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RNA Interference (RNAi)

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RNA Interference (RNAi)

Practice MCQs

At a glance

RNA interference switches off a target gene by destroying its message. It helps treat disease and protect crops. It does not supply hormones.

01 **The trigger**Double-stranded RNA starts RNAi.
02 **The machinery**Dicer cuts it. RISC finds the mRNA.
03 **The uses**Gene-silencing therapies, cancer research, virus-resistant crops.
04 **Official key**CSP 2019 Q96 is (a), 1, 2 and 4.

- Fire and Mello published the discovery in Nature on 19 February 1998.
- They won the 2006 Nobel Prize in Physiology or Medicine.
- Patisiran, approved in 2018, was the first siRNA drug.

Source: Nobel Assembly, 2006 press release

mRNA The message copied from a gene.
Dicer A protein complex that cuts double-stranded RNA.
siRNA A small RNA fragment, 20 to 25 base pairs long.
RISC A complex that uses one strand to find mRNA.

RNA interference is a way for cells to switch off a chosen gene. An siRNA can be designed to match one target mRNA. In practice it may also act on other similar sequences. Scientists test for such **off-target effects** in experiments. UPSC asked about it in CSP 2019, and the question tested one clear idea. Scientists use RNAi to silence genes, and that idea explains why it matters for medicine and crops. This lesson explains what RNAi is and how it works. It then shows where it is used and how the exam tested it.

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2. How it works
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4. RNAi drugs
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What is RNA interference, and who discovered it?

Start with the idea. Then meet the two scientists who found it and the puzzle that came first.

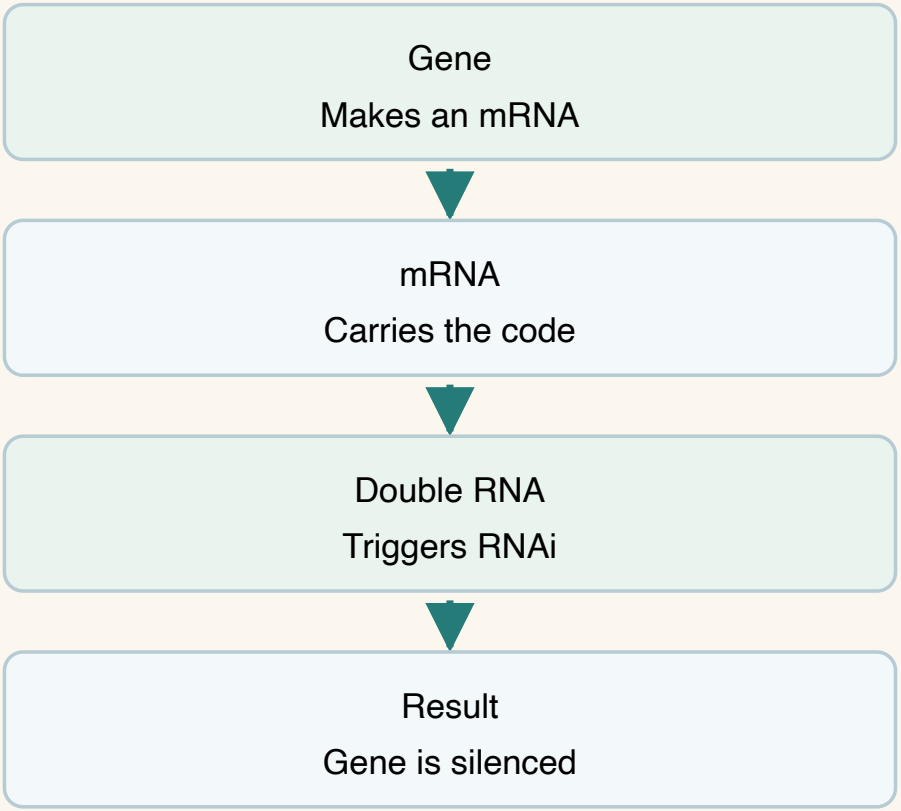
1. What is RNA interference?

A protein-coding gene sends out instructions in a molecule called **messenger RNA (mRNA)**. The cell reads the mRNA to make a protein.

RNA interference (RNAi) is a mechanism that destroys the mRNA of one specific gene. It switches on when RNA appears as a **double-stranded** pair in the cell.

When the mRNA is destroyed, no protein is made. The gene is said to be **silenced**.

RNAi occurs in plants, animals and humans.



RNAi destroys one mRNA, so its protein is not made.

Source: Nobel Assembly, 2006 press release, item 1

Source: Nobel Assembly, 2006 popular information, item 1

2. Who discovered RNAi, and when?

The American scientists Andrew Fire and Craig Mello published their discovery in the journal *Nature* on 19 February 1998. They worked on the roundworm *Caenorhabditis elegans*.

The Nobel Assembly gave them the 2006 Nobel Prize in Physiology or Medicine. The prize was for “RNA interference – gene silencing by double-stranded RNA”.

Here is the experiment in short. Injecting the sense RNA of a muscle-protein gene did nothing. Injecting the antisense RNA also did nothing. Injecting both together made the worms twitch. The twitching looked like that of worms with no working muscle gene.

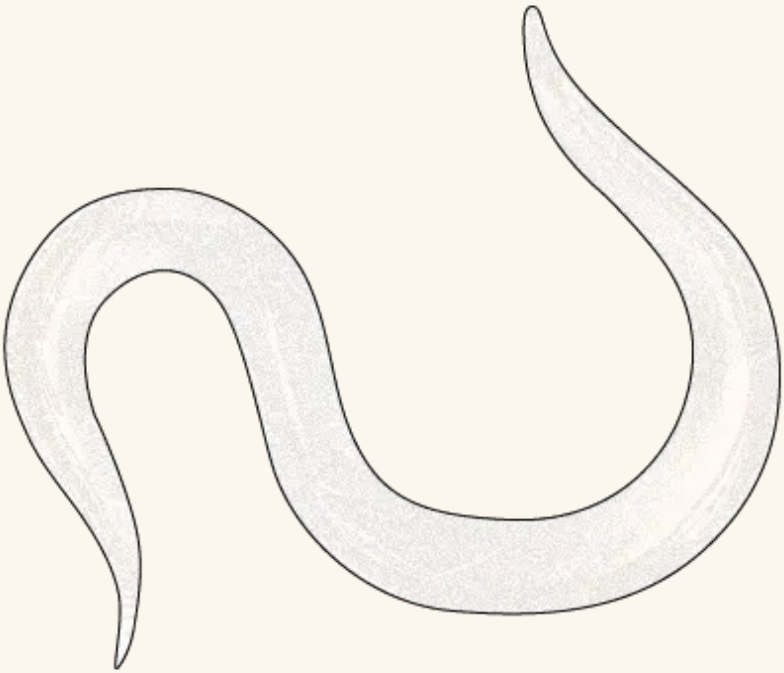
So the pair of strands, double-stranded RNA, switched the gene off.

