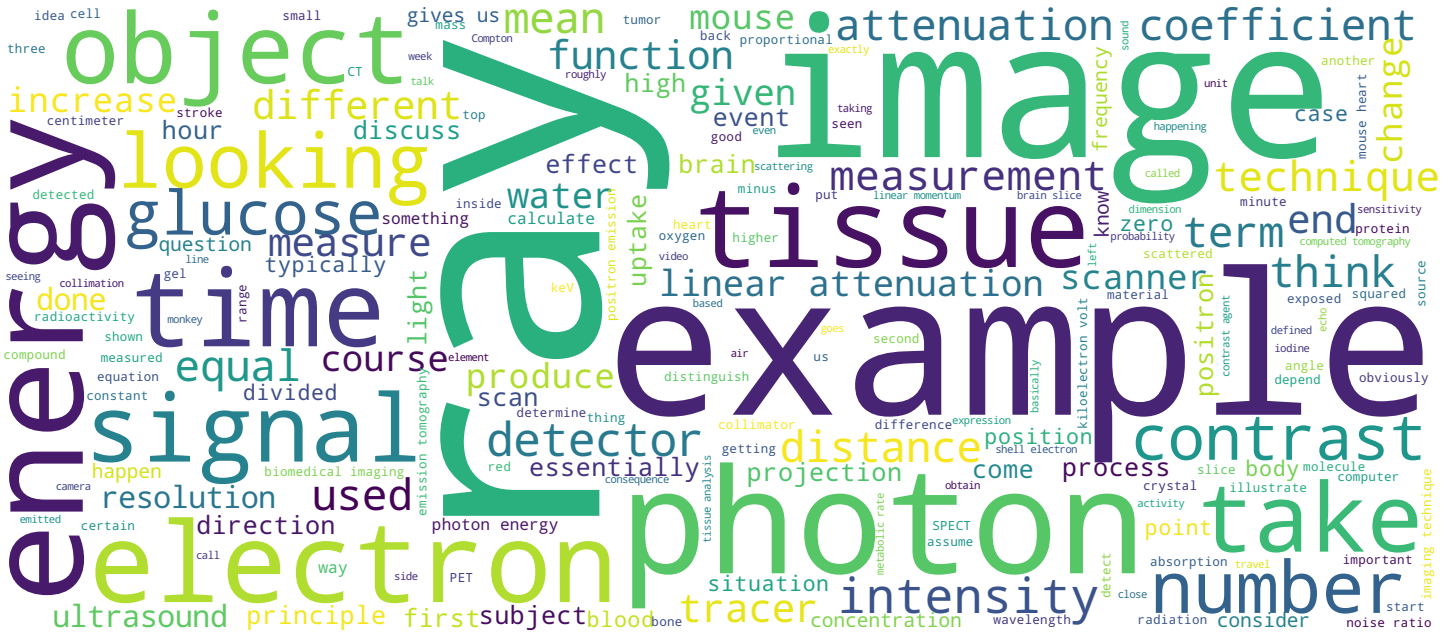
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

1.4 Examples

Fundamentals of Biomedical Imaging

Prof. Rolf Gruetter



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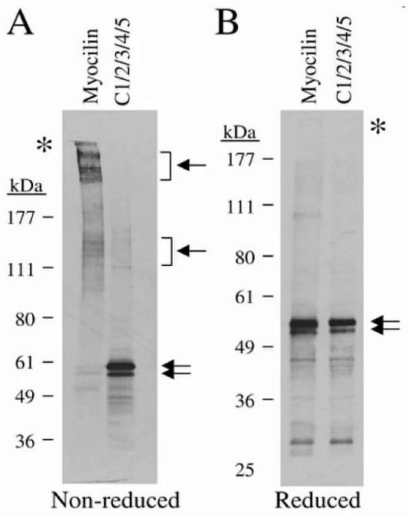
Video

