



eduresourceza.com

LIFE SCIENCES: PAPER II

**SOURCE MATERIAL BOOKLET FOR
QUESTIONS 1, 2 AND 3**

SECTION A

QUESTION 1

Read the information below. Refer to this information, as well as your own knowledge, to answer Question 1 in the question paper.

1.1 Protea Pollination

The majority of proteas flower in spring and summer, with fewest species flowering in autumn. This pattern may relate to the abundance of pollinators and the optimal conditions for nectar secretion.

A feature of protea pollination is that pollen is deposited by the anthers onto a modified tip of the style (called the pollen presenter). Flowers usually remain closed until triggered by a visiting bird, mammal or insect, when they snap open releasing the style which rubs pollen onto the visitor. If no visitors arrive, flowers may open during the heat of day (or late afternoon in mouse-pollinated species). Pollen falls off the pollen presenter after a few hours of exposure to air.

The stigmatic grooves of proteas are closed when flowers open, but open maximally after 24 to 36 hours. The stigma is then ready to receive pollen brought by visitors. Thus, proteas are protandrous: the male organs mature before the female and prevent self-pollination.

Flower-heads may remain open for a few days up to several weeks. Flowers almost always open from the outside towards the middle of a flowerhead.

- **Rodent pollination:** Several species of gerbils, mice, rats and shrews visit flower-heads of some Protea species. Rodents are attracted by a strong musty odour, and a reward of syrupy sugar which is secreted in large quantities. In order to prevent birds and insects from stealing this nectar, rodent-pollinated (therophilous) proteas have inconspicuous pale brown or black flower heads. Flower-heads are usually hidden inside the bush at ground level, where they are accessible to rodents. Since most therophilous proteas flower in spring, nectar is available during the rodents' breeding period.
- **Bird pollination:** In contrast to therophily, flower-heads of bird-pollinated (ornithophilous) proteas are often brightly coloured. The bright red, orange, yellow, green and pink colouring on involucral bracts and styles serve as visual attraction. The colours are relatively inconspicuous to many insects which cannot see red and orange. Since birds do not rely on smell, ornithophilous proteas have little odour. A perch may be provided by stems, unopened florets, and awns, whereas, in some species, birds have to sit on the ground. Copious quantities of easily digested glucose-rich (fruit sugar) nectar are secreted. The most important bird visitors are the Sugarbirds, which can truly be considered Protea-birds, and the Sunbirds.

1.2 Protea Flowering

Like animals, plants must make babies. Flowering plants have spectacular sex organs: flowers! The purpose of flowers is to con some poor bird or insect to carry the pollen from one flower to another so that the plants can make babies (fruit). Unlike animals, these babies - the fruit - can be stored (in cones, where they are safe from fire and some predators) or hidden (by conning ants or rats to bury them underground), or just discarded on the ground to survive there.

Flowering has a cost. Flowerheads are expensive to produce (especially if the pollinators are large). And animals are not stupid: they need a reward to entice them to visit the flowerheads - nectar. Nectar is energy expensive and also water expensive. Birds need lots of water-rich nectar (about the same as tea with 2-5 spoons of sugar); insects a little, but more concentrated. Getting rodents to visit requires lots of nectar, but this can be syrupy and thus not water-expensive. Wind pollination does away with any rewards, but is expensive in terms of nitrogen and energy, in that large quantities of pollen must be made. And as wind does not conveniently move from one flowerhead to the next, most of the pollen is wasted.

Because flowerheads are water and energy expensive, they cannot be made in large quantities all year round. When should plants flower?

Also, there is no point in flowering and then forgetting to look after the fruit. Fruit stored on the plant must be protected, but the flowerhead may do, or be modified, for that. Fruit buried by ants needs to be released when ants are active. Fruit buried by rats needs to be dropped "en masse" so that the rats will be swamped and store the excess (where hopefully they will forget about some: the squirrel strategy) - If the fruit were to be released slowly the rats could eat them all! Another important thing is that the time between making the fruit and the greatest chance of fire must be as short as possible (not too short, they must be ripe BEFORE the fires come).