Single strand	Both strands
Sense RNA	Double-stranded
Antisense RNA	Worms twitch
No effect	Gene silent

Only the pair of strands switched the gene off.



Craig Mello at the Nobel Week Dialogue 2014. He shared the 2006 Nobel Prize with Andrew Fire. Photo: Bengt Oberger, CC BY-SA 4.0, via Wikimedia Commons. File page. Licence: CC BY-SA 4.0.



The roundworm Caenorhabditis elegans, the animal of the key experiment. Image: Database Center for Life Science (DBCLS), CC BY 3.0, via Wikimedia Commons. File page. Licence: CC BY 3.0.

True or False: Fire and Mello first described RNA interference in human cells.
Source: Nobel Assembly, 2006 press release, item 2

Source: Nobel Assembly, 2006 popular information, item 2

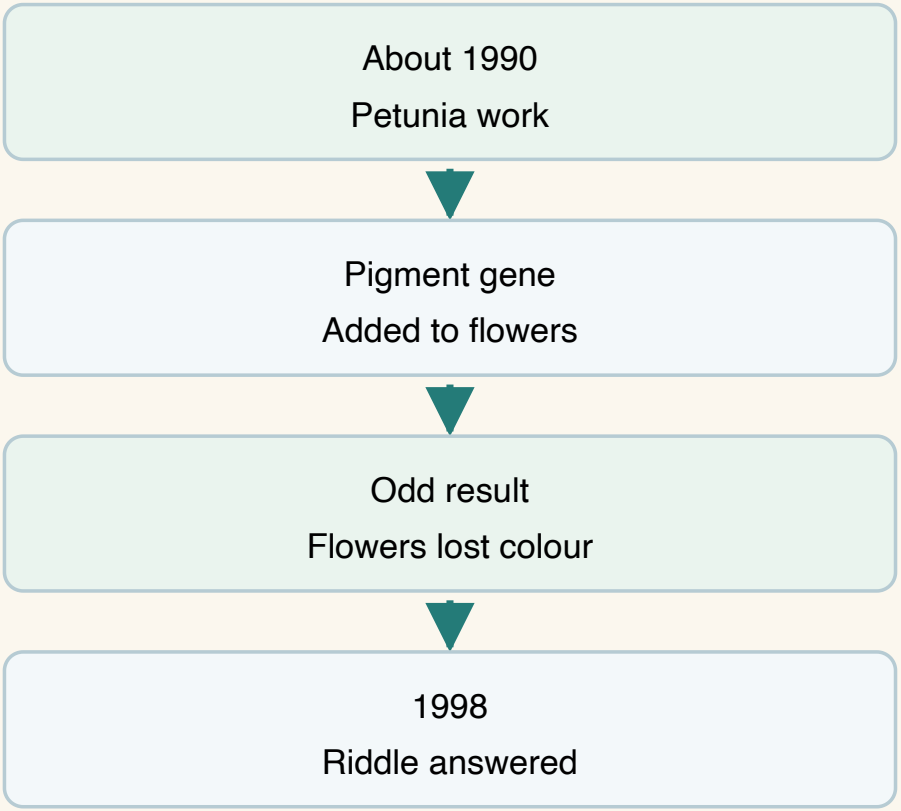
3. Which puzzle came before the discovery?

Around 1990, plant scientists wanted deeper red petunias. They added a gene that controls red pigment.

Sometimes the flowers lost all their colour instead. The mRNA for the pigment had disappeared.

Nobody could explain this at the time. The riddle stayed open until Fire and Mello made their discovery.

Common misconception: “RNAi was found in humans.” It was not. The key experiment used a worm. Plant puzzles, like the petunia, came earlier.



The petunia puzzle stayed open until Fire and Mello.



A garden petunia. Plant scientists adding a pigment gene to petunias saw some flowers lose colour. Photo: Dandy1022, CC BY-SA 4.0, via Wikimedia Commons. File page. Licence: CC BY-SA 4.0.

Source: Nobel Assembly, 2006 popular information, item 3

Source: Nobel Assembly, 2006 press release, item 3

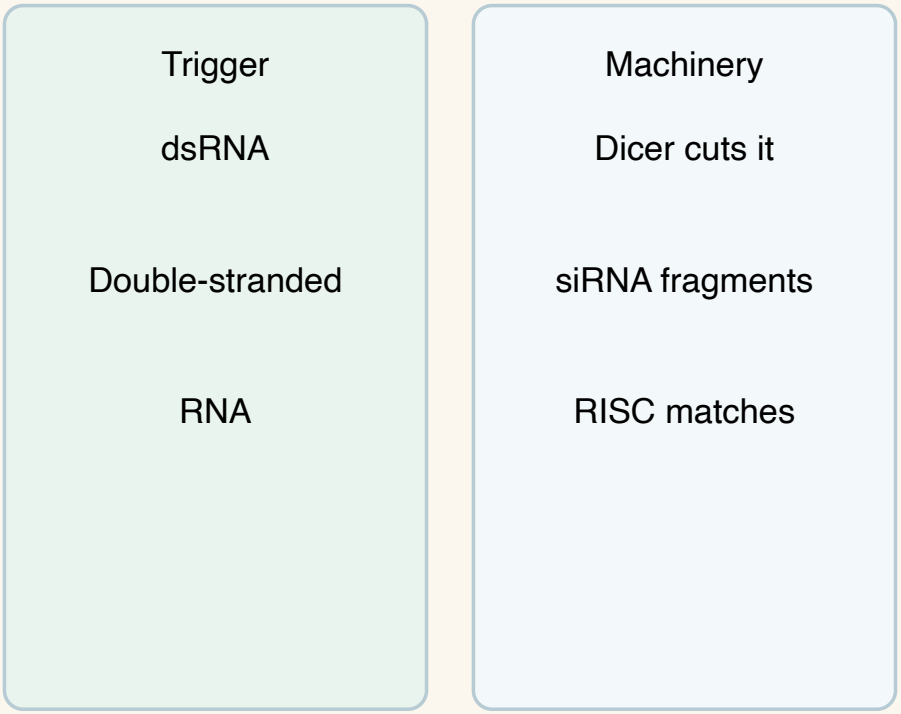
How does RNA interference work, step by step?

