him safe from himself. "It was such an incredibly awesome, all-encompassing responsibility," says Emme, who became the sole caretaker of Toby, their daughter, then 2 years old. Even when the depression began to lift, her husband's moodiness took a toll on their marriage and Emme's career. "I had to be caretaker, I had to be a supportive wife, I had to leave my work. I was developing a new TV show and had to drop it." Today Phil is recovered, and Emme is thrilled to once again have a partner who makes her laugh, contributes to the relationship and helps parent Toby, now 5.

20 Success and wealth offer no protection from the **ravages** of depression. At 46, Philip Burguières was running a Fortune 500 company, traveling constantly and meeting with shareholders, when, in the middle of a staff meeting on a Tuesday afternoon, he suddenly collapsed. Doctors diagnosed him with depression and encouraged him to leave his high-stress job. But after a short hospital stay, he was back in the game and by the following year was running Weatherford International, an energy-services company with $3 billion in revenues. The pressure became unbearable, and in 1996 he once again took a medical leave. "The second one was a grade-A, level-10, atomic-bomb depression," he says. In his darkest moments, he was certain the world would be better off without him, but even then, he felt enormous pressure to succeed. "I want out, but am stuck because I have never quit anything in my life," he wrote in a hospital diary. Strengthened by counseling and a friendship with a similarly depressed CEO, Burguières attained what he describes as a "full recovery" and stepped down as CEO. He found new work running a family investment company and as vice chairman of the NFL's Houston Texans, positions that permit him to delegate more responsibility and have more fun. He also found that helping other people was the best way for him to get better, and since 1998, he has been privately counseling the numerous depressed CEOs who seek him out. "You get outside yourself; you don't obsess on your own issues," he says.

21 Fading social stigmas are already making it easier for young men to come forward. Recently, Zach Braff, filmmaker and star of TV's "Scrubs," told a reporter from Parade magazine that he thinks he suffers from "mild depression." At colleges and universities across the nation, health officials are putting mental-health care front and center. At UCLA, the Student Psychological Services moved two years ago from a basement office to a bright building in the center of campus across from Pauley Pavilion. In

January, center director Elizabeth Gong-Guy walked through the waiting room and noticed that every person there was male. "It was amazing to me," she says. "I've been doing this for 18 years and that's not something you would have seen even three years ago."

22 Social attitudes toward depression are changing, thanks in part to men themselves. John Aberle is a sales and marketing consultant, retired Air Force security specialist, part-time radio talk-show host, devoted husband, active father and a 6-foot-4, 250-pound body-builder who twice faced a depression so deep, he cried on his knees. He readily tells other men it's their duty to get better. "There's no crime in having a disorder, whatever it is," says Aberle, 38. "The crime is not dealing with it. It's your responsibility to be at the top of your game." Taking care of yourself physically, mentally and emotionally—maybe that's the real definition of what it means to be a man.

Task 16: Fill in the blanks in the following science news report with the information you hear.

Shakespeare called sleep the (1)________________________________. But today we know it's so much more. (2) ________________________ contributes to the risk of cardiovascular disease, (3) ________________________________.

And now a study finds that too little or too much sleep are both associated with (4) ________________________________sick days away from work.

Almost 4,000 men and women between 30 and 64 years old (in Finland)

(5) ________________________________the study, which followed them for seven years. The research revealed that the absence from work due to illness (6) ________________________________ for those who said they slept less than six hours or more than nine hours per night. The sleep time that (7) ________________________________ the lowest number of sick days was seven hours 38 minutes for women and

(8) ________________________________ for men. The study is in the journal *Sleep*.

Of course these findings are associative and not necessarily causal. Other factors may be responsible for the under- or oversleeping to begin with. But (9)

__________________________________ are still a warning sign for increased illness and health complications. Shakespeare put it best: Sleep…that (10) __________________________________.

Task 17: Listen to a report on children's intellectual development and answer the following questions.

1) What is Dr Kelly's research interest?

____

2) Why did she carry out the research on children?

____

3) How did she conduct the research?

____

4) What did she find from her research?

____

Task 18：Answer the following questions according to what you hear.

1) What was the prevailing view about autism and dyslexia in the 1960s?

____

____

2) What was Uta's research purpose?

____

____

3) What is the significance of her studies?

____

____

4) What technology was used to support Uta's theory about autism?

____

5) What is the practical use of Uta's research findings?

____

6) What is Uta hope's now?

____

____

Task 19: Watch the video of Tali Sharot's "The optimism bias" and answer the following questions.

1) What is optimistic bias?

____

2) What is the logic of the people who say the secret to happiness is low expectations?

____

3) Why is that theory wrong?

____

4) What is the most surprising benefit of optimism?

____

Task 20: Listen to a report on psychosomatic medicine and note down the information you hear.

1) The uncharted terrain: ______________________________

____

2) The finding of recent respectable research ____________________

____

3) The concentration of Dr Fredrickson and Dr Kok:_______________

____

4) The job of vagus nerve: ______________________________

____

5) The difference between people with high vagal-tone and those with low

____

____

6) The purpose of the experiment on 65 university staff:

____

____

7) The finding of the experiment:

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____

8) The finding of another experiment by Dr Kok:

____

____

Task 21: Watch the video of Martin Seligman's "The new era of positive psychology" and complete the following outline.

1) What is the state of psychology today? (One word)

____.

Reasons:

- ____
- ____
- ____

Conclusion: ____

____

2) What is the state of psychology today? (Two words)

____

Reasons:

- ____
- ____
- ____

The three happy lives:

- ____
- ____
- ____

Conclusion

____

____

3) What is the state of psychology today? (Three words)

____

Reasons:

- ____
- ____
- ____

Task 22: Watch the video of Russell Foster's "Why do we sleep" and answer the following questions.

1) How do the following people describe sleep?

Shakespeare:

____

____

Thomas Dekker: ____

____

Thomas Edison: ____

____

Margaret Thatcher: ____

____

Gordon Gekko: ____

____

2) Why do we abandon sleep in our thoughts?

____

3) Why do we sleep?

Hypothesis 1: ____

____

____

Hypothesis 2: ____

____

____

Hypothesis 3: ____

____

____

4) What is the difference in the amounts of sleep in the past and now?

In the past: ____

____

Now: ____

____

Unit 6

Climate Change

Objectives

- Acquaint yourselves with the Claim/theory-Evidence/facts discourse pattern in argumentation;
- Identify the counter-argument strategy and explain its role in argumentation;
- Understand the mechanism of how the amount of carbon dioxide in the atmosphere determines the temperature of the Earth's surface;
- Identify the Summary-Comment discourse pattern in technical reviews;
- Acquaint yourselves with the strategy of quoting others' voices in giving comments;
- Identify different forms of quoting such as summary, paraphrase, direct speech, indirect speech in technical reviews;
- Distinguish quotations from the author's own voice;
- Identify the causes and effects in discussions of climate change;
- Discuss technological, political, social and economic consequences of geoengineering;
- Note down the main points of science reports and interviews about climate change.

Task 1: Familiarize yourselves with the following new words, set expressions or lexical chunks to prepare for reading the texts in this unit.

absorb appreciably in the relevant spectral region in the infrared	在相关红外光谱区域内吸收明显
absorb strongly over at least a portion of the infrared spectrum	至少在红外光谱的一部分区域内吸收强烈
accumulated precipitation on land	陆地积水
accumulation of carbon dioxide	二氧化碳积聚
accurate infrared measurement	准确的红外测量
acidification	酸化
adamant	坚定不移的
Antarctic Circumpolar Current	绕南极洋流
Antarctic krill	南极虾
Antarctic zooplankton	南极浮游动物
assess the risks of the technique	评估该技术的风险
atom interferometer	原子干涉仪
attenuation	减少
barking mad	疯狂到极点
benthic community	海底生物群落
benthos	海底生物

biota	生物群
browse on the algae	吃海藻
calcified skeletal element	钙化骨骼元素
calcium carbonate	碳酸钙
calculation of the infrared flux in the atmosphere	大气中的红外辐射通量计算
canister	霰弹筒
carbon-14 dating	碳-14 年代测定法
carbon sequestration	碳封存
carbonate deposition	碳酸钙沉积
climatic oscillation	气候波动周期
come to equilibrium	达到平衡状态
complete nonstarter	完全不可能实现的想法
concentration of carbon dioxide	二氧化碳浓度
congregate	聚集
census	普查
continental shelf	大陆架
counterintuitive	违反直觉的
culminate with	以……而结束
culprit	罪魁祸首
daunting	使人气馁的
decalcification-related mortality	因脱钙而死亡
demonic system	具有魔力的系统
diatom	硅藻
disperse fine droplets of sulfuric acid	喷洒硫酸雾滴
disrupting precipitation patterns	扰乱降水模式
dormant	休眠的，不活动的
dredge up	挖掘
drought-prone area	易发生干旱的地区
dwarf	（使）显得矮小
eat away the ozone layer	消耗臭氧层
elevated concentrations of the gas	（二氧化碳）气体浓度的升高
embryonic and larval development	胚胎和幼虫发育
ensuing surplus	随之产生的过剩
excavate from	从……中挖掘
exquisite control	精准的控制
extensive outbursts of mountain building	造山运动的广泛大爆发
fanatic	狂热分子
fissure	缝隙
forage	觅食
function like a moratorium	起到暂停令的作用
genus	(动植物的）属，类，种
geoengineering	地球工程
give plausible explanations for	给出合理的解释

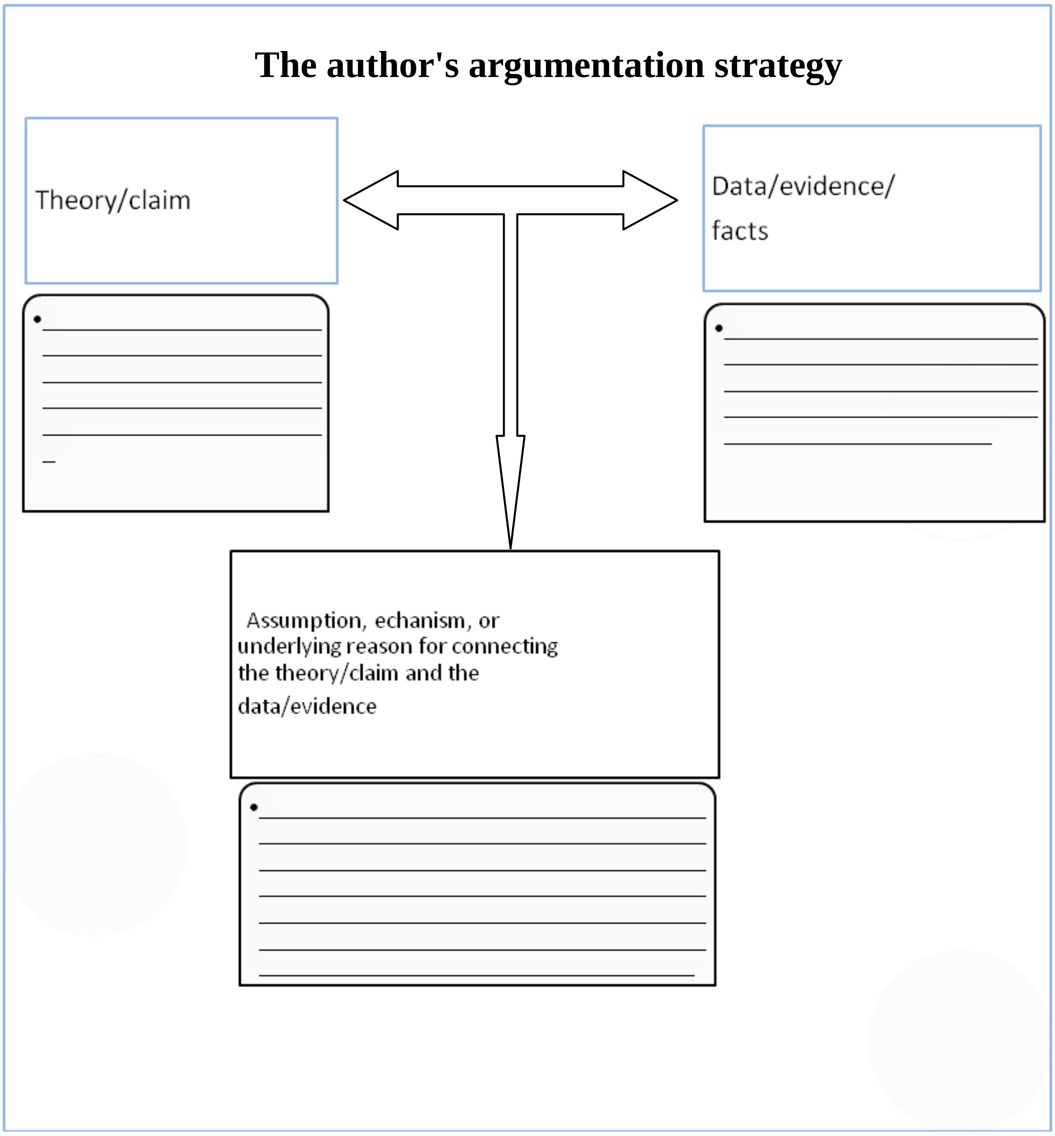
glaciation	冰川作用
greenhouse-gas emission	温室气体排放
grim	严峻的
habitat	（动物的）栖息地
hack the planet	攻击地球，对地球实施黑客行为
herbivore	食草动物
ice shelf	冰架
in peril	处在危险中
in the vicinity of	在......附近
in the visible and infrared portions of the spectrum	在可见光和红外光谱范围内
increased precipitation during a glacial epoch	冰河时期的降水量增加
inexorable move toward full-scale deployment	朝着势不可挡的方向全面展开
infrared absorption properties of carbon dioxide， water vapor, and ozone	二氧化碳、水汽和臭氧的红外吸收特性
infrared region of the spectrum	红外光谱区域
inhibit	抑制
injection of sulfuric acid	硫酸注射
intrusion	侵入
invertebrate animal	无脊椎动物
vertebrate	脊椎动物
irreversible	不可逆的
lapse into annoyance	陷入恼怒之中
lethal cocktail	致命毒液
lower stratosphere	低平流层
magnesium	镁
maintain equilibrium between the atmosphere and the oceans	保持大气与海洋之间的平衡
marine plankton	海洋浮游生物
microbial respiration	微生物呼吸
miniature	小型的，微小的
mitigate	使缓和，使减轻
narcotic effect	麻醉剂的作用
narcosis	麻醉
native to	(动植物)当地土生的，原产地的
negligent	疏忽的，粗心大意的
no conceivable impact	无明显影响
northern extremity	最北端
offset rising temperatures	与不断上升的气温相抵消
offset the warming effects	抵消气候变暖的影响
one micron wide on either side of the center of the carbon dioxide band	二氧化碳带中心两侧一微米宽

one-off event	一次性的孤立事件
opaque glass	不透明玻璃
optimize	使优化
outgoing radiation from the Earth to space	地球向太空的辐射
overriding reason	最主要的原因
overwinter	过冬
oxygen, nitrogen, and argon	氧、氮、氩
pelagic organism	浮游生物
perturbation experiments	扰动试验
photosynthesis	光合作用
phytoplankton	浮游植物
pious wish	虔诚的愿望
prominent atmospheric chemist	著名的大气化学家
public advocacy for	公开提倡
public outcry	公众的呼吁
put the world in a really precarious state	把地球置于危险的境地，使地球遭受灭顶之灾
reckless	鲁莽的，不顾后果的
recorded geological history	有记录的地质历史
reduce the acidification of the oceans	降低海洋的酸化程度
remain intact	保持完好无损
reroute	重定次序
retreat	后退
reverberate	回荡
salps and pteropods	樽海鞘和翼足类动物
sanguine	乐观的
satellite telemetry	卫星遥测技术
self-perpetuating cycle	永动（能量）循环
set Earth’s thermostat	设定地球的恒温器
shale	页岩
single-celled plant	单细胞植物
siliceous shells	硅质壳
spearhead a project	牵头完成一个项目
spray the sulfuric acid	喷洒硫酸
stave off some effects of climate change	延缓气候变化的影响
sulfate aerosol	硫酸盐气溶胶
susceptible to	易受......影响的
talk unflinchingly about	毫不畏惧地谈论
tectonic activity	地壳构造活动
temperate latitude	温带地区
the planet’s albedo	地球的反照率
thin hose held aloft by a helium balloon	由氦气球支撑在空中的软管
thornier issue	更棘手的问题
threshold temperature	临界温度

transparency	透明度
transparent glass	透明玻璃
tremendous quantities of igneous rock	大量的火成岩
turn down Earth's thermostat	调低地球恒温器
ultraviolet radiation	紫外辐射
unabated	不减弱的，不减退的
unfathomably difficult	困难不可估量
unravel the chemistry	解释其化学特性
upward flux of radiation	向上的辐射通量
variations in the average elevation	平均海拔高度的变化
vigorous convection current	强对流
volcanic dust in the atmosphere	大气中的火山灰
voracious predator	贪婪的捕食动物

Task 2: Read the underlined parts in Text I and determine which of the following is the author's communicative purpose. Then skim through Text I and work out the discourse pattern and the author's argumentation strategy with the help of the following chart.

1) Argue the carbon dioxide theory can explain the facts about variations in climate**.**
2) Compare various theories scientists proposed to account for climatic variations.
3) Find out how the increase of carbon dioxide concentration leads to global warming.
4) Persuade the public to take actions against possible carbon dioxide concentration.
5) Show it is impossible to test whether the climate change theories are right or not.



