NATIONAL SENIOR CERTIFICATE EXAMINATION
NOVEMBER 2015

LIFE SCIENCES: PAPER II

Time: 2 hours 100 marks

PLEASE READ THE FOLLOWING INSTRUCTIONS CAREFULLY

1. This question paper consists of 14 pages. Please check that your question paper is complete.
2. All questions must be answered in the Answer Book provided.
3. This Paper comprises 2 sections. Section A consists of Question 1 and Question 2, which are case studies. Section B consists of Question 3, which is an essay.
4. Read the questions carefully.
5. Read the sources provided for the case studies and use the information and your own knowledge to answer Question 1 and 2.
6. Source material is also provided for the essay. Use this information and your own knowledge to first plan and then write your response.
7. Number the answers exactly as the questions are numbered.
8. Use the total number of marks that can be awarded for each part of the questions in Questions 1 and 2 as an indication of the detail required.
9. It is in your own interest to write legibly and to present your work neatly.

SECTION A

QUESTION 1

1.1 Read the following information about the production of potatoes, an important crop plant worldwide.

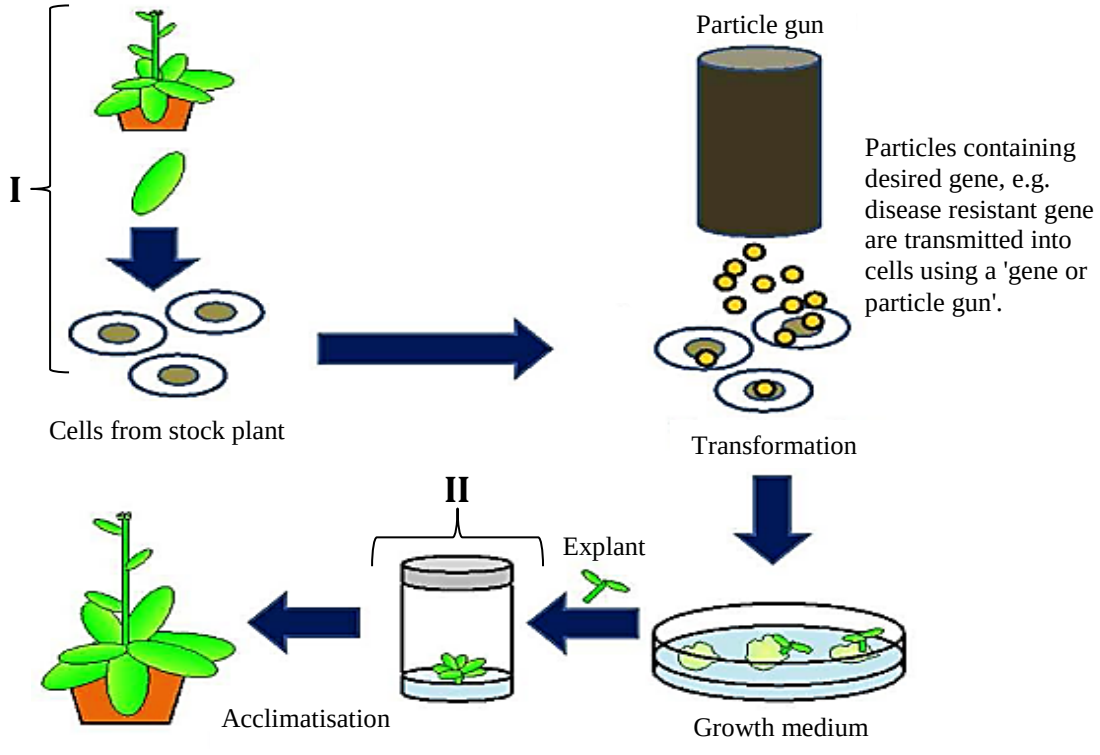
Micropropagation is the tissue culture technique used for rapid vegetative multiplication of plants by using small-sized explants (tiny plants grown from the stock plant). Because of the minute size of the explants in the culture, the propagation technique is named as *micropropagation*. This method of tissue culture produces many plants. Each of these plants will be genetically identical to the original plant from where they were grown.