Follow one piece of double-stranded RNA from the moment it enters a cell.

4. Which molecules take part?

Four players matter:

- **Double-stranded RNA (dsRNA):** the trigger.
- **Dicer:** a protein complex that cuts the dsRNA into small fragments.
- **siRNA:** the small fragments, called small interfering RNAs. They are about 20 to 25 base pairs long.
- **RISC:** a protein complex that holds one strand of the fragment and uses it to find mRNA.



Dicer makes siRNA, and RISC uses it.

Source: Nobel Assembly, 2006 press release, item 4

Source: Review, siRNA-based molecular therapy of cancers, item 4

5. What happens inside the cell?

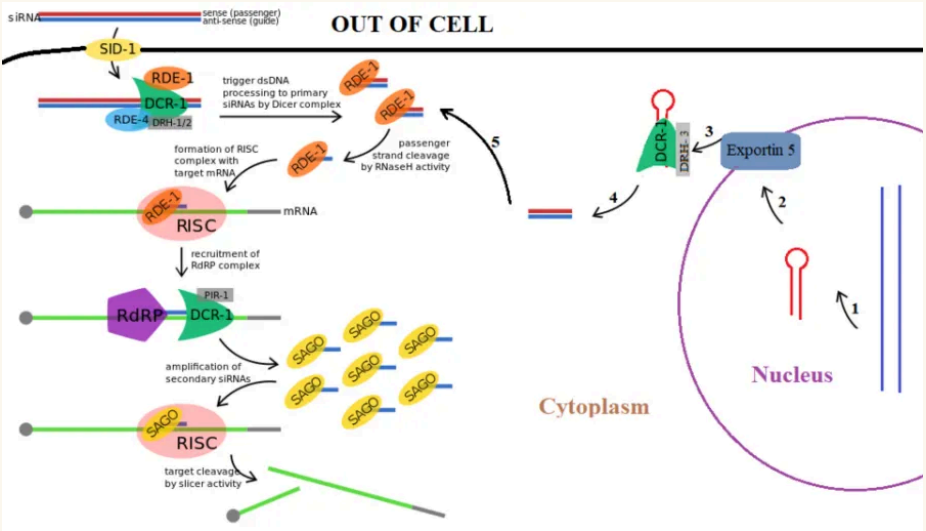
Follow the steps in order:

1. Double-stranded RNA binds to **Dicer**. Dicer cleaves it into fragments. 2. The fragments join **RISC**. One strand is removed. 3. The other strand stays on RISC and works as a probe. 4. The probe finds an mRNA with a matching code. 5. The mRNA is cleaved and degraded. The gene is silenced.

Think of RISC as a guard with a photograph. It checks every message and shreds only the one that matches.



The matching mRNA is cut and degraded.



How a cell responds to double-stranded RNA: Dicer cuts it, and RISC finds the matching message. Image: Mertmetin96, CC BY-SA 4.0, via Wikimedia Commons. File page. Licence: CC BY-SA 4.0.

True or False: In RNAi, RISC keeps one RNA strand and uses it as a probe for matching mRNA.
Source: Nobel Assembly, 2006 press release, item 5

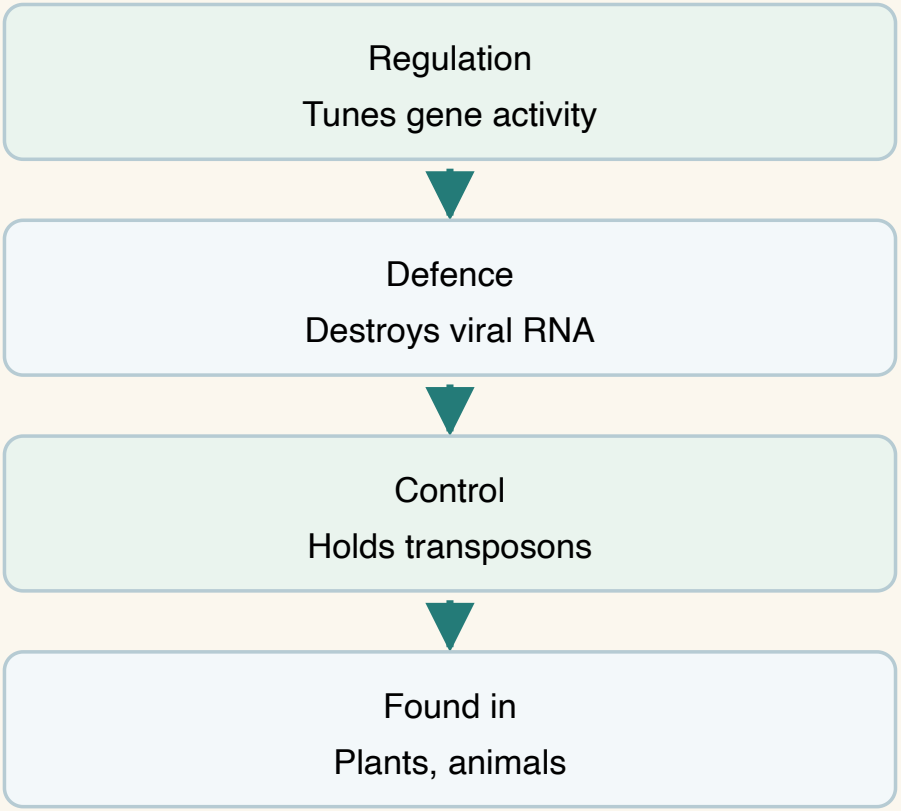
Source: StatPearls, small interfering RNA therapy, item 5

6. What does RNAi do in nature?

RNAi is a natural defence and control system. It does three jobs:

- It helps regulate gene expression.
- It defends cells against viruses. Many viruses carry double-stranded RNA. When one infects a cell, its RNA binds to Dicer, and RISC destroys the viral RNA.
- It keeps jumping genes, called **transposons**, under control.

Humans also have an immune system with antibodies and killer cells. In simpler organisms, RNAi is an important defence against viral infection.



