Brain and Action

SCI2034

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Brain and Action

Problems

Course coordinator

Manuela Heins, University College Maastricht, room 1.020; Tel. 043-3885477; e-mail manuela.heins@maastrichtuniversity.nl

Introduction

The present course deals with the human nervous system and its relation to what we see, hear, feel, and do. The focus lies on the central nervous system, i.e. anatomy and function of the brain mainly. In order to get a full understanding of human nature and behaviour, (basic) knowledge of the central nervous system and its workings are considered to be essential. Human beings mostly go through their lives without paying much attention to what they do and how they do it. For example, we breathe, eat and learn without real conscious effort and are not aware of how our nervous system controls these actions. Our brains seem to take care of us in an almost effortless way by planning, initiating and executing our actions and by regulating our somatic homeostasis. The course *Brain and Action* is concerned with exactly how the nervous system does so. The course deals with the scientific study of the central and peripheral nervous system as well as with some of the latest developments in neuroscience.

The course material is divided into eleven topics. The first five are aimed at getting students acquainted with the basic anatomy, location and functions of the brain and its structures/ cells. The latter six cover the functions of these structures/ cells in more detail.

- **Living with an 'old' brain in a 'new' world**:

Students are encouraged to keep in mind that from an evolutionary perspective our brains adapted to a rather different environment than the modern one we are currently living in. So for some of the eleven topics covered in the current course students will also read some research articles on the (sometimes negative) effects that our current modern lifestyles (e.g. using smartphones, artificial light exposure long after dark, listening to music via headphones) have on our nervous system. However, to end with a positive note the readings also give suggestions how to counteract some of the negative effects.

After this course, students should:

- Be familiar with the basic division, anatomy and functions of the central and peripheral nervous system
- Have knowledge of the workings and anatomy of the brain's most important structures
- Have knowledge of the basic neurochemistry and neurophysiology
- Have acquired basic knowledge of methods to explore the brain
- Have basic understanding of the impact society and its technological advances have on our evolutionary 'old' brains
- Have basic practical knowledge of brain dissection

Set-up of the course

The course consists of two parts: 1) studying the anatomy and functions of the human nervous system using Problem-Based Learning (PBL) and 2) studying the anatomy and functions of the brain via a sheep brain anatomy practical.

- **Problems and Tutorials**

Even the basic anatomy human nervous system and all its functions involves much more than can be studied in a single seven-week course. Therefore, only the relatively more important brain structures and their relation to human behaviour are covered in the current course. Furthermore, since this course is taught a PBL-format, problems differ in the emphasis they put on certain structures or functions. Your tutor will intervene if your learning objectives do not cover the area intended by the problem in question. Note that this precludes a tempting solution for formulating learning objectives: it often happens that tutorial groups come up with the obvious question of 'How do we..?' It should be clear that using this question as learning objectives may in most cases simply be too general. It does not help you focus on those parts of the literature that are most relevant for a certain topic. General learning objectives will turn out to be a problem when selecting the appropriate chapters and pages for self-study. Of course (one of) those two questions might serve as problem statement for the brainstorm in your group. But remember; if you want to ask these kinds of questions, use them as a starting point but not as the conclusion of the first discussion of a problem.

- **Literature study**

As is common practice in PBL, the learning objectives emerging from the group discussion should give rise to literature study. The next question is where to find relevant sources of information. Note that even though in this course we do use a basic textbook, it is always wise to review another source as well to get a full overview of the topics that are discussed during this course. Even though page numbers are given for the relevant chapters, do not attempt to study all the information that is given by heart in those pages, instead use the learning objectives and concept list offered in this manual's appendix as guidelines for what to study. Do not be afraid to skip some paragraphs or pages if need be.

The paper and practical

- **The literature research paper: boxes of special interest**

Next to taking an exam, you also have to write a paper on a topic of choice. If you are having difficulties finding one, there are several nice topics in the 'of special interest boxes' in the book *Neuroscience, exploring the brain* by Bear, Connor, and Paradiso (2016). The boxes contain rather specific topics and sometimes are a bit too detailed in the way the topic is described. Your paper may of course be much less specific and look at the topic in a more general fashion. For example, Box 8.3 on page 279 is about human pheromones or at least the question whether or not we have or use them like animals do. You may stray from the topic by e.g. looking at pheromones and love or more generally look at pheromones in general in animals. Important is that once you have chosen a box that interests you (a short list of the boxes can be found on pages xli-xlii and in more detail in the expanded contents pages xxv-xl) you need to not only read the relevant literature for that topic

that is listed in this course manual, but you also have to find some additional literature on this topic (http://www.maastrichtuniversity.nl/web/Library/home.htm). Keep in mind that it will only be a very short paper, so do not use more than 3-5 sources and make sure they fit your level of expertise; if page one already contains more than 10 words that seem like Latin (because they probably are) and therefore unintelligible, stop reading and find a nicer, less technical source on the topic. Writing the paper should be a fun way of finding out about an interesting phenomenon, not the source of stress or displeasure.

- **Criteria for the paper**

The paper should:

- Be between 2000 and 2200 words (this does not include title page, appendices, reference list etc.).
- Be in a research format, so contain one central research question and an overview of how the question is answered in the introduction, answer(s) to the research question should mainly be based on recent articles (2009 and up) and a conclusion.
- Have an APA style reference list.
- Be handed in before Friday December 15nd 2017, 18:00 hours (via safe assignment, no hardcopy needed).

- **The practical**

The practical consists of one session of sheep brain dissection. You will be working in pairs identifying the brain structures that you learned about in the first weeks of the course in a sheep brain. More information is made available through a sheep brain dissection manual that can be found on Eleum. Practical attendance is 100%: missing the practical means you have failed the course.

Attendance and Grading

The current course is taught in a PBL format, so an 85% tutorial attendance rate is required to pass the course. This means that you can miss 2 of the 12 tutorial meetings without it having any negative consequences for your attendance requirement. Keep in mind that you are still advised to attend all meetings. If you miss 3 meetings you can ask for an additional assignment by emailing the coordinator to make up for failing attendance. If you miss more than 3 meetings you will fail the current course with no chance of making up for failed attendance. There are three moments of assessment during this course:

1. There is an exam at the end of the course. This exam consists of 7 - 11 open-ended questions (on the literature as well as the lectures!) and will be graded on a 0 -10 scale.
2. You will write a research paper on a topic of choice.
3. During the practical attendance and participation is graded as pass/ fail.

The final grade is a weighted average of the exam grade (65%) and the literature research paper (35%). The practical is pass/ fail. If your final grade is 5.4 or below, you may be eligible for a resit exam.

You are eligible to resit if the following requirements are met:

- Your final grade is 5.4 or below
- Your exam and paper are considered a valid attempt[1]
- You passed attendance

There is one general written resit that covers the exam. If the paper is a fail, a new paper can be written on a new topic.

Course overview per week

Week	Monday/Tuesday	Thursday
1 30/10-03/11	**Opening lecture** by M. Heins Pre-discussion problem 1	Post-discussion problem 1 Pre-discussion problem 2
2 06/11-10/11	**Lecture** 'Neurons and transmission' by M. Heins Post-discussion problem 2 Pre-discussion problem 3	Post-discussion problem 3 Pre-discussion problem 4
3 13/11-17/11	**Lecture** 'Methods in behavioural neuroscience' by M. Capalbo Post-discussion problem 4 Pre-discussion problem 5	Post-discussion problem 5 Pre-discussion problem 6
4 20/11-24/11	**No lecture: practical** Post-discussion problem 6 Pre-discussion problem 7	Post-discussion problem 7 Pre-discussion problem 8
5 27/11-01/12	**Lecture** 'Eating and drinking' by M. Heins Post-discussion problem 8 Pre-discussion problem 9	Post-discussion problem 9 Pre-discussion problem 10
6 04/12-08/12	**Lecture** 'The neurobiology of sleep' by M. Heins Post-discussion problem 10 Pre-discussion problem 11	Post-discussion problem 11
7 11/12-15/12	Date/ time exam t.b.a.	