Text I

Carbon Dioxide and the Climate [16]

Gilbert N. Plass

1 Scientists have long been fascinated with the problem of explaining variations in the climate. For at least nine-tenths of the time since the beginning of **recorded geological history**, the average temperature of the Earth has been higher than it is today. Between these warm epochs there have been severe periods of **glaciation** which have lasted a few million years

and which have occurred at intervals of roughly 250,000,000 years. Of more immediate interest to us is the general warming of the climate that has taken place in the last sixty years.

2 Theories of climatic change are exceedingly numerous. Is it possible that any of these theories can explain most of the known facts about climate? The most widely held theories at the present time call upon variations in the solar energy received by the earth, changes in the amount of **volcanic dust in the atmosphere**, and **variations in the average elevation** of the continents. Although it is entirely possible that changes in each of these factors may have had an influence on the Earth's climate at particular times and places, none of these theories alone seems able to explain a majority of the known facts about world-wide climatic variations.

3 Although the carbon dioxide theory of climatic change was one of the most widely held fifty years ago, in recent years it has had relatively few adherents. However, recent research work suggests that the usual reasons for rejecting this theory are not valid. Thus it seems appropriate to reconsider the question of variations in the amount of carbon dioxide in the atmosphere and whether it can satisfactorily account for many of the world-wide climatic changes**.**

4 Because of the relatively low temperatures at the Earth's surface and in the atmosphere, virtually all of the **outgoing radiation from the Earth to space** is in the **infrared region of the spectrum**. Thus it is important to know which constituents of the atmosphere absorb in the infrared. The three most abundant gases in our atmosphere are **oxygen, nitrogen, and argon**. However, none of these three gases **absorb appreciably in the relevant spectral region in the infrared**. If these were the only gases in our atmosphere, our climate would be considerably colder than it is today. The heat radiated from the surface of the Earth would not be stopped in its passage out to space with the result that the Earth's surface would cool rapidly.

5 Fortunately for us, three other gases occur in our atmosphere in relatively minute quantities: carbon dioxide, water vapor, and ozone. Unlike the more abundant gases, all three of these rarer gases **absorb strongly over at least a portion of the infrared spectrum**. The **concentration of carbon dioxide** in the atmosphere is about 0.03 per cent by volume. Water vapor and ozone also exist in very small concentrations in the atmosphere, but the exact amount that is present varies with time and place.

6 The **infrared absorption properties of carbon dioxide**, **water vapor, and ozone** determine our climate to a large extent. Their action has often been compared to that of a greenhouse. There the rays of the sun bring the heat energy in through the **transparent glass**. However, the outgoing heat energy from the plants and other objects in the greenhouse is in the infrared where

glass is largely **opaque**. The heat energy is fairly effectively trapped inside the greenhouse and the temperature is considerably warmer than outside.

7 In a similar manner the temperature at the surface of the Earth is controlled by the **transparency** of the atmosphere **in the visible and infrared portions of the spectrum**. The incoming radiation from the sun in the visible portion of the spectrum reaches the surface of the Earth on a clear day with relatively little **attenuation** since the atmosphere is transparent to most frequencies in the visible. However, in order to have a warm climate, this heat energy must be held near the surface of the Earth and cannot be reradiated to space immediately. The atmosphere is opaque or partially opaque to a large range of frequencies in the infrared because of the absorption properties of the three relatively rare gases described above. Thus radiation emitted by the Earth's surface cannot escape freely to space and the temperature at the surface is higher than it would be otherwise. The atmosphere has just the same properties as the glass in the greenhouse. The carbon dioxide theory states that, as the amount of carbon dioxide increases, the atmosphere becomes opaque over a larger frequency interval; the outgoing radiation is trapped more effectively near the Earth's surface and the temperature rises. The latest calculations show that if the carbon dioxide content of the atmosphere should double, the surface temperature would rise 3.6 degrees Celsius and if the amount should be cut in half, the surface temperature would fall 3.8 degrees.

8 The carbon dioxide theory was first proposed in 1861 by Tyndall. The first extensive calculations were necessarily done by very approximate methods. Only recently has a reasonably accurate solution to the problem of the influence of carbon dioxide on surface temperature been possible, because of **accurate infrared measurements**, theoretical developments, and the availability of a high-speed electronic computer.

9 The fact that water vapor absorbs to some extent in the same spectral interval as carbon dioxide is the basis for the usual objection to the carbon dioxide theory. According to this argument the water vapor absorption is so large that there would be virtually no change in the outgoing radiation if the carbon dioxide concentration should change. However, this conclusion was based on early, very approximate treatments of the very complex problem of the **calculation of the infrared flux in the atmosphere**. Recent and more accurate calculations that take into account the detailed structure of the spectra of these two gases show that they are relatively independent of one another in their influence on the infrared absorption.

10 One further objection has been raised to the carbon dioxide theory: the atmosphere is completely opaque at the center of the carbon dioxide band and therefore there is no change in the absorption as the carbon dioxide amount varies. This is entirely true for a spectral interval about **one micron**

wide on either side of the center of the carbon dioxide band. However, the argument neglects the hundreds of spectral lines from carbon dioxide that are outside this interval of complete absorption. The change in absorption for a given variation in carbon dioxide amount is greatest for a spectral interval that is only partially opaque; the temperature variation at the surface of the Earth is determined by the change in absorption of such intervals.

11 Thus there does not seem to be a fundamental objection to the carbon dioxide theory of climate change. Further the temperature changes given by the theory for reasonable variations in the carbon dioxide amount are more than enough to cause noticeable changes in the climate. It is not usually appreciated that very small changes in the average temperature can have an appreciable influence on the climate. For example, various authorities estimate that, if the average temperature should decrease from 1.5 to 8 degrees, the glaciers would again form over an appreciable fraction of the Earth's surface. Similarly a rise in the average temperature of perhaps only 4 degrees would bring a tropical climate to most of the Earth's surface.

12 The carbon dioxide theory provides a simple, straight-forward explanation for the **increased precipitation during a glacial epoch**. One of the parameters that determines the amount of precipitation from a given cloud is the radiant loss of heat energy from the upper surface of the cloud. If this radiation loss increases, the temperature at the upper surface of the cloud decreases. This increases the temperature difference between the upper and lower surface of the cloud. Because of these more **vigorous convection currents**, it is more likely that rain will fall from the cloud. Thus on the average there is more rainfall from a given cloud if the radiation loss from its upper surface increases.

13 According to the carbon dioxide theory there is a smaller than normal amount of carbon dioxide in the atmosphere when glaciers are beginning to form. Not only the surface of the Earth, but also the upper surface of a cloud is cooler, since they can lose heat energy more rapidly to space. Recent calculations show that the upper surface of a cloud at a height of 4 kilometers is 2.2 degrees cooler when the carbon dioxide pressure is half the present value. Further the **upward flux of radiation** that strikes the lower surface of the cloud is larger when the carbon dioxide amount is reduced; thus the lower surface of the cloud is warmer than before. Thus, the larger temperature difference between the upper and lower surfaces of the cloud causes increased convection in the cloud; the level of precipitation should increase appreciably. Thus, according to the carbon dioxide theory, colder and wetter climates occur together.

14 There is considerable geological evidence that **extensive outbursts of mountain building** occurred several millions of year before each of the last two major glacial epochs. Again the carbon dioxide theory seems to be the

only theory that suggests a reason for the time lag between these two events. During a major period of mountain building, **tremendous quantities of igneous rock** are exposed to weathering. In mountainous country the zone for the active disintegration of rock extends much farther beneath the surface than it does in flat country. The weathering of igneous rock changes it into carbonates, thus removing carbon dioxide from the atmosphere.

15 The explanation of the time lag in terms of the carbon dioxide theory is that large quantities of carbon dioxide are removed from the atmosphere by the increased weathering after a period of major mountain building. After some millions of years, the carbon dioxide content of the atmosphere is reduced sufficiently to bring on a period of glaciation. From estimates of the increased weathering that occurs after the uplift of a mountain range, it is found that the time lag is of the order of a million years.

16 However, during an epoch of mountain building, greatly increased amounts of carbon dioxide must be released from the interior of the Earth into the atmosphere through volcanic vents and hot springs. Additional millions of years are required to use up this additional carbon dioxide by the process of weathering. Thus the actual time interval between the onset of an epoch of mountain building and the ensuing glaciation can be considerably greater than a million years, if large additional quantities of carbon dioxide are released from the interior of the Earth. Indeed, if these amounts are very large, weathering would be unable to reduce the atmospheric carbon dioxide content to a sufficiently low level to cause a glacial period. In fact some periods of mountain building have not been followed by extensive glaciation. Such theories of glacial change as the variation in the amount of volcanic dust in the atmosphere and the change in the average elevation of the lands have found it difficult to explain why the glaciers do not form immediately after the uplift of a major mountain range.

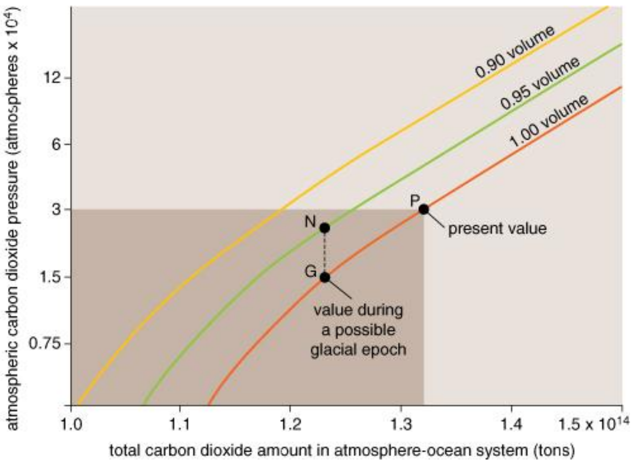
17 The carbon dioxide theory has **given plausible explanations for** the beginning of a glacial period and of the **climatic oscillations** that occur during a glacial period. What is the reason for the recent temperature rise that is found throughout the world? Will this trend toward warmer climates continue for some time? The carbon dioxide theory may provide the answer. The burning of fossil fuels which is adding more than 6×10^9 tons per year of carbon dioxide to the atmosphere. If all of this extra carbon dioxide remains in the atmosphere, the average temperature is increasing at the rate of 1.1 degrees per century from this cause. Since 1900 a careful study of world temperature records shows that the average temperature has been increasing at roughly this rate. Of course, the agreement between these two numbers could be merely a coincidence.

18 As the concentration of carbon dioxide in the atmosphere increases, there are two factors in the carbon dioxide balance that can change. First the oceans

absorb more carbon dioxide to **come to equilibrium** with the larger atmospheric concentration. However, only the surface waters can absorb this gas and because of the slow circulation of the oceans, it probably takes at least ten thousand years for this process to come to equilibrium.

19 The second factor that can change is the amount used in **photosynthesis**. A higher level of photosynthetic activity can be supported by the increased carbon dioxide amount. This process temporarily withdraws some of the additional carbon dioxide from the atmosphere into the organic world. However, in a relatively few years the increased rates of respiration and decay bring this process back into equilibrium and only a relatively small amount of carbon dioxide is permanently lost from the atmosphere. Thus it appears that a major fraction of the additional carbon dioxide that is released into the atmosphere remains there for at least several centuries.

20 Even if there may be some question as to whether or not the change of the climate in the last fifty years has really been caused by increased industrial activity, there can be no doubt that this will become an increasingly serious problem as the level of industrial activity increases. In a few centuries the amount of carbon dioxide released into the atmosphere will have become so large that it will have a profound influence on our climate.



21 After making allowance for industrial growth, a conservative estimate shows that the known reserves of coal and oil will be used up in about 1,000 years. If this occurs, nearly 4×10^{13} tons of carbon dioxide will have been added to the atmosphere; this is seventeen times the present amount. The total amount in the atmosphere-ocean system will have increased from 1.32×10^{14} tons to 1.72×10^{14} tons. Even if the atmosphere-ocean system is assumed to be in equilibrium at the end of the thousand year period, the atmospheric carbon dioxide pressure will be 3×10^{-3} atmospheres, which is 10 times the present value; the corresponding increase in the temperature from this cause will be 13.4 degrees. If it is further assumed that there would be sufficient time for the **calcium carbonate** to dissolve and come to equilibrium in the oceans, the atmospheric pressure will be 1.1×10^{-3} atmospheres and the temperature

rise 7.0 degrees. The last figure is a lower limit for the temperature rise that will occur because of man's industrial activities; the actual temperature rise must be larger since there will be insufficient time for these various equilibria to be established.

22 Unfortunately it is difficult to obtain any direct evidence for the carbon dioxide content of the atmosphere during past geological epochs. In fact it is not even certain from direct measurements whether or not the carbon dioxide content has increased in the last 50 years. It is possible though that we will be able to calculate the carbon dioxide amount of a past epoch from measurements of the ocean temperature and the rate of **carbonate deposition** during that epoch together with further studies of the atmosphere-ocean equilibrium.

23 Further evidence as to the carbon dioxide amounts in the past is provided by the pH of sea water. There is a definite pH value associated with a given atmospheric carbon dioxide amount when the atmosphere-ocean system is in equilibrium. Further, many marine animals are very sensitive to the pH value, the higher marine animals being more sensitive in general than the lower. For example, herring are killed if the pH changes by more than one-half unit; lower marine animals such as sea urchins, diatoms, and algae cannot tolerate pH changes of more than one unit.

24 This suggests that the pH of the oceans has not varied by more than these amounts since the time when these animals evolved or at most that the pH has changed extremely slowly so that these animals could evolve to live in the changed environment. However, even with the stringent requirement that the pH of sea water should not change by more than one-half unit, the atmospheric carbon dioxide amount can still vary by a factor of fifty and **maintain equilibrium between the atmosphere and the oceans**. Thus very large changes in the atmospheric carbon dioxide amount can occur without influencing either marine or land animals; still larger variations would even be possible over time intervals sufficiently long to allow the animals to adapt to their new environment.

25 A very large number of different theories of climatic change has been proposed. As more evidence about past climatic change is obtained, each theory has to meet continually more rigorous tests in order to explain the known facts. Each of the major theories of climatic change predicts a different temperature trend during the remainder of this century. A comparison of these predictions with the actual record at the end of the century will provide an important test of these theories.

26 The variable sun theory predicts that the temperature will decrease for some decades. The maximum of the 80-year period in the sunspot cycle probably occurred in 1947. Thus the total energy received from the sun including the **ultraviolet** should decrease for some decades when the records are averaged

over the shorter periods in the cycle. On the other hand a continued increase in the average temperature could be justified by the variable sun theory only if measurement showed a corresponding increase in the solar constant.

27 Changes in the average elevation of the continents clearly cannot be used to explain any variations in the climate over a period of a few centuries. However, the volcanic dust theory predicts appreciably lower temperatures for a few years following volcanic activity that throws large quantities of dust into the atmosphere. The last such explosion was when Katmai on the Aleutian Islands erupted in 1912. More volcanic explosions of this kind must occur before sufficient data can be obtained to correlate with the predictions of this theory. At the present time it is entirely possible that volcanic dust creates small perturbations in the climate while the general trend is determined by some other factor.

28 On the other hand the carbon dioxide theory is the only one that predicts a continually rising average temperature for the remainder of this century because of the **accumulation of carbon dioxide** in the atmosphere as a result of industrial activity. In fact the temperature rise from this cause may be so large in several centuries that it will present a serious problem to future generations. The removal of vast quantities of carbon dioxide from the atmosphere would be an extremely costly operation. If at the end of this century the average temperature has continued to rise and in addition measurement also shows that the atmospheric carbon dioxide amount has also increased, then it will be firmly established that carbon dioxide is a determining factor in causing climatic change.

Task 3: Read Text I carefully and answer the following questions.

1) What were the most widely held theories, at the time when the article was written, to explain the variations in the climate?

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2) Why did the author think it appropriate to reconsider the carbon dioxide theory about climate change?

____

____

____

3) What strategy is used in paragraphs 9-11?

____

____

____

4) Why does the author discuss the two factors that can change as a result of increased carbon dioxide in the atmosphere in paras.19 and 20?

____

____

____

5) What is the author's prediction of the temperature in about 1000 years?

____

____

____

Task 4: Skim through Text II and complete the following chart which demonstrates the Summary-Comment discourse pattern of the technical review.

Summary	**Comment**
Intentionally engineering Earth's atmosphere to offset rising temperatures could be far more doable than you imagine, says David Keith.	**But is it a good idea?**
Why It Matters Summary of ________________	Barking Mad ________________ ________________
The Experiment Summary of ________________	A Moratorium Social political consequences
Switching It On Summary of ________________	Comment on Keith's argument SRM is ________________.

Task 5: Explain the communicative purpose of the technical review in Text II and the rhetorical strategy to achieve this purpose.

The communicative purpose: ________________________________

____

____

The rhetorical strategy: ______________________________________

____

____

Text II

A Cheap and Easy Plan to Stop Global Warming[17]

Intentionally engineering Earth's atmosphere to **offset rising temperatures** could be far more doable than you imagine, says David Keith. But is it a good idea?

David Rotman

Why It Matters

1 The climate warming resulting from increased levels of carbon dioxide will last at least a thousand years. **Geoengineering** might be the only way to **turn down Earth's thermostat**.