RNAi is a natural control and defence system.

True or False: RNAi helps cells defend against viruses.
Source: Nobel Assembly, 2006 press release, item 6

Source: Nobel Assembly, 2006 popular information, item 6

Where can RNA interference be used?

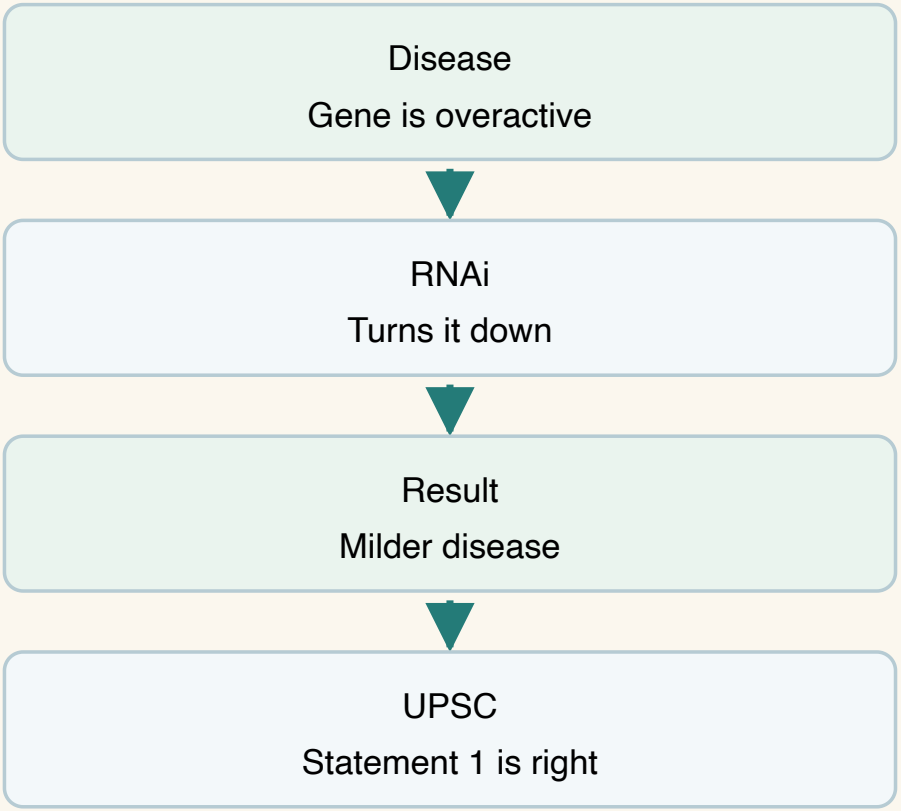
This is the heart of the UPSC question. Check each use against one rule: does it silence a gene?

7. Why does gene silencing suit medicine?

In many diseases, certain genes are **over-expressed**. That means they are overactive. If you could turn those genes down, you could ease the disease.

RNAi does exactly this. The discovery raised hopes for treating viral infections, cardiovascular diseases, cancer and metabolic disorders.

So **developing gene-silencing therapies** is a real use. This is statement 1 in the UPSC question.



Overactive genes can be turned down.

Source: Nobel Assembly, 2006 popular information, item 7

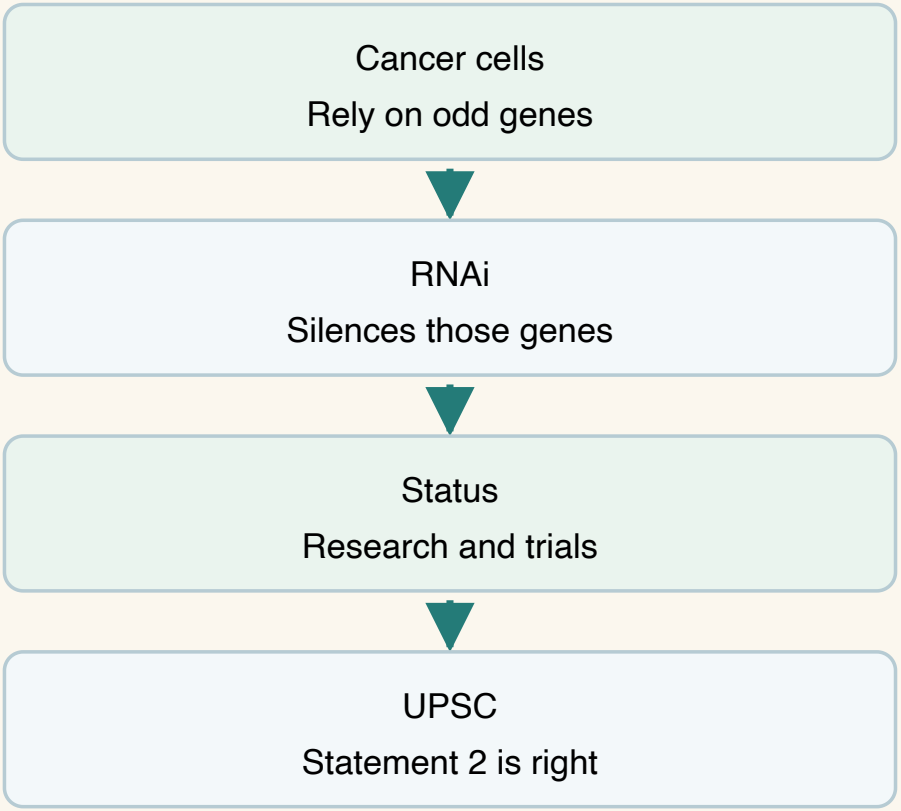
8. Can RNAi help treat cancer?

Cancer cells often rely on overactive genes. Silencing those genes is an obvious idea.

A review calls RNAi a promising therapeutic tool for cancer. It says many preclinical studies have shown that silencing cancer-driving genes can work. Some approaches have entered clinical trials.

So **developing therapies for cancer** is a real direction of use. This is statement 2 in the UPSC question.

One caution helps in other questions. The six siRNA drugs approved so far, as of a 2024 update, treat other conditions. Cancer-targeting RNAi drugs are still in research and trials.



Cancer RNAi drugs are still in research and trials.