[1] The person who grades the exam and paper decides if they are valid attempts.

Problems

Problem 1: The nervous system I

"He who joyfully marches to music in rank and file has already earned my contempt. He has been given a large brain by mistake, since for him the spinal cord would suffice" Albert Einstein

A.

A puzzle of anatomy and function.

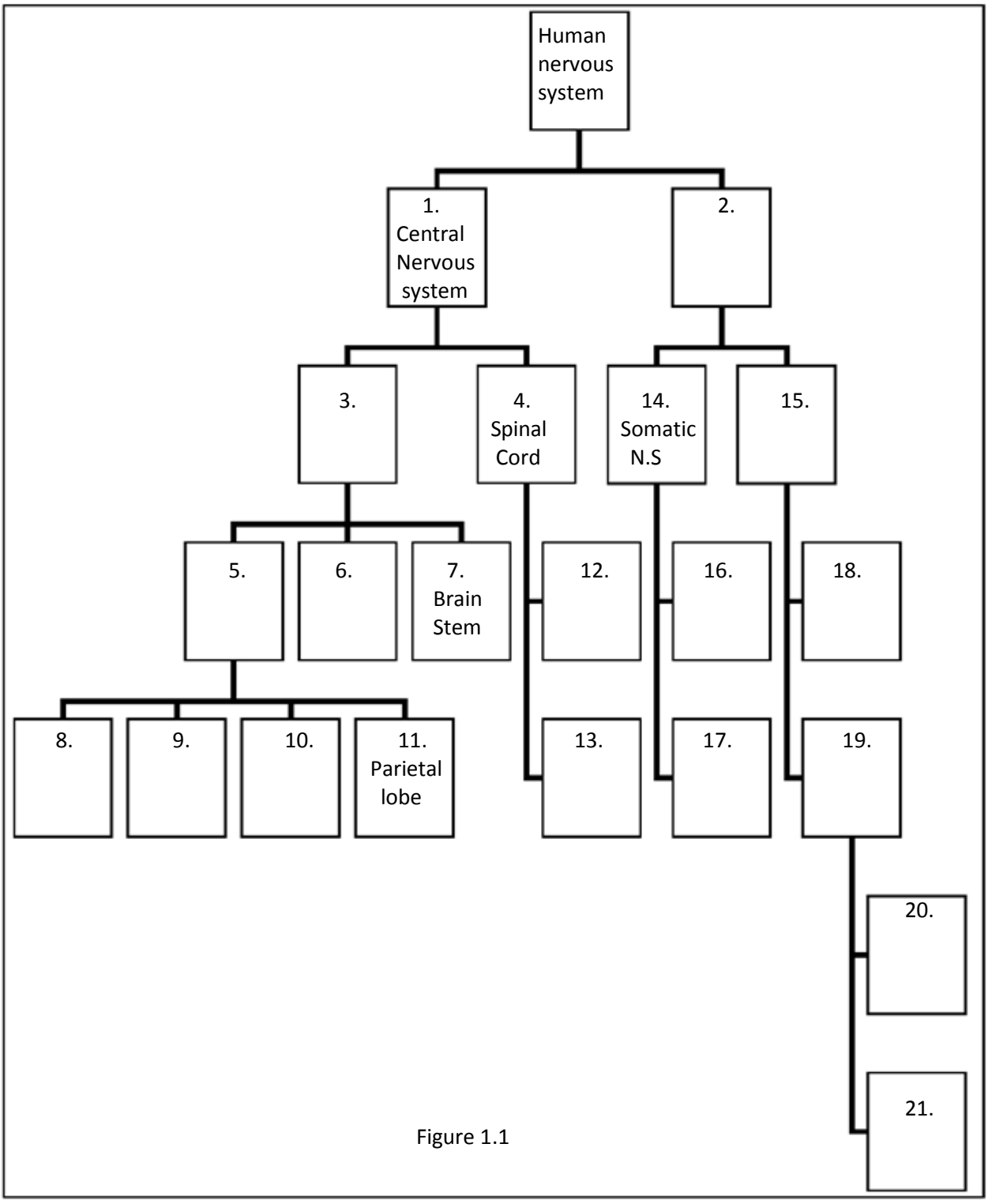
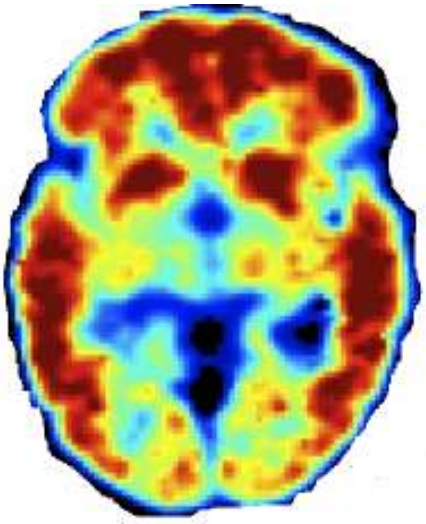


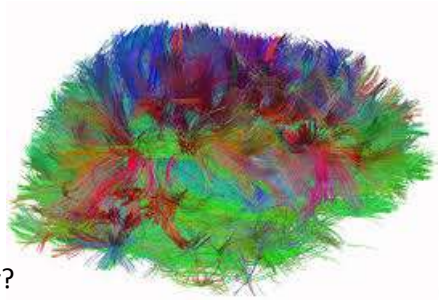
Figure 1.1

B.

In order to measure structure or activity (or perhaps both) in the brain scientists have a choice of very different measurement tools. Obviously they don't measure or do the same thing, but some are just more invasive than others.



or?



or?

C.

Maybe even more importantly, when talking about the brain scientists need to be able to discuss parts of the brain with colleagues without having to point at the location on a picture like one of the above ones. For example, when a neurologist mentions that a patient has a tumour in his right dorsolateral pre-frontal cortex (DLPFC), her colleague might ask: "Was it visible on a horizontal, sagittal or coronal plane?"

(Note: in figure 1.2 below, 1-3 are cross-sections/ planes, 4-9 are anatomical directions)

