

7. Nucleic Acids (AHL) – 7.1 DNA Structure and Replication

Name:

Understandings, Applications and Skills (This is what you maybe assessed on)

	Statement	Guidance
7.1.U1	Nucleosomes help to supercoil the DNA.	
7.1.U2	DNA structure suggested a mechanism for DNA replication.	
7.1.U3	DNA polymerases can only add nucleotides to the 3' end of a primer.	
7.1.U4	DNA replication is continuous on the leading strand and discontinuous on the lagging strand.	Details of DNA replication differ between prokaryotes and eukaryotes. Only the prokaryotic system is expected.
7.1.U5	DNA replication is carried out by a complex system of enzymes.	The proteins and enzymes involved in DNA replication should include helicase, DNA gyrase, single strand binding proteins, DNA primase and DNA polymerases I and III.
7.1.U6	Some regions of DNA do not code for proteins but have other important functions.	The regions of DNA that do not code for proteins should be limited to regulators of gene expression, introns, telomeres and genes for tRNAs.
7.1.A1	Rosalind Franklin's and Maurice Wilkins' investigation of DNA structure by X-ray diffraction.	
7.1.A2	Use of nucleotides containing dideoxyribonucleic acid to stop DNA replication in preparation of samples for base sequencing.	
7.1.A3	Tandem repeats are used in DNA profiling.	
7.1.S1	Analysis of results of the Hershey and Chase experiment providing evidence that DNA is the genetic material.	
7.1.S2	Utilization of molecular visualization software to analyse the association between protein and DNA within a nucleosome.	

Recommended resources:

<http://bioknowledgy.weebly.com/71-dna-structure-and-replication.html>

Allott, Andrew. *Biology: Course Companion*. S.I.: Oxford UP, 2014. Print.



7.1.S1 Analysis of results of the Hershey and Chase experiment providing evidence that DNA is the genetic material.

Use one or more of the animations to learn about the Hersey-Chase experiment:

- [The Hershey-Chase experiment](#) by Norton books
- [Hershey and Chase experiment](#) by McGraw and Hill
- [Bacteriophage studies](#) by UC Davis

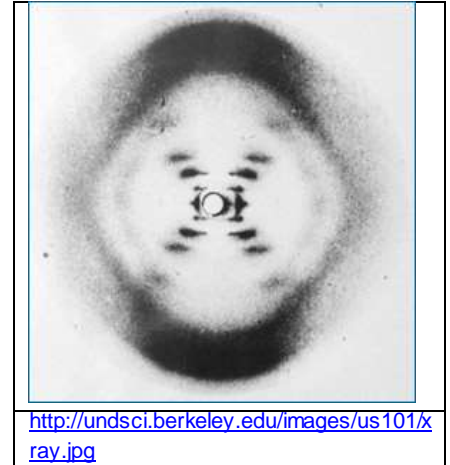
1. Explain why was sulphur used in one experiment and phosphorus in the other.
2. Describe what the supernatant is.
3. In both experiments state what separates into the supernatant and the pellet and explain why.
4. Explain why most of the radioactive sulphur (^{35}S) was found in the supernatant.
5. Explain why little of the radioactive phosphorous (^{32}P) was found in the supernatant, i.e. most remained in the pellet.



7.1.A1 Rosalind Franklin's and Maurice Wilkins' investigation of DNA structure by X-ray diffraction.

When X-rays are directed at a material some is scattered by the material. This scattering is known as diffraction. For X-ray diffraction to work well the material ideally should be crystallised so that the repeating pattern causes diffraction to occur in a regular way. DNA cannot be crystallised but the molecules were arranged regularly enough for the technique to work.

6. Use the animation (<http://www.dnalc.org/view/15874-Franklin-s-X-ray.html>) to understand how to interpret the Rosalind Franklin's and Maurice Wilkins' X-ray diffraction photographs of DNA. To the right is an example of a X-ray diffraction photograph of DNA.



n.b. Your answers to the questions below may well be helped by diagrams.

- a. What can be deduced from the X-shaped pattern?
- b. What deduction can be made about the regular nature of the pattern?
- c. The vertical distance between the horizontal bars is a measure of what feature of the DNA helix
- d. The distance from the middle of the image to the top measure what feature of the DNA molecule?
- e. What can be deduced given the answers to c and d?

- f. What can be deduced from the angle between the horizontal axis and the arms of X-shaped pattern?
- g. From their images what deduction did Franklin make about the positions of molecular units within the helical structure?