The micropropagation technique has been used for potatoes as it provides an opportunity to produce virus-free plants. Potatoes are an important crop worldwide and rank fourth in the world in terms of agricultural production, behind cereals, rice and wheat. The popularity of potatoes is increasing in many countries, even Asian countries.

Until recently new varieties (subspecies) of potatoes could only be produced by cross-breeding plants with desired features. However, there are a number of subspecies of potato plants and many will not cross-breed. Of those that will cross-breed, many produce sterile varieties. There is also the problem that it takes about 10 to 15 years to produce a stable new variety by repeated genetic crossings.

Using tissue culture, wild relatives of the potato and cultivated varieties can be mass-produced. Transferring desired genes from wild varieties or even from totally unrelated species into single cells by genetic engineering techniques can 'instantly' create new varieties. The changed cells can then be grown into small transgenic plants and multiplied as shown in the diagram below.

A: Process illustrating cloning of potato plants



[Adapted from: <http://medcraveonline.com>]

An example of a successful potato variety grown this way is the one that has a gene from the 'potato leaf roll virus' introduced to the cells. This is the equivalent to vaccination against the virus. Although the potato plant may still get infected, the virus multiplies much more slowly than normal and the plant shows no, or few, signs of disease.

The advantages of micropropagation are that it ensures rapid multiplication of desired varieties, ensures genetic uniformity and can produce disease free plants. Tissue culture of the small potato plants takes up little space and can be carried out independently of seasonal changes in climate. Plant development is closely controlled and guarantees product uniformity for customers.

The disadvantages are that it is labour intensive, requires skilled workers and is very costly. Sterile conditions have to be maintained and some plants undergo spontaneous and undesirable genetic changes. The identical plants are also more susceptible to new diseases or changing environmental conditions.

[Adapted from: *Biological Science 1 & 2*; Taylor, D et al., 1997]

1.1.1 From the text give the scientific term for the following descriptions:

(a) a minute plant grown from cloned potato cells (1)

(b) a type of asexual reproduction (1)

(c) a plant with a foreign gene inserted into its DNA (1)

1.1.2 Study diagram A on the previous page showing the cloning method for growing potato plants and explain what is happening at the following stages:

(a) I

(b) II (4)

1.1.3 Explain why the introduction of the 'potato leaf roll virus' into the potato cells is likened to the vaccination of the potato plant against the virus. (2)

1.1.4 (a) Does 'cross-breeding' methods in paragraph 3 refer to sexual or asexual reproduction? (1)

(b) Briefly describe how new varieties of potato plants could be produced using the traditional cross-breeding methods. (4)

(c) From the text explain ONE disadvantage of producing potato plants by cross-breeding methods. (2)

1.1.5 List THREE advantages and THREE disadvantages of micropropagation of potato plants. (6)

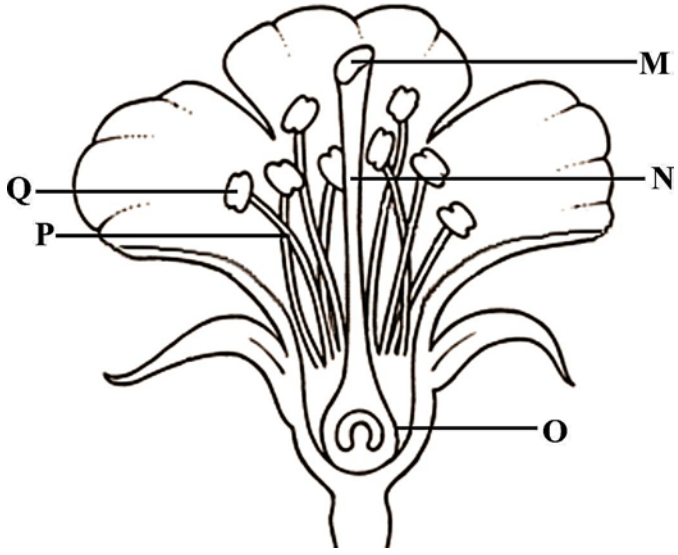
1.2 Study the images of potato fruits (B below) and a flower (C below).