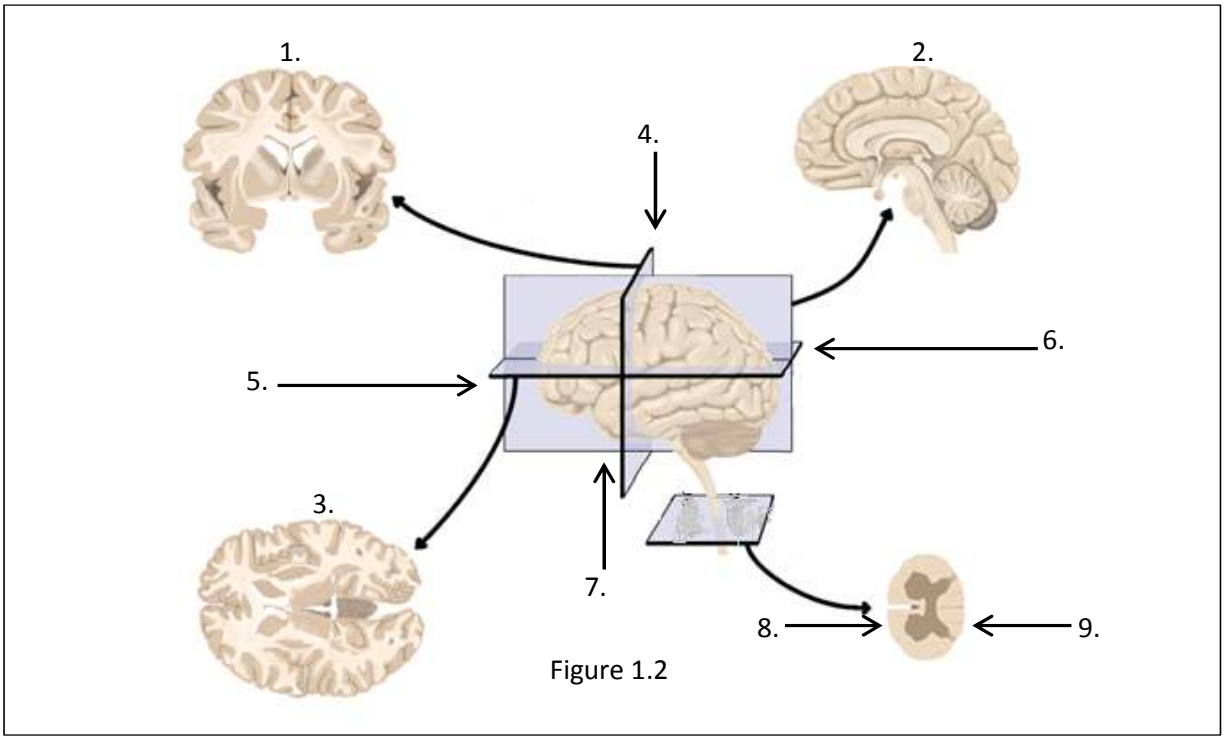


Figure 1.2

Problem 2: The nervous system II

A.

Besides the anatomical directions you just read about, neuroscientists have other ways of specifying the location of a certain brain area. As you know by now: the brain is divided into four lobes, however location in the brain can also be referred to by mention one of the five major divisions of the brain, from top to bottom:

1. Telencephalon

2.

3.

4.

5.

B.

Again with the filling-in-the-numbers? Ah, wait this time the names are given: Thalamus, hypothalamus, medulla, pons, cerebellum, pineal body, cingulate gyrus, corpus callosum, and fornix. Hmm, which one goes where?

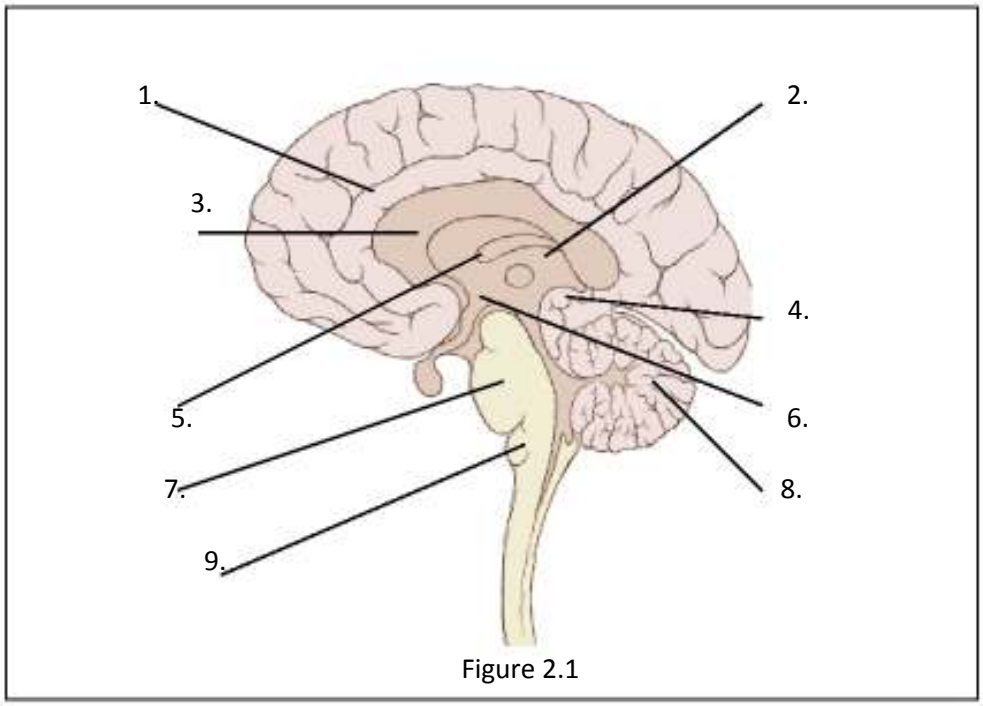


Figure 2.1

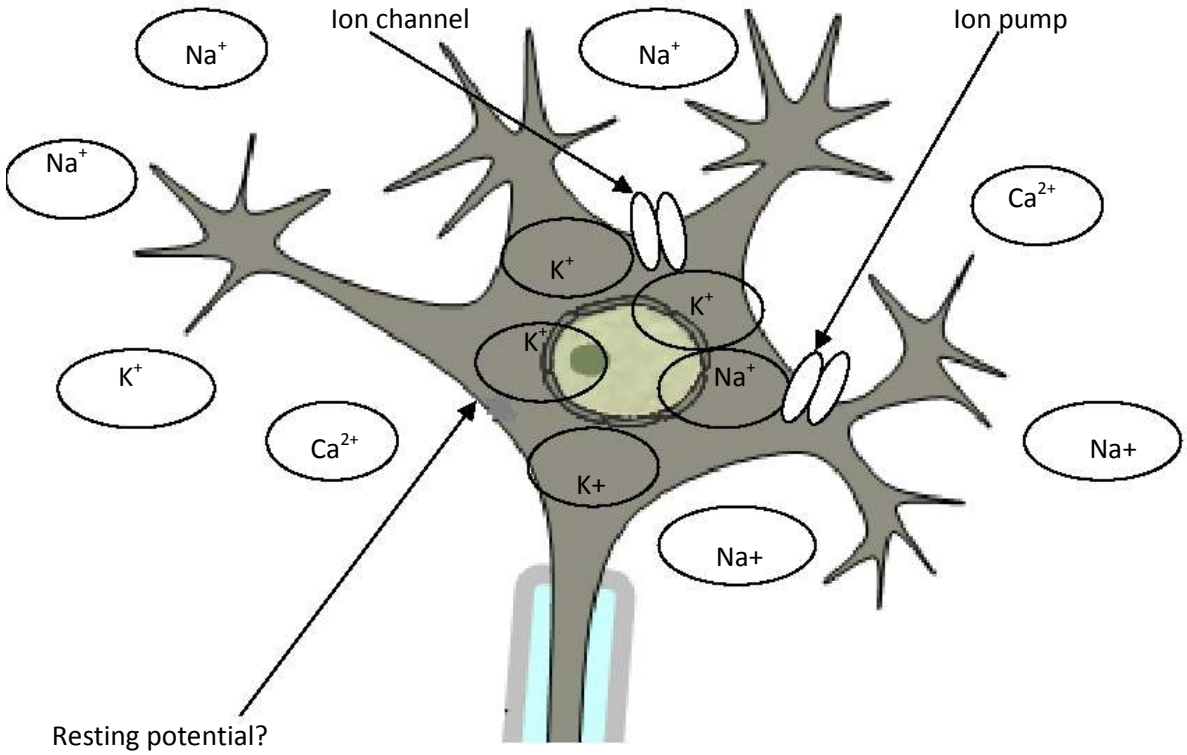
C.