Some plants use birds, and even mammals, to disperse the fruit - by providing a reward - a fleshy bit as the reward. Mammal and bird dispersal is ideal where fruit should be placed in a particular place (e.g. on a tree trunk for a parasitic plant or strangler fig), or where special places are needed to help the seeds to germinate and grow.

No proteas use birds for dispersal! Why not? (clue: What ecological process levels the playing field and gives every seed and seedling an equal chance to get going?).

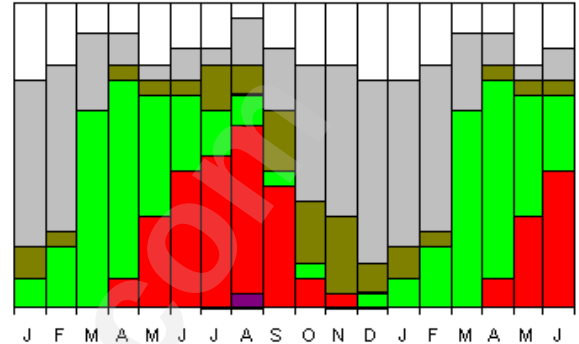
See if you can answer some of these questions from the information displayed below. The graphs show the state of flowering for each month from January through January to June - a period of 18 months.

	Nothing: no flowers or fruit present on plants
	Cone: no flowers, but fruits on plants
	Bud: most flowerheads in bud stage
	Over: most flowerheads in finished stage
	Flowering: flowerheads flowering with Buds & Overs present
	Peak: nearly all flowerheads flowering

Key

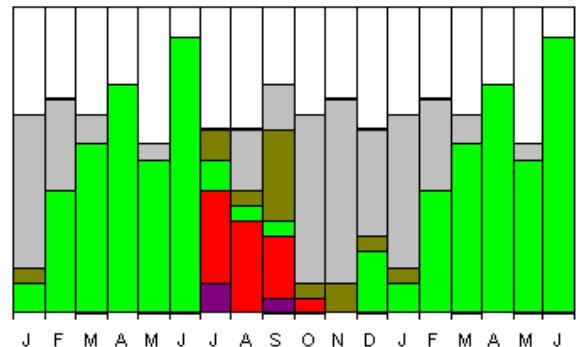
Greyleaf Sugarbush *Protea laurifolia*

This is a tree-like Sugarbush of the Western Cape. It is pollinated by birds (mainly the Cape Sugarbird and Orangebreasted Sunbird) and beetles (many different types - several thousand of several species may live in a single flowerhead), and many other insects visit the flowerheads (not only to drink nectar, but also to eat those living inside). Note the long winter Flowering period (8 months), which runs straight into the start of Buds. The high level of Cones shows that this species stores the fruit in fire-proof seedheads, and the fruit are only released after the fire has killed the plants. However, being so big (compared to the heaths and reeds) the fires often sweep around the trees without killing them, although smaller plants are almost always killed.

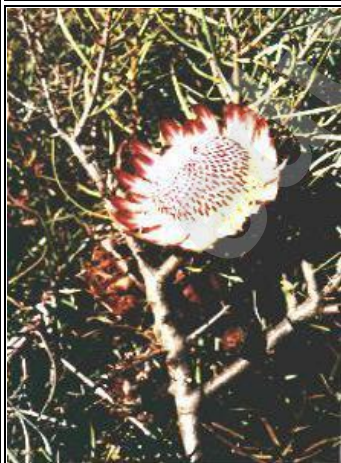


Patentleaf Sugarbush *Protea humiflora*

This is a fairly widespread species. It is pollinated by rats. Note the spring Flowering period which lasts for 4 months - more or less the same time as the rats are having their babies. It is in Bud for most of the year, with only a very short rest period (1 month - November). Fruit is stored in fire-proof fruitheads, but these are not very long-lived. The plants are killed by fire. Unlike all other Sugarbushes, this species has its flowerheads at the base of the bush: this is handy for the rodents, but it also means that branch growth is not bothered by having the flowerheads at the tips.