True or False: As of a 2024 update, all six approved siRNA drugs treat cancer.
Source: Review, siRNA-based molecular therapy of cancers, item 8

Source: StatPearls, small interfering RNA therapy, item 8

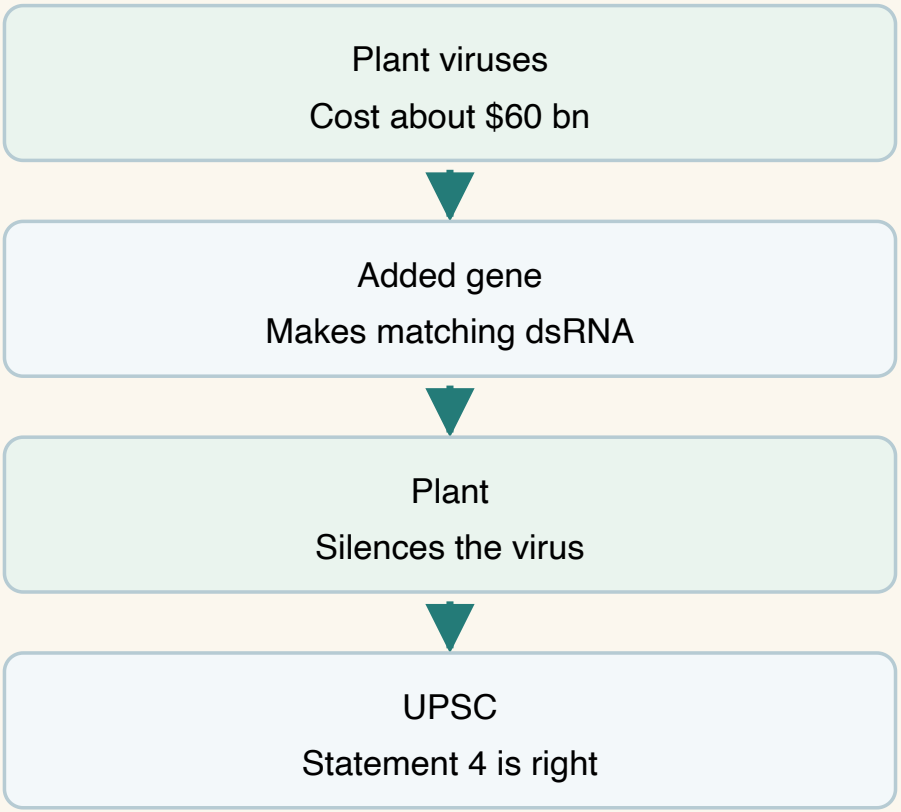
9. Can RNAi protect crops from viruses?

Plant viruses harm crop yield and quality. One estimate puts losses from viral diseases at about 60 billion dollars.

RNAi offers a defence. Scientists add a gene that makes double-stranded RNA matching a viral gene. The plant then silences the virus when it attacks.

A review calls RNAi an effective method to develop transgenic plants that are highly resistant to virus infection. In wheat, transgenic lines with hairpin RNA showed resistance to the wheat streak mosaic virus.

So **producing crop plants resistant to viral pathogens** is a real use. This is statement 4 in the UPSC question.



Hairpin RNA gave wheat resistance to a virus.

Source: Review, RNAi against plant viruses, item 9

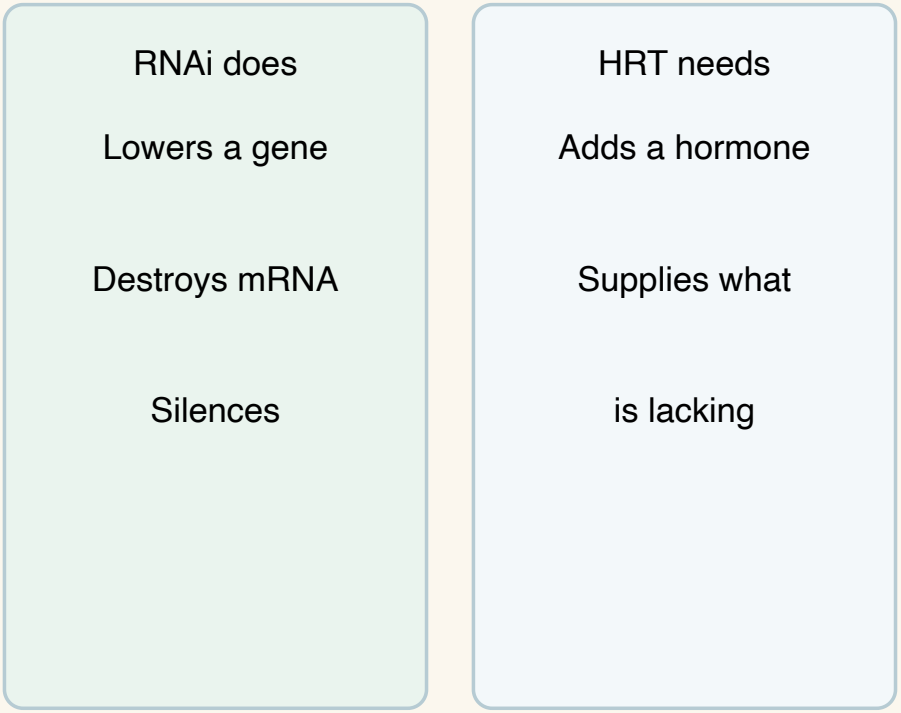
10. Is RNAi used for hormone replacement therapy?

No. This is the statement UPSC used as the trap.

Hormone replacement gives the body a hormone it lacks. RNAi works the other way round. It turns a gene down by destroying its mRNA.

A tool that lowers gene activity does not supply a missing hormone. So statement 3 is not a use of RNAi.

Common misconception: “RNAi edits genes.” It does not. RNAi acts on mRNA, the message copied from a gene. It turns the message down.



A tool that lowers genes cannot supply a hormone.

True or False: RNAi is used to supply missing hormones in hormone replacement therapy.
Source: Nobel Assembly, 2006 press release, item 10

Source: Union Public Service Commission, CSP 2019 answer key, item 10

Which RNAi drugs already exist?