2 Here is the plan. Customize several Gulfstream business jets with military engines and with equipment to produce and **disperse fine droplets of sulfuric acid**. Fly the jets up around 20 kilometers—significantly higher than the cruising altitude for a commercial jetliner but still well within their range. At that altitude in the tropics, the aircraft are in the **lower stratosphere**. The planes **spray the sulfuric acid**, carefully controlling the rate of its release. The sulfur combines with water vapor to form **sulfate aerosols**, fine particles less than a micrometer in diameter. These get swept upward by natural wind patterns and are dispersed over the globe, including the poles. Once spread across the stratosphere, the aerosols will reflect about 1 percent of the sunlight hitting Earth back into space. Increasing what scientists call **the planet's albedo**, or reflective power, will partially **offset the warming effects** caused by rising levels of greenhouse gases.

3 The author of this so-called geoengineering scheme, David Keith, doesn't want to implement it anytime soon, if ever. Much more research is needed to determine whether injecting sulfur into the stratosphere would have dangerous consequences such as **disrupting precipitation patterns** or further **eating away the ozone layer** that protects us from damaging **ultraviolet radiation**. Even **thornier,** in some ways, are the ethical and governance issues that surround geoengineering—questions about who should be allowed to do what and when. Still, Keith, a professor of applied physics at Harvard University and a leading expert on energy technology,

has done enough analysis to suspect it could be a cheap and easy way to head off some of the worst effects of climate change.

4 According to Keith’s calculations, if operations were begun in 2020, it would take 25,000 metric tons of sulfuric acid to cut global warming in half after one year. Once under way, the **injection of sulfuric acid** would proceed continuously. By 2040, 11 or so jets delivering roughly 250,000 metric tons of it each year, at an annual cost of $700 million, would be required to compensate for the increased warming caused by rising levels of carbon dioxide. By 2070, he estimates, the program would need to be injecting a bit more than a million tons per year using a fleet of a hundred aircraft.

5 One of the startling things about Keith’s proposal is just how little sulfur would be required. A few grams of it in the stratosphere will offset the warming caused by a ton of carbon dioxide, according to his estimate. And even the amount that would be needed by 2070 is **dwarfed** by the roughly 50 million metric tons of sulfur emitted by the burning of fossil fuels every year. Most of that pollution stays in the lower atmosphere, and the sulfur molecules are washed out in a matter of days. In contrast, sulfate particles remain in the stratosphere for a few years, making them more effective at reflecting sunlight.

6 The idea of using sulfate aerosols to offset climate warming is not new. Crude versions of the concept have been around at least since a Russian climate scientist named Mikhail Budkyo proposed the idea in the mid-1970s, and more refined descriptions of how it might work have been discussed for decades. These days the idea of using sulfur particles to counteract warming—often known as solar radiation management, or SRM—is the subject of hundreds of papers in academic journals by scientists who use computer models to try to predict its consequences.

7 But Keith, who has published on geoengineering since the early 1990s, has emerged as a leading figure in the field because of his aggressive **public advocacy for** more research on the technology—and his willingness to **talk unflinchingly about** how it might work. Keith is one of the world’s most influential voices on solar geoengineering. He is one of the few who have done detailed engineering studies and logistical calculations on just how SRM might be carried out. And if he and his collaborator James Anderson, a **prominent atmospheric chemist** at Harvard, gain public funding, they plan to conduct some of the first field experiments to **assess the risks of the technique**.

8 Leaning forward from the edge of his chair in a small, sparse Harvard office on an unusually warm day this winter, he explains his urgency. Whether or not **greenhouse-gas emissions** are cut sharply—and there is little evidence that such reductions are coming—"there is a realistic chance that solar

geoengineering technologies could actually reduce climate risk significantly, and we would be **negligent** if we didn't look at that," he says. "I'm not saying it will work, and I'm not saying we should do it." But "it would be **reckless** not to begin serious research on it," he adds. "The sooner we find out whether it works or not, the better."

9 The **overriding reason** why Keith and other scientists are exploring solar geoengineering is simple and well documented, though often overlooked: the warming caused by atmospheric carbon dioxide buildup is for all practical purposes **irreversible**, because the climate change is directly related to the total cumulative emissions. Even if we halt carbon dioxide emissions entirely, the **elevated concentrations of the gas** in the atmosphere will persist for decades. And according to recent studies, the warming itself will continue largely **unabated** for at least 1,000 years. If we find in, say, 2030 or 2040 that climate change has become intolerable, cutting emissions alone won't solve the problem.

10 "That's the key insight," says Keith. While he strongly supports cutting carbon dioxide emissions as rapidly as possible, he says that if the climate "dice" roll against us, that won't be enough: "The only thing that we think might actually help reverse the warming in our lifetime is in fact geoengineering."

The Experiment

11 David Keith clearly sees the world through the eyes of an experimental physicist. During his time as a graduate student in the MIT lab of David Pritchard, he **spearheaded a projec**t that built the first **atom interferometer**. Keith and his coworkers outcompeted some of the world's top atomic-physics labs, including one at Stanford led by Steven Chu, who later won a Nobel Prize and served as the U.S. secretary of energy. Everyone knew the interferometer would be a breakthrough, recalls Pritchard, but Keith displayed a rare combination of creativity and the ability to "blast ahead" through the frustrations and difficulties of building and testing it.

12 Soon, Keith had moved on from atomic physics to energy problems. In 1992, he published a paper called "A Serious Look at Geoengineering," one of the first rigorous scientific reviews of the topic. Almost no one cared.

13 Indeed, the field of geoengineering remained more or less **dormant** for much of the next decade. A handful of serious scientists wrote occasional papers and the field attracted a few **fanatics,** but academic discussion of the subject—let alone actual research—remained somewhat taboo. Many felt that discussing geoengineering as a realistic option would take attention away from the urgency of cutting greenhouse-gas emissions. Then, in 2006, Paul Crutzen, one of the world's leading climate scientists and a winner of the 1995 Nobel Prize in chemistry for his work on atmospheric ozone

depletion, published a paper called "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolve a Policy Dilemma?"

14 In the paper, Crutzen acknowledged that the "preferred way" to address climate warming was to lower emissions of greenhouse gases, but he concluded that making sufficient cuts was only "a **pious wish**." Not only did he give his blessing to the idea of geoengineering, but he singled out the use of sulfate aerosols in particular as worthy of research, even though it's well known that the particles can facilitate the chemical reactions that lead to ozone loss. He pointed to the eruption of Mount Pinatubo on an island in the Philippines in 1991 as evidence that sulfate particles can effectively cool the planet. The giant volcano spewed some 10 million metric tons of sulfur into the stratosphere. Subsequent analysis showed that the world's temperature decreased by an average of 0.5 ℃ for a couple of years.

15 At a time when many experts were increasingly frustrated with the lack of progress in cutting greenhouse gases, the paper permitted the topic of intentional climate alteration to be more openly discussed. In subsequent years, geoengineering gained still more attention, including high-profile reviews by the U.K.'s Royal Society and the Washington-based Bipartisan Policy Center, both of which recommended further exploring SRM. (Keith helped write both reports.) Endless modeling and computer simulations have followed. But now Keith is anxious to conduct field experiments.

16 That idea is highly controversial. Many climate scientists still consider field experimentation premature, and critics of geoengineering tend to believe it would be the first step in what would turn into an **inexorable move toward full-scale deployment**. Last year, a **public outcry** led by several international environmental groups helped shut down a simple experiment that a team of British researchers had proposed. The group wanted to pump water to a height of one kilometer through a **thin hose held aloft by a helium balloon.** The object would have been to test whether a similar system could someday be used to inject sulfur particles into the stratosphere at an altitude of 20 kilometers.

17 The experiments Keith and Anderson are considering would be far more ambitious. Their goals: first, to test how sulfuric acid should be distributed to **optimize** the size and longevity of the resulting particles, and second, to measure how sulfur affects ozone at the altitude and under the conditions associated with SRM.

18 Anderson, who helped **unravel the chemistry** behind the ozone hole that appeared in the Antarctic during the 1980s, says the "**demonic system**" that implicates sulfate particles in ozone destruction is highly sensitive to the levels of water vapor in the air. So in one set of experiments, using a scheme based on Anderson's earlier work, the group would send a helium-filled balloon to the lower stratosphere, use a Kevlar thread to lower **canisters**

filled with water vapor and sulfur, and release small amounts of the test samples. Then the researchers would drop down **miniature** laser-based analytic instruments to monitor the chemistry in the small “seeded” area. The setup, says Anderson, provides “**exquisite control**” and a way to precisely monitor the effect of different amounts of sulfur and water vapor.

19 Anderson stresses that the experiment would have **no conceivable impact** on the stratosphere: it would use only “micro-amounts” of sulfur and would be confined to a very small region. And he says it is critical to study the reactions under the conditions “where they actually take place” and not in the confines of the lab.

20 Still, while he is keen to test SRM, Anderson says that adding sulfates to the stratosphere worries him “tremendously” because of the potential impact on ozone. He points to a study his group published last year in *Science* showing that increasingly intense summer storms over the United States—triggered by climate warming—are injecting more water vapor into the stratosphere. That, he says, could speed the ozone-destroying reactions: “If nature is adding increased water vapor to the stratosphere and we’re adding sulfates, it is a very **lethal cocktail** for ozone loss.”

21 Keith appears more **sanguine**. “The uncertainties are substantial,” he says. “You could get very bad ozone outcomes, but there are also ways where you could have no impact, or even a positive impact, on ozone.” In any case, he says, it is “just crazy” not to begin conducting experiments on solar geoengineering to find out. Nearly all the work done on SRM is based on computer modeling, and Keith says we need to move to “**perturbation experiments**” to learn whether we can use it to safely and effectively intervene in the climate. The field “really needs to grow up” and begin experiments in “the real world,” he says.

Barking Mad

22 Critics of SRM—and even its advocates—note that the technology has numerous limitations, and that no one is entirely sure what the consequences would be. Sulfate aerosols reflect sunlight in the upper atmosphere, thus directly cooling the planet. But greenhouse gases operate very differently, trapping long-wave infrared radiation escaping from Earth’s surface and thus warming it. While sulfates would be likely to offset warming, it’s not clear exactly how they would counteract some of the other effects of greenhouse gases, particularly changes in precipitation patterns. And SRM would do nothing to **reduce the acidification of the oceans** caused by rising levels of carbon dioxide in the atmosphere.

23 The term "solar radiation management" is meant to give you a feeling that we really understand what we would be doing,” says Raymond Pierrehumbert, a geophysicist at the University of Chicago. “It’s a way to

increase comfort levels with this crazy idea. What we're really talking about is **hacking the planet** in a case where we don't really know what it is going to do." In delivering the prestigious Tyndall Lecture at the annual American Geophysical Union meeting last December, he said the idea of putting sulfate aerosols in the stratosphere was "**barking mad**."

24 Pierrehumbert also rejects the value of doing field experiments. "The whole idea of geoengineering is so crazy and would lead to such bad consequences. It really is pretty pointless since we already know enough about sulfate albedo engineering. It would **put the world in a really precarious state**. Field experiments are really a dangerous step on the way to deployment, and I have a lot of doubts what would actually be learned."

25 The fundamental problem with albedo engineering, says Pierrehumbert, is that once we start using it, we'll need to continue indefinitely. Since it only offsets warming, once the process stops, temperature changes caused by greenhouse gases will manifest themselves suddenly and dramatically. "If you stop—or if you *have* to stop—then you're toast," he says. Even using it as a temporary Band-Aid doesn't make sense, he argues: "Once you get to the point in terms of climate changes that you feel you have to use it, then you have to use SRM forever." He believes that this makes the idea a "**complete nonstarter**."

26 Besides, Pierrehumbert says, our climate models "are nowhere near advanced enough for us to begin thinking of actually engineering the planet." In particular, computer models don't accurately predict specific regional precipitation patterns. And, he says, it's not possible to use existing models to know how geoengineering might affect, say, India's monsoons or precipitation in such **drought-prone areas** as northern Africa. "Our ability to actually say what the regional climate patterns will be in a geoengineered world is very limited," he says.

27 Alan Robock, meanwhile, has a long list of questions concerning SRM, at the top of which is: can it even be done? Robock, an expert on how volcanoes affect climate and a professor of environmental sciences at Rutgers University, cautions that while the Pinatubo eruption confirmed the cooling effect of sulfate aerosols, it injected a massive amount of sulfur dioxide into the stratosphere over a few days. Solar geoengineering would use far less sulfur but disperse it continuously over an extended period. That could be a critical difference. The optimal way to achieve SRM is with sulfur particles only about half a micrometer in diameter. Sunlight reflects off the surface of the particles, and smaller particles have more surface area than larger ones, making them far more efficient at blocking the sun. Robock worries that as sulfur is continuously injected and concentrations build up, the small particles will clump together into large ones, necessitating far more sulfur than some current proposals assume.

28 These details of aerosol chemistry could help determine the viability of SRM. “David [Keith] thinks it is going to be easy and cheap, and I don’t agree,” says Robock. He estimates that several million tons of sulfur would have to be injected into the atmosphere annually to offset doubled levels of carbon dioxide, but if the particles clump together, “it could be many times that.”

29 Research so far shows that producing a cloud in the stratosphere—Robock’s preferred description of SRM—”could cool the climate,” he says. “But you would have a very different planet, and other things could be worse.” He points out, for example, that in the aftermath of Mount Pinatubo, rainfall decreased significantly in some parts of the world. Robock supports more modeling on solar geoengineering, but “right now, I don’t see a path in which it would be used,” he says. “I don’t see how the benefits outweigh the negatives.”

30 Still, climate scientists differ widely in the way they interpret the research on those risks. Phil Rasch, for one, who published a paper with Crutzen in 2008 on using sulfate aerosols for geoengineering, says research shows that the particles will cause some ozone depletion—"it is absolutely something we need to pay attention to"—but that the loss of ozone is somewhat tempered by the ability of the sulfate particles to block ultraviolet radiation. As for rainfall, he says, models tend to agree that SRM “leads to a [future] world that’s closer to the present day with respect to precipitation than if you don’t geoengineer.” Overall, says Rasch, SRM would **stave off some effects of climate change**, though “some parts of the planet are more strongly affected than others, and there are many issues that remain unexplored.”

A Moratorium

31 The scientific uncertainties and the prospect of winners and losers among different parts of the world make it almost **unfathomably difficult** to envision how SRM might be appropriately implemented and controlled. How could we fashion the international system of governance that would eventually be needed? Who would decide how and when to implement the technology? Who would monitor and control it? Who would **set Earth’s thermostat** and at what temperature? If anything, the questions about who would make the decisions on solar geoengineering are more **daunting** than the questions about the science itself.

32 While the need for international governance is still years in the future, Keith and several close collaborators, including Edward Parson, a law professor at the University of California, Los Angeles, are already thinking about how such a system might evolve. Research on the technology is key, Parson says, to achieving a better understanding of what solar geoengineering can do and

what the risks are. Without such knowledge, he says, “you don’t know what you need to govern.”

33 The controversy over field experiments, such as the ones Keith and Anderson are designing, is emerging as an early battleground for the social and political issues. Keith is **adamant** that work will not go forward unless he and his colleagues receive public funding and approval from established scientific agencies. Indeed, he and his collaborators see the experiments as an early test not only for the technology but also for how a governance system can work. The hope, says Parson, is that the funding and approval process could provide an opportunity to establish “norms” that will help shape longer-term discussions—standards such as transparency, public review, and open disclosure of the results.

34 No one thinks that field experiments involving tiny amounts of sulfur would be physically dangerous, says Parson. “What concerns people,” he says, “is the political and social consequences of the research going ahead, followed by bigger and bigger experiments—and then you’re on the slippery slope all the way to full-scale deployment.” These worries should be taken seriously, he says: “You need to encourage small-scale research, but you need some kind of limited governance to mitigate the risk of a slide to deployment.” Established scientific funding agencies could probably take care of that, he believes. And he suggests that early experiments must be strictly limited, and researchers need to clearly state that no one is going to do anything big for the time being.

35 Keith and his collaborators are pushing fellow researchers to sign an agreement that would “**function like a moratorium**” on deploying solar engineering. That, Keith believes, could calm fears that some are rushing ahead on the technology—worries that he concedes are “not ungrounded,” since there are, in fact, no international laws or regulations barring anyone from implementing geoengineering schemes. By signing a moratorium, he hopes, scientists could “help free up research” on the risks and efficacy of SRM.

Switching It On

36 For very brief spells, Keith sometimes **lapses into annoyance** with SRM critics. A moment later, however, he is calmly and logically countering the criticism with responses he has developed after years of thinking and writing about geoengineering. He sketches a graph showing that, in fact, sulfur injection could be rationally ended a century or less after it’s begun; while the underlying climate changes it was masking would return, the rate of change affecting ecosystems and humans would have been slowed and managed. The idea that initiating SRM would commit us to continuing it indefinitely “is just not true,” he states with characteristic self-confidence.

37 Even many of the strongest advocates of SRM research say the technology would be a nearly unthinkable last resort for a desperate world facing climate changes so destructive that the risks would be worth taking. Keith, however, has a far less pessimistic vision. “If we’ve actually found something that could substantially reduce the risk of climate change over the next century and save a lot of lives, that’s nothing to be upset about,” he says. “It’s something to celebrate.” In fact, he says framing the case for geoengineering as a last resort in a climate emergency is “a bit of a rhetorical trick”: it leaves undefined what a “climate emergency” is, and “there is no simple definition.”