Size matters?

The human brain appears to be one the relatively largest in terms of brain-to-body ration when compared to other species. Some say this is why we have better cognitive abilities than other animals.

Problem 3: Signalling I: Neurons at rest

In order for your brain to work properly, one part has to be able to communicate with the next. More specifically one neuron has to convey a message to the next and so on. But before we even go there, let's look at what a neuron does when it's 'inactive' first. Hmm that sounds rather paradoxical: 'doing' while 'inactive'? Below is a drawing of a typical neuron; focus on what is going on outside, on, and inside the neuron's membrane (Note: the ionic movements through channels are influenced by both diffusion and electricity).



One very important component of neurons that enable the resting potential is the cell's membrane. Perhaps nutrition is a great way to insure that the cell membranes will stay healthy, at least in terms of fat consumption.

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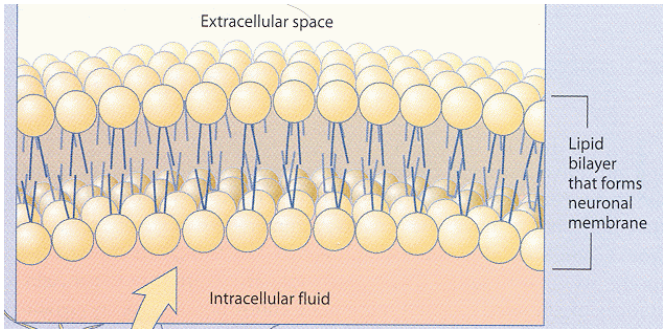


?

Problem 4: Signalling II: Neurons in action

After reading for the previous problem, you should now know that the neural membrane of an inactive neuron with respect to its outside is -65 mV. This voltage difference is very important for neurotransmission. It allows for rapid electro-chemical transmission. Wait: electro- AND chemical?

A nice piece of know-how: to prevent your brain from having to build axons as thick as thumbs, it came up with a good alternative to speed up action potential propagation down an axon: myelin.

Step 1: electrical transmission

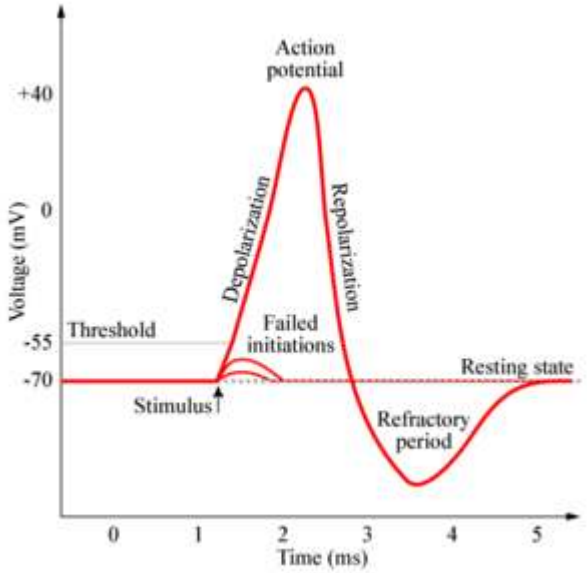


Figure 5.1 (The different phases of an action potential)

Step 2: chemical transmission

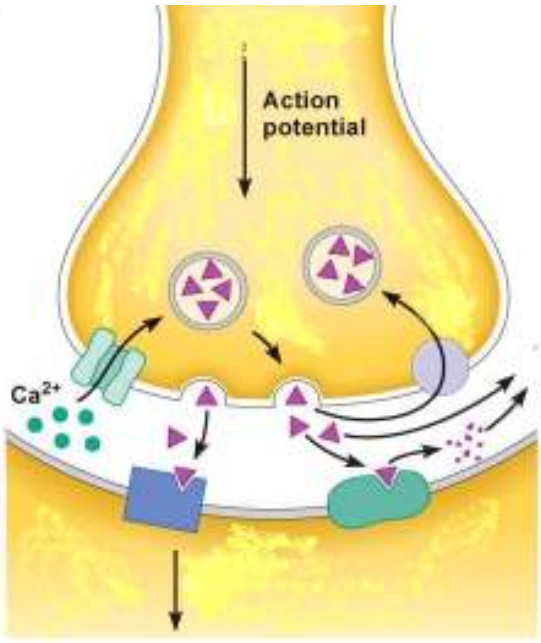


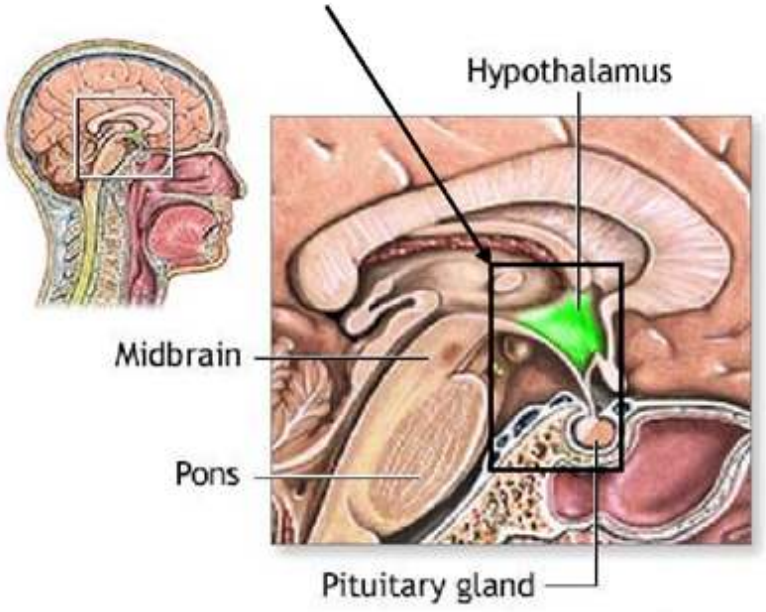
Figure 5.2 (The different phases of neurotransmission)

Problem 5: Hormones and sex

A.

Where neurotransmission is fast and short-lasting, hormonal communication is relatively slow but usually has longer lasting effects. Some are even permanent (e.g. organizational versus activational effects).

Two of the most important hormonal structures in the brain:



B.

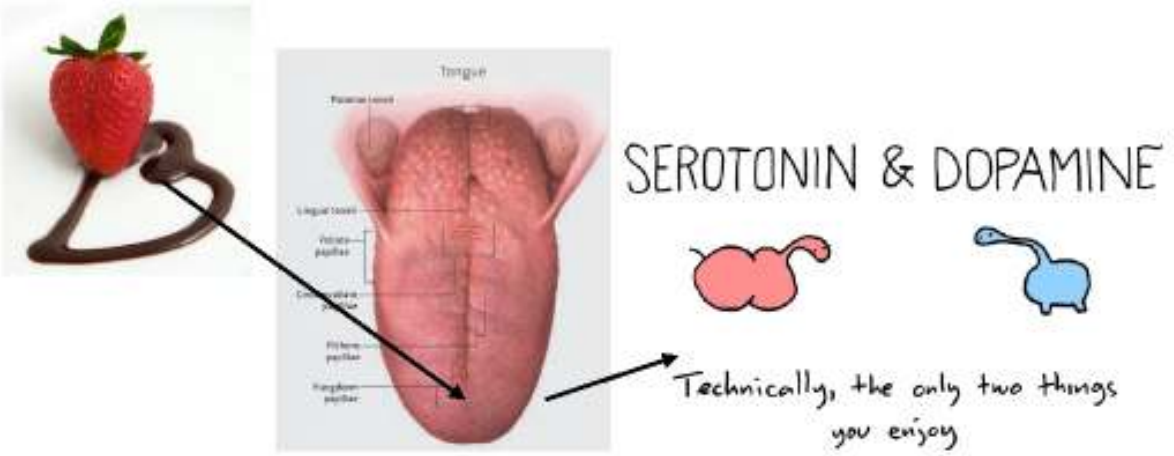
The most permanent of all hormonal effects is shaping your sex. Can you imagine that your entire bodily make-up is the result of the presence or absence of one little gene? Moreover, there is a nice interplay between bodily make-up and hormones: on the one hand hormones determine what your reproductive organs look like and on the other hand these same organs determine what hormones are secreted into your bloodstream. Like it or not, these little chemicals then in turn partly determine your sexual and reproductive behaviour. Furthermore, when considering that some of the variations found in both genetic and anatomical sex are more than just 'male' or 'female', is this idea of two sexes perhaps a bit too simplistic?