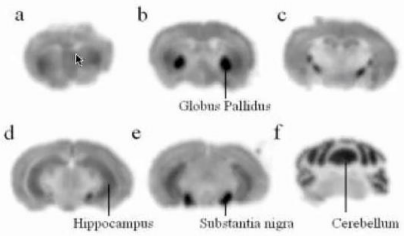
EPFL

1-4. Examples

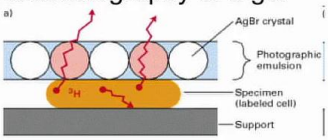
Autoradiography



Autoradiography of a brain slice



Autoradiography of a gel



1-13

In the last segment of this week we will conclude by some examples, and I'll start off with something very basic. For those of you in biological sciences you may be familiar with these graphs here. These are gels. What is happening here is that there are proteins that are put at the end of the gel and then, based for example on electrical gradient, the proteins start to bond in one direction in this gel, and the proteins carry radioactive charge like phosphorus-32, tritium or carbon-14. Then they are exposed to a camera, and we can see how far the protein has moved. This is an imaging way to determine the mass of a protein of a product that one has isolated. The procedure that's used here is, we have the support here, we have the specimen-- in this case it would be the gel, and on top of here is the photographic emulsion, that is, the electrons are passing through the photographic emulsion then create a chemical reaction, which is what essentially is imaged here. So this is the standard way of producing early images, and this has been used also, mainly some time ago, for imaging, for example, brain slices. So what was done here, this is a rodent brain cut into slices.