38 It is often assumed that SRM would be “turned on with a big switch,” says Keith. “But there’s no reason you can’t ramp it up.” And that ability to turn on the system slowly and with minimal risk is behind his “willingness to take geoengineering seriously,” he says: “If it was a one-time decision, I would be much more skeptical about doing it. It would be very hard to persuade me that it was sensible.” Given the possibility of a more deliberate approach, “I lean pretty strongly, I got to say, to doing it.”

39 Listening to Keith’s logical arguments and careful descriptions of how SRM might be carried out, it’s just possible to start believing that intentionally adjusting the climate wouldn’t be an extreme action. But it would. It would create a different planet—even the color of the sky would be whiter. And it would almost certainly be driven by desperation. On the other hand, the buildup of greenhouse gases is already altering the atmosphere and climate in an unprecedented and uncontrolled manner. How big a leap is it to intentionally “engineer” ways to begin counteracting that? And Keith is surely right that climate researchers should explore solar geoengineering to determine whether it would actually work and how safe it would be, and that political scientists need to start thinking about how we might implement such an unprecedented planetary project. All that will be left then is for society and governments to face the impossibly difficult task of deciding whether to do it.

Task 6: Read the first two sections of Text II carefully and summarize the main points of Keith's idea of geoengineering. Identify the different ways of quoting Keith's idea. For example:

"The author of <u>this so-called geoenginering scheme</u>, David Keith..." in paragraph 3 indicates that the summary of the geoengineering idea in the preceding paragraph is quoted from Keith. This part of the quote takes the form of summary. In other words, summarizing is one way of quoting.

1) Quoting Keith' scheme of solar geoengineering (in the form of summary):

___

___

2) Quoting Keith's calculations (in the form of summary):

___

___

3) Quoting Keith's explanation of the solar geoengineering (in the form of direct speech):

___

___

4) Quoting Keith and Anderson's description of the experiment they are considering (in the form of indirect speech, or paraphrase):

Goals:

___

___

Method:

___

___

Task 7: Read the "Barking Mad" and "A Moratorium" sections and identify the comments on the SRM field experiment. Explain the different ways of quoting the critics.

1) Raymond Pierrehumbert's comments:

- ___
- ___
- ___
- ___

2) Alan Robock' comments:

- ___

- ____
- ____
- ____

3) Phil Rasch's comments

- ____
- ____
- ____
- ____

4) The author's comments:

- ____
- ____
- ____
- ____

5) Edward Parson's comments

- ____
- ____
- ____
- ____

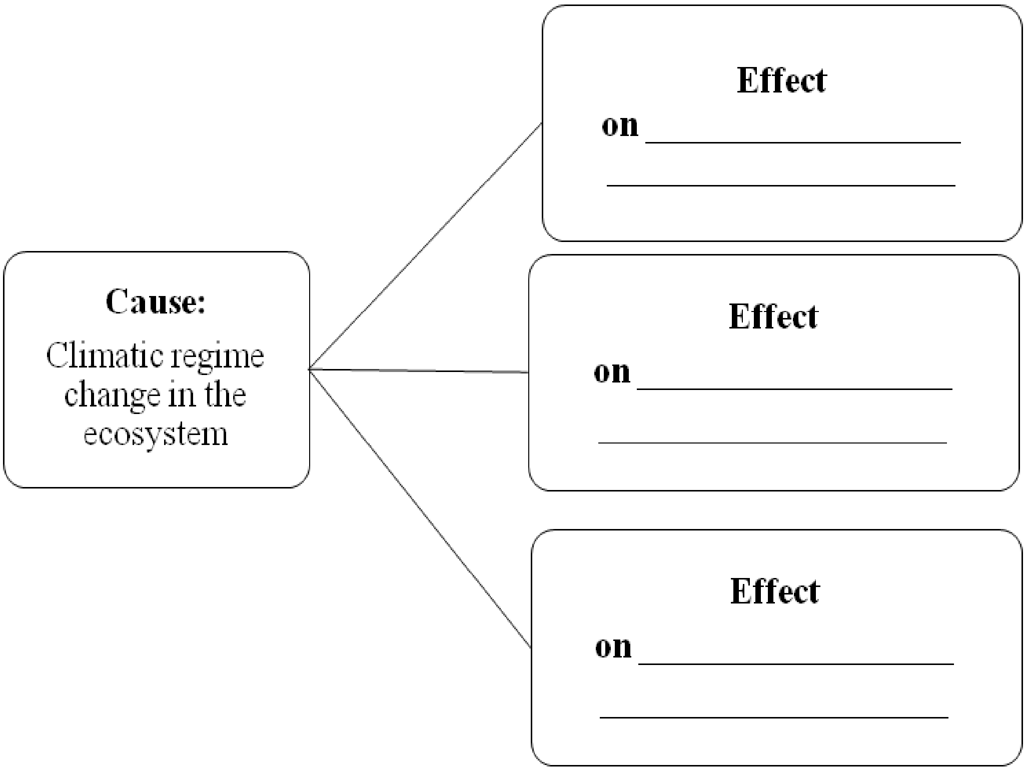
Task 8: Read the "Switching It On" section and answer the question asked at the beginning of the text, whether geoengineering is a good idea. Determine whether the following sentences are quotations or the author's own comments.

1) Keith sometimes lapses into animated annoyance with SRM critics.
2) A moment later, however, he is calmly and logically countering the criticism with responses he has developed after years of thinking and writing about geoengineering.
3) Sulfur injection could be rationally ended a century or less after it’s begun.
4) While the underlying climate changes it was masking would return, the rate of change affecting ecosystems and humans would have been slowed and managed.

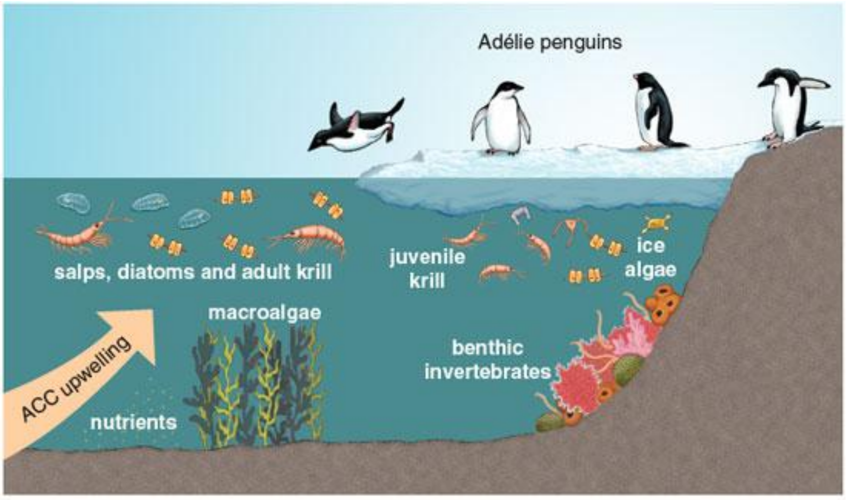
5) The idea that initiating SRM would commit us to continuing it indefinitely is definitely false.
6) SRM could meaningfully reduce climate risks without too many risks of its own.
7) Technology for SRM could be ready to be deployed as early as 2020 (or, more realistically, 2030) and would involve levels of stratospheric sulfur “practically” within normal ranges for the first decade.
8) The process could be monitored and evaluated, and because the amounts of sulfur injected into the stratosphere would be relatively small.
9) SRM would not be turned on with a big switch.
10) Intentionally adjusting the climate would be an extreme and desperate action.
11) It is impossible for society and governments to decide whether to carry out the implement the SRM project.

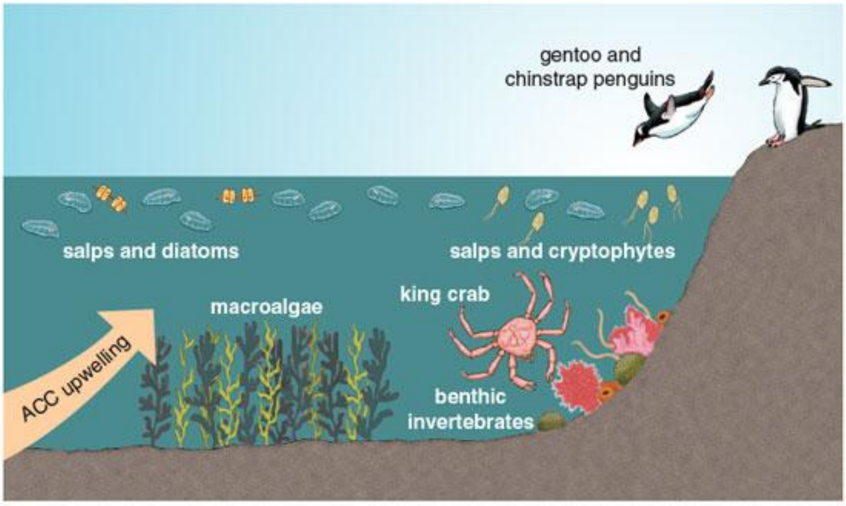
Task 9: Work in groups and list the consequences of SRM according to the critics. Then write an essay to explain whether you would support SRM to reduce global warming.

Task 10: Identify the sentence in the opening section which indicates the information structure of Text III and supply information indicated in the following structure.



Task 11: Identify the differences in the ecosystem shown in the following picture.





Text III

Ecological Responses to Climate Change on the Antarctic Peninsula [18]

The peninsula is an icy world that's warming faster than anywhere else on Earth, threatening a rich but delicate biological community.

James McClintock, Hugh Ducklow, William Fraser

1 The crack of an iceberg splitting away from the Marr glacier **reverberates** through the halls of the Bio Lab at Palmer Station, on the western shore of the Antarctic Peninsula. That sound has grown increasingly familiar to the three of us. (We've spent a collective total of 36 seasons at Palmer.) The **retreat** of the Marr glacier—and even more dramatic losses of ice elsewhere on the peninsula—signals ongoing environmental change. The average midwinter temperature here has increased by 6 degrees Celsius since 1950;

this is the highest rate of warming anywhere on the planet, five times the global average.

2 The isolated biological community of the peninsula and its coastal waters evolved in a polar climate that remained relatively stable for many millennia. Now, as the climate shifts, we are trying to document and understand how the ecosystem responds. Our studies focus on three segments of the community. Ducklow works with **marine plankton**, the small organisms that swim or drift near the sea surface. McClintock's realm is the **benthos**, the community of bottom-dwelling plants and **invertebrate animals**. And Fraser studies the penguins and other seabirds that dwell at the triple interface of land, air and sea.

Climatic Regime Change

3 The Antarctic Peninsula is the long, curving arm that reaches north from the Antarctic mainland and extends its fingers toward the tip of South America. Forty million years ago, the peninsula was a narrow strip of land connecting the two continents. Then **tectonic activity** carried Antarctica farther toward the South Pole, opening up the Drake Passage, which is now a thousand kilometers of open water between Cape Horn and the **northern extremity** of the peninsula.

4 The creation of the Drake Passage removed the last land barrier to ocean circulation at latitude 60 degrees south. The result was the formation of the **Antarctic Circumpolar Current** (ACC), which flows from west to east, or clockwise as seen from the South Pole. The ACC is the strongest and fastest of all ocean currents, transporting a volume of water equivalent to 30,000 times the flow at Niagara Falls.

5 The upwelling of the ACC brings both warmth and nutrients to the coastal waters of the western peninsula. Surface waters there range in temperature from a winter low of just above –2 degrees Celsius (the freezing point of seawater) to a summer high of about +1 degree. The temperature of the ACC water is +2 degrees, with little seasonal variation. Although +2 is far from warm by the standards of summer beachgoers, the slight warming has a tremendous biological impact.

6 The peninsula also differs from the rest of Antarctica in its response to recent global climatic trends. Whereas the continent proper has not warmed appreciably in the past century, there has been a 3.4-degree increase in the mean annual temperature along the peninsula. And, as already noted, the average midwinter temperature has climbed 6 degrees since 1950. If the trend continues, the average midwinter temperature will rise above the freezing point of seawater by the middle of this century. After that, sea ice will not form in most years, leading to a regime change in the ecosystem. Already, in the past quarter-century, the mean extent of sea ice coverage

along the western peninsula has declined by 40 percent, and the average annual duration of sea ice cover has shortened by 80 days.

7 The glaciers and **ice shelves** along the peninsula are also in retreat. Glacial ice is formed not from seawater but from **accumulated precipitation on land**, which then flows into the sea to form a shelf. Over the past 50 years, rapid warming has triggered the loss of eight peninsular ice shelves. For example, in 2002 a section of ice the size of Rhode Island broke away from the Larsen B ice shelf on the eastern side of the peninsula. On the western shore, a 400-square-kilometer chunk of the Wilkins ice shelf collapsed just this past March.

The Base of the Food Chain

8 The western coast of the Antarctic Peninsula is a highly productive ecosystem, but it is also closely attuned to the rhythms of the physical environment and thus is vulnerable to disruption. Of particular importance are fluctuations in sea ice, both seasonally and from year to year.

9 A bloom of **phytoplankton** in spring and summer depends on the annual cycle of the ice. Many **single-celled plants overwinter** in pockets of liquid within the ice. In the spring melt, the phytoplankton are released and exposed to increased sunlight, stimulating their growth and causing the bloom. **Diatoms**—single-celled phytoplankton with siliceous shells—are best adapted to the sea ice margin and dominate the blooms over the **continental shelf** of the western peninsula. The diatoms are the preferred food for **Antarctic krill**, a key link in the food chain; krill pass energy and nutrients captured by phytoplankton up to penguins, seals and whales.

10 As regional warming reduces both the extent and the duration of sea ice cover, changes are already evident at most levels of the food web. In some areas, for example, there are indications that diatoms are being replaced by cryptophytes—smaller phytoplankton lacking mineral shells. If such a shift becomes widespread, it will surely have observable effects at higher trophic levels.

11 Krill are the principal **Antarctic zooplankton**. They are highly dependent on sea ice; without it they cannot complete their life cycle and breed successfully. Juvenile krill **congregate** under the ice, **browsing on the algae** growing in **fissures** and using the ice **habitat** as a refuge from predators. As sea ice declines, the krill habitat is shrinking in space and time.

12 In addition to krill, two other groups are major components of the zooplankton: **salps and pteropods**. Salps are gelatinous, transparent organisms that look a little like jellyfish although they are actually chordates, primitive relatives of the **vertebrates**. Individual salps can be as large as 10 centimeters, and colonies are meters long. They can be **voracious predators**, clearing large volumes of water of all particles larger than a few micrometers.

Salps are **pelagic organisms**, usually inhabiting offshore waters with lower plankton concentrations (their feeding nets become clogged in blooms); they are carried onto the continental shelf by **intrusions** of the circumpolar current. Salps have few predators, which makes them a dead end in the food chain.

13 Pteropods are sometimes called sea butterflies; they are swimming pelagic snails with **calcium carbonate** shells. Like salps, pteropods commonly feed with mucus nets**,** but they are **herbivores**, grazing on phytoplankton. Moreover, unlike salps, they have predators and thus participate in the food chain.

14 As sea ice declines and intrusions of offshore warm water increase in frequency and volume, the various kinds of zooplankton respond differently. A large-scale decline in krill populations has been under way for decades, although changes in sea ice may not be the only cause. Increasing predation could also be a factor, since the regulation of whaling has allowed a slow recovery of krill-eating whale species. But the ongoing reductions in sea ice are expected to have further adverse effects on krill. In contrast, salps may be increasing over the western peninsular continental shelf, in response to changes in ice and water properties. This replacement of krill by salps has potentially grave consequences for an Antarctic food web that is highly dependent on krill as food for larger predators, including penguins.

15 In summary, it appears that current climatic trends are likely to be detrimental to some members of the zooplankton, while favoring the "gelatinous" organisms, including the salps as well as tunicates and a few other groups. Similar changes have already happened or are currently in progress for other reasons throughout the world's oceans.

16 The shifting balance between krill and salps will affect still another planktonic community: bacteria. But it remains unclear how the bacteria will respond to population changes at higher levels in the food chain. Elsewhere in the world, rising populations of gelatinous zooplankton appear to **reroute** organic matter into the bacterial biomass. Whether this "microbialization" will also happen in cold Antarctic waters is not yet known.

17 Ironically, atmospheric carbon dioxide—the main **culprit** in global warming—may in turn be **susceptible to** influence by ecosystem changes in the Southern Ocean. Planktonic organisms take up CO_2, converting it into carbon-rich organic compounds, some of which ultimately fall to the sea floor and are withdrawn from active circulation. The effect of various marine population shifts on this biological carbon pump is not known. An abundance of salps could increase **carbon sequestration**. Bacteria, on the other hand, break down complex carbon compounds and release CO_2. If this **microbial respiration** increases, oceanic CO_2 storage may be reduced,

creating a positive feedback loop: CO_2 induces warming, which decreases the CO_2 capacity of the oceans, bringing further warming.

Forests of the Antarctic

18 Dive beneath the water's surface near Palmer Station and you enter a surprisingly lush and diverse **benthic community**. The steep rock slopes are densely populated with **invertebrate**s such as sponges and corals, along with a variety of other bottom-dwelling animals. The plant community is equally impressive. Some 90 percent of the sea floor is covered by large algae. These are the forests of Antarctica.

