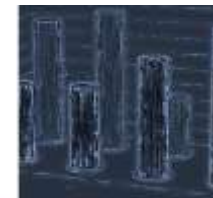




The mediating role played by Mathematics in Nuclear Medicine

Miguel Patrício



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Beauty

Richard Feynman:

I have a friend who's an artist [...] He'll hold up a flower and say

- "look how beautiful it is"



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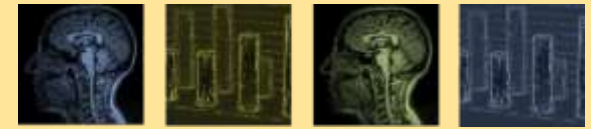
- "look how beautiful it is"

and I'll agree. Then he says

- "I as an artist can see how beautiful this is but you as a scientist take this all apart and it becomes a dull thing" [...]



Nuclear Medicine is beautiful



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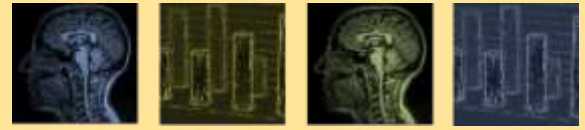
Arguably Nuclear Medicine* produces beauty

* medical specialty involving the application of radioactive substances in the diagnosis and treatment of disease



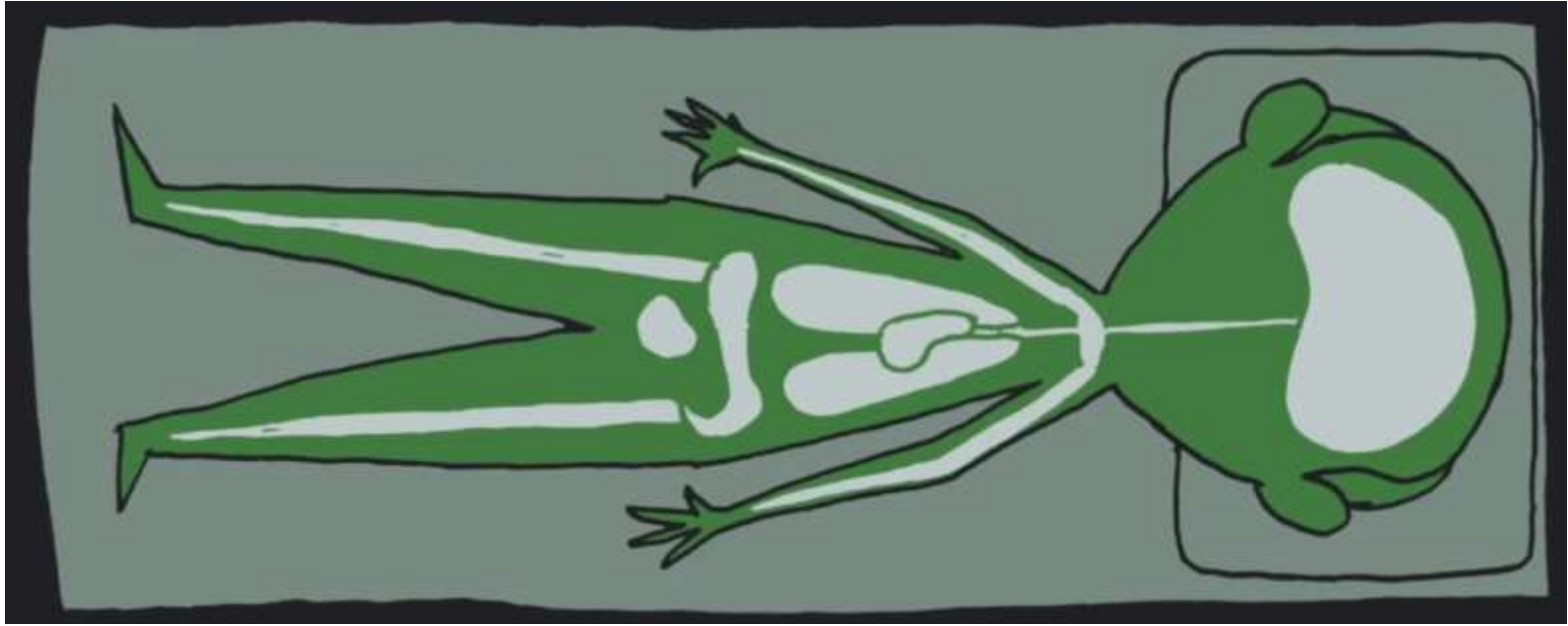
<http://www.isotope.com/userfiles/images/headerimages/NuclearMedIllustration.jpg>

