



SCIENCE CONCEPTS SCIENCE ITEMS

The *Science Concepts and Science Items* section contains two science assessment units and eight questions related to these units. These are the released items from the 2000 assessment (they are distinct from the secure items, which are kept confidential so that they may be used in subsequent cycles to monitor trends). In addition, an excerpt from the science curriculum framework is included at the back of this volume.

Turn the page for instructions and an illustrative example.

A large, stylized number "5.3" in a teal color, positioned in the bottom right corner of the page. It is surrounded by faint, overlapping circular and curved lines in various colors (blue, yellow, teal) that create a sense of motion or orbit.

Guide to the Content and Layout of This Section

A **unit** is made up of

- stimulus material, and
- questions relating to this material.

Semmelweis is the name given to the first unit you will see. The four questions that follow ask questions about the Semmelweis stimulus material—for example, *Suppose you were Semmelweis. Give a reason...*

Process and concept descriptors appear directly under the question heading:

- **Process** identifies the class of scientific processes required. For *Semmelweis* Question 1, the process is *Critically evaluating scientific evidence/data*; and
- **Content** refers to the broad scientific category. For *Semmelweis* Question 1, the content is *Science in life and health (Human Biology)*.

Each unit may use as many as three different **question-and-response formats**. All three formats are described below.

- **Multiple-choice response formats** ask the student to choose among several alternatives. For *Semmelweis*, Question 2 is a multiple-choice item.
- **Short-answer response formats** ask the student to write down a short answer to the question. For *Semmelweis*, Question 1 asks for a short-answer response.
- **Extended-response formats** ask the student to write a somewhat extended answer to the question. In the unit *Ozone*, Question 1 asks for an extended response.

Scoring of student responses takes two forms:

- **Correct/incorrect**—some items are simply scored as correct/incorrect. In the *Semmelweis* example, Question 3 is scored this way.
- **Correct/partly correct/incorrect**—the scoring for some items allows partial credit for the response in addition to full credit and no credit. In the *Ozone* example, Question 1 is scored this way.

Scoring guides are provided for each question. In this kit, only the general instructions are provided. Illustrative examples present in the original version of the scoring guide have been deleted in the interest of conserving space. The full version of these scoring guides can be found in the Organization for Economic Cooperation and Development (OECD) publication *Sample Tasks from the PISA 2000 Assessment* (see the publications guide in the *Readme First* book).

International benchmarks are provided next to each question. These consist of statistics on the percentage of students in each country who answered the question correctly. The countries are ordered in terms of this percentage. The OECD average is included as well. This display also indicates which countries scored significantly higher, significantly lower and no differently from this OECD average.

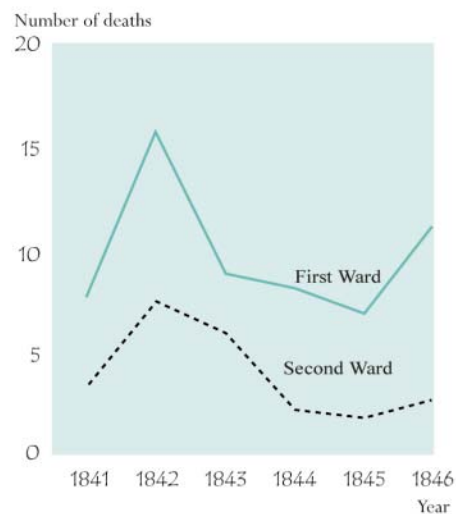
SCIENTIFIC UNIT 1

Semmelweis

Semmelweis' diary text 1

'July 1846. Next week I will take up a position as "Herr Doktor" at the First Ward of the maternity clinic of the Vienna General Hospital. I was frightened when I heard about the percentage of patients who die in this clinic. This month not less than 36 of the 208 mothers died there, all from puerperal fever. Giving birth to a child is as dangerous as first-degree pneumonia.'

Number of deaths per 100 deliveries from puerperal fever



These lines from the diary of Ignaz Semmelweis (1818-1865) illustrate the devastating effects of puerperal fever, a contagious disease that killed many women after childbirth. Semmelweis collected data about the number of deaths from puerperal fever in both the First and the Second Wards (see diagram).

Physicians, among them Semmelweis, were completely in the dark about the cause of puerperal fever. Semmelweis' diary again:

'December 1846. Why do so many women die from this fever after giving birth without any problems? For centuries science has told us that it is an invisible epidemic that kills mothers. Causes may be changes in the air or some extraterrestrial influence or a movement of the earth itself, an earthquake.'