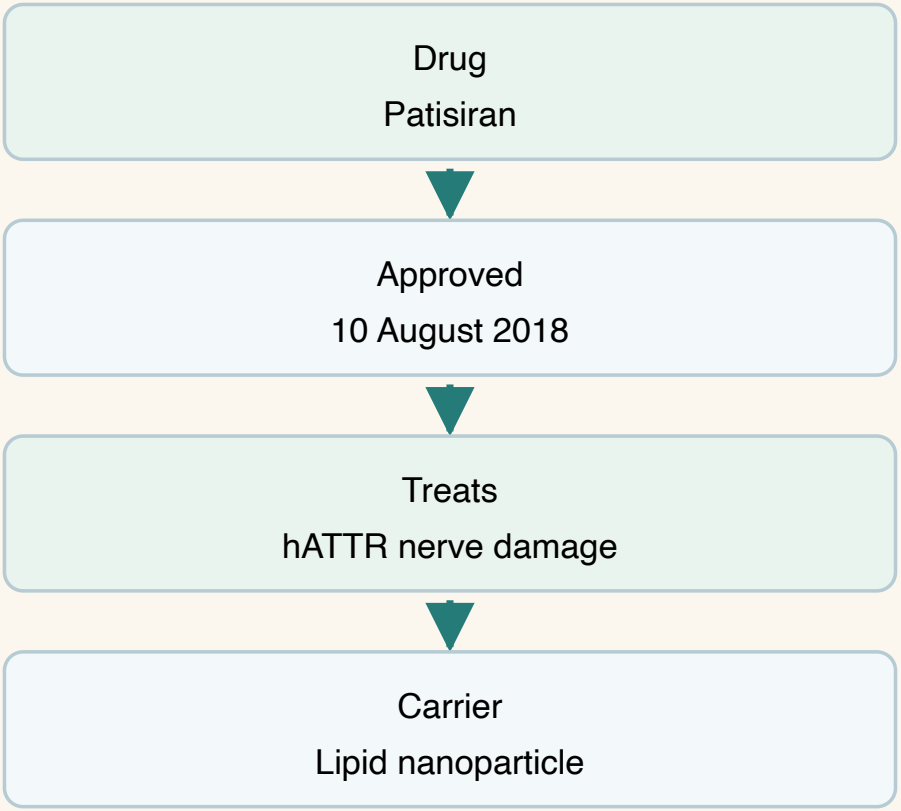
RNAi is not only a lab idea. Real medicines already use it.

11. Which RNAi drug was approved first?

The first siRNA drug was **patisiran**. The US Food and Drug Administration approved it on 10 August 2018.

It treats nerve damage, called polyneuropathy, caused by a hereditary disease named hATTR. The drug silences the gene for a protein called transthyretin.

Patisiran is packed in a lipid nanoparticle. Liver cells take it up.



Patisiran silences the transthyretin gene.

True or False: Patisiran was the first siRNA drug approved by the US FDA.
Source: StatPearls, small interfering RNA therapy, item 11

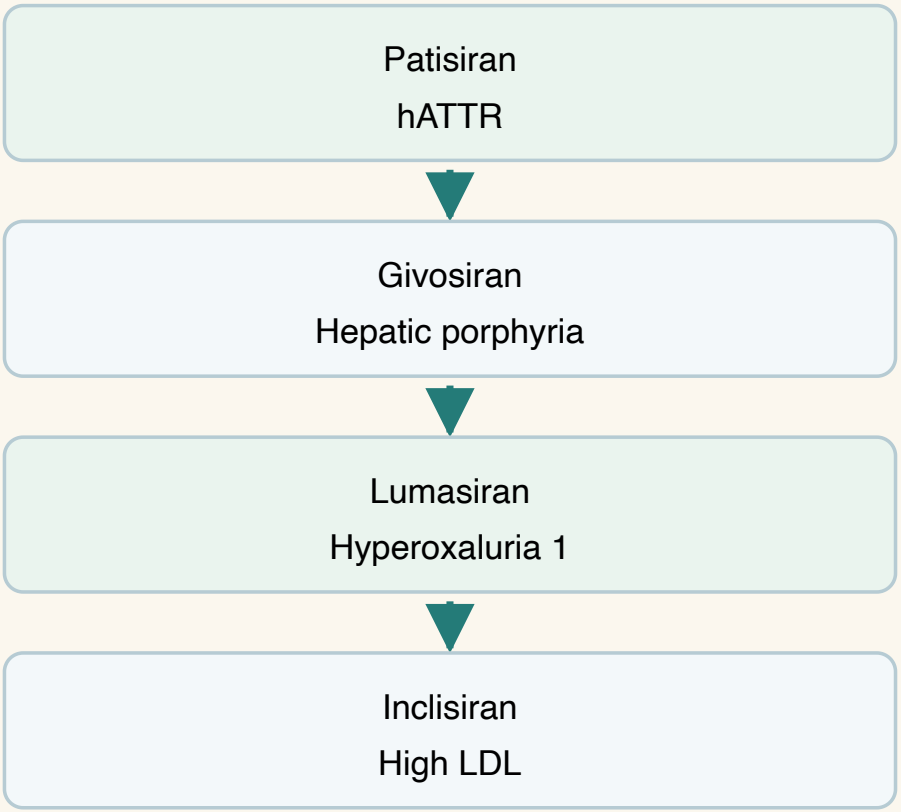
12. How many siRNA drugs are approved, and what do they treat?

As of a 2024 update, the FDA had approved six siRNA drugs. They are patisiran, givosiran, lumasiran, inclisiran, nedosiran and vutrisiran.

They treat these conditions:

- Hereditary transthyretin amyloidosis (hATTR).
- Acute hepatic porphyria.
- Primary hyperoxaluria type 1.
- High LDL cholesterol in some patients.

Most of these drugs reach liver cells. Givosiran and nedosiran carry a sugar tag called GalNAc to get there.



Nedosiran and vutrisiran complete the six.

True or False: As of a 2024 update, the FDA had approved six siRNA drugs.

Source: StatPearls, small interfering RNA therapy, item 12

How did UPSC test this topic?

UPSC set this in the 2019 Civil Services Preliminary paper. Learn the verbatim question, then the reasoning.

13. What did the CSP 2019 question ask?

The question was Q96 in General Studies Paper I.

1. It is used in developing gene silencing therapies. 2. It can be used in developing therapies for the treatment of cancer. 3. It can be used to develop hormone replacement therapies. 4. It can be used to produce crop plants that are resistant to viral pathogens.

Select the correct answer using the code given below.

- (a) 1, 2 and 4
- (b) 2 and 3
- (c) 1 and 3
- (d) 1 and 4 only

The official answer key gives **(a) 1, 2 and 4**. Statement 3 is the trap.