To harvest potato seeds, the berries that are like small green cherry tomatoes are picked. When the berries are ripe, they become soft and turn slightly yellow. Potato seeds remain viable for years and are less likely than clones to transmit diseases or pests to next year's crop.

B: Potato plant showing the fruit, leaves and flowers

[Source: <www.motherearthnews.com>]

C: Longitudinal section of a potato flower



[<www.biologydiscussion.com>]

1.2.1 Give the letter of the part shown in diagram C above that develops into the potato berry seen in diagram B. (1)

1.2.2 (a) State the **letters** and **names** of the following parts of the flower in diagram C:

(i) where the male gametes are produced. (2)

(ii) where the pollen grains are received by the female parts of the flower. (2)

(b) Describe ONE way in which male gametes may be transferred to the female reproductive parts. (1)

1.2.3 Although it is difficult and time-consuming to grow potato plants from seed, it is essential to preserve the seeds of wild varieties in seed banks. Suggest why this is important to global food security. (2)

[30]

QUESTION 2

2.1 The following information is adapted from research conducted at the University of KwaZulu-Natal into the effects of Antiretroviral drugs in HIV/Aids affected men.

Introduction to ARVs and HIV

Antiretroviral (ARV) therapy is currently effective in lowering the replication of the Human Immunodeficiency Virus (HIV) in the blood. However, it does not completely remove the virus from the host tissues.

Destination of ARVs

The testes are an example of a hiding place for the HI-virus as many of the ARV drugs cannot move from the blood into the tissues of some organs. This is called the blood tissue barrier. The protected tissue of the testes allows HIV to continue replicating, even if a person is taking ARVs. The testes can then act as an area in which drug-resistant strains of HIV can develop. Some other studies have also shown that the concentration of ARV drugs in the semen and seminiferous tubules is too low to prevent viral replication. The challenge for scientists is to find the correct combinations of ARVs that can get through to the seminiferous tubules.

Effects of ARVs on spermatogenesis

Spermatogenesis is the process that produces mature functional sperm in the testis and this process takes 72 days to complete. The hormones LH, FSH and testosterone are required to control the correct development of healthy sperm cells. ARVs can pass as far as the germinal epithelium layer in the testes where sperm is produced, but cannot enter any further. Recent studies also show that some ARVs significantly lower the sperm count, reduce the sperm movement and increase the amount of abnormal sperm.

Effect of ARVs on mitochondria

One reason for this is that some ARVs act as mitochondrial toxins. It is believed that these toxins damage some mitochondria and also reduce the amount of mitochondrial DNA. This damage then inhibits the action of their enzymes such as DNA polymerase. Other research studies show that men on ARV treatment show a loss of germinal epithelium cells and their sperm do not mature. Their testosterone levels are also below normal. However, much still needs to be done to determine the exact relationship between ARVs and loss of fertility in men.

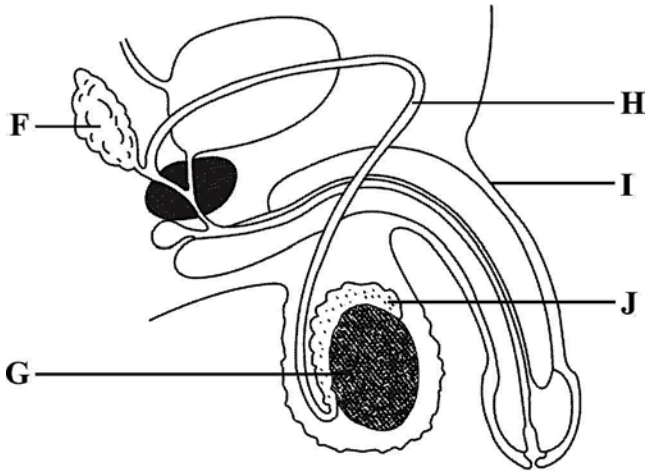
Table A: Summary of studies showing the effects of different ARV treatments (drugs) on tissue of the testes