Nowadays not many people would consider extraterrestrial influence or an earthquake as possible causes of fever. We now know it has to do with hygienic conditions. But in the time Semmelweis lived, many people, even scientists, did! However, Semmelweis knew that it was unlikely that fever could be caused by extraterrestrial influence or an earthquake. He pointed at the data he collected (see diagram) and used this to try to persuade his colleagues.

This task requires students to relate the data given as evidence in order to:

- evaluate different perspectives.
- relate data systematically to possible conclusions using a chain of reasoning that is not given to the students.

Question 1: SEMMELWEIS' DIARY

Process: Critically evaluating scientific evidence/data

Concept: Science in life and health (Human biology)

Suppose you were Semmelweis. Give a reason (based on the data Semmelweis collected) why puerperal fever is unlikely to be caused by earthquakes.

Scoring – Question 1: SEMMELWEIS' DIARY

Fully

- Correct:** 1. Answers which refer to the difference between the number of deaths (per 100 deliveries) in both wards.

Partially

- Correct:** 1. Answers which refer to the fact that earthquakes don't occur frequently.
 2. Answers which refer to the fact that earthquakes also influence people outside the wards.
 3. Answers which refer to the thought that when earthquakes occur, men don't get puerperal fever.

- Incorrect:** 1. Answers which state (only) that earthquakes cannot cause the fever.
 2. Answers which state (only) that the fever must have another cause (right or wrong).
 3. Answers which are combinations of the two incorrect answers above.

Overall Percent Correct

Japan	58	▲
Korea, Republic of	48	▲
France	45	▲
Belgium	37	▲
Hungary	35	○
Denmark	35	○
Poland	34	○
Norway	34	○
United Kingdom	33	○
New Zealand	32	○
Finland	32	○
Sweden	31	○
OECD average	30	
Spain	30	○
Iceland	29	○
Canada	28	○
Germany	28	○
Czech Republic	27	○
Italy	27	○
Portugal	27	○
Ireland	26	○
Australia	26	○
Russian Federation	23	▼
Austria	22	▼
Switzerland	21	▼
Latvia	21	▼
United States	20	▼
Luxembourg	19	▼
Liechtenstein	16	○
Greece	16	▼
Brazil	8	▼
Mexico	7	▼

Country average vs. OECD average:	
Higher	▲
Not different	○
Lower	▼

The OECD average is the average of 27 of the 32 national averages. Brazil, Latvia, Liechtenstein, and the Russian Federation are not OECD countries. The Netherlands is omitted for technical reasons.

This task asks students to refer to given data or information and to draw conclusions.

Semmelweis' diary text 2

Part of the research in the hospital was dissection. The body of a deceased person was cut open to find a cause of death. Semmelweis recorded that the students working on the First Ward usually took part in dissections on women who died the previous day, before they examined women who had just given birth. They did not pay much attention to cleaning themselves after the dissections. Some were even proud of the fact that you could tell by their smell that they had been working in the mortuary, as this showed how industrious they were!

One of Semmelweis' friends died after having cut himself during such a dissection. Dissection of his body showed he had the same symptoms as mothers who died from puerperal fever. This gave Semmelweis a new idea.

Question 2: SEMMELWEIS' DIARY

Process: Recognizing questions

Concept: Science in life and health (Human biology)

Semmelweis' new idea had to do with the high percentage of women dying in the maternity wards and the students' behavior.

What was this idea?

- A Having students clean themselves after dissections should lead to a decrease of puerperal fever.
- B Students should not take part in dissections because they may cut themselves.
- C Students smell because they do not clean themselves after a dissection.
- D Students want to show that they are industrious, which makes them careless when they examine the women.

Scoring – Question 2: SEMMELWEIS' DIARY

Correct: Answer A – having students clean themselves after dissections should lead to a decrease of puerperal fever.

Incorrect: Other answers.