Statements	Official key
1 Gene silencing	(a)
2 Cancer	1, 2 and 4
3 Hormone therapy	Not statement 3
4 Virus-proof crops	

The key is (a), 1, 2 and 4.

Source: Union Public Service Commission, CSP 2019 General Studies Paper I, item 13

Source: Union Public Service Commission, CSP 2019 answer key, item 13

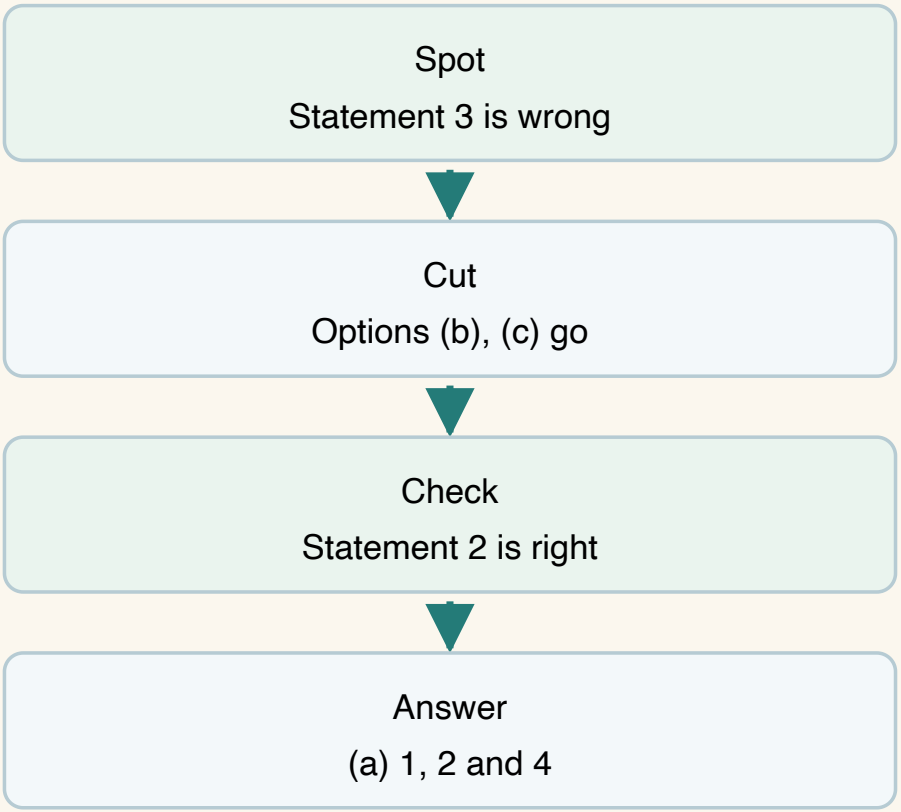
14. Why is each statement right or wrong?

Check each statement in turn:

- **Statement 1, gene-silencing therapies: right.** Silencing genes is what RNAi does.
- **Statement 2, cancer therapies: right.** Cancer research is a major direction of RNAi use.

- **Statement 3, hormone replacement: wrong.** RNAi lowers gene activity. It does not supply a hormone.
- **Statement 4, virus-resistant crops: right.** RNAi in plants gives resistance to viruses.

How to solve it fast. Statement 3 appears in options (b) and (c). Rule it out and only (a) and (d) remain. Statement 2 is right, so (d) fails. Option (a) stays.



Elimination gets the answer in four moves.

Source: Union Public Service Commission, CSP 2019 answer key, item 14

Source: Nobel Assembly, 2006 popular information, item 14

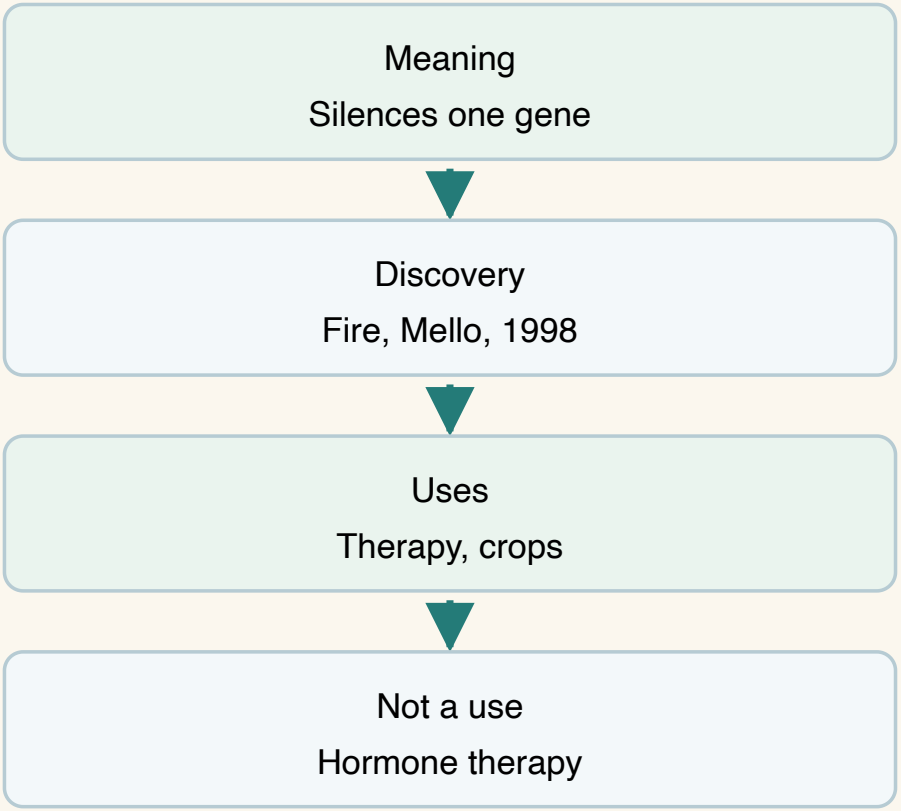
Source: Review, RNAi against plant viruses, item 14

15. What should you revise before the exam?

Use this list:

- **Meaning:** RNAi destroys the mRNA of one gene and so silences it.
- **Trigger:** double-stranded RNA. Dicer cuts it, and RISC does the matching.
- **Discovery:** Fire and Mello, roundworm, 1998. Nobel Prize in 2006.
- **Uses:** gene-silencing therapies, cancer research, virus-resistant crops.
- **Not a use:** hormone replacement therapy.
- **First approved siRNA drug:** patisiran, 2018.
- **Official key:** CSP 2019 Q96 is (a), 1, 2 and 4.