Treatment (drugs used)		Effects	Type of Experimental Investigation	Duration of experiment
A	**Drug 1 and Drug 2**	Reduced sperm movement, reduced sperm count and reduced sperm survival. Reduced testosterone.	Animal testing	21 days
B	**Combination of three or more drugs**	Levels of testosterone, FSH and LH not significantly altered.	Analysis of human sperm and tissue in testes	4 years
C	**Drug 3 and Drug 4**	Semen altered, decreased sperm movement, reduces mechanisms essential for fertilisation of an ovum.	Trials in test tube samples of sperm	48 weeks

D	**Drug 5 and Drug 4**	Higher percentage of active sperm, increase in healthy sperm.	Semen samples and cross sections of testes	ongoing
E	**Drug 6 and Drug 4**	Diabetes	Ongoing sperm and testis analysis	4 years
F	**Drug 7 and Drug 8**	Increase in testosterone levels.	Sperm and testis analysis	7 days

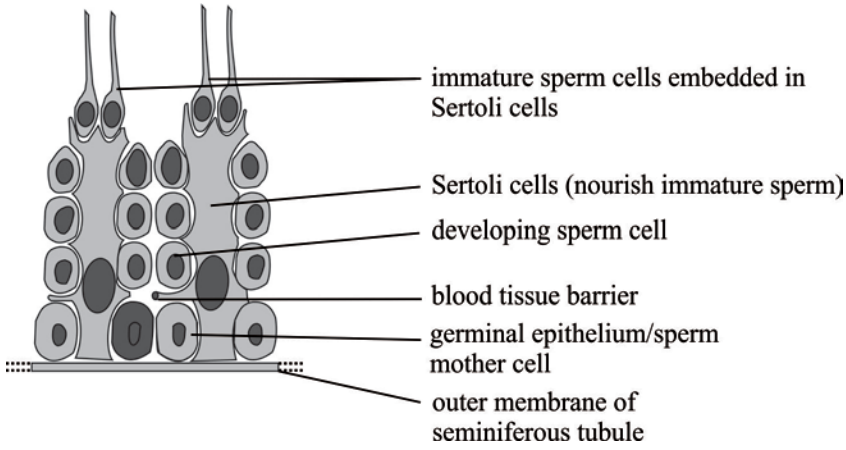
[Adapted from: *Highly Active Antiretroviral Therapy (HAART) and Testicular Morphology*, Onyemaeychi O, Azu; UKZN – 2012]

B: Human male reproductive organs



[Source: <www.biologydiscussion.com>]

C: Cross section of a section of a seminiferous tubule found in G above



[Adapted from: *Highly Active Antiretroviral Therapy (HAART) and Testicular Morphology*, Onyemaeychi O, Azu; UKZN – 2012]

2.1.1 State whether each of the following statements based on the information is TRUE or FALSE:

(a) antiretroviral drugs do not completely remove HIV from an infected person

(b) the HIV does not enter the tissue of the testes

(c) antiretroviral therapy is given as a combination of drugs (3)

2.1.2 Give the letter of the following parts/structures from diagram B:

(a) the sperm duct/*vas deferens*

(b) the part where sperm cells are stored while they mature

(c) the organ that places sperm in the female body (3)

2.1.3 (a) Where are the mitochondria found in a sperm cell? (1)

(b) From information provided in the text and diagram C, describe the blood tissue barrier in the testes. (3)

(c) Explain clearly in your own words how ARVs affect mitochondria and suggest why this contributes to infertility in HIV-positive men. (4)