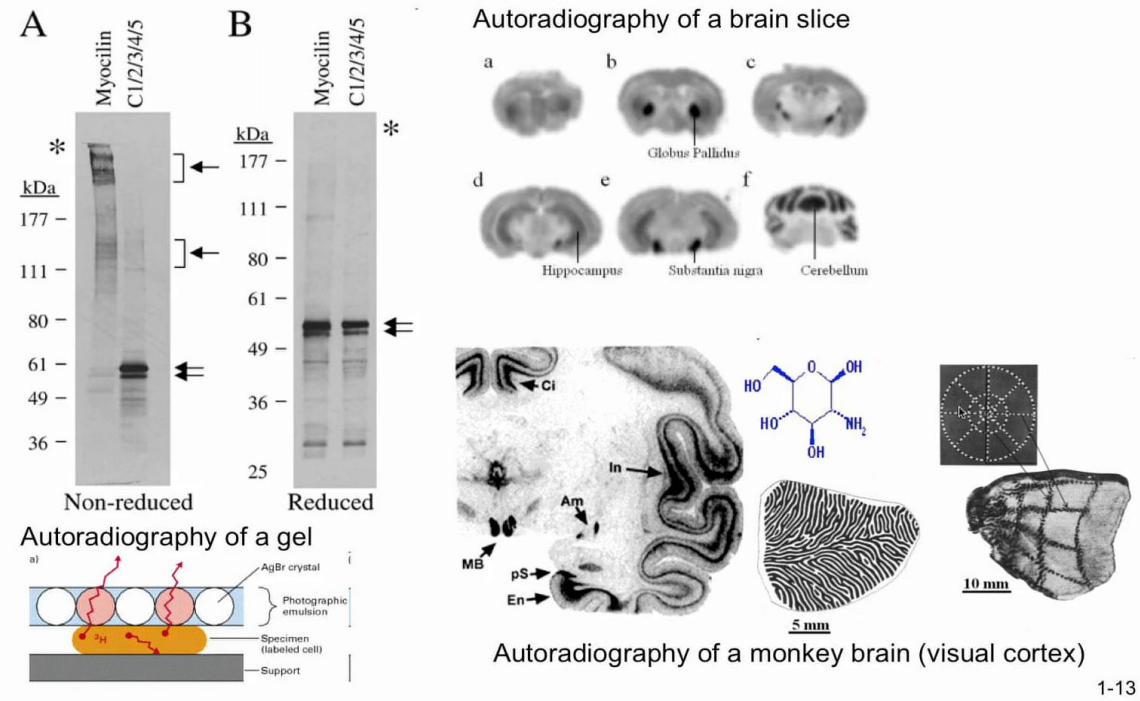
Notes

Summary

0m 04s

1-4. Examples

Autoradiography



1-13

These slices are then placed on a support, and the film is placed on top of it. That creates a photographic image here of the radioactivity that's inside this brain slice. So obviously there was some radioactivity injected into this animal here, and we can see here some compound that's accumulated in this particular area implicated in Parkinson disease, namely substantia nigra. On these examples-- I want to end with a-- -- a very prominent example from monkey brains-- so this is now uptake here, in the brain, of glucose, which is a main substrate that allows us to think. Here is the glucose radioactivity marked. This is the fine structure of the area. And now, what this monkey-- so this is a brain slice-- so this monkey was exposed to radioactive glucose and to some task. The task we can see here. The monkey was looking at this image here, and looking at this image, there has been a representation of glucose uptake in his visual cortex according to the activity of what he is seeing, and actually what one can see here is the uptake of glucose is high in a pattern that resembles to structures that he has been looking at.