Problem 6: Taste and Eating

Some say sex is the most powerful motivator, others say food is. Others substitute one for the other (If you ever want to become a 'chocolatier': do so in a rural area with lots of singles). No matter which opinion you share: there is almost no behaviour that is more essential to the survival of the species than eating. Making (sex) hormones takes up a lot of your body's energy; it is only fair then that your hormonal system also works to regulate your eating behaviour to help restore that energy. Consider the following case of a so-called ob/ob mouse: it lacks the hormone *leptin* (Leptin comes from the Greek, meaning slender):

A game of 'Find-it': which one is the ob/ob mouse?

Another important and probably more well-known hormone that regulates food intake is *insulin*. And there are a few more even. But is that really what makes us eat?



The ‘only two things you enjoy’ unfortunately are mainly released by brains that are used to the so-called Western diet (high in saturated fat and ‘fast’ sugars, e.g. one of those yummy glossy pink doughnuts.. ohhh with the multi-coloured sprinkles on top…). We all know fat and sugar are very bad for the body (obesity, diabetes, coronary problem, increased morbidity, etc.). But did you ever stop to think that the food we have thanks to the industrial revolution may also be very bad for brain and cognition?

Problem 7: The emotional brain

A

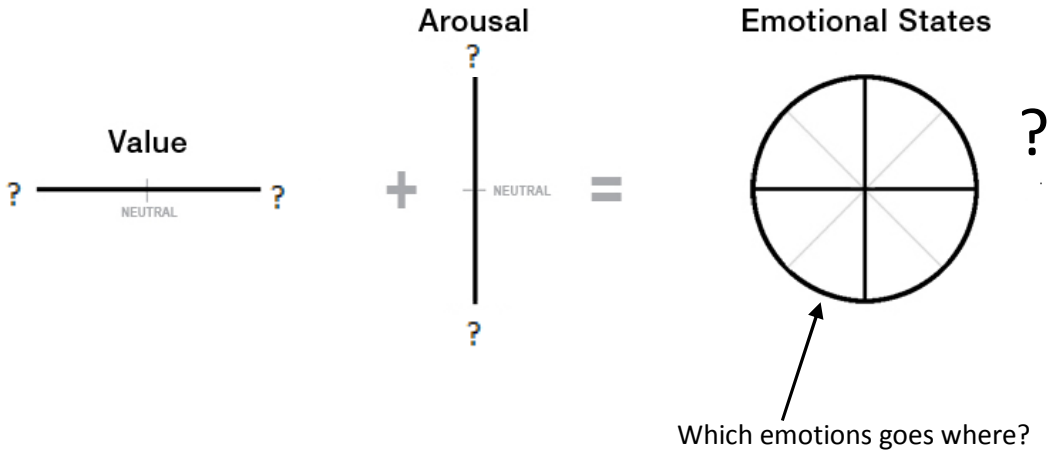
Emotions are difficult concepts in neuroscience… So difficult that there are different theories on what emotions are and what brain activity are associated with our feelings.

However most researchers agree on that at least or Limbic system seems of importance, although some say it's more accurate to refer to some parts of them as the Circuit of Papez.

B

?

or



Problem 8: The motor system

Close your eyes and touch the tip of your nose with your left index finger. Easy, isn't it? Keep in mind that in order for you to move your finger, your brain does more than just set muscles into motion. Voluntary movement involves three different levels of motor control: a high, middle, and low level. You have to plan, decide and execute. Furthermore, there are different types of muscles that have to be controlled; for now let us focus on the skeletal ones.

A.

Communication between the spinal cord and the brain is essential for any movement that you make since it's the spinal cord that actually makes your muscles move. Your brain tells your spinal cord which muscles to enervate via several descending tracts (see figure 8.1). Note: the primary motor cortex is under voluntary control.

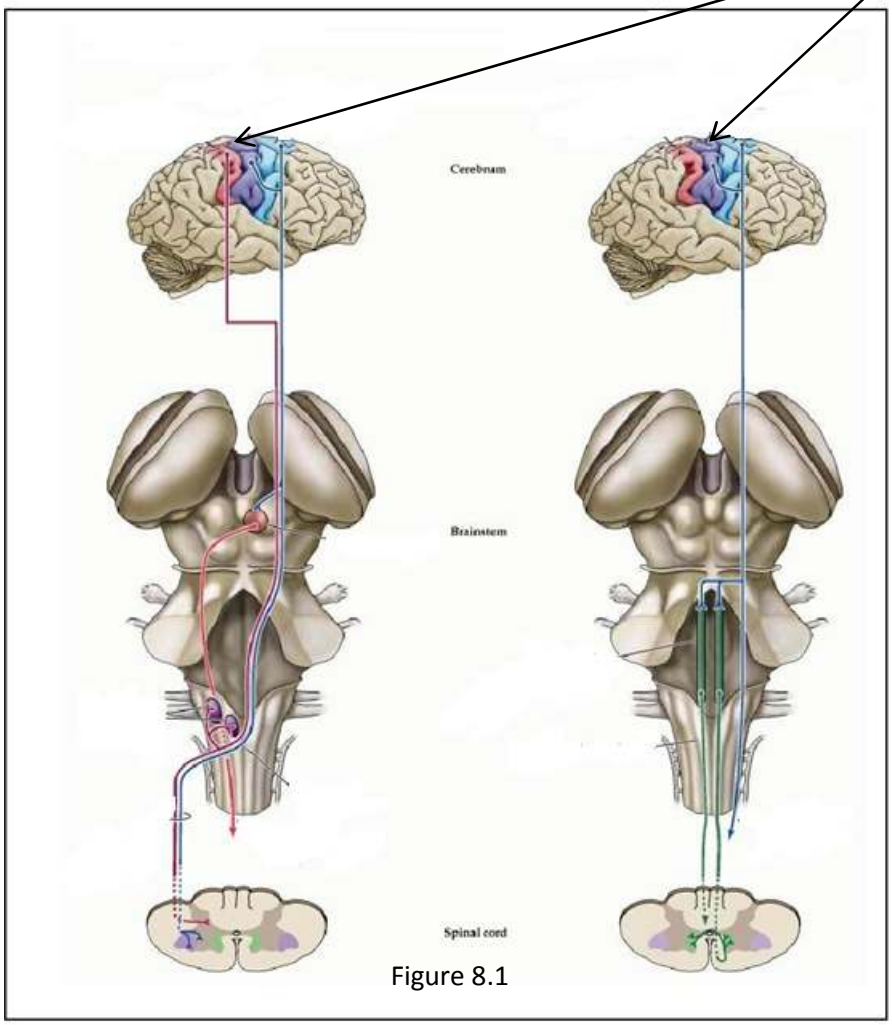
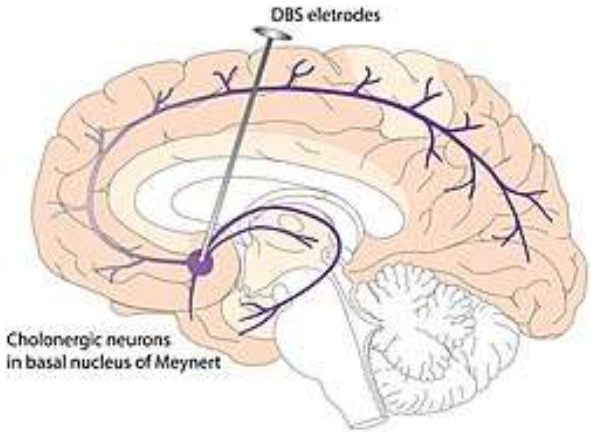
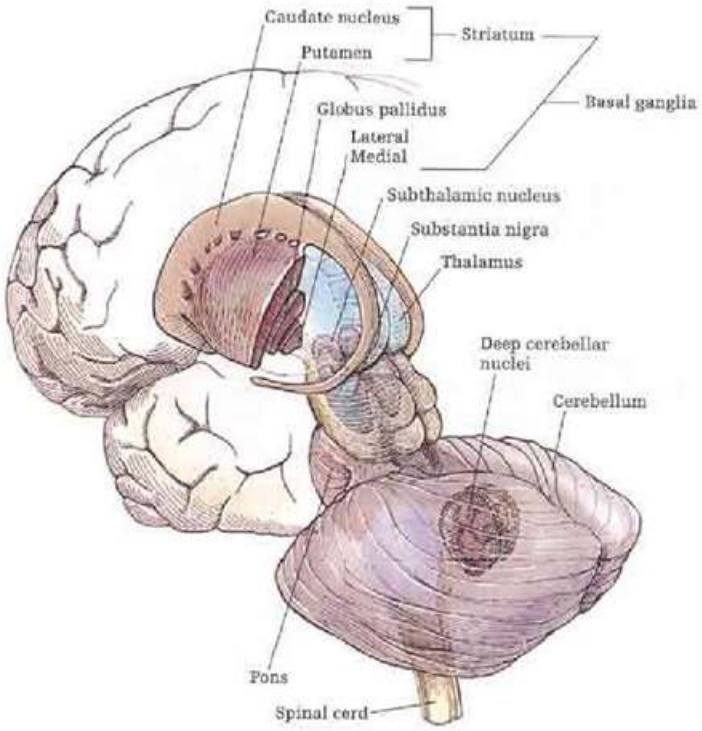