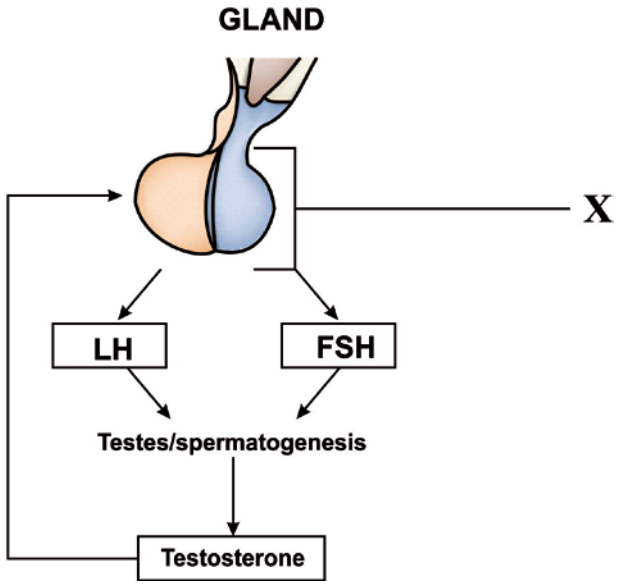
2.1.4 (a) Using the information about ARVs in Table A, which treatment do you think is most suitable for an HIV-positive man who still wants to father children using his own sperm? Give a scientific reason to support your answer. (3)

(b) From the information provided in the text about the development of sperm, do you think that the duration of the testing of treatment A with Drug 1 and Drug 2 (row 1 in Table A) produced reliable results? Explain your answer. (2)

(c) Draw a bar graph to illustrate the duration of the experimental investigation for the following TWO drug therapies illustrated in the table; Drug 3 and Drug 4 (row C), and Drug 7 and Drug 8 (row F). (5)

2.2 Study the diagram below of a negative feedback mechanism.

D: Negative feedback between male reproductive hormones



2.2.1 Name the gland labelled X in the diagram above. (1)

2.2.2 (a) Explain the negative feedback mechanism illustrated in the diagram above. (4)

(b) State ONE secondary sexual characteristic controlled by testosterone. (1)

[30]

60 marks

SECTION B

QUESTION 3

THE ORAL CONTRACEPTIVE PILL

So small. So powerful. And so misunderstood.

[Source: Nancy Gibbs – *Time* magazine, vol. 175, no. 17, 2010]

The oral contraceptive pill has had a positive impact on modern society. Do you agree with this statement?

Using the source material provided as well as any other knowledge you have, discuss your opinion on the above statement in the form of a 2½ – 3 page essay.

To answer this question you are expected to:

- Read the source material carefully and present a debated argument to illustrate your point of view.
- Select relevant information from Sources A to G. Do not attempt to use all the detail provided.
- It is important to integrate your own relevant biological knowledge. However, do not write an essay based solely on your own knowledge.
- Take a definite stand on the question and arrange the information to best develop your argument.
- Write in a way that is scientifically appropriate and communicates your point of view clearly.
- Provide a clear plan of your essay before you start writing. Note that the plan will be marked as part of the assessment of this question.

40 marks

SOURCE A

A brief history of the birth control pill

By **Alexandra Nikolchev** – May 7, 2010

Katherine McCormick & Margaret Sanger. Courtesy: Smithsonian Institute

Margaret Sanger – her Catholic mother died prematurely at age 50 after complications from 18 pregnancies. Margaret was determined to find a 'magic pill' that would prevent pregnancy.

Katherine McCormick – set out to help women prevent pregnancy. She was very wealthy and funded research into the oral contraceptive pill.

Gregory Pincus – the scientist that Sanger persuaded to work on developing the contraceptive pill.

1951 Sanger and Pincus meet at a dinner party in New York; she persuades him to work on a birth control pill.

1952 Pincus tests progesterone in rats and finds it works. He meets gynaecologist John Rock, who has already begun testing chemical contraception in women.

1953 Katherine McCormick — writes Pincus a cheque for US$40,000 to conduct research.

1954 Rock and Pincus conduct the first human trials on 50 women in Massachusetts. It works.

1956 Large scale clinical trials are conducted in Puerto Rico, where there were no anti-birth control laws. The pill is 100% effective, but some serious side effects are ignored.

1957 The Food and Drug Administration Agency (FDA) in America approves the pill, but only for severe menstrual disorders, not as a contraceptive. An unusually large number of women report severe menstrual disorders.

1960 The pill is approved for contraceptive use.

1962 It is an instant hit. After two years, 1,2 million American women are on the pill; after three years, the number almost doubles, to 2,3 million.

1965 Five years after the FDA approval, 6,5 million American women are on the pill, making it the most popular form of birth control.