Overall Percent Correct

Korea, Republic of	84	▲
Austria	79	▲
Finland	79	▲
Sweden	77	▲
New Zealand	76	▲
Canada	76	▲
Denmark	75	▲
Liechtenstein	75	○
Japan	74	○
Germany	74	○
United Kingdom	74	▲
Ireland	73	○
Australia	73	○
Norway	73	○
Poland	73	○
France	73	○
Switzerland	71	○
United States	70	○
OECD average	70	
Hungary	68	○
Spain	67	○
Iceland	67	○
Czech Republic	66	○
Belgium	65	▼
Italy	63	▼
Luxembourg	62	▼
Russian Federation	59	▼
Latvia	57	▼
Greece	51	▼
Portugal	48	▼
Brazil	47	▼
Mexico	41	▼

Country average vs.

OECD average:

Higher	▲
Not different	○
Lower	▼

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This task requires students to apply the common scientific knowledge that heat kills bacteria in order to describe why this procedure is effective.

Question 3: SEMMELWEIS' DIARY

Process: Apply scientific knowledge in situation presented

Concept: Science in life and health (Human biology)

Semmelweis succeeded in his attempts to reduce the number of deaths due to puerperal fever. But puerperal fever even today remains a disease that is difficult to eliminate.

Fevers that are difficult to cure are still a problem in hospitals. Many routine measures serve to control this problem. Among those measures are washing sheets at high temperatures.

Explain why high temperature (while washing sheets) helps to reduce the risk that patients will contract a fever.

Scoring – Question 3: SEMMELWEIS' DIARY

- Correct:**
1. Answers which refer to *killing* of bacteria.
 2. Answers which refer to *killing* of micro-organisms, germs or viruses.
 3. Answers which refer to the *removal* (not killing) of bacteria.
 4. Answers which refer to the *removal* (not killing) of micro-organisms, germs or viruses.
 5. Answers which refer to sterilization of the sheets.

- Incorrect:**
1. Answers which refer to killing of disease.
 2. Other incorrect answers.

Overall Percent Correct		
Japan	94	▲
Finland	92	▲
Italy	91	▲
Greece	90	▲
Korea, Republic of	89	▲
Hungary	88	▲
Russian Federation	88	▲
Sweden	88	▲
Norway	88	▲
Poland	87	○
France	87	▲
Austria	85	○
Spain	84	○
Denmark	84	○
Latvia	83	○
United Kingdom	83	○
New Zealand	83	○
OECD average	83	
Australia	83	○
Canada	82	○
Iceland	81	○
Germany	81	○
Ireland	80	○
Switzerland	79	○
Czech Republic	78	○
Belgium	78	▼
Portugal	77	▼
Luxembourg	75	▼
United States	73	▼
Brazil	65	▼
Mexico	54	▼

Country average vs. OECD average:	
Higher	▲
Not different	○
Lower	▼

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This task asks students to go beyond the historical example to asking for the common scientific knowledge needed to provide an explanation for a scientific phenomenon. It asks students to use scientific concepts (as opposed to scientific knowledge) to create explanations.

Question 4: SEMMELWEIS' DIARY

Process: Apply scientific knowledge to situation presented

Concept: Science in life and health (Biodiversity)

Many diseases may be cured by using antibiotics. However, the success of some antibiotics against puerperal fever has diminished in recent years.

What is the reason for this?

- A Once produced, antibiotics gradually lose their activity.
- B Bacteria become resistant to antibiotics.
- C These antibiotics only help against puerperal fever, but not against other diseases.
- D The need for these antibiotics has been reduced because public health conditions have improved considerably in recent years.

Scoring – Question 4: SEMMELWEIS' DIARY

Correct: Answer B – bacteria become resistant to antibiotics.

Incorrect: Other answers.

Overall Percent Correct		
Finland	82	▲
Denmark	79	▲
Switzerland	76	▲
Iceland	76	▲
Liechtenstein	75	0
Japan	74	▲
Austria	74	▲
Poland	74	▲
Hungary	73	▲
Norway	72	▲
Germany	72	▲
France	70	▲
New Zealand	70	○
Korea, Republic of	69	○
Czech Republic	68	○
Australia	68	○
Sweden	66	○
OECD average	66	
Canada	66	○
Belgium	63	○
United States	62	○
Netherlands	61	○
Luxembourg	61	○
United Kingdom	60	▼
Italy	59	▼
Spain	54	▼
Ireland	54	▼
Latvia	53	▼
Greece	52	▼
Portugal	51	▼
Russian Federation	47	▼
Brazil	43	▼
Mexico	33	▼

Country average vs. OECD average:	
Higher	▲
Not different	○
Lower	▼

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SCIENTIFIC UNIT 2

Ozone

Read the following section of an article about the ozone layer.