Figure 8.1

B.

Important brain structures involved in voluntary movement are the cerebellum and the basal ganglia. Especially damage to the latter are associated with movement disorders such as Parkinson's disease. Thankfully science gave us a so far rather promising way of treating these disorders: *deep brain stimulation*.





Problem 9: The visual system

"A beautiful rose" step 1:

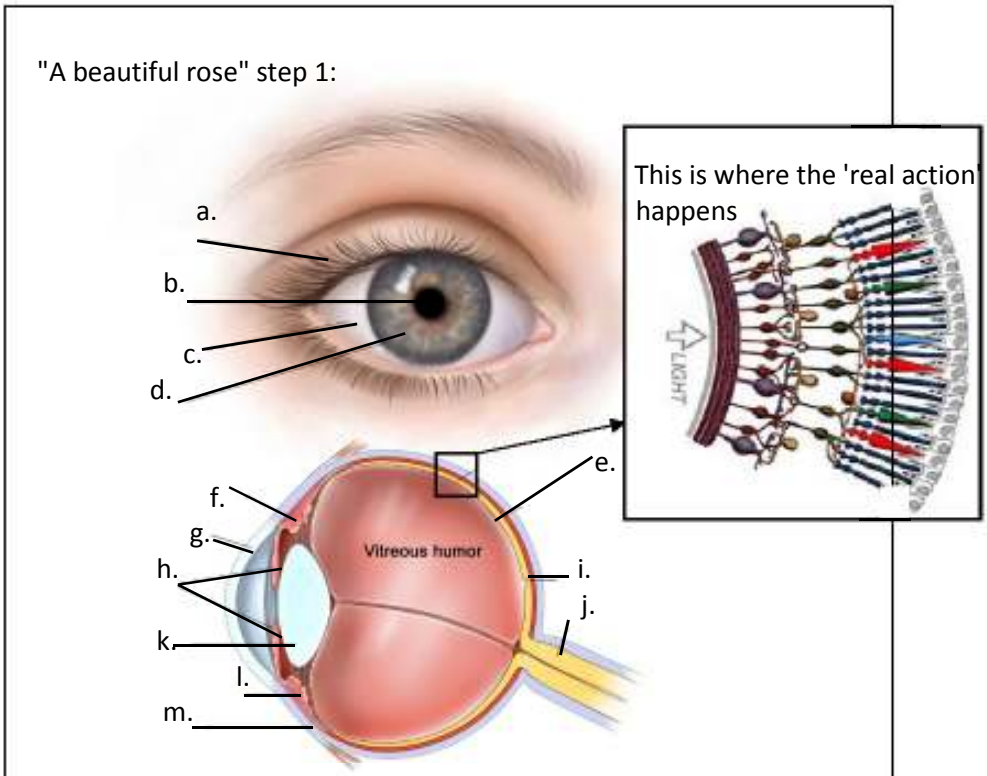


Figure 9.1

"A beautiful rose" steps 2-7

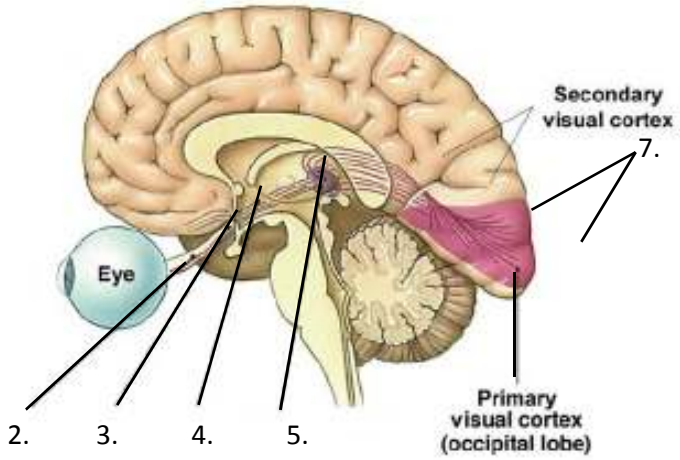


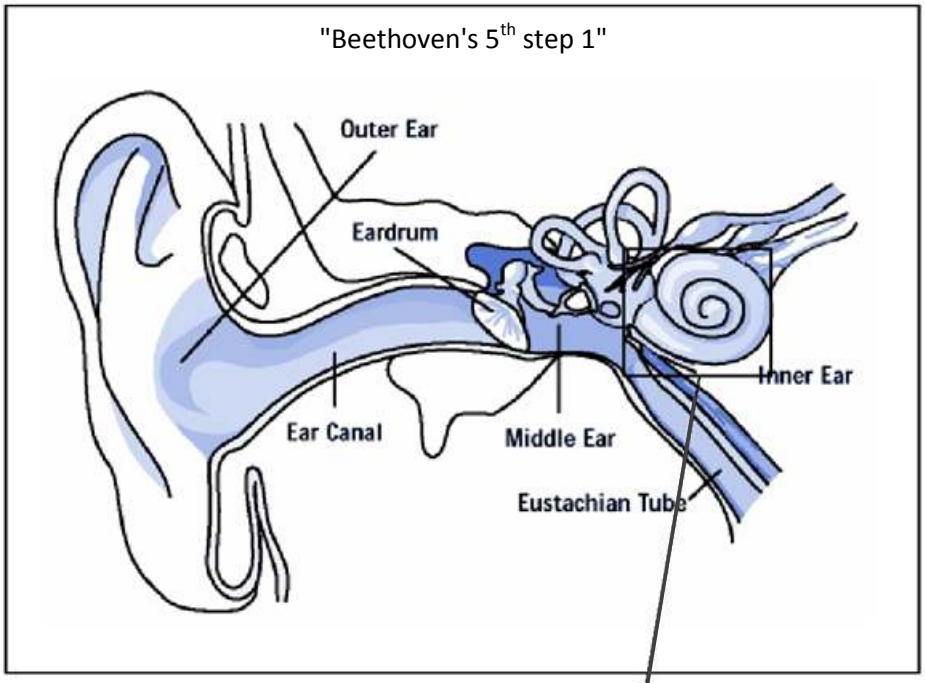
Figure 9.2

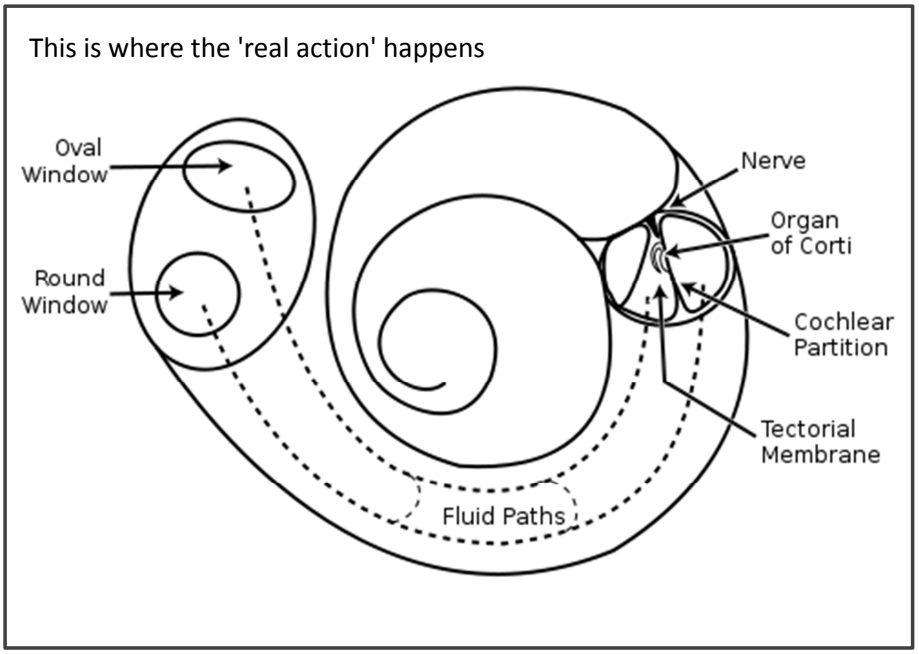
And yes, again there are problems associated with our current lifestyles when we look at eye and eyesight development, e.g. myopia seems to be on the rise. Any idea why? But perhaps we should also focus (no pun intended…) of prevention of myopia in children especially.

Problem 10: The auditory system

A.

Sound is nothing more than audible air pressure. How we hear is actually very similar to how we see. Remember the pathway light rays travel from retinal cells to the visual cortex via the LGN of the thalamus? Imagine something similar for air waves. Simple isn't it?





