



Dr Sarah Mizielska

Module:

Biological Foundations of Mental Health

Week 1:

Introduction to brain anatomy

Topic 3:

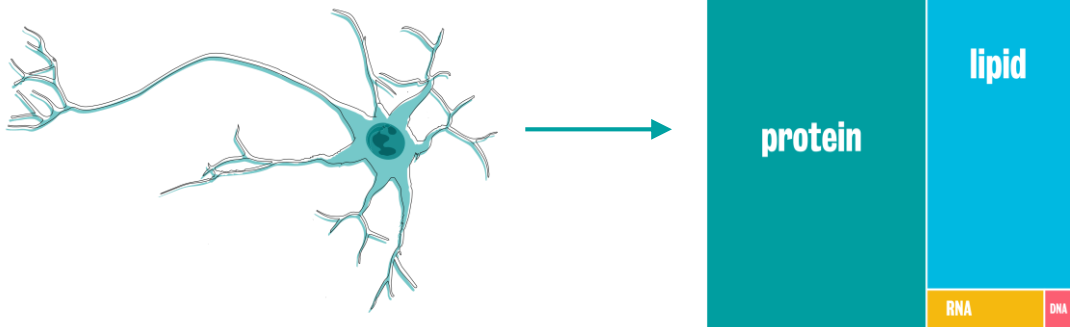
Microanatomy of the nervous system

Part 3 of 3

Part 3

Gene expression

Chemical composition of a neuron



A high protein content means that the neuron's ability to renew protein content is essential for maintaining cell health and allowing **plasticity**.

↳ the key ability of neurons to adapt to stimuli

Protein renewal can occur through **protein synthesis** or **protein recycling**.

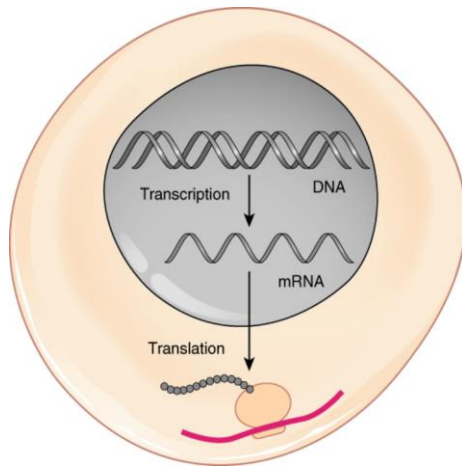
Gene expression and protein synthesis

Gene expression – the process by which a gene (DNA) is used to synthesis the product it encodes

↳ Mostly protein, but also includes functional RNAs, such as transfer RNA (tRNA) and ribosomal RNA (rRNA)

Protein synthesis – how gene expression generates new protein from the genetic code

Gene expression and protein synthesis

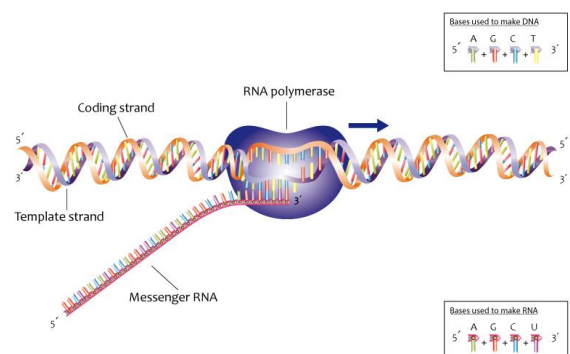


Transcription – photocopying DNA into messenger RNA (mRNA)

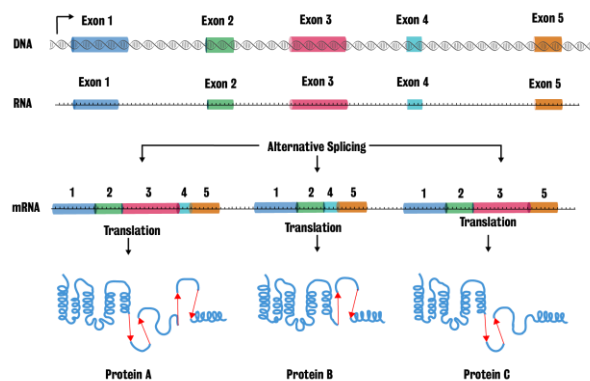
Translation – the literal translation of the genetic code on the mRNA photocopy into protein

Transcription

- RNA polymerase enzyme copies DNA code (A, G, C, T) into mRNA (A, G, C, U).
- DNA structure is normally condensed, and must be relaxed so the transcription factors can bind and initiate transcription.
- Epigenetics, eg DNA methylation, can control whether DNA structure can be relaxed.