The atmosphere is an ocean of air and a precious natural resource for sustaining life on the Earth. Unfortunately, human activities based on national/personal interests are causing harm to this common resource, notably by depleting the fragile ozone layer, which acts as a protective shield for life on the Earth.

- 5 Ozone molecules consist of three oxygen atoms, as opposed to oxygen molecules which consist of two oxygen atoms. Ozone molecules are exceedingly rare: fewer than ten in every million molecules of air. However, for nearly a billion years, their presence in the atmosphere has played a vital role in safeguarding life on Earth. Depending on where it is located, ozone can either protect or harm life on Earth. The ozone in the troposphere (up to 10 kilometers above the
- 10 Earth's surface) is "bad" ozone which can damage lung tissues and plants. But about 90 percent of ozone found in the stratosphere (between 10 and 40 kilometers above the Earth's surface) is "good" ozone which plays a beneficial role by absorbing dangerous ultraviolet (UV-B) radiation from the Sun.

- Without this beneficial ozone layer, humans would be more susceptible to certain diseases due
- 15 to the increased incidence of ultra-violet rays from the Sun. In the last decades the amount of ozone has decreased. In 1974 it was hypothesized that chlorofluorocarbons (CFCs) could be a cause for this. Until 1987, scientific assessment of the cause-effect relationship was not convincing enough to implicate CFCs. However, in September 1987, diplomats from around the world met in Montreal (Canada) and agreed to set sharp limits to the use of CFCs.

Source: Connect, UNESCO International Science, Technology & Environmental Education Newsletter, section from an article entitled "The Chemistry of Atmospheric policy", Vol., XXII No. 2, 1997 (spelling adapted).

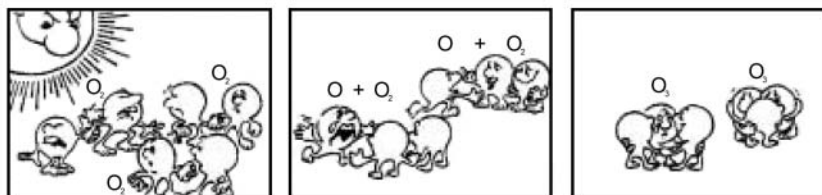
Students are shown a comic strip showing three stages as oxygen molecules are split under the influence of the sun and recombine into ozone molecules. This task requires students to interpret the comic strip and communicate it to a person with limited scientific knowledge. To gain full credit, students need to describe what is happening in at least two of the three stages of the comic strip with a fair level of precision and detail. To gain partial credit, students need to communicate a simple scientific description.

Question 1: OZONE

Process: Communicating to others valid conclusions from evidence/data

Concept: Science in Earth and environment (chemical and physical changes)

In the text above nothing is mentioned about the way ozone is formed in the atmosphere. In fact each day some ozone is formed and some other ozone disappears. The way ozone is formed is illustrated in the following comic strip.



Source: Deilig er den Himme, Temahefte 1, Institute for Physics, University of Oslo, August 1997.

Suppose you have an uncle who tries to understand the meaning of this strip. However, he did not get any science education at school and he doesn't understand what the author of the strip is explaining. He knows that there are no little fellows in the atmosphere but he wonders what those little fellows in the strip stand for, what those strange notations O, O₂ and O₃ mean and which processes the strip represents. He asks you to explain the strip. Assume that your uncle knows:

- that O is the symbol for oxygen;
- what atoms and molecules are.

Write an explanation of the comic strip for your uncle. In your explanation, use the words **atoms** and **molecules** in the way they are used in lines 5 and 6.

Overall Percent Correct

Liechtenstein	50	○
Japan	44	▲
Switzerland	43	▲
Hungary	42	▲
France	39	▲
Poland	39	○
Russian Federation	38	▲
Latvia	38	○
Belgium	36	▲
Austria	36	▲
Norway	35	○
Greece	34	○
Czech Republic	34	○
Australia	32	○
Sweden	31	○
Italy	30	○
Denmark	30	○
Canada	30	○

OECD average	29	
Spain	29	○
United Kingdom	29	○
Germany	28	○
Finland	25	○
New Zealand	24	○
Ireland	22	▼
Portugal	21	▼
Luxembourg	20	▼
Korea, Republic of	18	▼
Iceland	16	▼
United States	16	▼
Brazil	13	▼
Mexico	12	▼

Country average vs. OECD average:

Higher	▲
Not different	○
Lower	▼

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Scoring – Question 1: OZONE

Fully

Correct: Answers which mention the following three aspects:

1. an oxygen molecule or some oxygen molecules (each consisting of two oxygen atoms) are split into oxygen atoms (picture 1).
2. the splitting (of oxygen molecules) takes place under the influence of sunlight (picture 1).
3. the oxygen atoms combine with other oxygen molecules to form ozone molecules (pictures 2 and 3).