Patentleaf Sugarbush - *Protea humiflora*



Habit: Low sprawling shrub to 2m across

Fire survival: Killed, only seeds survive

Sexual system: Both sexes in each flower

Flowers: July to September, but mainly August

Pollinator: Rats and Mice

Fruit: Stored on plant for a few years

Seed dispersal: Wind

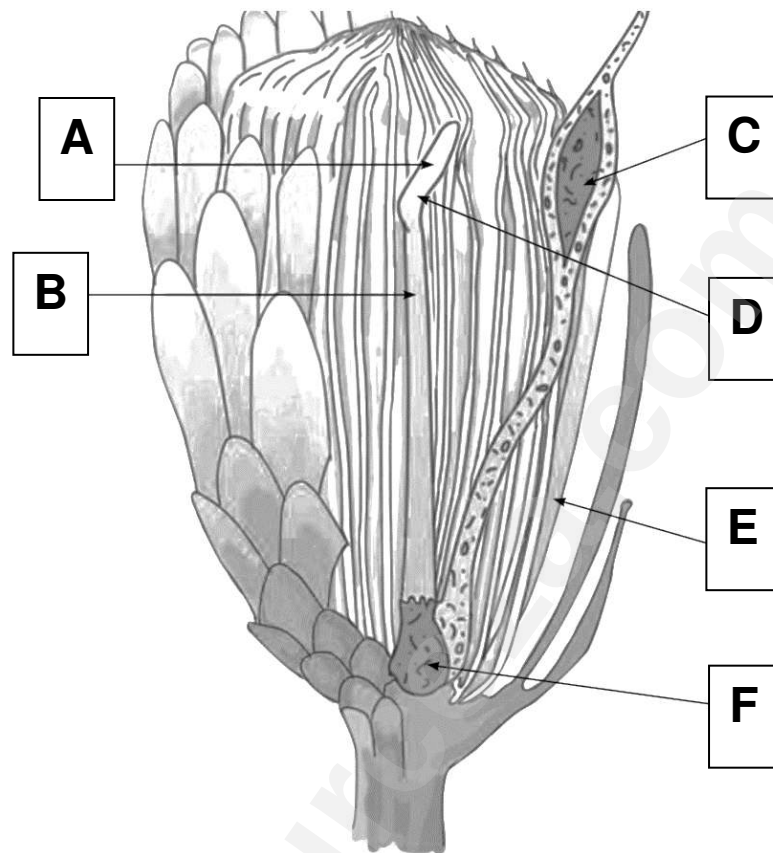
Seed storage: In seedheads on plant

Rarity status: Not threatened

Habitat: Hot dry slopes on the Fynbos/Karoo ecotone, 450-1200m

Distribution: Du Toitskloof to Langeberg and Waboomsberg

1.3 Protea Flowerhead



1.4 Protea Pollinator Visits and Nectar properties

Table 1. Nectar properties per floret of *Protea canaliculata*, *P. humiflora* and *P. sulphurea*.

Nectar measurement	<i>Protea canaliculata</i>	<i>Protea humiflora</i>	<i>Protea sulphurea</i>
Standing crop			
Volume (µl)	1.2	0.5	3.9
Sugar concentration (%)	56.3	39.1	47.1
Overnight accumulation			
Volume (µl)	5.8	9.6	5.6
Sugar concentration (%)	42.9	34.1	41.5

Table 2: Number of occurrences of vertebrate species recorded visiting inflorescences of *Protea canaliculata*, *P. humiflora*, and *P. sulphurea* over a three-day period.

Visitor species	<i>Protea canaliculata</i>	<i>Protea humiflora</i>	<i>Protea sulphurea</i>	Total
Mammals				
<i>Dendromys mesomelas</i>	-	14	1	15
<i>Micaelamys namaquensis</i>	46	10	27	83
<i>Mus minutoides</i>	2	–	–	2
<i>Rhabdomys pumilio</i>	–	5	6	11
<i>Elephantulus edwardii</i>	11	-	10	21
Birds				
<i>Anthobaphes violacea</i>	–	15	6	21
<i>Cinnyris chalybeus</i>	4	19	4	27
<i>Promerops cafer</i>	4	10	1	15
Total	67	73	55	195

1.5 Namaqua rock rat *Micaelamys namaquensis*

Distribution

This species is widely distributed in semi-arid to mesic savannahs of southern Africa, it is considered common in all provinces within South Africa, and also occurs extensively in Swaziland and Lesotho, avoiding only parts of the coastal areas in Kwa-Zulu Natal and the Eastern Cape provinces, and central and coastal Mozambique (Skinner & Chimimba 2005).