Nature of Science: Making careful observations—Rosalind Franklin's X-ray diffraction provided crucial evidence that DNA is a double helix. (1.8)

Rosalind Franklin's careful observation and interpretation of the photographic evidence was crucial to Crick's and Watson's successful discovery of the structure of DNA. Her work and her calculations were shown to Crick and Watson without her permission and they subsequently published their model before she had an opportunity to publish her work. Her work is now widely recognised as being as important to the discovery of DNA as Crick and Watson, but unfortunately she has never shared in the Nobel prize awarded to Crick and Watson as Nobel prizes cannot be given posthumously (Franklin died in 1958 aged just 37).

7.1.U2 DNA structure suggested a mechanism for DNA replication.

7. Mechanisms for DNA replication are implied by the presence of complementary base pairing in DNA. Explain why it is only possible for cytosine to pair with guanine and adenine to pair with thymine.



c. Outline how nucleosomes help regulate transcription.

d. State the part of the cell cycle in which the most DNA would be supercoiled.

7.1.S2 Utilization of molecular visualization software to analyse the association between protein and DNA within a nucleosome.

11. Use the RCSB Protein Bank to read about nucleosomes and examine Jmol images of them.

Article on nucleosomes: <http://www.rcsb.org/pdb/101/motm.do?momID=7>

Jmol visualisation of a nucleosome: <http://www.rcsb.org/pdb/explore/jmol.do?structureId=1AOI&biNumber=1>

- a. Identify the two copies of each histone protein. This can be done by locating the 'tail of each protein'. The tails of the proteins are involved in regulating gene expression.
- b. Suggest how the positive charges help to form the nucleosome with the negatively charged DNA molecule.

7.1.U3 DNA polymerases can only add nucleotides to the 3' end of a primer.

12. Outline what a primer is and the role it has in DNA Replication.

13. In which direction does DNA polymerase move along the template strand? What implication does this have for the addition of bases on the growing strand?



7.1.U4 DNA replication is continuous on the leading strand and discontinuous on the lagging strand.

7.1.U5 DNA replication is carried out by a complex system of enzymes.

14. Explain the process of DNA Replication (focusing on prokaryotes):

- a. Distinguish between the lead strand and the lagging strand.

- b. Explain the process of DNA replication on the lagging strand, with reference to DNA primase, RNA primers, DNA gyrase, single strand binding proteins, DNA polymerase III, Okazaki fragments, DNA polymerase I and DNA ligase.



c. Summarise the roles of the enzymes of DNA Replication:

Enzyme	Function
DNA Gyrase (aka topoisomerase)	
DNA Helicase	
DNA Polymerase III	
RNA Primase	
DNA Polymerase I	
DNA Ligase	

15. Some biochemists are making a mixture of enzymes for DNA replication in the lab. In each of these cases, something was missing from the mixture. For each situation, deduce which one enzyme was missing, with a reason:

a. The DNA produced came out as lots of short sections of DNA, a few hundred base-pairs long, rather than one continuous strand.

b. Only the lead strand was replicated.

c. No DNA was replicated. The original DNA remained untouched.



7.1.U6 Some regions of DNA do not code for proteins but have other important functions.

16. Distinguish between coding and non-coding regions of DNA.

17. Outline how non-coding regions can be involved in gene expression.

18. Most of the eukaryotic genome is non-coding. There are two types of repetitive sequences: moderately repetitive sequences and highly repetitive sequences otherwise known as satellite DNA. Give an example of a region of DNA that contains highly repetitive sequences and outline the function of that region.

7.1.A2 Use of nucleotides containing dideoxyribonucleic acid to stop DNA replication in preparation of samples for base sequencing.

19. State how dideoxyribonucleic acid affect DNA replication.

20. State what is attached to dideoxyribonucleic acid during base sequencing.

21. Outline how do the answers to the above two questions enable scientists to identify the base sequence of DNA.



7.1.A3 Tandem repeats are used in DNA profiling.

22. State the two different sources of DNA used in paternal and maternal profiling.

23. Suggest a reason why non-coding regions are more useful than coding regions in DNA profiling.

24. Describe what is meant by the term tandem repeat sequence.

25. Describe why tandem repeats are useful in DNA profiling.

26. Explain how tandem repeats are used in DNA profiling.

Citations:

Allott, Andrew. *Biology: Course Companion*. S.I.: Oxford UP, 2014. Print.

Taylor, Stephen. "Essential Biology 03.3 07.1 DNA Structure.docx." Web. 1 Oct. 2014.
<<http://www.slideshare.net/gurustip/essential-biology-33-71-dna-structure-core-ahl>>.

Taylor, Stephen. "Essential Biology 03.4 07.2 DNA Replication.docx." Web. 1 Oct. 2014.
<<http://www.slideshare.net/gurustip/essential-biology-34-72-dna-replication-core-ahl>>.