B.

Once the ear has processed the sound, it travels through various brain areas before it finally ends up in the cortex. Funny thing though: the 'processing of sound'. Apparently somehow your neurons have ways of encoding all the characteristics of sound like intensity, pitch and location.

C.

Hearing loss due to recreational exposure to loud sounds, such as listening to (loud) music by use of Personal Music Players is on the rise. Compared to previous generations, yours may be the one that already has poorer hearing ability than your parent and grandparent when they were your age. If this is really the case, what should we do?

Is this still valid?

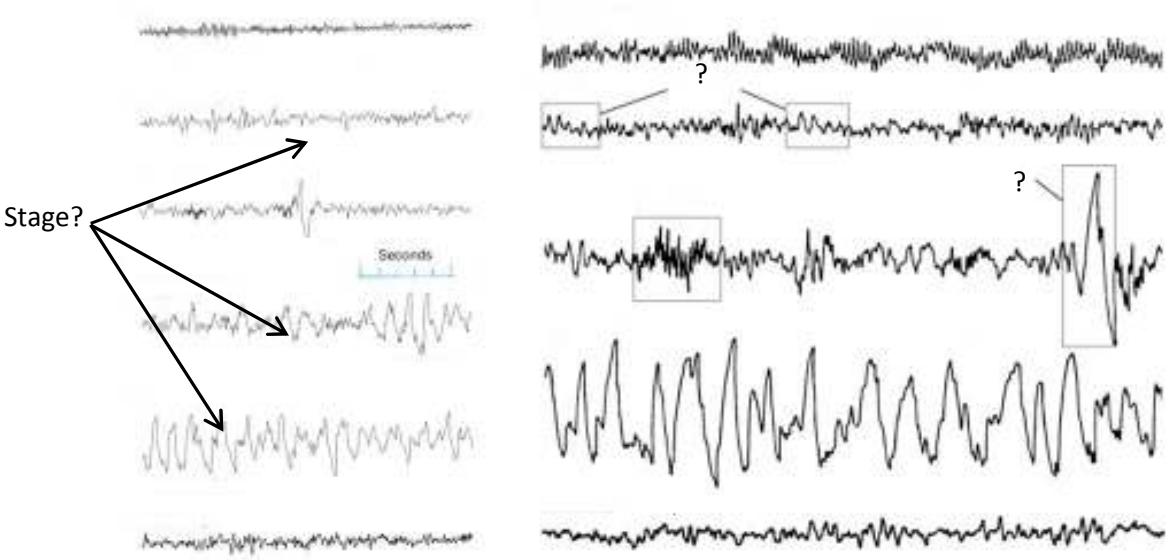
Or is this more accurate?

Friend or foe?

Problem 11: Sleep

A.

In 1929 the Austrian psychiatrist Hans Berger noticed that the EEG patterns of a person that is awake compared to when that person is asleep are quite different. Funny detail though: the EEG pattern associated with alertness (high frequency, low amplitude) and waking is similar to some signalling deeper sleep.

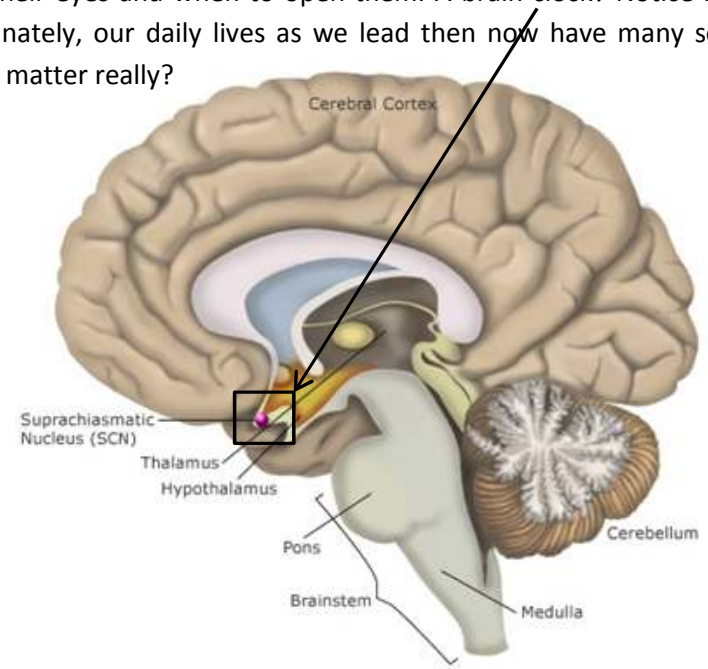


B.