Although it is often encountered away from rocky habitats (for example, in woodlands and grasslands), even small rocky knolls can offer sufficient habitat for a population to thrive (Power 2014). Similarly, the amount of rubble or size of the rocks (or boulders) does not seem to influence its distribution, as it has been captured on hilly slopes covered in small rocks and stones (for example, the foothills of the Lubombo Mountains) or on small, isolated rocky outcrops (Monadjem 1998). It co-occurs with *Elephantulus myurus* in many parts of its range in the assessment area (for example, Lancaster & Pillay 2010).

Habitat: Terrestrial

This species occupies a wide range of habitats, as long as they contain patches of rocky areas. It prefers areas with rocky koppies, outcrops and boulders, and shelters in rocky crevices, hollow trees or in burrows constructed under logs or dense shrubs. It is commensal with humans, often found in houses and huts. Juveniles are regularly recorded in the buildings at Tswalu Kalahari Reserve in the Northern Cape Province (D. MacFadyen pers. obs.).

It is a predominantly nocturnal and communal species (Perrin 1981). It is omnivorous, feeding on seeds, green plant material and insects (Breytenbach 1982; Kerley et al. 1990; Monadjem 1997). It has a preference for *Protea caffra* seeds, and may consume large numbers in a relatively short period of time. On a number of occasions where two individuals were captured, signs of cannibalism were recorded (MacFadyen 2014). The presence of this species is often observed by nests of large amounts of dry grass between rock cracks and between rocky overhangs.

Ecosystem and cultural services

They act as seed dispersers (Bond & Breytenbach 1985) and move large amounts of vegetation between areas, and are thus important in regulating the nutrient cycle of soil. They are also pollinators of certain geoflorous *Protea* species by consuming the nectar; for example, *Protea humiflora*. However, there are also concerns that the abundance of this species equates to it being a reservoir for zoonotic diseases (Fagir et al. 2014).

Population trend

This species is widespread and common, at densities of up to 54 individuals / ha (Taylor et al. 2015). It was the most abundant species sampled on the Bokkeveld plateau near Nieuwoudtville, Northern Cape Province, comprising 75% of 219 small mammal individuals (Farrell et al. 2008),

Russo et al. (2006) reveal at least eight genetically unique subpopulations across the range where physical barriers such as rivers and mountains do not appear to separate the lineages.

Breeding

Breeding. Reproduction is seasonal. Live young are born altricial and nipple-cling for about two or three weeks. Gestation period exceeds 22 days. Litter size 1 - 7. 80% of rats survive until sexual maturity.