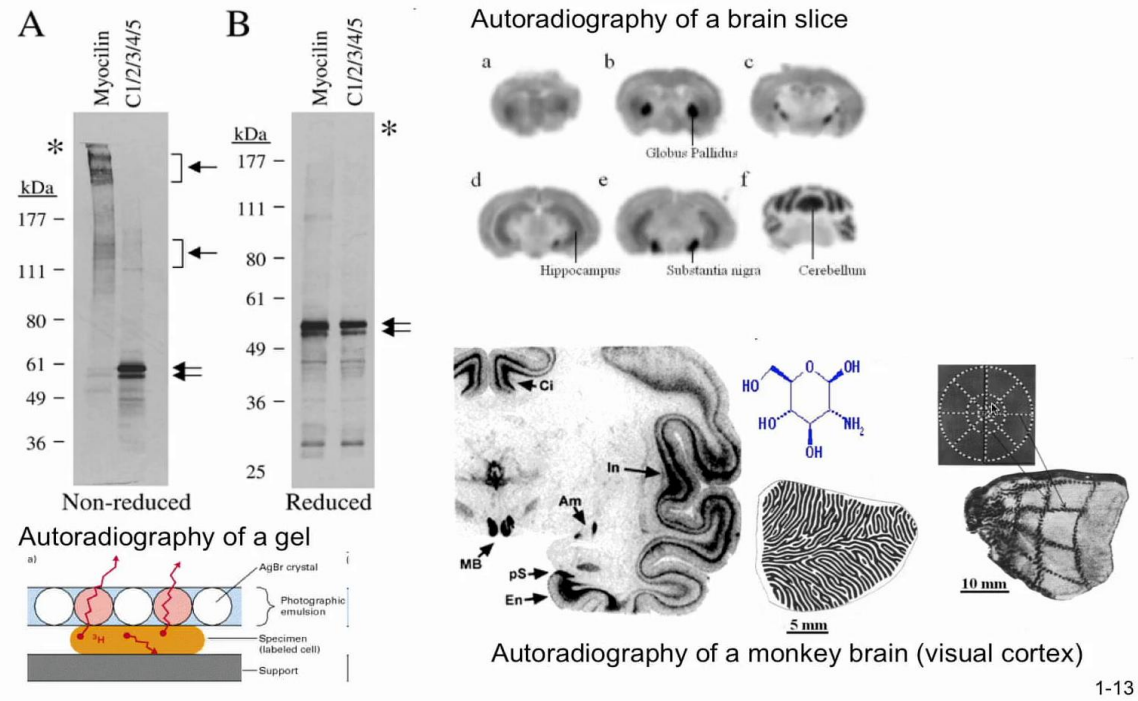
Notes

Summary

1m 32s

1-4. Examples

Autoradiography



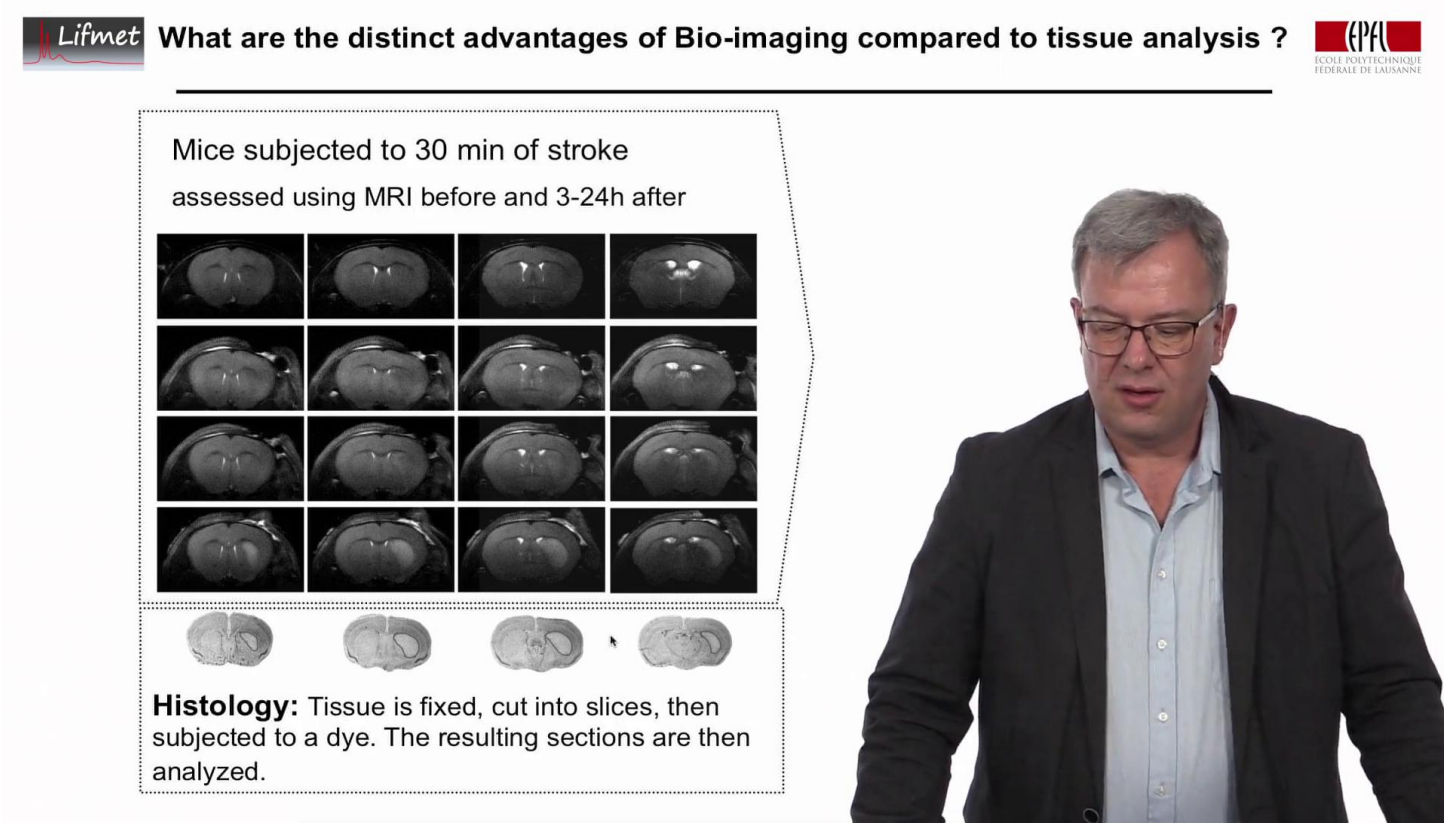
1-13

So we actually have-- this has been a very important insight, we have a representation with imaging, representation of the outside world directly in our brain, that is a fairly good match. And a few years back some researchers in Boston have actually shown with functional MRI, showing them the letter M in Martinos, Massachusetts but this letter M showed up also in the brain of the volunteers.