19 All of these organisms are obviously well adapted to life in frigid water. How will they respond to the climatic changes expected in the coming decades and centuries?

20 The giant algae could in some respects be beneficiaries of warming. Their growth is limited mainly by access to sunlight, since they are shaded by sea ice for part of each year. As warming continues to erode the extent of the ice, the undersea forests are likely to expand into territory previously unavailable for colonization. But the further effects of changes in the plants' environment are hard to predict. With more energy available for photosynthesis, the algae may invest more of their resources in chemical defenses to prevent herbivores from consuming their tissues. The result could be a fundamental change in the dynamics of the community of organisms supported by the algae.

21 Among the benthic invertebrates, one potential trouble spot is in the timing of **embryonic and larval development**. Data gathered for species from various latitudes show a striking correlation between water temperature and time to maturity. The developmental processes are much slower in the Arctic and Antarctic, where reaching adulthood can take four or five times as long as it does in the tropics. Moreover, at the cold end of the temperature scale the slope of the graph is very steep, so that even slight temperature shifts correspond to a substantial change in development time. This finding suggests that environmental warming could shorten the embryonic and larval stages of life. The consequences of any change in the duration of development could be disastrous for those species. The eggs would hatch and the larvae would emerge into a sea that had insufficient resources to support them.

22 Another prospective community-altering impact was vividly brought to our attention recently when adult specimens of the spider crab *Hyas araneus* were **dredged up** from waters off King George Island, near the northern tip of the Antarctic Peninsula. This crab species is **native to** sub-Arctic northern waters and probably reached the Antarctic by traveling

as larvae or juveniles in ship ballast water. What's most surprising is that the crabs were able to survive and grow in the colder waters of the Antarctic.

23 Crabs run into serious difficulty at very low temperature. As in many other animals, their activity level is reduced in the cold, but in addition they face a peculiar physiological challenge. Crabs cannot cleanse their bloodstream of **magnesium**, which has a **narcotic effect**. The magnesium concentration is no greater in cold water, but the **narcosis** is more severe there because the animals are already slower-moving. Below a **threshold temperature**, the crabs are immobilized and die.

24 Warming trends along the peninsula are removing this physiological barrier. The specimens discovered at King George Island are not the only evidence. In 2007 a population of large, deep-water king crabs was discovered at a depth of 1,100 meters on the Antarctic continental slope. At these depths, the temperature is slightly higher than it is in shallow water, allowing the crabs to overcome the magnesium narcosis.

25 An invasion of crabs would present a significant threat to benthic invertebrates that lack defenses against crushing predators. And, as with the planktonic shelled pteropods, ocean acidification magnifies the risk. As absorbed CO_2 continues to lower the *p*H of seawater, benthic invertebrates whose larvae or adults rely on **calcified skeletal elements** may either be killed outright or, with weakened shells, become increasingly vulnerable to durophagous predators. Evidence from **temperate latitudes** indicates that larvae of such key **invertebrates** as oysters and sea urchins can suffer significant **decalcification-related mortality** when exposed to seawater with even modestly lowered *p*H. Chemical and physical properties of southern seawater are known to inhibit calcification, and so it seems likely that the **biota** of this region will be among the first to show the effects of global ocean acidification.

Displaced Penguins

26 The top predators of the Antarctic Peninsula—the seabirds and seals—are highly sensitive indicators of ecosystem change. Because they are long-lived and wide-ranging, their life histories integrate the effects of marine environmental variability over long periods and large areas. From a more practical point of view, these species are also good candidates for the role of canary in the coal mine because they are abundant and readily accessible. They breed on land (but feed at sea), and so it is comparatively easy to gather data on their reproductive success, their population, their diet and other aspects of their biology. In some sectors of Antarctica, databases on these predators now span seven decades, making them among the best-studied wild vertebrates on Earth. Importantly, the long time series allow investigators to distinguish genuine trends from mere ecosystem noise.

27 On the western Antarctic Peninsula, and specifically **in the vicinity of** Palmer Station, one such study has been going on for more than 30 years. The subjects of the study are three closely related species of penguins, the Adélie, the gentoo and the chinstrap, collectively known as the brush-tailed penguins because of their long, stiff tail feathers.

28 Although the three penguins are members of the same **genus**, they have quite different life histories and favor different habitats. Adélie penguins are a true Antarctic species, distributed all around the coast of the continent, though only in areas where sea ice can be relied on to last throughout the winter. Chinstrap and gentoo penguins, in contrast, tend to avoid areas with persistent sea ice; they evolved in sub-Antarctic habitats where conditions favor open water with only minimal sea ice. At Palmer Station, Adélies are in decline, whereas gentoos and chinstraps are growing more abundant.

29 Adélie penguins have always occupied territory near Palmer Station, but gentoos and chinstraps were unknown there until recent years. The first chinstrap colony was established in 1976, and gentoos arrived in 1994. Thus biologists from the station have been able to observe the entire history of these local populations. **Carbon-14 dating** of material **excavated from** local colonies reveals evidence of Adélie occupation going back 700 years, but no hint of the other two brush-tailed species. Thus it appears the environmental conditions promoting the local presence of gentoos and chinstraps are unprecedented in the period covered by this record.

30 Adélie penguin populations are decreasing throughout the mid- to northern Antarctic Peninsula, and there is wide concurrence that this regional trend is correlated with a gradual decrease in the availability of winter sea ice. However, the exact role played by sea ice in the ecology of the species has remained uncertain, primarily because few winter studies have been conducted. In a recent effort to address this gap in our understanding, the penguins' movements, distribution and **foraging** were monitored continuously for 24 months using **satellite telemetry**, at-sea **censuses** and extensive field collections of diet information.

31 A key finding of the study is that Adélie penguins find their prey in winter primarily at isolated "hot spots" where the **topography** of the sea floor creates upwellings of warmer water from the circumpolar current; the upwellings in turn promote congregations of krill and fish. The birds' access to these hotspots requires winter sea ice. Adélie penguins do not forage at night, and hence they cannot travel far to find food during the short days of the polar winter. Only by migrating over the sea ice can they stay close enough to their feeding grounds. As sea ice continues its long-term retreat in the waters of the western Antarctic Peninsula, Adélie penguins will lose access to the most productive winter foraging regions.

32 A second process implicated in the shrinking of Adélie populations is increasing snowfall over the Antarctic Peninsula. Although it may seem **counterintuitive** that a polar species would be adversely affected by snow, Antarctica is a polar desert with low average **precipitation**, and it is in this environment that Adélie penguins evolved. Snow has been increasing over the peninsula since at least the beginning of the 20th century. The loss of sea ice is one factor causing this change in weather patterns. Exposing open ocean to the atmosphere brings higher levels of evaporation and increasing cloud cover. Spring blizzards during the Adélie penguins' breeding season (November) have increased in frequency and severity. The storms kill large numbers of eggs and chicks when the snow eventually melts and floods the nests.

33 Some of the same factors that are negatively affecting Adélie penguins are helping chinstrap and gentoo penguins to prosper. Both of the latter species have maintained their sub-Antarctic breeding chronologies; by breeding approximately three weeks later than Adélie penguins, they reduce the risk of nest flooding in the aftermath of spring blizzards. In winter, both species forage successfully in ice-free areas. Chinstrap penguins accomplish this by migrating north beyond the sea-ice zone. Gentoo penguins winter at their summer breeding colonies, but they choose sites for these colonies close to areas where fast currents or an upwelling of warmer water ensure that sea ice does not persist.

Ice, Krill and Penguins

34 Much remains to be understood about the food web that **culminates with** penguins and other **avian and mammalian predator**s. Some two decades ago, the prevailing model for the dynamics of these populations was the "krill surplus hypothesis." According to this view, krill populations had long been held in check by baleen whales, but when those whales were nearly exterminated in the 20th century, krill were released from predation; the **ensuing surplus** led to significant population growth in other krill-dependent predators. This explanation no longer seems fully adequate. Although krill are indeed a key component of the food web and critical to the diets of many top predators, the surplus hypothesis cannot explain the population trends in brush-tailed penguins, for example. Because all three species have diets dominated by krill, a surplus would be expected to produce similar trends in all of them.

35 An analogous situation has been observed among seals. Like Adélie penguins, Weddell seals are ice-dependent, and their populations have **plummeted,** while the populations of ice-avoiding fur and elephant seals have increased significantly. Of the three species, only fur seals are krill-dependent. An obvious inference is that sea ice, rather than diet, is the dominant factor governing the animals' response to climate change.

36 In the years since the krill-surplus hypothesis was first put forward and then challenged by the ice-reduction hypothesis, we have learned that krill themselves are an ice-dependent species. Without sea ice, krill do not reproduce successfully because the larvae need to graze on phytoplankton on the underside of the ice to survive winter. Along the northern half of the western Antarctic Peninsula, and in much of the Atlantic sector of the Southern Ocean, there is no krill surplus; on the contrary, this area has experienced an 80 percent decrease in krill abundance over the past 30 years, attributed to loss of winter sea ice.

37 Theories of top-predator population dynamics are necessarily shifting to take into account changes in both krill abundance and winter ice cover. Sea ice is increasingly regarded as the variable that mediates food-web interactions. The extent of the ice has a direct impact on krill reproductive success and abundance. Then the presence or absence of ice determines which predators are best able to reach the prey populations. This double effect of sea ice may explain why some krill-dependent but ice-avoiding predators, such as gentoo penguins, have continued to increase even as krill abundance has decreased.

38 Our collective observations paint a picture of the Antarctic Peninsula as an environment undergoing unprecedented ecological shifts in response to climate change. We would not claim to fully understand all the mechanisms driving the patterns we have observed; we are acutely aware that much more research is needed. But we have learned enough to conclude that this unique ecosystem is **in peril**. We sound an urgent call to **mitigate** all the factors under human control that are contributing to global climate change.

Task 12: Note down the main points of each section in Text III.

Climatic Regime Change

1) The creation of Drake Passage contributes to the formation of the ACC.
2) The temperature increases in this region.
3) Sea ice will not form in most of the year, and the glaciers and ice shelves are in retreat.
4) All this may in turn cause the regional ecosystem change.

The Base of the Food Chain

1) The dominate phytoplankton, Diatoms, which are the preferred food for Antarctic krill, are being replaced by crytophytes.
2) The replacement of diatoms by cryptophytes will surely have observable effects on ____

____
3) Second, the replacement of krill by salps ______________________________

____

Forests of the Antarctic

1) As warming continues to erode the extent of ice, the undersea forests, ______
   ____
   ____
2) Because of more energy available for photosynthesis, it may prevent herbivores from consuming their tissues with chemical defenses.
3) The dynamics of the organisms supported by the algae could be fundamentally changed.
4) As for the benthic invertebrates, warming could ______________________
   ____
   ____
5) The warming trend makes the crabs survive and grow in the waters of the Antarctic. Therefore, ____
   ____
   ____
6) As absorbed CO_2 continues to lower the *p*H of seawater, benthic invertebrates whose larvae or adults rely on calcified skeletal elements may either be killed outright or, with weakened shells, _____________________
   ____

Displaced Penguins

1) The first reason to study penguins is that seabirds are long-lived and wide-ranging. Their life histories integrate the effects of marine environmental variability and allow the investigators to distinguish the genuine trends from mere ecosystem noise.
   Second, ____
   ____
   Third, ____
   ____
2) Adélie penguins are decreasing while _______________________________
   ____
3) Two reasons for the decline of Adélie penguins. First, as sea ice retreats continuously in the waters of the western Antarctic Peninsula, ____________
   ____
   Second, increasing precipitation in Antarctic Peninsular _________________
   ____
   ____
4) Chinstrap and gentoo penguins prosper because ______________________
   ____
   ____

Ice, Kril and Penguins

1) The krill surplus hypothesis: ____
   ____

____

2) Along the northern half of the western Antarctic Peninsula, and in much of the Atlantic sector of the Southern Ocean, there is no krill surplus; on the contrary, ____

____

3) The ice-reduction hypothesis: ____

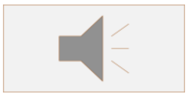
____

____

____

Therefore, *ice-reduction hypothesis* is confirmed. Sea ice is the dominant factor governing the animals' response to climate change.

Task 13: Use your notes to explain the effect of the warming temperature on the biological community in Antarctic Peninsula.



Task 14: Complete the following science report according to what you hear.

Climate change is real. Carbon dioxide from (1) ________________________ and clearing forests, among other human activities, is to blame. And more and more of that global warming pollution is being dumped (2) ___________________ each year.

So says the United Nations Intergovernmental Panel on Climate Change's new synthesis report released on November 2. The synthesis (3) __________________________________ thousands of pages of scientific knowledge (4) ________________________. That essence, however, has hardly changed since the last synthesis report in 2007.

What has changed is the (5) ________________________ in the atmosphere, which have now touched 400 parts per million. Pollution in the first decade of the 21st century grew (6) ________________________ it did in the last few decades of the 20th century. The resulting global warming (7) ________________________ ranging from rising sea levels that drown inhabited coasts to crop failures from (8) ________________________.

The IPCC has now offered a budget from how much pollution people can add to the atmosphere without too much climate change. (9) ________________________, humanity has already used more than half of that budget.

The world's nations are meeting in Lima this year in hopes of hammering out a global deal to combat climate change (10) ______________________ in Paris in 2015. The new report is a reminder to world leaders that the stakes, like the seas, are high.

Task 15: Answer the following questions according to the interview you hear about the link between climate change and ozone loss.

1) What are the consequences of ozone loss?

____

____

2) What did Jim Professor Anderson's newly published research show? Why does his research result raise concern?

____

____

3) How does the stormy summer weather account for the ozone destruction?

____

____

4) How is rising carbon dioxide level linked to the depletion of ozone layer?

- Climate change through rising carbon dioxide level
- CO_2→____
- →____
- → ____
- → the fundamental shift in _________________________________
- ____
- → depletion of ozone layer.

Task 16: Paul Olsen, the researcher of Columbia University's Lamont-Doherty Earth Observatory, takes us to a basalt quarry in New Jersey and explains what makes the rock ideal for soaking up carbon dioxide emissions. Watch the video clip and answer the following questions.

1) What do the scientists hypothesize about the basalt flows?

____

____

2) What is the process of CO_2 emissions and sequestration?

3) What have the experts found in the up-flow underneath?

4) Where is the best potential place to store the CO_2?

5) How much CO_2 could one spot of basalt flows in New Jersey hold?

Task 17: Answer the following questions according to what you hear.

1) Where is most of the world's forest located?

2) What is the size of untouched forests in the world?

3) Why are the world's forests under serious threat?

4) What are the two suggestions to protect the world's forests?

Task 18: A public-private partnership is teaching farmers better soil-management and how to adapt to climate change in order to safeguard their livelihoods. Watch the video clip "Climate-smart coffee farming in Uganda" and supply the missing information.

1) The conditions for the growth of the high quality African coffee beans in Mount Elgon in south-east Uganda:

____,

____, and

____.

2) Due to climate change and poor farming practices, their present potential yield of coffee here: ____.

3) The reasons for the increasing risk of landslides:

____,

____,

____.

4) To protect against the effects of climate change, farmers are trained to:

____

____.

Task 19: Answer the following questions based on David Keith's speech on global warming and climate change.

1) How fast is the growth rate of CO_2 in the atmosphere?

____

____

2) What could we do to cut CO_2 emission? What is the problem with it?

____

____

3) What might we do if we did not cut CO_2 emission?

____

____

4) Why is David Keith certain that the geo-engineering idea will work?

____

____

5) What are the problems with sulfates?

____

____

6) What is David Keith's new idea?

____

____

7) What does David Keith want to convey with the metaphor of the alien box?

____

____

Task 20: Note down the impacts of El Niño according to what you hear.

- ____
- ____
- ____
- ____

Task 21: Work in groups and discuss what technical, political, social and economic consequences would be resulted from the implementation of Keith's idea.

Unit 7

Automation

Objectives

- Identify The Hypothetical-The Real discourse pattern in text construction;
- Explain the gap the predicted and the actual social and economic consequences of automation;
- Find out different attitudes towards an automated society;
- Understand the problem of data preservation and comprehensibility in the digital age;
- Explain the benefits generated from information digitalization;
- Analyze the pros and cons of the application of farmerbots and agrobots;
- Predict the future life resulting from robotics development and automation;
- Discuss how to prepare for the challenges in an automated society;
- Note down the main points of the listening materials about the development of robotics and automation.