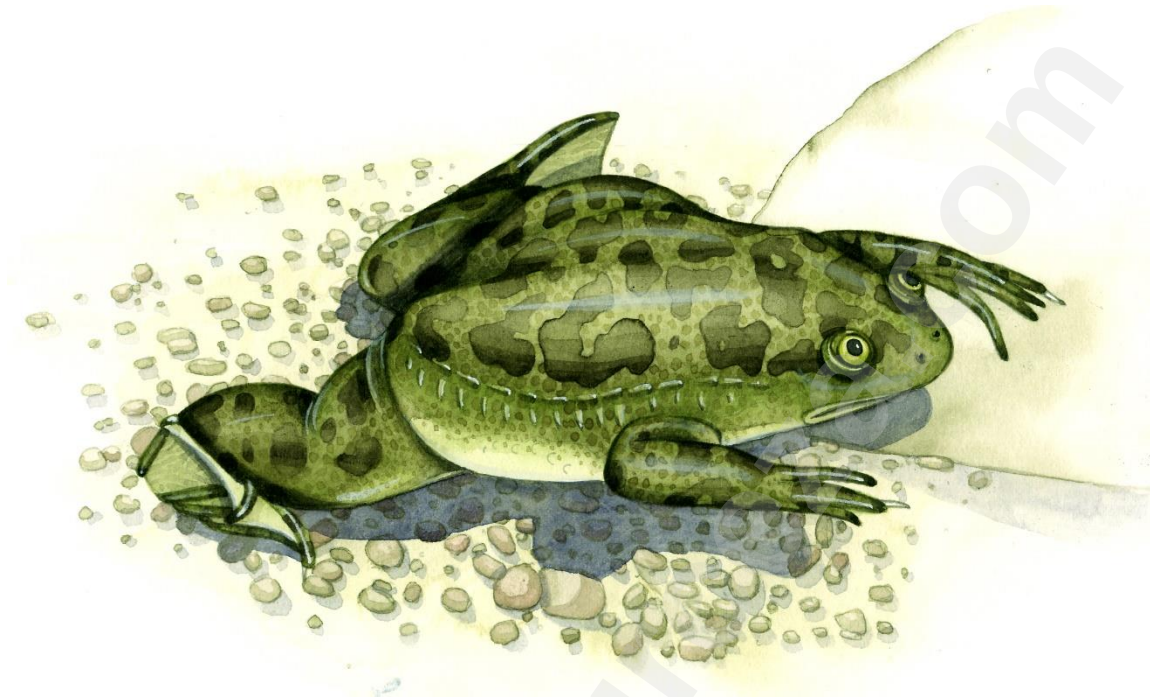
References for Question 1

1. <https://www.proteaatlas.org.za/pollinat.htm>
2. <https://www.proteaatlas.org.za/flowgr.htm>
3. <https://www.proteaatlas.org.za/sugar5.htm>
4. <https://www.sciencedirect.com/science/article/pii/S1749461323000234>
5. <https://www.sciencedirect.com/science/article/pii/S0254629917300510>
6. <https://speciesstatus.sanbi.org/assessment/last-assessment/1935/>

QUESTION 2

2.1 The “Hogben Test” for pregnancy

In the 1950s, if a woman wanted to know if she was pregnant, she needed to get her urine injected into a frog.



The African clawed frog, *Xenopus laevis*, is a palm-sized, greenish-gray animal that hails from the ponds and rivers of sub-Saharan Africa. To get close to prey it can camouflage by changing the colour of its skin. Scientist (Hogben et al) removed the pituitary gland of the frog to see if it will interfere with its camouflage abilities. When the pituitary was removed the frog could no longer camouflage.

Lancelot Hogben was a talented zoologist, who early on in his career studied hormones by injecting them into frogs, and when he moved to South Africa in 1927, he continued those experiments with the local amphibians. One of them—*Xenopus*—was so abundant and easy to work with that Hogben spent much of his time with the creature, and even named his house after it.

In 1930, Hogben injected *Xenopus* with extracts from an ox's pituitary gland—a pea-sized hormone factory at the base of the brain, to see if its camouflage abilities would return, instead, the frog started laying eggs. This accidental finding was a fortuitous one. At the time, scientists knew that the urine of pregnant women contained hormones that were made in the pituitary and that affected the development of ovaries.

If those same hormones could trigger egg-laying in *Xenopus*, perhaps the frog could act as a living pregnancy test.

Hogben never alluded to this application in his early reports, but it wasn't long before he was working towards it. Hogben returned to Britain shortly after his seminal experiments and brought a colony of *Xenopus* with him. His colleague Charles Bellerby worked out how to raise the frogs appropriately, showed that they would reliably lay eggs when exposed to the urine of pregnant women, and confirmed that when they're not mating, they don't lay eggs spontaneously.

Another team from South Africa had been doing similar work, and as academics are, the two groups developed a bitter feud. It was never truly resolved, although Hogben could be said to have won, since the test that resulted from this work took his name.

And so it was that tens of thousands of frogs were infused with human urine between the 1940s and 1960s.

The "Hogben test" was simple. Collect a woman's urine and inject it, fresh and untreated, under the skin of a female *Xenopus*. Then, wait. If the woman is pregnant, between five and 12 hours later, the frog will produce a cluster of millimetre-sized, black-and-white "eggs". The results were reliable. One researcher reported that after injecting 150 frogs, he never got any false positives and only missed three actual pregnancies. And as one doctor wrote to Hogben's colleagues:

"Thank you for your report on the pregnancy test on Mrs. X. You may be interested to know that of one GP of many years' standing, one specialist gynaecologist and one frog, only the frog was correct."