RNA splicing – processing prior to translation



- messenger RNA contains both coding (exons) and non-coding regions (introns)
- the splicing machinery cuts out introns
- the resultant mature RNA (also called mRNA) contains only protein-coding regions

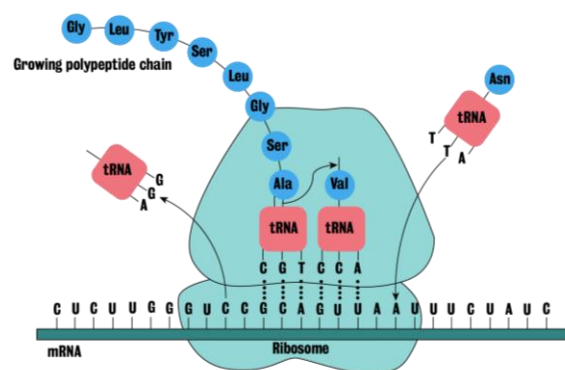
Alternative splicing can produce different proteins from a single messenger RNA

- mature RNA is then exported from the nucleus to the cytoplasm for translation into protein

Gene expression is often assessed at the mature RNA level by **RNA sequencing**.

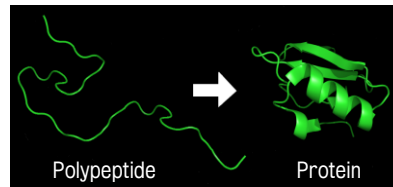
Translation

- ribosomes translate RNA → protein
- 3 base-pair code = **1 amino acid** (ATG = start)
- **transfer RNA (tRNA)** brings amino acids into the ribosome where they are bound together to form a polypeptide chain (= protein)



Though translation normally occurs close to the nucleus, it can also occur far away at sites with high protein demand, such as synapses. This is called **local translation**.

Protein processing and folding



- **protein folding** occurs as soon as a protein is made
- folding undergoes quality control to ensure it is correct: misfolded proteins → degradation
- post-translational modification of proteins can modulate their folding and function (eg phosphorylation)

Protein misfolding and accumulation is a major cause of neurodegenerative disease.

This is increase in disease due to: genetic mutations, cellular stress and impairment of protein clearance.

Topic summary

Part 1

The nervous system is comprised of neurons and glia which come in many different forms with specific functions.

Part 2

Neurons and glia have specialised morphologies which enable them to carry out their function.

Neurons share many substructures with a standard eukaryotic cells, but also have unique features and demands.

Part 3

Gene expression and protein synthesis are critical processes for cell renewal and occur via highly regulated sub-steps.

Figures

Slide 4

Tree diagram – Mizielska

Slide 6

https://commons.wikimedia.org/wiki/File:0328_Transcription-translation_Summary.jpg

Slide 7

[https://commons.wikimedia.org/wiki/File:Process_of_transcription_\(13080846733\).jpg](https://commons.wikimedia.org/wiki/File:Process_of_transcription_(13080846733).jpg)

Slide 8 (redrawn)

https://commons.wikimedia.org/wiki/File:DNA_alternative_splicing.gif

Slide 9 (redrawn)

<https://www.humbleisd.net/cms/lib/TX01001414/Centricity/Domain/9505/translation%202.jpg>

Slide 10

https://commons.wikimedia.org/wiki/File:Protein_folding.png

References

Recommended textbook:

The Neuron: Cell and Molecular Biology by Irwin B. Levitan and Leonard K. Kaczmarek – available online via King's library services

References

Further reading on astrocytes:

Santello, M., Toni, N., & Volterra, A. (2019). Astrocyte function from information processing to cognition and cognitive impairment. *Nature neuroscience*, 1.

Further reading on microglia:

Lannes, N., Eppler, E., Etemad S., Yotovskii, P., & Filgueira, L. (2017). Microglia at center stage: a comprehensive review about the versatile and unique residential macrophages of the central nervous system. *Oncotarget*, 8(69), 114393.

End of topic