Revise the list line by line.



Four facts anchor the topic.

Source: Nobel Assembly, 2006 press release, item 15

Source: StatPearls, small interfering RNA therapy, item 15

Source: Union Public Service Commission, CSP 2019 answer key, item 15

Four questions to think through

Why is statement 3 the trap in the UPSC question?

Hormone replacement supplies a hormone the body lacks. RNAi does the opposite kind of job. It turns a gene down.

Why must the RNA be double-stranded to start RNAi?

Dicer acts on double-stranded RNA. It cuts the pair into fragments. Those fragments then guide RISC to the matching mRNA.

How does RNAi protect a cell from a virus?

Many viruses carry double-stranded RNA. When the viral RNA enters, Dicer binds it and RISC destroys it. The cell can survive the infection.

What does it mean to say a gene is silenced?

The mRNA of the gene is destroyed. No protein is made from it. The gene itself is still in the cell.

Check your understanding

Your 7 quick checks Answered 0 of · Correct
This score resets when the page reloads.

Continue to the practice MCQs

✅ Test Yourself

Try practice questions on RNA interference and how UPSC tested it.

Practice MCQs

1. RNA interference (RNAi) was first characterised in which organism?

A. The fruit fly Drosophila

B. The bacterium E. coli

C. The roundworm C. elegans

D. Brewer's yeast

See answer ↓

2. 'RNA interference (RNAi)' technology has gained popularity in the last few years. Why?1. It is used in developing gene silencing therapies.2. It can be used in developing therapies for the treatment of cancer.3. It can be used to develop hormone replacement therapies.4. It can be used to produce crop plants that are resistant to viral pathogens. Select the correct answer using the code given below.

A. 1, 2 and 4

B. 2 and 3

C. 1 and 3

D. 1 and 4 only

See answer ↓

3. Which scientists received the 2006 Nobel Prize in Physiology or Medicine for the discovery of RNA interference?

A. Frederick Sanger and Walter Gilbert

B. James Watson and Francis Crick

C. Andrew Fire and Craig Mello

D. Francois Jacob and Jacques Monod

See answer ↓

4. What does the protein complex Dicer do in RNA interference?

A. It joins amino acids into a protein

B. It repairs breaks in DNA

C. It copies DNA into messenger RNA

D. It cuts double-stranded RNA into small fragments

See answer ↓

5. In RNA interference, which complex keeps one RNA strand as a probe and uses it to cleave matching mRNA?

A. A transposon

B. A virus

C. Dicer

D. RISC

See answer ↓

6. Which was the first siRNA drug approved by the US Food and Drug Administration?

A. Patisiran

B. Lumasiran

C. Givosiran

D. Inclisiran

See answer ↓

7. In which year did Fire and Mello publish their discovery of RNA interference in the journal Nature?

A. 1998

B. 2006

C. 2018

D. 1990

See answer ↓

8. In the experiment of Fire and Mello on roundworms, what made the worms twitch like worms with no working muscle gene?

A. Injecting nothing

B. Injecting only sense RNA

C. Injecting only antisense RNA

D. Injecting sense and antisense RNA together

See answer ↓

Answer Key

1. **C.** The roundworm Caenorhabditis elegans is the answer. Andrew Fire and Craig Mello published their discovery in Nature on 19 February 1998. They injected sense and antisense RNA together into the worms, and the worms twitched as if the muscle gene were gone. This work won them the 2006 Nobel Prize in Physiology or Medicine. The fruit fly, the E. coli bacterium and yeast were not the organism of that key experiment. Memory hook: a worm gave us RNAi. ↑ Q1
2. **A.** Statements 1, 2 and 4 are correct, so the answer is 1, 2 and 4. RNAi destroys the message of one chosen gene, so it suits gene-silencing therapies. Researchers are also testing it against cancer. In plants, it can give resistance to viruses. Statement 3 is wrong because hormone replacement supplies a missing hormone, while RNAi turns a gene down. Options (b) and (c) fail because they include statement 3. Option (d) fails because it leaves out statement 2. Memory hook: RNAi silences genes, it does not supply hormones. ↑ Q2
3. **C.** Andrew Fire and Craig Mello received the prize. It honoured their discovery of RNA interference, gene silencing by double-stranded RNA. Jacob and Monod are known for the basic rules of gene regulation, found more than 40 years before. Watson and Crick are known for the structure of DNA. Sanger and Gilbert are known for methods to read DNA, not for RNAi. Memory hook: Fire and Mello, roundworm, 2006. ↑ Q3
4. **D.** Dicer cuts double-stranded RNA into small fragments. These fragments are called siRNA. Another complex, RISC, then uses them to find matching mRNA. Copying DNA into mRNA is transcription, which happens before RNAi acts. Joining amino acids into a protein is the job of the protein-making machinery. DNA repair is not a step in RNAi. Memory hook: Dicer dices the double strand. ↑ Q4
5. **D.** RISC is the complex. It keeps one strand of the small RNA fragment and removes the other. The kept strand finds mRNA with a matching code, and RISC cleaves it. Dicer only cuts the double-stranded RNA into fragments. A transposon is a jumping gene that RNAi keeps under control. A virus may trigger the response, but it does not perform it. Memory hook: RISC is the guard with the photograph. ↑ Q5

6. **A.** Patisiran was the first, approved on 10 August 2018. It treats nerve damage caused by hereditary transthyretin amyloidosis. A lipid nanoparticle carries it to liver cells. Givosiran was approved a year later as the second siRNA drug. Inclisiran and lumasiran were also approved after patisiran. Memory hook: the first siRNA drug came in 2018. ↑ Q6
7. **A.** They published it on 19 February 1998. The year 2006 is when they received the Nobel Prize. The year 2018 is when the first siRNA drug was approved. Around 1990 is when petunia flowers lost colour in puzzling experiments. That puzzle stayed unexplained until the 1998 paper. Memory hook: discovery in 1998, prize in 2006. ↑ Q7
8. **D.** Injecting sense and antisense RNA together made the worms twitch. Together the two strands form double-stranded RNA. Injecting sense RNA alone changed nothing. Injecting antisense RNA alone also changed nothing. Without any injection there was no effect either. Memory hook: only the pair silences the gene. ↑ Q8

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