There's a long history of folk pregnancy tests: As my former colleague Cari "a long, long time before women peed on sticks, they peed on plenty of other things." But the first reliable test was created in 1927 by German scientists Bernhard Zondek and Selmar Aschheim. Their "A-Z test" involved injecting human urine into immature female mice for a few days, dissecting the animals, and checking if their ovaries were bigger than normal.

A later version of this test used rabbits instead of mice. For some reason, people came to believe that the rabbits would die if the test was positive, and the phrase "the rabbit died" became a euphemism for pregnancy. In truth, the rabbits *a/ways* died, because, like the mice, they had to be dissected to check the size of their ovaries. This meant that testing for pregnancy was laborious, expensive, and bloody work. In one Pregnancy Diagnosis Station, run by a friend of Hogben's, around 6,000 rabbits were sacrificed every year.

By comparison, the *Xenopus* test was faster, simpler for practitioners, and much easier on the animals. The frogs can live for up to 30 years in captivity, and since the tests didn't kill them, they could be reused. They were also easy to get. At first, doctors imported them from South Africa where, in the words of scientist Edward Elkan, "animal dealers seem to have no difficulty in catching as many as are required." Later, many *Xenopus* colonies were established overseas.

And so it was that tens of thousands of frogs were infused with human urine between the 1940s and 1960s.

In the 1960s, scientists developed chemical tests that searched directly for human chorionic gonadotropin (hCG)—the tell-tale hormone that the frogs were reacting to. The frogs were slowly abandoned. But according to medical historian Jesse Olszynko-Gryn, they were the innovation that turned pregnancy-testing into a large-scale activity. He wrote:

Although facilities existed, getting a test was neither a rite of passage for the expectant mother nor an aid to the woman who wanted to terminate an unwanted pregnancy. Doctors, not women, controlled pregnancy testing and they were not keen on making this laboratory service available to every woman on demand. If a woman sent her own urine specimen to a laboratory it would not be tested, and if she went to her family doctor she might well be told to return in a couple of months when the physical signs of an advanced pregnancy were apparent.

If *Xenopus* changed pregnancy testing, then pregnancy testing also changed *Xenopus*. With large stocks of *Xenopus* popping up around the world, scientists started using the animal for other lines of research. It became a “model organism”—one of the mainstays of laboratory research. It has been repeatedly used to study how cells work and how embryos develop. It has flown into space, to see if fertilisation and development continued normally in zero gravity. It was one of the very first back-boned animals to be cloned—a feat that led to a Nobel Prize.