1968 Pope Paul VI declares his opposition to the pill as an unnatural form of contraception.

1969 Barbara Seaman publishes *The Doctor's Case Against the Pill*, which exposes side effects including the risk of blood clots, heart attack, stroke, depression, weight gain and loss of libido.

1979 Sales of the pill drop by 24% in four years due to publicity about health risks.

1988 The original high-dose pill is taken off the market; an FDA study shows the health benefits of newer pills, including a decreased risk of ovarian cancer, iron deficiency anaemia and pelvic inflammatory disease.

1997 Not just a contraceptive any more — the FDA approves the pill as treatment for acne.

2000 The Equal Employment Opportunity Commission rules that prescription contraception must be covered by health insurance offered by employers.

2010 Fifty years after the FDA approval, problems remain: there are currently 1 100 lawsuits pending against Bayer Healthcare Corporation regarding blood clots, heart attacks and strokes allegedly caused by the popular pills Yaz, Yazmin and the generic Ocella.

[Adapted from: <www.pbs.org/wnet/need-to-know/health>]

SOURCE B

The birth control pill was the first medication approved for long-term use by healthy people and the first 99% effective way to prevent conception.

The Pill became the symbol of the 'sexual revolution' of the 1960s – 70s. Many blamed it for the events of these years — a rise in single motherhood, unmarried couples living together or in communes, open marriage and wife swapping, women's liberation, and increased visibility of sex in the media.

Scholars now recognise that these cultural shifts began well before the advent of the Pill.

[Adapted from: <www.case.edu>]

SOURCE C The termination of pregnancy debate

The following information is taken from research done by Physicians for Reproductive Choice and Health, a non-profit organisation led by medical specialists committed to preserving and enhancing reproductive health and freedom. Data is up to date for 2005.

Most Important Reason Given for Terminating an Unwanted Pregnancy

Inadequate finances	21%
Not ready for responsibility	21%
Woman's life would be changed too much	16%
Problems with relationship; unmarried	12%
Too young; not mature enough	11%
Children are grown; woman has all she wants	8%
Foetus has possible health problem	3%
Woman has health problem	3%
Pregnancy caused by rape, incest	1%
Other	4%
Average number of reasons given	3,7

[Source: Torres and Forrest]

SOURCE D 'The Birth of the Pill'

[Source: <http://www.nytimes.com>, 8 October 2014]

SOURCE E Opinions – on the 50th anniversary of the oral contraceptive pill

Fifty years ago the public spotlight was on the availability of 'safe, easy and effective birth control.' It would all be very easy – and women were to be 'empowered'. Little was said of the many harmful side effects among the women in the developing countries where the drug trials were conducted. The past 50 years has seen a steady stream of new formulations meant to reduce the unpleasant and risky side-effects (and lawsuits) of the last generation of pills.

Beyond that, how are women (and men) healthier or happier because of The Pill? A thoughtful person should connect the dots. Young people routinely have multiple sexual partners before marriage, no doubt facilitated by The Pill, and the divorce rate still soars. The Pill does not prevent the transmission of sexually transmitted diseases.

Theresa Notare *is assistant director of the Natural Family Planning Program of the United States Conference of Catholic Bishops.*

Some studies claim health benefits of The Pill, yet both the Centres for Disease Control and the World Health Organisation identify steroidal oestrogen, present in some birth control pills, as a carcinogen. And some scientists have begun to explore the link between the runoff of the oestrogen into local waters and disruption of fish populations.