Partially

- Correct:**
1. Answers which correctly mention only the first and second aspects.
 2. Answers which correctly mention only the first and third aspects.
 3. Answers which correctly mention only the second and third aspects.
 4. Answers which correctly mention only the first aspect.
 5. Answers which correctly mention only the second aspect.
 6. Answers which correctly mention only the third aspect.

Incorrect: Answers which do not correctly mention any of the three aspects.

This task requires students to link part of the text to their own experience of weather conditions (thunderstorms occurring relatively close to Earth), to draw a conclusion about the nature of the ozone produced ('good' or 'bad'). The task requires students to draw an inference, going beyond information stated.

Question 2: OZONE

Process: Critically evaluating scientific evidence/data

Concept: Science in Earth and environment (Earth/Space)

Ozone is also formed during thunderstorms. It causes the typical smell after such a storm. In lines 10-12 the author of the text distinguishes between “bad ozone” and “good ozone”.

In terms of the article, is the ozone that is formed during thunderstorms “bad ozone” or “good ozone”?

Choose the answer and the explanation that is supported by the text.

	Bad ozone or good ozone?	Explanation
A	Bad	It is formed during bad weather.
B	Bad	It is formed in the troposphere.
C	Good	It is formed in the stratosphere.
D	Good	It smells good.

Scoring – Question 2: OZONE

Correct: Answer B – bad. It is formed in the troposphere.

Incorrect: Other answers.

Overall Percent Correct

Japan	65	▲
Korea, Republic of	59	▲
Sweden	58	○
Austria	57	○
Italy	56	○
Belgium	56	○
Germany	56	○
Poland	55	○
Hungary	55	○
Czech Republic	55	○
Liechtenstein	54	○
France	54	○
Iceland	54	○
Spain	53	○
Norway	53	○
Australia	53	○
New Zealand	53	○
Ireland	53	○
OECD average	53	
Canada	52	○
Luxembourg	51	○
United Kingdom	50	○
Switzerland	50	○
Denmark	49	○
Portugal	46	○
Finland	46	○
United States	45	○
Latvia	44	○
Greece	44	▼
Russian Federation	40	▼
Brazil	39	▼
Mexico	36	▼

Country average vs.

OECD average:

Higher	▲
Not different	○
Lower	▼

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This task requires students to demonstrate specific knowledge of a possible consequence for human health (specifically skin cancer) of the depletion of the ozone layer.

Question 3: OZONE

Process: Applying scientific knowledge in situation presented

Concept: Science in life and health (physiological change)

Lines 14 and 15 state: “Without this beneficial ozone layer, humans would be more susceptible to certain diseases due to the increased incidence of ultra-violet rays from the Sun.”

Name one of these specific diseases.

Scoring – Question 3: OZONE

Correct: Answers which refer to skin cancer.

Incorrect: Answers which refer to other specific types of cancer or which only refer to cancer.

Overall Percent Correct

Japan	81	▲
Korea, Republic of	81	▲
Spain	78	▲
Switzerland	70	▲
Canada	70	▲
Brazil	70	○
Hungary	69	▲
New Zealand	69	▲
Finland	68	▲
Austria	67	○
France	65	○
Australia	65	○
Portugal	65	○
United States	63	○
Iceland	63	○
OECD average	63	
Greece	62	○
Liechtenstein	62	○
United Kingdom	60	○
Germany	60	○
Ireland	60	○
Czech Republic	58	○
Luxembourg	57	○
Norway	54	▼
Belgium	53	▼
Poland	52	▼
Denmark	51	▼
Sweden	50	▼
Italy	48	▼
Latvia	44	▼
Russian Federation	43	▼
Mexico	42	▼

Country average vs.

OECD average:

Higher	▲
Not different	○
Lower	▼

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This task requires students to recognize questions that can be answered by scientific investigation by emphasizing the international significance of scientific research in helping to solve environmental problems.