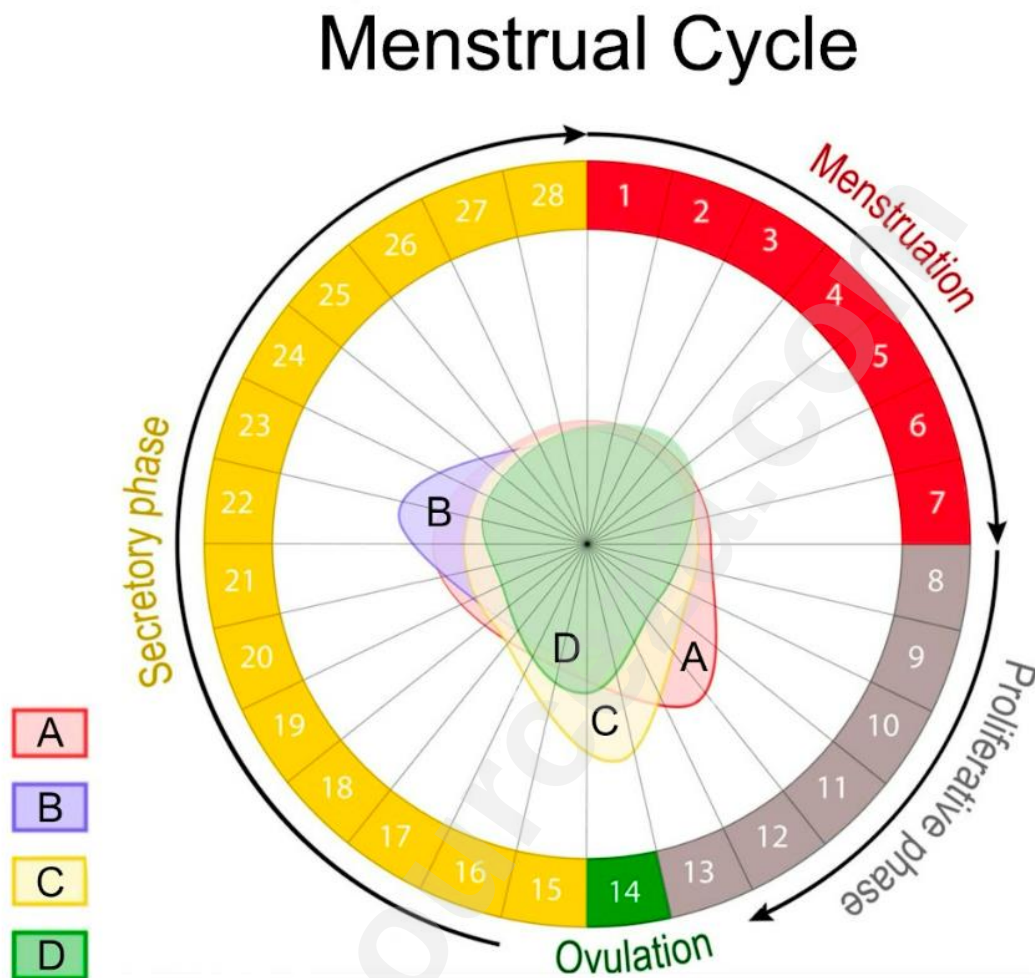
But the frog’s rise to fame may have had an inadvertent dark side. In 2004, Che Weldon from South Africa’s North-West University analyzed hundreds of *Xenopus* Museum specimens to show that the frog, in its native African home, is occasionally infected by a fungus called *Batrachochytrium dendrobatidis*, or *Bd* for short. *Xenopus* can tolerate these infections, but most other frogs aren’t so lucky. *Bd* has now spread across six continents and has killed countless populations of frogs in its wake.

On August 29, 2012, anthropologist and artist Eben Kirksey staged a “performative experiment” in Brooklyn, where he re-enacted the obsolete pregnancy test. His subject was Loretta—a frog that he had ordered from a company that supplies the animals to labs. Also present were three other people, one of whom had recently gone through IVF and genuinely wanted to know if she was pregnant.

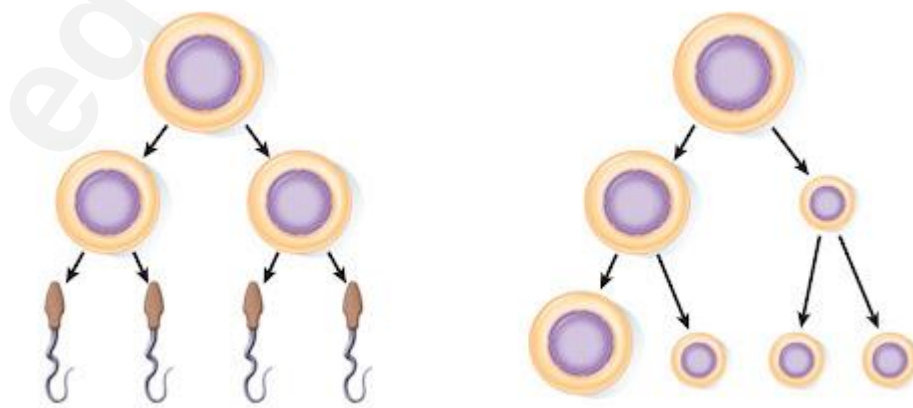
Kirksey has tried to stage several such experiments in recent years, with varying degrees of success. One was cancelled after protests from animal-rights campaigners, and another was disrupted by an audience member who rescued the frog. “First time stealing a frog, but strangely not my first time fighting a pregnant woman,” she later wrote.

<https://www.theatlantic.com/science/archive/2017/05/how-a-frog-became-the-first-mainstream-pregnancy-test/525285/>

2.2 Hormones of the human menstrual cycle



2.3 Spermatogenesis and Oogenesis



SECTION B

QUESTION 3

Read the information below. Use this information, as well as your own knowledge, to answer Question 3 in the question paper.

