Topic 7: Nucleic acids -- 4 lessons, once a week

7.1 DNA structure and replication Essential idea: The structure of DNA is ideally suited to its function.
7.1 Nature of science:
Making careful observations—Rosalind Franklin's X-ray diffraction provided crucial evidence that DNA is a double helix. (1.8)
7.1 Understandings:
* Nucleosomes help to supercoil the DNA.
* DNA structure suggested a mechanism for DNA replication.
* DNA polymerases can only add nucleotides to the 3' end of a primer.
* DNA replication is continuous on the leading strand and discontinuous on the lagging strand.
* DNA replication is carried out by a complex system of enzymes.
* Some regions of DNA do not code for proteins but have other important functions.
7.1 Applications and skills:
* Application: Rosalind Franklin's and Maurice Wilkins' investigation of DNA structure by X-ray diffraction.
* Application: Use of nucleotides containing dideoxyribonucleic acid to stop DNA replication in preparation of samples for base sequencing.
* Application: Tandem repeats are used in DNA profiling.
* Skill: Analysis of results of the Hershey and Chase experiment providing evidence that DNA is the genetic material.
* Skill: Utilization of molecular visualization software to analyse the association between protein and DNA within a nucleosome.
7.1 Theory of knowledge:
* Highly repetitive sequences were once classified as "junk DNA" showing a degree of confidence that it had no role. To what extent do the labels and categories used in the pursuit of knowledge affect the knowledge we obtain*
7.1 Syllabus and cross-curricular links:
Topic 2.6 Structure of DNA and RNA
7.1 Aims:
* Aim 6: Students could design models to illustrate the stages of DNA replication.
7.1 DNA structure and replication Guidance:
* Details of DNA replication differ between prokaryotes and eukaryotes. Only the prokaryotic system is expected. * 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.
* The regions of DNA that do not code for proteins should be limited to regulators of gene expression, introns, telomeres and genes for tRNAs.

NOS idea connected with the TOK idea related to the recent discovery that the "junk DNA" hypothesis was false: just because we do not understand what the function of something is does not mean there is no function.

PPTs:
02 DNA Replication.pptx
02 Transcription &Translation.pptx

HL Students were introduced to the process of investigation. Use of a google web-search gave some perspectives on this scientific questions, and notes were made about how to distinguish the usefulness of the references (Step 1: is there a date and author? Step 2: is it an academic article published in a peer-reviewed journal which makes reference to research?), and how to reference (author, date).
Examples looked at included:

- https://www.scientificamerican.com/article/what-is-known-about-the-f/
- https://www.news-medical.net/life-sciences/What-are-introns-and-exons.aspx
- https://www.advancedsciencenews.com/that-junk-dna-is-full-of-information/
- https://www.scientificamerican.com/article/hidden-treasures-in-junk-dna/
- https://www.frontiersin.org/articles/10.3389/fgene.2012.00055/full

7.1 TOK Research Task:
Find references to support the idea that introns and other non-protein-coding genes are junk. Or find references to support the idea that introns or non-protein-coding genes have a function. Proper citations are required: Author, Date, Title, Website (since your research will probably be online), and DOI (if you can find one). Record step-by-step (keep track of and describe) the method you used to find the research including search engine used, keywords used, which materials you decided not to use and why, and why you chose to use the references you selected.

Topic 7: Nucleic acids
7.2 Transcription and gene expression Essential idea: Information stored as a code in DNA is copied onto mRNA.
7.2 Nature of science:
Looking for patterns, trends and discrepancies—there is mounting evidence that the environment can trigger heritable changes in epigenetic factors. (3.1)
7.2 Understandings:
* Transcription occurs in a 5’ to 3’ direction.
* Nucleosomes help to regulate transcription in eukaryotes.
* Eukaryotic cells modify mRNA after transcription.
* Splicing of mRNA increases the number of different proteins an organism can produce.
* Gene expression is regulated by proteins that bind to specific base sequences in DNA.
* The environment of a cell and of an organism has an impact on gene expression.
7.2 Application and skills:
* Application: The promoter as an example of non-coding DNA with a function.
* Skill: Analysis of changes in the DNA methylation patterns.
7.2 Guidance:
* RNA polymerase adds the 5′ end of the free RNA nucleotide to the 3′ end of the growing mRNA molecule.
7.2 Theory of knowledge:
* The nature versus nurture debate concerning the relative importance of an individual’s innate qualities versus those acquired through experiences is still under discussion. Is it important for science to attempt to answer this question?
7.2 Syllabus and cross-curricular links:
Topic 2.7 DNA replication, transcription and translation