Question 4: OZONE

Process: Recognizing questions

Concept: Science in Earth and environment (Earth/Space)

At the end of the text, an international meeting in Montreal is mentioned. At that meeting lots of questions in relation to the possible depletion of the ozone layer were discussed. Two of those questions are given in the table below.

Which of the questions below can be answered by scientific research?

Circle Yes or No for each.

Question:	Answerable by scientific research?
Should the scientific uncertainties about the influence of CFCs on the ozone layer be a reason for governments to take no action?	Yes / No
What would the concentration of CFCs be in the atmosphere in the year 2002 if the release of CFCs into the atmosphere takes place at the same rate as it does now?	Yes / No

Scoring – Question 4: OZONE

Correct: Answers which indicate *No* and *Yes*, in that order.

Incorrect: Other responses.

Overall Percent Correct		
Italy	68	▲
Switzerland	68	▲
United Kingdom	67	▲
Ireland	66	▲
France	66	▲
Korea, Republic of	64	○
United States	64	○
Canada	64	▲
Austria	63	○
New Zealand	62	○
Germany	61	○
Australia	61	○
Belgium	60	○
Spain	60	○
OECD average	59	
Hungary	58	○
Japan	58	○
Sweden	58	○
Liechtenstein	58	○
Czech Republic	57	○
Mexico	57	○
Norway	56	○
Finland	56	○
Poland	56	○
Denmark	56	○
Iceland	54	○
Latvia	52	▼
Greece	51	▼
Luxembourg	51	▼
Russian Federation	49	▼
Brazil	46	▼
Portugal	37	▼

Country average vs. OECD average:	
Higher	▲
Not different	○
Lower	▼

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Basic Definitions from the Science Curriculum Framework

(Excerpt from Sample Tasks from the PISA 2000 Assessment of Reading, Mathematical, and Scientific Literacy-OECD, 2002)

The items contained in this package are sample tasks from the PISA 2000 assessment of mathematical literacy. PISA (Program for International Student Assessment) is a collaborative effort by members of the Organisation for Economic Co-operation and Development (OECD) to measure how well young adults at age 15, therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies. The assessment is forward looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than on the extent to which they have mastered a specific school curriculum.

PISA brings together mathematics expertise from the participating countries, steered jointly by their governments on the basis of shared, policy-driven interests. Experts from participating countries serve on working groups that are charged with linking the PISA policy objectives with the best available substantive and technical expertise in the field of international comparative assessment of educational outcomes. Through participating in these expert groups, countries ensure that the PISA assessment instruments are internationally valid and take into account the cultural and curricular contexts of OECD member countries, that they provide a realistic basis for measurement, and that they place an emphasis on authenticity and educational validity. The frameworks and assessment instruments for PISA 2000 are the product of a multi-year development process and were adopted by OECD countries in December 1999. The conceptual framework of PISA [described in its entirety in *Measuring Student Knowledge and Skills: A New Framework for Assessment* (OECD, 1999) - contained elsewhere in this package] is based on the content students need to acquire, processes that need to be performed, and the contexts in which knowledge and skills are applied.

The assessments are based on, and the items classified by, the following definitions of literacy:

Scientific Literacy - *The capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the external world and the changes made to it through human activity.*

The PISA scientific assessment framework is constructed of the following dimensions:

A.Processes: The mental processes that are involved in addressing a question or issue:

1. Recognizing scientifically investigable questions
2. Identifying evidence needed in a scientific investigation
3. Drawing or evaluating conclusions
4. Communicating valid conclusions
5. Demonstrating understanding of Scientific concepts

B. Content or scientific knowledge and conceptual understanding that are required in using these processes:

1. Structure and properties of matter
2. Atmospheric change
3. Chemical and physical changes
4. Energy transformations
5. Forces and movement
6. Form and function
7. Human biology
8. Physiological change
9. Biodiversity
10. Genetic control
11. Ecosystems
12. The Earth and its place in the universe
13. Geological change

C. Situations: A scientific situation is defined here as a real-world phenomenon in which science can be applied. The areas of applications of science have been grouped under three broad headings.

1. Science in life and health - health, disease and nutrition; maintenance and sustainable use of species; interdependence of physical and biological systems
2. Science in Earth and environment: Pollution; production and loss of soil; weather and climate
3. Science in technology: Biotechnology; use of materials and waste disposal; use of energy; transportation

Item Index

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