Task 1: Familiarize yourselves with the following new words, set expressions or lexical chunks to prepare for reading the texts in this unit.

affluence	富裕，富足
affluent	富裕的
algorithm	算法
amplitude of the audio signal	音频信号的振幅
analog and digital media	模拟媒体和数字媒体
analog compact cassette	袖珍模拟磁带
analog phonographic records	模拟唱片
archetypal example	典型例子
archivist	档案管理员
at the outset	在开始时
autonomous vehicle	无人驾驶汽车
awestruck reverence	敬畏之情
barcode	条形码
behoove us to understand	我们有必要了解
bumper harvest	丰收
circuit-switching machine	电路交换机
classical ballerina	古典芭蕾舞演员
clerical tasks, warehousing and even retailing	文书类工作、仓储业、甚至零售业工作
closed-loop control	闭环控制
combine harvester	联合收割机
computer-chip lithography	计算机芯片光刻

congressional hearing congressional hearings, blue-ribbon panels, newspaper editorials, think-tank studies, scholarly symposia	国会听证会、专门小组、报刊社论、智囊团的研究、学术讨论会
constant toil	长期辛苦的工作
contentious issue	有争议性的问题
contingent on	视……而定
continuous-process industries	流程工业
contraction of the workforce	劳动力缩减
cucumber harvester	黄瓜收获机
depopulated industrial landscape	工业界无人操作的景象
Dead Sea Scrolls	死海古卷（古代文献）
digital audio tape	数字录音带
disemployed trucker	下岗卡车司机
disgorge finished engine blocks	吐出发动机组件成品
disguised as tractors	乔装为拖拉机
dispense with	不需要，摒弃
distilling tower	蒸馏塔
dose a whole field with chemicals	把一剂化学制品喷洒在整块地上
draw the minuscule circuit patterns on silicon wafers	在硅晶片上画出极小的电路图
empower	授权，准许
emulator module	仿真器模块
entrust	委托，托付
etch	蚀刻（印记，图案）
extensive overhaul of the machinery	机器大检修
extrapolate	推算，推断
fault tolerance	故障容差
floppy disk	软盘
formulation	（想法或思想等的）系统阐述
geometrically arranged field	呈几何图形的农田
have rapport with computers in rapport with	与计算机保持和谐关系
high-precision satnav technique	高精度卫星导航技术
imminent	即将发生的，迫近的
implacably cheerful	持坚定不移的乐观态度
increase by a factor of between four and eight	增加 4–8 倍
infiltrate other areas of the economy	渗透到经济的其他方面
ink-jet printer	喷墨打印机
integrated circuit	集成电路
interface specification	接口规格
machine tool	机床

mainframe	大型计算机
mass aristocracy	大规模贵族
Matryoshka Dolls	俄罗斯套娃（民间工艺品）
microdot of pesticide	微量杀虫剂
millennia	几千年
millennium	一千年
momentous development	重大发展
monitor a gauge and adjust valve settings	监控仪表、调整阀门
nexus of control	控制中心
oil refining	炼油业
parchment and papyrus	羊皮纸和草片纸
parchment and vellum	羊皮纸和牛皮纸
pervasive	无处不在的，遍布的
phonographic record	唱片
photographic film	胶片
pilot testing	初步试验
postdoc	博士后
primary repository	主要存储方式
printed circuit board	印制电路板
proliferate	扩散
proprietary encoding scheme	专用的编码体系
prune into	修剪成为
pulse code modulation	脉冲编码调制
punch card	穿孔卡片
raisin industry	葡萄干行业
raw casting	粗铸件
recursion	递归
reduce porosity	降低孔隙率
redundancy	冗余
redundant	冗余的
reel-to-reel audio tape recorder	盘式录音机
refined pursuits	高雅追求
refinery	炼油厂
roam the streets	在街上闲逛
roller-coaster financial system	过山车似的金融体系
run assembly lines	运行生产线
seek equilibrium	寻求平衡
self-steering	自动驾驶的
sharp-eyed	目光敏锐的
show their mettle	大显身手
sobering	使人清醒的，令人冷静的
solder the connections one by one	一个一个焊接

specimen	实例，样品，标本
stand idly by	无所事事地站在一旁
strive to emulate	努力仿效
substitution of machines for labor	用机器代替人力
superfluous	过剩的，多余的
technophile	技术爱好者
the silver lining of the dark clouds	乌云中的一线光明
theoretical underpinning	理论基础
throw the dice	掷骰子
trickle-down effect	涓滴效应
twofold	两方面，有两部分的
upheaval	突然的巨变
upper bound	上限，最大值
venerable institution	有声望的机构，权威机构
wrenching experience	痛苦的经历

Task 2: Skim through Text I and match the subheadings on the left column with the types of information on the right.

Subheadings	The types of information
1) Opening Section	[A] A new social and economic calculus
2) The Problem of Leisure	[B] The author's prediction of automated future
3) Where Is My 15-Hour Workweek?	[C] Automation applications: starting from manufacturing
4) On the Factory Floor	[D] Different attitudes towards automation development
5) The Do-It-Yourself economy	[E] Explanations of no great workforce decline in the past 50 years
6) The Full-Employment Paradox	[F] Predicted social and economic consequences of automation
7) The Future of the Future	[G] Realistic impacts of automation

Text I

Automation on the Job[19]

Computers were supposed to be labor-saving devices. How come we're still working so hard?

Brian Hayes

1 Automation was a hot topic in the 1950s and '60s—a subject for **congressional hearings**, **blue-ribbon panels**, **newspaper editorials**,

think-tank studies, **scholarly symposia**, documentary films, World's Fair exhibits, even comic strips and protest songs. There was interest in the technology itself—everybody wanted to know about "the factory of the future"—but the editorials and white papers focused mainly on the social and economic consequences of automation. Nearly everyone agreed that people would be working less once computers and other kinds of automatic machinery became widespread. For optimists, this was a promise of liberation: At last humanity would be freed from **constant toil**, and we could all devote our days to more **refined pursuits**. But others saw a threat: Millions of people would be thrown out of work, and desperate masses would **roam the streets**.

2 Looking back from 50 years hence, the controversy over automation seems a quaint and curious episode. The dispute was never resolved; it just faded away. The factory of the future did indeed evolve; but at the same time the future evolved away from the factory, which is no longer such a central institution in the economic scheme of things, at least in the United States. As predicted, computers guide **machine tools** and **run assembly lines**, but that's a minor part of their role in society. The computer is far more **pervasive** in everyday life than even the boldest **technophiles** dared to dream back in the days of **punch cards** and **mainframes**.

3 As for economic consequences, worries about unemployment have certainly not gone away—not with job losses in the current recession approaching 2 million workers in the U.S. alone. But recent job losses are commonly attributed to causes other than automation, such as competition from overseas or a **roller-coaster financial system**. In any case, the vision of a world where machines do all the work and people **stand idly by** has simply not come to pass.

The Problem of Leisure

4 In 1930 the British economist John Maynard Keynes published a short essay titled "Economic Possibilities for Our Grandchildren." At the time, the economic possibilities looked pretty grim, but Keynes was **implacably cheerful**. By 2030, he predicted, average income would **increase by a factor of between four and eight**. This prosperity would be brought about by gains in productivity: Aided by new technology, workers would produce more with less effort.

5 Keynes did not mention *automation*—the word would not be introduced until some years later—but he did refer to *technological unemployment*, a term that goes back to Karl Marx. For Keynes, a drop in the demand for labor was a problem with an easy solution: Just work less. A 3-hour shift and a 15-hour workweek would become the norm for the grandchildren of the children of 1930, he said. This would be a **momentous development** in human history. After **millennia** of struggle, we would have finally solved

“the economic problem”: How to get enough to eat. The new challenge would be the problem of leisure: How to fill the idle hours.

6 Decades later, when automation became a **contentious issue**, there were other optimists. The conservative economist Yale Brozen wrote in 1963:

> Perhaps the gains of the automation revolution will carry us on from a mass democracy to a **mass aristocracy**.... The common man will become a university-educated world traveler with a summer place in the country, enjoying such leisure-time activities as sailing and concert going.

7 But others looked at the same prospect and saw a darker picture. Norbert Wiener had made important contributions to the theory of automatic control, but he was wary of its social implications. In *The Human Use of Human Beings* (1950) he wrote:

> Let us remember that the automatic machine... is the precise economic equivalent of slave labor. Any labor which competes with slave labor must accept the economic conditions of slave labor. It is perfectly clear that this will produce an unemployment situation, in comparison with which the present recession and even the depression of the thirties will seem a pleasant joke.

8 A. J. Hayes, a labor leader (and no relation to me), wrote in 1964:

> Automation is not just a new kind of mechanization but a revolutionary force capable of overturning our social order. Whereas mechanization made workers more efficient—and thus more valuable—automation threatens to make them **superfluous**—and thus without value.

9 Keynes’s “problem of leisure” is also mentioned with much anxiety throughout the literature of the automation era. In a 1962 pamphlet Donald N. Michael wrote:

> These people will work short hours, with much time for the pursuit of leisure activities.... Even with a college education, what will they do all their long lives, day after day, four-day weekend after weekend, vacation after vacation...?

10 The opinions I have cited here represent extreme positions, and there were also many milder views. But I think it’s fair to say that most early students of automation, including both critics and enthusiasts, believed the new technology would lead us into a world where people worked much less.

Where’s My 15-Hour Workweek?

11 Keynes’s forecast of growth in productivity and personal income seemed wildly optimistic in 1930, but in fact he underestimated. The **upper bound** of his prediction—an eightfold increase over 100 years—works out to an annual growth rate of 2.1 percent. So far, the observed average rate comes to

2.9 percent per year. If that rate is **extrapolated** to 2030, worldwide income will have increased by a factor of 17 in a century. (These calculations are reported by Fabrizio Zilibotti of the University of Zurich in a recent book reassessing Keynes's 1930 essay.)

12 Keynes's promise of **affluence** has already been more than fulfilled—at least for citizens of wealthier nations. It's a remarkable achievement, even if we have not yet truly and permanently "solved the economic problem." If Keynes was right about the accumulation of wealth, however, he missed the mark in predicting time spent on the job. By most estimates, the average workweek was about 60 hours in 1900, and it had fallen to about 50 hours when Keynes wrote in 1930. There was a further decline to roughly 40 hours per week in the 1950s and '60s, but since then the workweek has changed little, at least in the U.S. Western Europeans work fewer hours, but even there the trend doesn't look like we're headed for a 15-hour week anytime soon.

13 Other measures of how hard people are working tell a similar story. The total labor force in the U.S. has increased by a factor of 2.5 since 1950, growing substantially faster than the working-age population. Thus labor-force participation (the percentage of people who hold jobs, among all those who could in principle be working) has risen from 59 percent to 66 percent.

14 These trends contradict almost all the expectations of early writers on automation, both optimists and pessimists. So far, automation has neither liberated us from the need to work nor deprived us of the opportunity to work. Instead, we're working more than ever.

15 Economists reflecting on Keynes's essay suggest he erred in supposing that people would willingly trade income for leisure. Instead, the commentators say, people work overtime to buy the new wide-screen TV even if they then have no time to enjoy it. Perhaps so. I would merely add that many who are working long hours (**postdocs**, say, or parents of young children) do not see their behavior as a product of conscious choice. And they do not think society has "solved the economic problem."

On the Factory Floor

16 Perhaps the most thoughtful and knowledgeable of the early writers on automation was John Diebold, a consultant and author. It was Diebold who introduced the word *automation* in its broad, modern sense. He clearly understood that there was more to it than reducing labor costs in factories. He foresaw applications to many other kinds of work, including **clerical tasks, warehousing and even retailing**. Nevertheless, when he chose examples for detailed description, they almost always came from manufacturing.

17 Automatic control first took hold in **continuous-process industries** such as **oil refining**. A **closed-loop control** mechanism could regulate the temperature of a **distilling tower**, eliminating the need for a worker to **monitor a gauge and adjust valve settings**. As such instruments **proliferated**, a **refinery** became a **depopulated industrial landscape**. An entire plant could be run by a few technicians, huddled together in a glass-walled control room. This hands-off mode of operation became the model that other industries **strove to emulate**.

18 In the automation literature of the 1950s and ’60s, attention focuses mainly on manufacturing, and especially on the machining of metal. A celebrated example was the Ford Motor Company’s Cleveland Engine Plant No. 1, built in 1951, where a series of interconnected machines took in **raw castings** at one end and **disgorged finished engine blocks** at the other. The various tools within this complex performed several hundred boring and milling operations on each engine, with little manual intervention.

19 A drawback of the Ford approach to automation was inflexibility. Any change to the product would require an **extensive overhaul of the machinery**. But this problem was overcome with the introduction of programmable metalworking tools, which eventually became computer-controlled devices.

20 Other kinds of manufacturing also shifted to automated methods, although the result was not always exactly what had been expected. In the early years, it was easy to imagine a straightforward **substitution of machines for labor**: Shove aside a worker and install a machine in his or her place. The task to be performed would not change, only the agent performing it. The ultimate expression of this idea was the robot—a one-for-one replacement for the factory worker. But automation has seldom gone this way.

21 Consider the manufacture of electronic devices. **At the outset**, this was a labor-intensive process of placing components on a chassis, stringing wires between them and **soldering the connections one by one**. Attempts to build automatic equipment to perform the same operations proved impractical. Instead, the underlying technology was changed by introducing **printed circuit boards**, with all the connections laid out in advance. Eventually, machines were developed for automatically placing the parts on the boards and for soldering the connections all at once.

22 The further evolution of this process takes us to the **integrated circuit**, a technology that was automated from birth. The manufacture of microprocessor chips could not possibly be carried out as a handicraft business; no **sharp-eyed** artisan could **draw the minuscule circuit patterns on silicon wafers**. For many other businesses as well, manual methods are simply unthinkable. Google could not operate by hiring thousands of clerks to read Web pages and type out the answers to queries.

23 The automation of factories has gone very much according to the script written by Diebold and other early advocates. Computer control is all but universal. Whole sections of automobile assembly plants are now walled off to exclude all workers. A computer screen and a keyboard are the main interface to most factory equipment.

24 Meanwhile, though, manufacturing as a whole has become a smaller part of the U.S. economy—12 percent of gross domestic product in 2005, down from more than double that in the 1950s. And because of the very success of industrial automation, employment on production lines has fallen even faster than the share of GDP. Thus, for most Americans, the factory automation that was so much the focus of early commentary is all but invisible. Few of us ever get a chance to see it at work.

25 But automation and computer technology have **infiltrated other areas of the economy** and daily life—office work, logistics, commerce, finance, household tasks. When you look for the impact of computers on society, **barcodes** are probably more important than machine tools.

The Do-It-Yourself Economy

26 In the 1950s, digital computers were exotic, expensive, unapproachable and mysterious. It was far easier to see such a machine becoming the **nexus of control** in a vast industrial enterprise than to imagine the computer transformed into a household object, comparable to a telephone or a typewriter—or even a toy for the children to play with. Donald Michael wrote:

> Most of our citizens will be unable to understand the cybernated world in which they live.... There will be a small, almost separate, society of people in rapport with the advanced computers.... Those with the talent for the work probably will have to develop it from childhood and will be trained as intensively as the **classical ballerina**.

27 If this attitude of **awestruck reverence** had persisted, most of the computer's productive potential would have been wasted. Computers became powerful when they became ubiquitous and familiar appliances on every desk. These days, we are all expected to **have rapport with computers**.

28 The spread of automation outside of the factory has altered its social and economic impact in some curious ways. In many cases, the net effect of automation is not that machines are doing work that people used to do. Instead we've **dispensed with** the people who used to be paid to run the machines, and we've learned to run them ourselves. When you withdraw money from the bank via an ATM, buy an airline ticket online, ride an elevator or fill up the gas tank at a self-service pump, you are interacting directly with a machine to carry out a task that once required an employee.

29 The dial telephone is the **archetypal example**. My grandmother's telephone had no dial; she placed calls by asking a switchboard operator to make the connection. The dial (and the various other mechanisms that have since replaced it) **empowers** you to set up the communications channel without human assistance. Thus it's not quite accurate to say that the operator has been replaced by a machine. A version of the **circuit-switching machine** was there all along; the dial merely provided a convenient interface to it.

30 The process of making travel arrangements has been transformed in a similar way. It was once the custom to telephone a travel agent, who would search an airline database for a suitable flight with seats available. Through the Web, most of us now access that database directly; we even print our own boarding passes. Again, what has happened here is not exactly the substitution of machines for people; it is a matter of putting the customer in control of the machines.

31 Other Internet technologies are taking this process one more dizzy step forward. Because many Web sites have published **interface specifications**, I now have the option of writing a program to access them. Having already removed the travel agent, I can now automate myself out of the loop as well.

The Full-Employment Paradox

32 Enabling people to place their own phone calls and make their own travel reservations has put whole categories of jobs on the brink of extinction. U.S. telephone companies once employed more than 250,000 telephone operators; the number remaining is a tenth of that, and falling fast. It's the same story for gas-station attendants, elevator operators and dozens of other occupations. And yet we have not seen the great **contraction of the workforce** that seemed inevitable 50 years ago.

33 One oft-heard explanation holds that automation brings a net increase in employment by creating jobs for people who design, build and maintain machines. A strong version of this thesis is scarcely plausible. It implies that the total labor requirement per unit of output is higher in the automated process than in the manual one; if that were the case, it would be hard to see the economic incentive for adopting automation. A weaker but likelier version concedes that labor per unit of output declines under automation, but total output increases enough to compensate. Even for this weaker prediction, however, there is no guarantee of such a rosy outcome. The relation may well be supported by historical evidence, but it has no **theoretical underpinning** in economic principles.

34 For a theoretical analysis we can turn to Herbert A. Simon, who was both an economist and a computer scientist and would thus seem to be the ideal analyst. In a 1965 essay, Simon noted that economies **seek equilibrium**, and so "both men and machines can be fully employed regardless of their

relative productivity." It's just a matter of adjusting the worker's wage until it balances the cost of machinery. Of course there's no guarantee that the equilibrium wage will be above the subsistence level. But Simon then offered a more complex argument showing that any increase in productivity, whatever the underlying cause, should increase wages as well as the return on capital investment. Do these two results add up to perpetual full employment at a living wage in an automated world? I don't believe they offer any such guarantee, but perhaps the calculations are reassuring nonetheless.