PPTs:

02 DNA Replication.pptx
02 Transcription &Translation.pptx

7.2 TOK Research Task:
Describe how epigenetics contributes to the nature (genes) versus nurture (environment) debate. Make reference to the material found in 7.2.4 and the suggested article https://www.aaas.org/shifting-genetic-paradigm-epigenetics.

Topic 7: Nucleic acids
7.3 Essential idea: Information transferred from DNA to mRNA is translated into an amino acid sequence.
7.3 Translation Nature of science: Developments in scientific research follow improvements in computing—the use of computers has enabled scientists to make advances in bioinformatics applications such as locating genes within genomes and identifying conserved sequences. (3.7)
7.3 Understandings:
* Initiation of translation involves assembly of the components that carry out the process.
* Synthesis of the polypeptide involves a repeated cycle of events.
* Disassembly of the components follows termination of translation. * Free ribosomes synthesize proteins for use primarily within the cell.
* Bound ribosomes synthesize proteins primarily for secretion or for use in lysosomes.
* Translation can occur immediately after transcription in prokaryotes due to the absence of a nuclear membrane. * The sequence and number of amino acids in the polypeptide is the primary structure.
* The secondary structure is the formation of alpha helices and beta pleated sheets stabilized by hydrogen bonding.
* The tertiary structure is the further folding of the polypeptide stabilized by interactions between R groups.
* The quaternary structure exists in proteins with more than one polypeptide chain.
7.3 Application and skills:
* Application: tRNA-activating enzymes illustrate enzyme–substrate specificity and the role of phosphorylation.
* Skill: Identification of polysomes in electron micrographs of prokaryotes and eukaryotes.
7.3 Syllabus and cross-curricular links:
Topic 2.7 DNA replication, transcription and translation
Option B: Biotechnology and bioinformatics
7.3 Translation
* Skill: The use of molecular visualization software to analyse the structure of eukaryotic ribosomes and a tRNA molecule.
Guidance:
* Names of the tRNA binding sites are expected as well as their roles.
* Examples of start and stop codons are not required.
* Polar and non-polar amino acids are relevant to the bonds formed between R groups.
* Quaternary structure may involve the binding of a prosthetic group to form a conjugated protein.

Student was not able to attend the final class, and the expectation that this topic be finished was clear.
Remaining students - including SL students - were invited to class and had time to review in class.

Additional resources:

- https://i-biology.net/ahl/07-nucleic-acids-and-proteins/
- http://www.ncbi.nlm.nih.gov/genome
- http://www.ncbi.nlm.nih.gov/genbank
- http://www.ebi.ac.uk

* Student performance on IB Exam-Style (past paper) Topic 7 questions was (38% - the student who had studied it before got 64%, the one who transferred into Biology HL late got 12%).

* Topic 7 Tests were returned to students with corrections and page number references relevant to written answers provided.

* Students did not complete any of the inquiry-based TOK homework.
Students admitted that their previous teacher had never looked at a TOK connection with them.
Perhaps the importance of TOK and of engaging in inquiry needs to be emphasized, or perhaps they need to be invited to create their own TOK investigation questions?

* I tried to inspire students with these TOK assignments and to help develop ATL skills such as research through modeling, but I feel like I might have to simply assign more Kognity questions if students do not feel compelled to engage in these activities.

* The suggestion on the table to encourage student-engagement, foster student ownership of, and let them take responsibility for their own learning, is to ask students how they want to learn.