Sleep is very important, isn't it? We all know that sleep is a necessary 'evil': no matter how much we would like to stay awake for days (such a shame having to spend ⅓ of your life in a non- conscious state), we simply are unable to. Sleep seems to be about getting enough, but not too much rest. But if the body only needs rest, you could just lie down while reading a nice book giving your bodily muscles the time they need to recover from your busy day.

C.

Most land animals behave according to so-called circadian rhythms. Apparently something tells them when to close their eyes and when to open them. A brain clock? Notice its proximity to the optic chiasm. Unfortunately, our daily lives as we lead then now have many sources of circadian disruption. But does it matter really?



Recommended sources of information

Problem 1: The nervous system I

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 1: page 8: Figure 1.7 and page 9: Figure 1.9, chapter 7: pp 179-191. (NOTE: the rest of the chapter is for problem 2)

On http://neuroscience.uth.tmc.edu/s2/chapter01.html you can find a chapter on the anatomy of the brain. **For now only read part 1.5 The Peripheral Nervous System (PNS).**
(NOTE: the rest you CAN read for problem 2, but to be honest I wouldn't... the book by Bear, Connors, and Paradiso is much nicer and contains all the info you need for problem two, this online chapter just really is a nice source for the PNS)

Problem 2: The nervous system II

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 7: pp 192-217. Chapter 18: pp. 621-624.

(NOTE: The appendix of chapter 7 is nice to read too, however for the current course way too much detailed info, so do not worry about having to know all the details mentioned there, just look at the pictures to get an idea of what goes where in the brain)

Parts of (be selective: just get the general message and some evidence for it, this applies to all research articles mentioned in the recommended literature):

Chittka, L., & Niven, J. (2009). Are bigger brains better? *Current Biology*, 19: R995–R1008. **E-reader**

Healy, S. D., & Rowe, C. (2013). Costs and benefits of evolving a larger brain: doubts over the evidence that large brains lead to better cognition. *Animal Behaviour*, 86: e1-e3. **E-reader**

Problem 3: Signalling I: Neurons at rest

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 3. (NOTE: not all the details, be selective: skip irrelevant parts)

Swanson, D., Block, R., & Mousa, S. A. (2012). Omega-3 Fatty Acids EPA and DHA: Health Benefits Throughout Life. Adv. Nutr. 3: 1–7, doi:10.3945/an.111.000893. **E-reader**

Problem 4: Signalling II: Neurons in action

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 4 (NOTE: not all the details, be selective: skip irrelevant parts). Chapter 5: pp122-124, and 130.

Problem 5: Hormones and sex

Ainsworth, C. (2015). Sex Redefined. *Nature*, 518:288-291. **E-reader**

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 15: pp 521-532, chapter 17: pp 579-587 and 599. (NOTE: All the other parts are very interesting but do skip it for post-discussion, write a nice paper on it or tell your parents what you know after reading so that they see how well-spent their tuition money is)

Problem 6: The emotional brain

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 18.

Wilson-Mendenhall, C. D., Feldman Barrett, L., & Barsalou, L.W. (2013). Neural Evidence That Human Emotions Share Core Affective Properties. Psychological Science, 24(6): 947–956. DOI: 10.1177/0956797612464242. **E-reader**

Problem 7: Taste and eating

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 8: pp 265-269, chapter 15: 540 (Box 15.2) and chapter 16: pp 551-572.

Francis, H., & Stevenson, R. (2013). The longer-term impacts of Western diet on human cognition and the brain. *Appetite*, 63:119–128. **E-reader**

Otaegui-Arrazola, A., Amiano, P., Elbusto, A., Urdaneta, E., & Martínez-Lage, P. (2014). Diet, cognition, and Alzheimer's disease: food for thought. *Eur J Nutr*, 53:1–23. DOI 10.1007/s00394-013-0561-3. **E-reader**

Problem 8: The motor system

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 13: 453-456, chapter 14: pp 483-494 (NOTE: skip 'Neural correlates of... ' and 'Mirror Neuron') and 498-517 (NOTE: only VERY general info on basal ganglia, M1, and cerebellum is needed: what and where they are and in a basic sense how they regulate movement, do not tire your brain with input-output organizations and so on.. again it does not fit the level of the current course, but clearly still very interesting)

Larson, P.S. (2014). Deep Brain Stimulation for Movement Disorders. *Neurotherapeutics*, 11:465–474. DOI 10.1007/s13311-014-0274-1. **E-reader**

Problem 9: The visual system

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 9: pp 293-312, chapter 10: pp 331-341. (NOTE: really by now you should have noticed a pattern: the current course is introductory, even though the book we use is the most beautiful book you will ever own, skip the for-now-irrelevant details, these are very interesting for when you are doing a master/ PhD in neuroscience mainly)

Dolgin, E. (2015). The myopia boom: shortsightedness is reaching epidemic proportions. Some scientists think they have found the reason why. *Nature*, 519: 276- 278. **E-reader**

Foster, P. J., & Jiang, Y. Epidemiology of myopia. *Eye*, 28: 202–208. **E-reader**

Repka, M, X. (2015). Prevention of Myopia in Children. *JAMA*, 314 (11): 1137- 1139. **E-reader**

Problem 10: The auditory system

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 11: pp 369-399. (NOTE: feel free to skip the cortex and vestibular system, life and the current course are too complex already without them)

Breinbauer, H. A., Anabalón, J. L., Gutierrez, D., Cárcamo, R., Olivares, C., & Caro, J. (2012). Output Capabilities of Personal Music Players and Assessment of Preferred Listening Levels of Test Subjects: Outlining Recommendations for Preventing Music-Induced Hearing Loss. *The Laryngoscope*, 122: 2549–2556. **E-reader**

World Health Organisation (2015). Hearing loss due to recreational exposure to loud sounds: A review. Retrieved from:
http://apps.who.int/iris/bitstream/10665/154589/1/9789241508513_eng.pdf

Problem 11: Sleep

Bear, M.F., Connors, B.W., & Paradiso, M.A. (2016). Neuroscience: Exploring the Brain. Wolters Kluwer. Chapter 19. (NOTE: again skip irrelevant parts such as 'The seizures of Epilepsy', interesting as they may, focus mainly on answering the learning goals)

Bedrosian, T. A., Fonken, L. K., & Nelson, R. J. (2016). Endocrine Effects of Circadian Disruption. *Annu. Rev. Physiol*., 78: 109–31. **E-reader**

Cronin-Golomb, A. (2016). SPECIAL ISSUE: BEHAVIORAL NEUROSCIENCE OF SLEEP: *Great Nature's Second Course: Introduction to the Special Issue on the Behavioral Neuroscience of Sleep*. Vol. 130, No. 3, 267–270. **E-reader**

Figueiro, M. G. (2013). An Overview of the Effects of Light on Human Circadian Rhythms: Implications for New Light Sources and Lighting Systems Design. J. Light & Vis. Env., 37 (2 & 3): 15-25. **E-reader**