35 Another kind of economic equilibrium also offers a measure of cheer. The premise is that whatever you earn, you eventually spend. (Or else your heirs spend it for you.) If technological progress makes some commodity cheaper, then the money that used to go to that product will have to be spent on something else. The flow of funds toward the alternative sectors will drive up prices there and create new economic opportunities. This mode of reasoning offers an answer to questions such as, "Why has health care become so expensive in recent years?" The answer is: Because everything else has gotten so cheap.

36 I can't say that any of these **formulations** puts my mind at ease. On the other hand, I do have faith in the resilience of people and societies. The demographic history of agriculture offers a precedent that is both **sobering** and reassuring. It's not too much of an exaggeration to say that before 1800 everyone in North America was a farmer, and now no one is. In other words, productivity gains in agriculture put an entire population out of work. This was a **wrenching experience** for those forced to leave the farm, but the fact remains that they survived and found other ways of life. The occupational shifts caused by computers and automation cannot possibly match the magnitude of that great **upheaval**.

The Future of the Future

37 What comes next in the march of progress? Have we reached the end point in the evolution of computerized society?

38 Since I have poked fun at the predictions of an earlier generation, it's only fair that I put some of my own silly notions on the record, giving some future pundit a chance to mock me in turn. I think the main folly of my predecessors was not being **reckless** enough. I'll probably make the same mistake myself. So here are three insufficiently outrageous predictions.

(1) We'll automate medicine. I don't mean robot surgeons, although they're in the works too. What I have in mind is Internet-enabled, do-it-yourself diagnostics. Google is already the primary-care physician for many of us; that role can be expanded in various directions. Furthermore, as

mentioned above, medical care is where the money is going, and so that's where investment in cost-saving technologies has the most leverage.

(2) We'll automate driving. The car that drives itself is a perennial on lists of future marvels, mentioned by a number of the automation prophets of the 50s and 60s. A fully **autonomous vehicle**, able to navigate ordinary streets and roads, is not much closer now than it was then, but a combination of smarter cars and smarter roads could be made to work. Building those roads would require a major infrastructure project, which might help make up for all the **disemployed truckers** and taxi drivers. I admit to a certain boyish fascination with the idea of a car that drops me at the office and then goes to fetch the dry cleaning and fill up its own gas tank.

(3) We'll automate warfare. I take no pleasure in this one, but I see no escaping it either. The most horrific weapons of the 20th century had the redeeming quality that they are difficult and expensive to build, and this has limited their proliferation. When it comes to the most fashionable weapons of the present day—pilotless aircraft, cruise missiles, precision-guided munitions—the key technology is available on the shelf at Radio Shack.

39 What about trades closer to my own vital interests? Will science be automated? Technology already has a central role in many areas of research; for example, genome sequences could not be read by traditional lab-bench methods. Replacing the scientist will presumably be a little harder than replacing the lab technician, but when a machine exhibits enough curiosity and tenacity, I think we'll just have to welcome it as a companion in zealous research.

40 And if the scientist is elbowed aside by an automation, then surely the science writer can't hold out either. I'm ready for my 15-hour workweek.

Task 3: Read the opening section of Text I and identify the issues to be discussed in the main part of the article.

The hypothetical (In the 1950s and 1960s)	**The real** (At present)
Computers were supposed to be labor-saving devices.	We're still working so hard.
Optimists: ______________________	As predicted, ______________________

____________________ ____________________ ____________________ Pessimists: ____________________ ____________________ ____________________ ____________________	____________________ ____________________ ____________________ As predicted, ____________________ ____________________ ____________________ ____________________

Task 4: Summarize the hypotheses of different authors and the contrasting realities based on the information in "The Problem of Leisure" and "Where's My 15-Hour Workweek" sections regarding the issue of automation on the job.

The hypothetical		**The real**
J. M. Keynes	____________________ ____________________ ____________________ ____________________	____________________ ____________________ ____________________ ____________________
Y. Brozen	____________________ ____________________ ____________________ ____________________	____________________ ____________________ ____________________ ____________________
N. Wiener	____________________ ____________________ ____________________ ____________________	____________________ ____________________ ____________________ ____________________
A. J. Hayes	____________________ ____________________ ____________________	____________________ ____________________ ____________________

	______________________	______________________
D. N. Michael	______________________ ______________________ ______________________ ______________________	______________________ ______________________ ______________________ ______________________

Task 5: Compare automation in the past and automation at present based on the information in the "On the Factory Floor" section. Explain the rhetorical strategies used in this section.

Automation (In the 1950s and 1960s)	**Automation** (At present)
In manufacturing	**In all areas of life**
▪ Reducing labor costs in factories. ▪ Helping with clerical tasks, warehousing and retailing. ▪ Control in continuous-process industries such as oil refining. ▪ Using various tools to perform several hundred boring and milling operations.	______________________ ______________________ ______________________ ______________________ ______________________ ______________________ ______________________

Rhetorical strategies: ____

Task 6: Answer the following questions based on "The Do-It-Yourself Economy" section which discusses new economic trends with automation development.

1) What did Donald Michael hypothesize about the spread of computers? What is the reality now?

____

____

2) What is the social and economic impact of the spread of automation outside of factory?

3) What examples are provided to explain the social and economic impact of automation?

Task 7: Read the "The Full-Employment Paradox" section and answer the following questions.

1) What does the full-employment paradox refer to?

2) How is this paradox often explained?

3) How did Herbert A. Simon explain this paradox?

4) What is the third explanation of the full-employment paradox?

5) What example does the author use to explain that people are able adapt to change?

Task 8: Write an essay to explain whether each of the author's three predictions is likely to become a reality in the near future. Explain what technological advances are necessary for them to become a reality.

Task 9: Read Text II and answer the following questions.

1) What does the Digital Dark Age refer to?

2) What are the two challenges in digital data preservation?

3) What sources can we refer to in our efforts to preserve digital data?

4) What historical trends and advances in data representation are mentioned? What are the strengths and weaknesses of each type of information-storage medium?

5) What dispute is uncovered through the whirlwind tour of historical advances in data preservation?

6) In what aspects does analog data coding differ from digital data encoding?

7) What example is cited to demonstrate the problem of comprehensibility in digital data preservation? What approaches could be taken to solve such a problem?

8) According to the text, how can we make good data-representation choices?

9) What approach can we take if data could not be accessible with modern hardware and software? What examples does the author cite to illustrate his point?

10) According to the text, what can we do to save our personal digital data?

Text II

Avoiding the Digital Dark Age[20]

Data longevity depends on both the storage medium and the ability to decipher the information.

Kurt D. Bollacker

1 When I was a boy, I discovered a magnetic **reel-to-reel audio tape recorder** that my father had used to create “audio letters” to my mother while he was serving in the Vietnam War. To my delight (and his horror), I could listen to many of the old tapes he had made a decade before. Even better, I could make recordings myself and listen to them. However, all of my father’s tapes were decaying to some degree. It was clear that these tapes would not last forever, so I copied a few of them to new cassette tapes. While playing back the cassettes, I noticed that some of the sound quality was lost in the copying process. I wondered how many times I could make a copy before there was nothing left but a murky hiss.

2 A decade later in the 1980s I was in high school making backups of the hard drive of my PC onto 5-¼-inch **floppy disks**. I thought that because digital copies were “perfect,” and I could make perfect copies of perfect copies, I couldn’t lose my data, except by accident. I continued to believe that until years later in college, when I tried to restore my backup of 70 floppy disks onto a new PC. To my dismay, I discovered that I had lost the floppy disk containing the backup program itself, and thus could not restore my data. Some investigation revealed that the company that made the software had long since gone out of business. Requests on electronic bulletin board systems and searches on *Usenet* turned up nothing useful. Although all of the data on them may have survived, my disks were useless because of the **proprietary encoding scheme** used by my backup program.

3 The **Dead Sea scrolls**, made out of still-readable **parchment and papyrus**, are believed to have been created more than 2,000 years ago. Yet my barely 10-year-old digital floppy disks were essentially lost. I was furious! How had the shiny new world of digital data, which I had been taught was so superior to the old “analog” world, failed me? I wondered: Had I had simply misplaced my faith, or was I missing something?

4 Over the course of the 20th century and into the 21st, an increasing proportion of the information we create and use has been in the form of digital data. Many (most?) of us have given up writing messages on paper, instead adopting electronic formats, and have exchanged film-based photographic cameras for digital ones. Will those precious family

photographs and letters—that is, email messages—created today survive for future generations, or will they suffer a sad fate like my backup floppy disks? It seems unavoidable that most of the data in our future will be digital, so it **behooves us to understand** how to manage and preserve digital data so we can avoid what some have called the "digital dark age." This is the idea—or fear!—that if we cannot learn to explicitly save our digital data, we will lose that data and, with it, the record that future generations might use to remember and understand us.

Save Our Bits!

5 The general problem of data preservation is **twofold**. The first matter is preservation of the data itself: The physical media on which data are written must be preserved, and this media must continue to accurately hold the data that are **entrusted** to it. This problem is the same for **analog and digital media**, but unless we are careful, digital media can be more fragile.

6 The second part of the equation is the comprehensibility of the data. Even if the storage medium survives perfectly, it will be of no use unless we can read and understand the data on it. With most analog technologies such as photographic prints and paper text documents, one can look directly at the medium to access the information. With all digital media, a machine and software are required to read and translate the data into a human-observable and comprehensible form. If the machine or software is lost, the data are likely to be unavailable or, effectively, lost as well.

Preservation

7 Unlike the many **venerable institutions** that have for centuries refined their techniques for preserving analog data on clay, stone, ceramic or paper, we have no corresponding reservoir of historical wisdom to teach us how to save our digital data. That does not mean there is nothing to learn from the past, only that we must work a little harder to find it. We can start by briefly looking at the historical trends and advances in data representation in human history. We can also turn to nature for a few important lessons.

8 The earliest known human records are millennia-old physical scrapings on whatever hard materials were available. This medium was often stone, dried clay, bone, bamboo strips or even tortoise shells. These substances were very durable—indeed, some **specimens** have survived for more than 5,000 years. However, stone tablets were heavy and bulky, and thus not very practical.

9 Possibly the first big advance in data representation was the invention of papyrus in Egypt about 5,500 years ago. Paper was lighter and easier to make, and it took up considerably less space. It worked so well that paper and its variants, such as **parchment and vellum**, served as the **primary repositories** for most of the world's information until the advent of the technological revolution of the 20th century.

10 Technology brought us **photographic film**, **analog phonographic records**, magnetic tapes and disks, optical recording, and a myriad of exotic, experimental and often short-lived data media. These technologies were able to represent data for which paper cannot easily be used (video, for example). The successful ones were also usually smaller, faster, cheaper and easier to use for their intended applications. In the last half of the 20th century, a large part of this advancement included a transition from analog to digital representations of data.

11 Even a brief investigation into a small sampling of information-storage media technologies throughout history quickly uncovers much dispute regarding how long a single piece of each type of media might survive. Such uncertainty cannot be settled without a time machine, but we can make reasonable guesses based on several sources of varying reliability. If we look at the time of invention, the estimated lifespan of a single piece of each type of media and the encoding method (analog or digital) for each type of data storage, we can see that new media types tend to have shorter lifespans than older ones, and digital types have shorter lifespans than analog ones. Why are these new media types less durable? Shouldn't technology be getting better rather than worse? This mystery clamors for a little investigation.

12 To better understand the nature of and differences between analog and digital data encoding, let us use the example of magnetic tape, because it is one of the oldest media that has been used in both analog and digital domains. First, let's look at the relationship between information density and data-loss risk. A standard 90-minute **analog compact cassette** is 0.00381 meters wide by about 129 meters long, and a typical **digital audio tape** (DAT) is 0.004 meters wide by 60 meters long. For audio encodings of similar quality (such as 16 bit, 44.1 kilohertz for digital, or 47.6 millimeters per second for analog), the DAT can record 500 minutes of stereo audio data per square meter of recordable surface, whereas the analog cassette can record 184 minutes per square meter. This means the DAT holds data about 2.7 times more densely than the cassette. Furthermore, disk technologies tend to hold data more densely than tapes, so it is no surprise that magnetic tape has all but disappeared from the consumer marketplace.

13 However, enhanced recording density is a double-edged sword. Assume that for each medium a square millimeter of surface is completely corrupted. Common sense tells us that media that hold more data in this square millimeter would experience more actual data loss; thus for a given amount of lost physical medium, more data will be lost from digital formats. There is a way to design digital encoding with a lower data density so as to avoid this problem, but it is not often used. Why? Cost and efficiency: It is usually cheaper to store data on digital media because of the increased density.

14 A possibly more important difference between digital and analog media comes from the intrinsic techniques that comprise their data representations. Analog is simply that—a physical analog of the data recorded. In the case of analog audio recordings on tape, the **amplitude of the audio signal** is represented as an amplitude in the magnetization of a point on the tape. If the tape is damaged, we hear a distortion, or "noise," in the signal as it is played back. In general, the worse the damage, the worse the noise, but it is a smooth transition known as *graceful degradation.* This is a common property of a system that exhibits ***fault tolerance***, so that partial failure of a system does not mean total failure.

15 Unlike in the analog world, digital data representations do not inherently degrade gracefully, because digital encoding methods represent data as a string of binary digits ("bits"). In all digital symbol number systems, some digits are worth more than others. A common digital encoding mechanism, **pulse code modulation** (PCM), represents the total amplitude value of an audio signal as a binary number, so damage to a random bit causes an unpredictable amount of actual damage to the signal.

16 But digital media are supposed to be better, so what's wrong here? The answer is that analog data-encoding techniques are intrinsically more robust in cases of media damage than are naive digital-encoding schemes because of their inherent **redundancy**—there's more to them, because they're continuous signals. That does not mean digital encodings are worse; rather, it's just that we have to do more work to build a better system. Luckily, that is not too hard. A very common way to do this is to use a binary-number representation that does not mind if a few bits are missing or broken.

17 Nature can also serve as a guide to the preservation of digital data. The digital data represented in the DNA of living creatures is copied into descendents, with only very rare errors when they reproduce. Bad copies (with destructive mutations) do not tend to survive. Similarly, we can copy digital data from medium to medium with very little or no error over a large number of generations. We can use easy and effective techniques to see whether a copy has errors, and if so, we can make another copy. For instance, a common error-catching program is called a *checksum function*: The **algorithm** breaks the data into binary numbers of arbitrary length and then adds them in some fashion to create a total, which can be compared to the total in the copied data. If the totals don't match, there was likely an accidental error in copying. Error-free copying is not possible with analog data: Each generation of copies is worse than the one before, as I learned from my father's reel-to-reel audiotapes.

18 Because any single piece of digital media tends to have a relatively short lifetime, we will have to make copies far more often than has been historically required of analog media. Like species in nature, a copy of data

that is more easily "reproduced" before it dies makes the data more likely to survive. This notion of *data promiscuousness* is helpful in thinking about preserving our own data. As an example, compare storage on a typical PC hard drive to that of a magnetic tape. Typically, hard drives are installed in a PC and used frequently until they die or are replaced. Tapes are usually written to only a few times (often as a backup, ironically) and then placed on a shelf. If a hard drive starts to fail, the user is likely to notice and can quickly make a copy. If a tape on a shelf starts to die, there is no easy way for the user to know, so very often the data on the tape perishes silently, likely to the future disappointment of the user.

Comprehensibility

19 In the 1960s, NASA launched *Lunar Orbiter 1*, which took breathtaking, famous photographs of the Earth juxtaposed with the Moon. In their rush to get astronauts to the Moon, NASA engineers created a mountain of magnetic tapes containing these important digital images and other space-mission-related data. However, only a specific, rare model of tape drive made for the U.S. military could read these tapes, and at the time (the 1970s to 1980s), NASA had no interest in keeping even one compatible drive in good repair. A heroic NASA **archivist** kept several donated broken tape drives in her garage for two decades until she was able to gain enough public interest to find experts to repair the drives and help her recover these images.

20 The example demonstrates digital data preservation's other challenge—comprehensibility. In order to survive, digital data must be understandable by both the machine reading them and the software interpreting them. Luckily, the short lifetime of digital media has forced us to gain some experience in solving this problem—**the silver lining of the dark clouds** of a potential digital dark age. There are at least two effective approaches: choosing data representation technologies wisely and creating mechanisms to reach backward in time from the future.

Make Good Choices …

21 In order to make sure digital data can be understood in the future, ideally we should choose representations for our data for which compatible hardware and software are likely to survive as well. Like species in nature, digital formats that are able to adapt to new environments and threats will tend to survive. Nature cannot predict the future, but the mechanism of mutation creates different species with different traits, and the fittest prevail.

22 Because we also can't predict the future to know the best data-representation choices, we try to do as nature does. We can copy our digital data into as many different media, formats and encodings as possible and hope that some survive.

23 Another way to make good choices is to simply follow the pack. A famous example comes from the 1970s, when two competing standards for home video recording existed: Betamax and VHS. Although Betamax, by many technical measures, was a superior standard and was introduced first, the companies supporting VHS had better business and marketing strategies and eventually won the standards war. Betamax mostly fell into disuse by the late 1980s; VHS survived until the mid-2000s. Thus if a format or media standard is in more common use, it may be a better choice than one that is rare.

… Or Fake It!