Notes

Summary

2m 52s

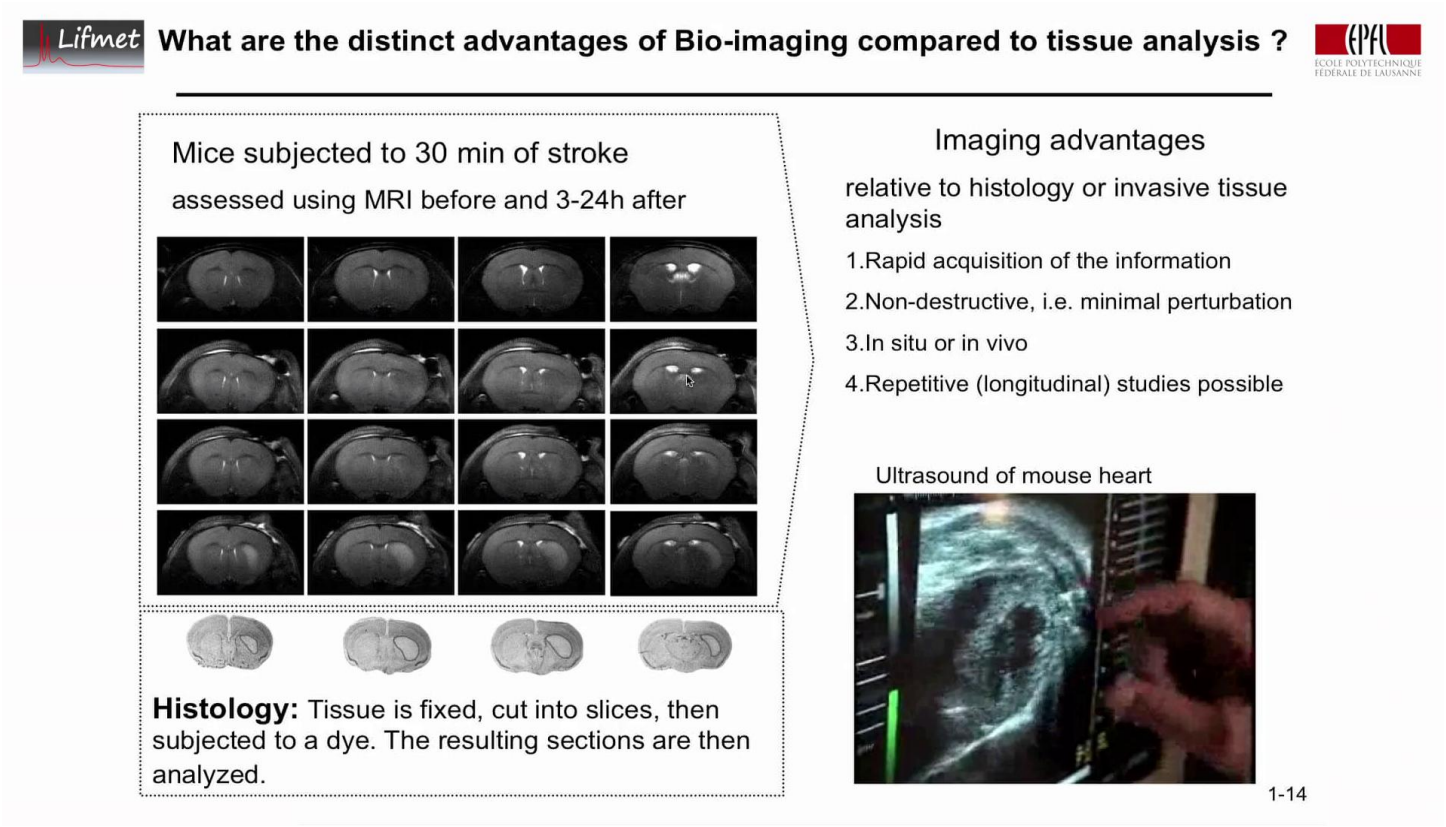


So why would we even bother developing biomedical imaging techniques? What is the advantage compared to tissue analysis? The examples that I just gave you actually don't give us any major advantages. Well, I'll give you an example here, we are looking at mice that were subjected to 30 minutes of stroke, and they were assessed using MRI at 3 hours-- that is here-- 7 hours, before 3 hours, 7 hours and 24 hours after the stroke. That is the same mouse that we are looking at before and after the stroke at different timepoints. In the end, after 24 hours, the brain was extracted, slices were cut and with Nitro staining here the neurons were counted; one can see very nicely the lesion of the stroke here corresponding to what we see in the MRI image. So we have one mouse here-- we have looked at it over 24 hours and in the end we can do a tissue analysis in extraction. The tissue extraction is pretty much always final, if you want to look at the tissue, and there is no continuation of the study. So we have the ability to produce longitudinal studies and repeated studies. So, let's say, if we take Bio-imaging relative to histology for invasive tissue analysis, typically the information is gathered relatively rapidly, we acquire these images in a few minutes.

Notes

Summary

3m 23s



They were acquired in a few minutes. Tissue dissection means freezing the tissue, dissecting with a microtome imaging, we are non-destructive, the mouse in principle after this measurement, and this measurement and so on, was the same mouse, so not impaired by the fact that we took the image. So one has minimal perturbation. The Bio-imaging techniques are either in situ or even in vivo, typically in vivo, and therefore repetitive, that is, longitudinal studies are possible, which gives us an increased statistical power, a reduced number of samples therefore and this role decide features. Here is an example of the ultrasound of a mouse heart. You don't think of ultrasound as a technique used on mice, and certainly not for mouse heart. Think about how small a mouse is, think about how small the mouse heart is, one can develop a technique, an ultrasound technique here, that is adapted to such small geometries, and, as shown in this video, one can obtain very good images of the beating mouse heart in real time. Think about how fast the mouse beats-- it is several hundred times per minute-- to get an appreciation of the challenges that were overcome here, in this example. And, of course, we can also see here the volunteer, the mouse, which all it is subjected to is putting a transducer on its chest.