SOURCE A

A brief history of the birth control pill

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



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. Katherine McCormick & Margaret Sanger. Courtesy: Smithsonian Institute

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.

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.

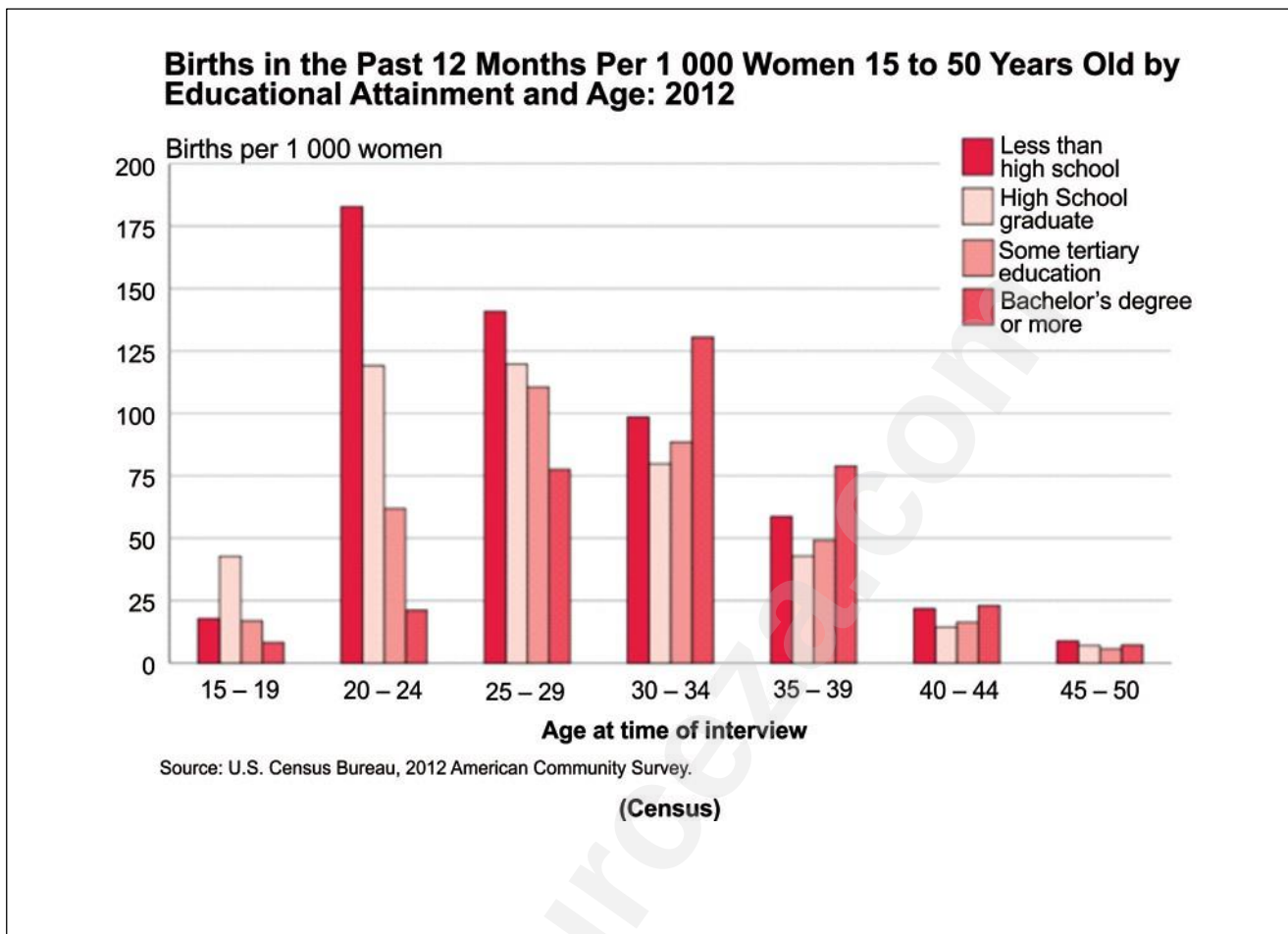


Claudia Goldin, an economic historian and labour economist, is director of the Development of the American Economy program at the National Bureau of Economic Research.

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: <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>>]