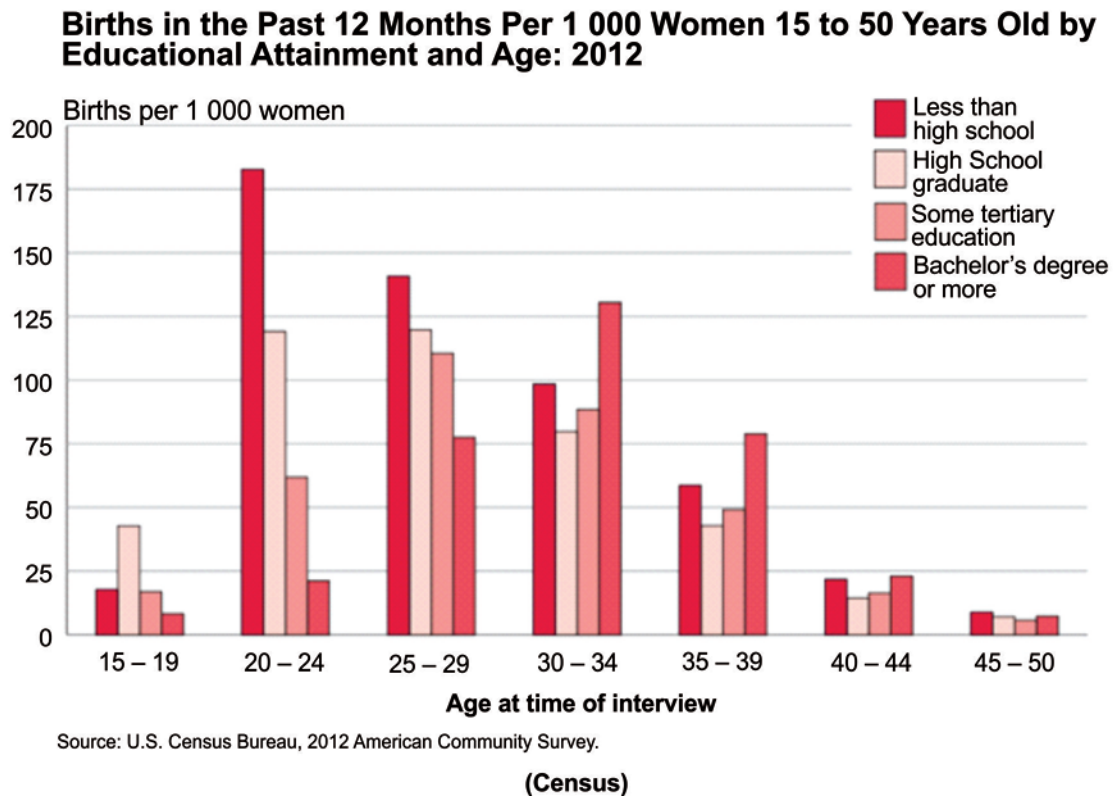
Claudia Goldin*, an economic historian and labour economist, is director of the Development of the American Economy program at the National Bureau of Economic Research.*

The Pill was a great 'enabler'. With The Pill, large numbers of college women could embark on careers that involved long-term, up-front time commitments in education and training as physicians, lawyers, veterinarians, managers, and academics, among others.

As more men and women delayed marriage, single women who pursued careers could still get married after their professional training. The upshot is that the marriage age increased and women were enabled to enter various professions because of The Pill.

[Adapted from: <edition.cnn.com>]

SOURCE F Birth rates peak earlier for less-educated women



Census Bureau report on fertility in the USA. The report identifies trends and patterns in 2012 census data. And it looks at how age, poverty and education interact with birth rates.

[Source: <www.census.gov/acs>]

SOURCE G The Pill could harm future fertility, by ISABEL OAKESHOTT, *Evening Standard*; March 2015

The contraceptive pill could damage fertility, according to new research. The powerful hormones could upset the reproductive system for months – or even years – after women stop taking it.

Women who have used the Pill are twice as likely to have problems conceiving later. The findings are the first to suggest a link between oral contraceptives and infertility, despite assurances from manufacturers that there are no long-term effects.

Today fertility experts described the research as 'highly significant' and said Pill users must be told about the possible risks. But family planning groups urged women not to panic – stressing that most women had no problem conceiving after they stopped taking it.

The link emerged in a study of more than 2 200 women attending UK antenatal clinics. On average former Pill users took twice as long to conceive than those who had used condoms. The longer they had been on the Pill, the longer it took to conceive. The risks appear to be even greater among women who are over 35, or obese, or suffer from irregular periods.

[Adapted from: <http://www.dailymail.co.uk/health>]

Total: 100 marks