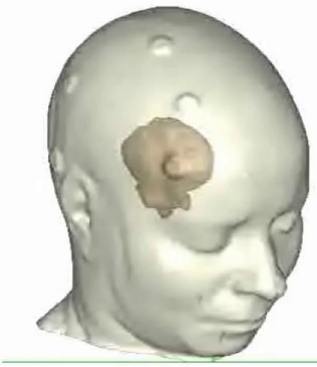
Notes

Summary

4m 55s

Examples: Biomedical Imaging

http://nobelprize.org/educational_games/physics/imaginglife/narratives.html



3D rendering of tumor for surgical planning (MRI)

So we have some other examples here for biomedical imaging. What you see here on the left is a-- 3D rendering of a tumor. You can see the image. So this is an MRI image taken of a person for surgical planning. You see on the top of the head the fiducial markers that allow the neurosurgeon to determine exactly the stereotaxic, that is, the coordinates of the brain, and then with the contrast that's generated by the image with a computer a three-dimensional image is generated, based on the contrast color-coded we have the tumor highlighted, as you can see here, and that tumor is then, very well defined in the image with respect to the fiducial markers in its position, and very often it is much easier to distinguish the contrast, that is, to distinguish the defective tissue, the disease tissue from the normal tissue than looking at it by eye. So this helps enormously in either planning where exactly to do the surgery or, if you do radiotherapy, to have an exact location of the tumor.

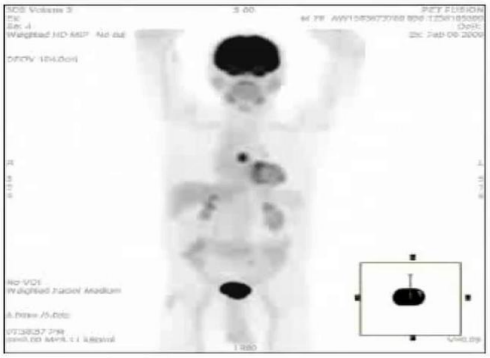
Notes

Summary

6m 27s

Examples: Biomedical Imaging

http://nobelprize.org/educational_games/physics/imaginglife/narratives.html



Metastasis localization (PET)

1-15

Here is another example of a very often used technique-- it's positron emission tomography, and it illustrates its major use in imaging. You can see here, this is glucose-- you see the brain takes up a lot of glucose, we use glucose to think-- we have also here, in the bladder, glucose. For obvious reasons, the glucose that was injected ends up in the bladder, and this part here in the center, it's the heart. Next to the heart you can see this dark spot that should not be there-- that is a metastasis. So with this technique, when it's used in practical means is to detect metastases, to determine how many metastases are there over the whole body. This is of course important for deciding what treatment approaches to use.