24 Once we've **thrown the dice** on our data-representation choices, is there anything else we can do? We can hope we will not be stuck for decades, like our NASA archivist, or left with a perfectly readable but incomprehensible disk. But what if our scattershot strategy of data representation fails, and we can't read or understand our data with modern hardware and software? A very common approach is to fake it!

25 If we have old digital media for which no compatible hardware still exists, modern devices sometimes can be substituted. For example, cheap and ubiquitous optical scanners have been commonly used to read old 80-column IBM punchcards. This output solves half of the problem, leaving us with the task of finding hardware to run the software and interpret the data that we are again able to read.

26 In the late 1950s IBM introduced the IBM 709 computer as a replacement for the older model IBM 704. The many technical improvements in the 709 made it unable to directly run software written for the 704. Because customers did not want either to lose their investment in the old software or to forgo new technological advances, IBM sold what they called an ***emulator*** **module** for the 709, which allowed it to pretend to be a 704 for the purposes of running the old software. Emulation is now a common technique used to run old software on new hardware. It does, however, have a problem of **recursion**—what happens when there is no longer compatible hardware to run the emulator itself? Emulators can by layered like **Matryoshka dolls**, one running inside another running inside another.

Being Practical

27 Given all of this varied advice, what can we do to save our personal digital data? First and foremost, make regular backup copies onto easily copied media (such as hard drives) and place these copies in different locations. Try reading documents, photos and other media whenever upgrading software or hardware, and convert them to new formats as needed. Lastly, if possible, print out highly important items and store them safely—there seems to be no getting away from occasionally reverting to this "outdated" media type.

None of these steps will guarantee the data’s survival, but not taking them almost guarantees that the data will be lost, sooner or later. This process does seem to involve a lot more effort than my grandparents went to when shoving photos into a shoebox in the attic decades ago, but perhaps this is one of the costs for the miracles of our digital age.

28 If all this seems like too much work, there is one last possibility. We could revert our digital data back to an analog form and use traditional media-preservation techniques. An extreme example of this is demonstrated by the Rosetta Project, a scholarly endeavor to preserve parallel texts of all of the world’s written languages. The project has created a metal disk on which miniaturized versions of more than 13,000 pages of text and images have been **etched** using techniques similar to **computer-chip lithography**. It is expected that this disk could last up to 2,000 years because, physically, the disk has more in common with a stone tablet than a modern hard drive. Although this approach should work for some important data, it is much more expensive to use in the short term than almost any practical digital solution and is less capable in some cases (for example, it’s not good for audio or video). Perhaps it is better thought of as a cautionary example of what our future might look like if we are not able to make the digital world in which we find ourselves remain successful over time.

Task 10: Identify the purpose of the article in Text III and find out the prospective applications of farmerbots and agribots. Work in groups and discuss the social, economic and environmental impacts of widespread application of farmerbots and agribots.

The purpose: ____

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The prospective applications of farmerbots and agribots:

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Text III

Farmerbots: A New Industrial Revolution [21]

Can robots do better than farmers by feeding the planet's rising population while helping to protect the environment?

James Mitchell Crow

1 Next time you stand at the supermarket checkout, spare a thought for the farmers who helped fill your shopping basket. They are finding life hard right now, and you can be sure this will mean higher food prices for you, and tougher times for the millions in the world for whom food shortages are a matter of life and death. Worse, studies suggest that the world will need twice as much food by 2050. Yet while farmers must squeeze more out of the land, they must also reduce their impact on the environment. All this means rethinking how agriculture is practised, and taking automation to a whole new level.

2 On the new model farms, precision will be key. Why **dose a whole field with chemicals** if you can spray only where they are needed? Each plant could get exactly the right amount of everything, no more or less, an approach that could slash chemical use and improve yields in one move. But this is easier said than done; the largest farms in Europe and the US can cover thousands of hectares. And that is why automation is key to precision farming. Specifically, say agricultural engineers, precision farming needs robot farmers.

3 Soon, we might see fields with agribots that can identify individual seedlings and coax them along with tailored drops of fertiliser and measured sips of water. Other machines would distinguish weeds and dispatch them with a **microdot of pesticide**, a burst from a flame gun or a shot from a high-power laser. These machines will also be able to identify and harvest all kinds of ripe vegetables.

4 Robots could bring major changes, too, in jobs and how we work, in the soil and its quality, and in how much energy, and thus carbon, goes into farming. They could reduce pollution and water use. The most visible change, though, for ordinary people, could be in how farmland looks. Crops could be planted in small, **geometrically arranged fields**, while fruit farms are filled with arrays of two-dimensional trees. Robofarmers might even influence the type of fruit and vegetables that reach our shelves.

5 More than a century of mechanisation has already turned farming into an industrial-scale activity in much of the world, with farms that grow cereals being among the most heavily automated. But a variety of other crops, including oranges and tomatoes that are destined for processed foods, are picked mechanically. On thousands of dairy farms cows are now milked by robots. These and other products arrive at your local store untouched by human hands.

6 Yet the next wave of autonomous farm machinery is already hard at work. You have probably seen it and not even noticed, for these robots are **disguised as tractors**. Many of today's tractors are **self-steering**, use GPS to

cross a field, and can even "talk" to their implements—a plough or sprayer, for example. And the implements can talk back. "A mechanical weeding tool will tell the tractor 'you are going too fast', or 'move to the left'," says Simon Blackmore, who researches agricultural technology at Harper Adams University College in Shropshire, UK. Such systems are becoming the norm, he says.

7 Farm vehicles are also beginning to talk to each other. A John Deere system on sale this year allows a **combine harvester**, say, to call over a tractor-trailer so the driver can unload the grain. German firm Fendt has created paired tractors, one driven manually with the second self-steering and mimicking the first tractor's movements in an adjacent row. The system can effectively halve the time a farmer spends in the field—and this is just the start.

8 However, when fully autonomous systems take to the field, they will look nothing like tractors. With their enormous size and weight, today's farm machines have significant downsides: they compact the soil, **reducing porosity** and killing beneficial life, meaning crops don't grow so well. Compaction also increases erosion by rainwater run-off. "Why do we plough? Mainly to repair the damage that we have caused with big tractors," says Blackmore. "Up to 80 per cent of the energy going into cultivation is there to repair this damage. Surely there is an opportunity to do things in different ways."

9 Fleets of lightweight autonomous robots have the potential to solve this problem, Blackmore believes. Replacing brute force with precision is key, he says. "A seed only needs one cubic centimetre of soil to grow—if we cultivate just that we only put tiny amounts of energy in and the plants still grow nicely."

10 These lightweight robots could remove the need for ploughing altogether, significantly reducing the amount of energy, and thus carbon dioxide emissions, coming from farming. And with less compaction, the soil keeps its structure and beneficial organisms, and is able to absorb more water and stay fertile for longer.

11 Autonomous robots with these kinds of abilities are already **showing their mettle** in field trials. These agribots need to have three key abilities: to navigate, to interpret the scene in front of them, and to be able to help the farmer, by blasting a weed, applying a chemical or harvesting the crop.

12 Navigation systems are the simplest part of the equation, particularly with the emergence of a **high-precision satnav technique** called RTK-GPS, which enables machines to locate themselves to within 2 centimetres. Arno Ruckelshausen from the University of Applied Sciences in Osnabrück, Germany, is developing this for a modular robot farmer called Boni Rob.

This four-wheeled field rover uses spectral imaging cameras to pick out green plants against brown soil. It then records the location of individual plants and repeatedly returns to each one during the season to monitor its growth.

Laser weed gun

13 Eliminating weeds is a particularly desirable aim, since they reduce yields in some crops by more than 50 per cent. So next, Ruckelshausen intends to fit this robot with a precision spraying system—based on an **ink-jet printer**—that can apply microdots of herbicide to the leaves of weeds. He calculates this could cut chemical use by up to 80 per cent. Even taking into account the initial investment in the robot, this would end up being cheaper than conventional weeding, Blackmore calculates. There are obvious benefits for biodiversity, too, by minimising the number of plants that are killed by herbicides. What's more, applying herbicide isn't the only way robots could kill weeds: prototypes have wielded flame guns and lasers to burn weeds, something that would be very useful for organic farming.

14 Similar savings are possible with fertiliser: field trials have shown that by using sensors to assess an individual wheat plant's nitrogen levels, a robot can tailor the amount of fertiliser it gives and reduce the overall amount used by more than 80 per cent, with no loss in yield. The decrease in fertiliser use, combined with reduced water run-off from less compacted soil could mean healthier rivers and waterways. Not to mention the fact that industrial production of fertiliser is a huge contributor to carbon emissions.

15 The next challenge is how to distinguish weed from crop. Researchers are developing machine vision systems that use the shape of the leaves to distinguish between, say, weeds and sugar cane. Progress is slow, though, says Salah Sukkarieh, a robotics researcher at the Australian Centre for Field Robotics in Sydney, because of a lack of funding. "If I had the money for agricultural robots that I have from mining and defence projects, I'd solve it. But there's just not enough money in farming. We have to learn from other industries, it's a **trickle-down effect**," he says. Still, machine vision should be ready in around three years, he predicts.

16 Blackmore, too, sees no technological reason why agricultural robots can't go commercial. Tests of robots with machine vision such as the Danish HortiBot have shown they can identify weeds in a field and spray them with precise amounts of pesticide. Other tests have shown that robotic irrigation systems can cut water use by up to half. "It's just a question of finding the investment. The technologies have all been developed," he says.

17 In Japan, the government has taken the matter into its own hands. The country currently grows 40 per cent of its own food, making it more reliant on imports than any other nation, but the government aims to increase this to

50 per cent within the next decade. And with an ageing population shrinking the pool of potential farm workers, the country is turning to robots.

18 Noboru Noguchi at Hokkaido University is leading a five-year, $8 million project funded by Japan's Ministry of Agriculture, Forestry and Fisheries to bring agribots to market. The project aims to automate everything from planting through to harvest, and will focus on Japan's three staple crops: rice, wheat and soya beans. By 2014, the team plans to be **pilot testing** its agribots on farms. "Five years from now, we want to be selling them," Noguchi says.

19 One big concern for Noguchi is the risk that a robot might hit hikers or stray cattle. So he is working with German engineering company Bosch to develop robots equipped with lasers and ultrasonic sensors that monitor their surroundings and jam on the brakes if a collision is **imminent**. As a back-up, touch-sensitive bumpers stop the robot should it strike anything.

20 After Japan, the next places to feel the pinch of farm labour shortage—and where robot farmers are likely to appear the soonest—are North America and western Europe. And it is a similar story in rapidly developing nations such as China. "Work in agriculture is not interesting, prestigious or usually very well paid. It is physically demanding and dirty—people prefer to go to the cities and work in factories or in office jobs," says Eldert van Henten, a robotics researcher at Wageningen University in the Netherlands. "While the population is growing and needs to be fed, a rapidly shrinking number of people are willing to work in agriculture."

21 Linda Calvin, an economist at the US Department of Agriculture, and Philip Martin at the University of California, Davis, have studied trends in mechanisation to predict how US farms might fare as the labour force shrinks. So far, migrant workers mainly from Mexico have kept the numbers high, but the flow of immigrants is slowing and many in the US are returning home. The US Department of Labor's National Agricultural Workers Survey has interviewed more than 50,000 farm workers during the past 25 years. More than half of respondents to recent surveys were illegal immigrants, yet even amongst this group, where legal status, education and language act as barriers to other employment, most give up farm work after less than a decade for less physically demanding jobs.

22 Rising employment costs have driven the adoption of labour-saving farm technology in the past, Calvin and Martin say, citing the **raisin industry** as an example. In 2000, a **bumper harvest** crashed prices and, with profits squeezed, farmers looked for savings. With labour one of their biggest costs—42 per cent of production expenses on US farms, on average—they started using a mechanical harvester adapted from a machine used by wine makers. By 2007, almost half of California's raisins were mechanically harvested and a labour force once numbering 50,000 had shrunk to 30,000.

23 Agribots may not be good news for labourers who depend on the land for their living, but what about farmers themselves? While studies suggest that robotic milking makes little impact on overall profits, the machines save dairy farmers the chore of daily milking. But calculations by Blackmore suggest that agribots could bring significant financial benefit, reducing weeding costs by about 20 per cent per hectare in cereal or sugar beet fields. Gains should be larger for organic farmers since labour makes up more than 50 per cent of their total costs. A study of organic farming in Denmark suggests agribots could halve the cost of weeding, once machinery and maintenance costs are taken into account.

Bot-friendly farm

24 Josh Stride from the UK's Soil Association—which backs organic farming—is excited by the prospect of technology that can reduce chemical use. But, he warns, we also need to appreciate the risks. "The introduction of any new technology should be **contingent on** its ability to provide demonstrable benefits."

25 Can agribots reduce the price of groceries, say? Perhaps, says Blackmore. So many forces control the price of food, from the weather to supermarket price wars, that it is hard to tell whether automation will make fruit and veg any cheaper in the long run, he says. Yet making farming less energy-intensive should give us a chance to keep prices down.

26 However, the widespread adoption of agribots might bring other changes at the supermarket. Lewis Holloway, who studies agriculture at the University of Hull, UK, says that robotic milking is likely to influence the genetics of dairy herds as farmers opt for "robot-friendly" cows, with udder shape, and even attitudes, suited to automated milking. Similarly, he says, it is conceivable that agribots could influence what fruit or vegetable varieties get to the shops, since farmers may prefer to grow those with, say, leaf shapes that are easier for their robots to discriminate from weeds.

27 Almost inevitably, these machines will eventually alter the landscape, too. The real tipping point for robot agriculture will come when farms are being designed with agribots in mind, says Sukkarieh. This could mean a return to smaller fields, with crops planted in grids rather than rows and fruit trees **pruned into** two-dimensional shapes to make harvesting easier. This alien, geometrical farms tended by robots is still a while away, says Sukkarieh, "but it will happen."

28 Van Henten agrees. "When we started on robotics in the mid-90s, growers were laughing and sceptical," he recalls. "But when we demonstrated a **cucumber harvester**, they asked if they could buy it tomorrow."

Task 11: Listen to a short talk about the development of new technology and write down every word you hear.

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Task 12: Note down the main points of the interview you hear.

1) The title of Andrew McAfee's new book: ________________________

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2) The readers' response to the new book: ________________________

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3) The difference between the technological change now and the technological upheavals in the past:

   In the past, ____

   ____

   ____

   But now ____

   ____

   ____

4) The classical bargain: ______________________________________

   ____

5) Cognitive labor refers to____________________________________

6) The nature of a doctor's work: ____________________________________

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7) Part of a doctor's work can be replaced by software because ____________

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8) Part of a lawyer's work can be automated because ____________________

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9) E-discovery refers to ____

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Task 13: Listen to an interview about the challenges in the new technological age and note down what the experts think of job security. Then work in groups and discuss how to address the challenges.

1) What challenges do young people have to face?

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2) Is there such a thing as job security in today's world?

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3) What attitude should we take toward education and careers according to experts?

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4) What should parents and schools do to prepare students for challenges?

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Task 14: Answer the following questions based on the video clip about robots.

1) What task is the robot performing at the beginning of the video clip?

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2) What toughest jobs were robots supposed to do until now?

3) How does Professor James Kuffner describe the traditional tasks for a robot?

4) What attitude does Professor James Kuffner take towards humanoid technologies?

5) What does Asimo look like?

6) What will Asimo be able to do for us?

7) What learning ability will the robots be able to acquire in the future?

8) What is projected to happen in the next 20 years?

Task 15: Watch the video clip about artificial intelligence and answer the following questions.

1) According to Ray Kurzweil, what probably will happen within 30 years?

2) What features does the exoskeleton have?

3) What does Professor Larry Yaeger think of artificial intelligence? What does he want to prove in his experiment "Polyworld?"

4) According to Professor Larry Yaeger, what can be expected by the year 2035?

Task 16: Answer the following questions based on the video you watch about robotics and data protection.

1) What features is Robert Wood's tiny robot expected to have?

2) What does Robert Wood have to learn first?

3) What are the practical reasons for making the robotic flies small?

4) What tasks might these devices undertake presumably?

5) According to Eran Feigenbaum, what is the future of data protection and what concept is it?

6) What does "cloud" refer to?

7) Why is moving data to the cloud very similar to banking?

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8) What results will be brought to us with this revolutionized way of data protection?

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Task 17: Watch the video clip about future transportation and answer the following questions.

1) What is the future of flight to Dan Hanchette?

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2) What can the next generation of personal jets do?

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3) In what ways does a corporate jet differ from a Viper Fanjet?

- ____
- ____
- ____

4) What system is Boeing developing?

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5) What does the Boeing system depend on? What automation technology will be embedded in future aircraft?

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6) According to Graham Hawkes, what will the future transportation be like?

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7) What are the features of Frank Rinderknecht's latest concept car sQuba?

8) In the diving mode, how does the sQuba car further distinguish itself?

Task 18: Answer the following questions based on the video about future transported presence and telepresence.

1) What does transported presence mean?

2) What map is Google Earth trying to build? How does Google Earth build such a map?

3) What is Margaret Hoosgmand's typical workday like?

4) What is telepresence and what benefits could it generate?

5) What can we learn about healthcare in the future?

Task 19: Work in groups and discuss the following questions.

1) Why are people still too busy in spite of automation?
2) Is technology making life more simple or more complicated?
3) How would you like working flexible hours? Does working flexible hours actually lead to working extra hours?