Notes

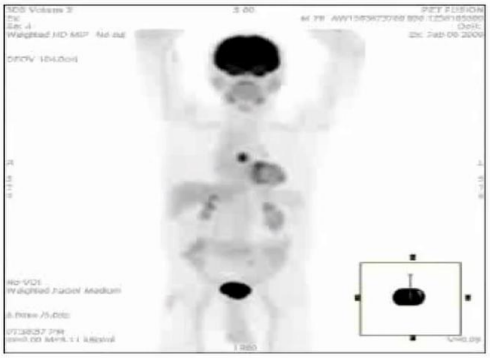
Summary

7m 38s

Examples: Biomedical Imaging

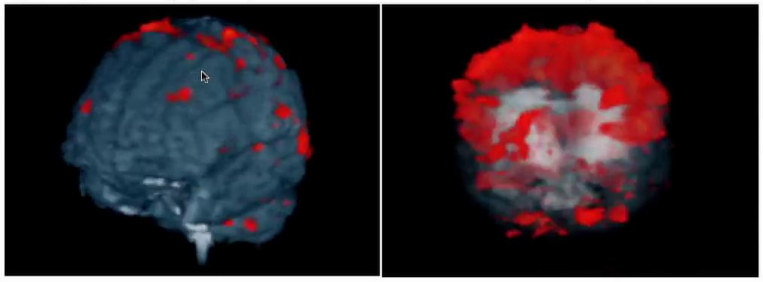
http://nobelprize.org/educational_games/physics/imaginglife/narratives.html

3D rendering of tumor for surgical planning (MRI)



Metastasis localization (PET)

fMRI of whole brain activation



1-15

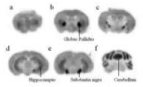
And here is the last example, this is the-- this functional imaging of a complex task-- I think it was a mental rotation task in this case, showing the ventral medial stream in such a fairly complex mental task. One can see the many brain areas that are activated-- they are shown in red-- overlaid on an anatomical image of the subject's head obtained with MRI, so this technique functional MRI provides an insight into the activation patterns when one does a certain task, how different brain areas are involved. So these are just some examples to illustrate some of the potentials, some of the applications of the techniques.

Notes

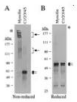
Summary

8m 27s

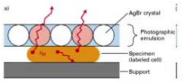
Credits



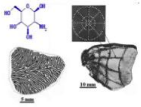
Neuroscience Core Facility
http://sites.gsu.edu/neuroscience-core/training/histology/



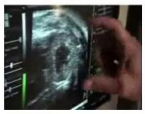
Molecular vision 2004; 10:417 (Fig. 5) Michael P. Fautsch
http://www.molvis.org/molvis/v10/a52/v10a52-fautsch.pdf



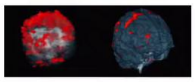
Autoradiography, Trina A. Schroer 2003
http://www.pha.jhu.edu/~ghzheng/old/webct/note1_5.htm



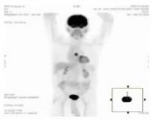
Hubel and Wiesel 1977 and **Journal of Neuroscience (Tootell, et al.)**
http://hubel.med.harvard.edu/book/b28.htm



Non-Invasive Ultrasound Imaging - Manning Innovation Award *(video extract)*
https://youtu.be/tfeg5j8gU64



fMRI
http://www.appsychology.com/Book/Biological/ways_to_study_the_brain.htm



Positron Emission Tomography *(video extract)*
https://youtu.be/pOejGHnvSV0

We will during the course, of course, illustrate every technique that we discuss with examples, typically at the beginning and at the end of the lecture.

Notes

Summary

9m 17s