PET



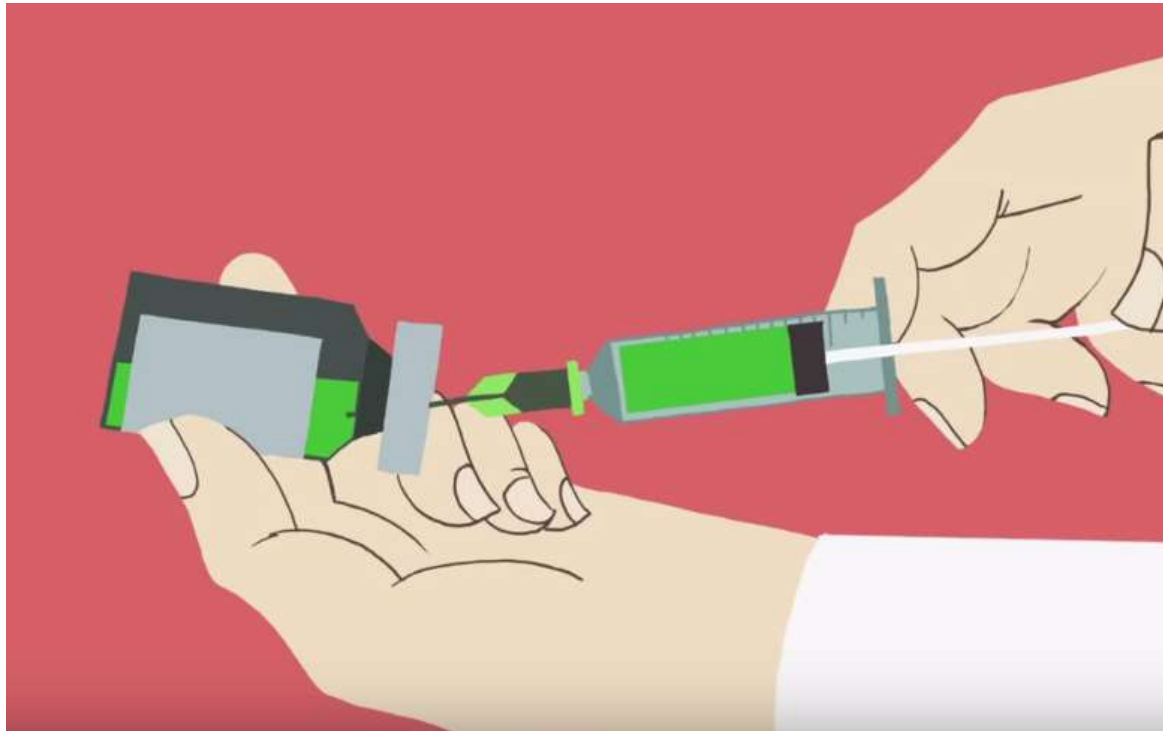
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Take Positron Emission Tomography (PET) for example, where someone lies on a bed



PET

Take Positron Emission Tomography (PET) for example, where someone lies on a bed and is injected a radioactive substance



PET



Take Positron Emission Tomography (PET) for example, where someone lies on a bed and is injected a radioactive substance. The scanner allows “seeing” where the substance accumulates.



Beautiful on the inside



Much like Pablo Neruda, Nuclear Medicine knows that true beauty lies within

"Como si estuvieras en llamas desde el interior... la luna vive dentro de la guarnición de la piel"

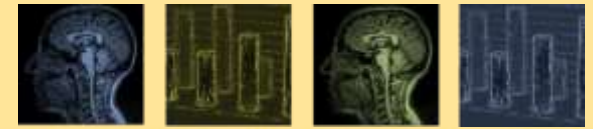
"As if you were on fire from within... The moon lives in the lining of your skin"



Pablo Neruda



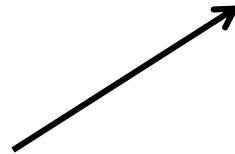
Beautiful on the inside



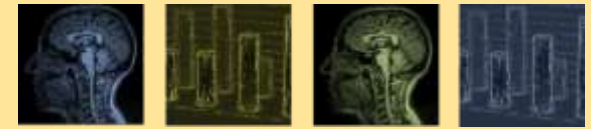
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You end up with a picture like this

this is (a PET image of) me!

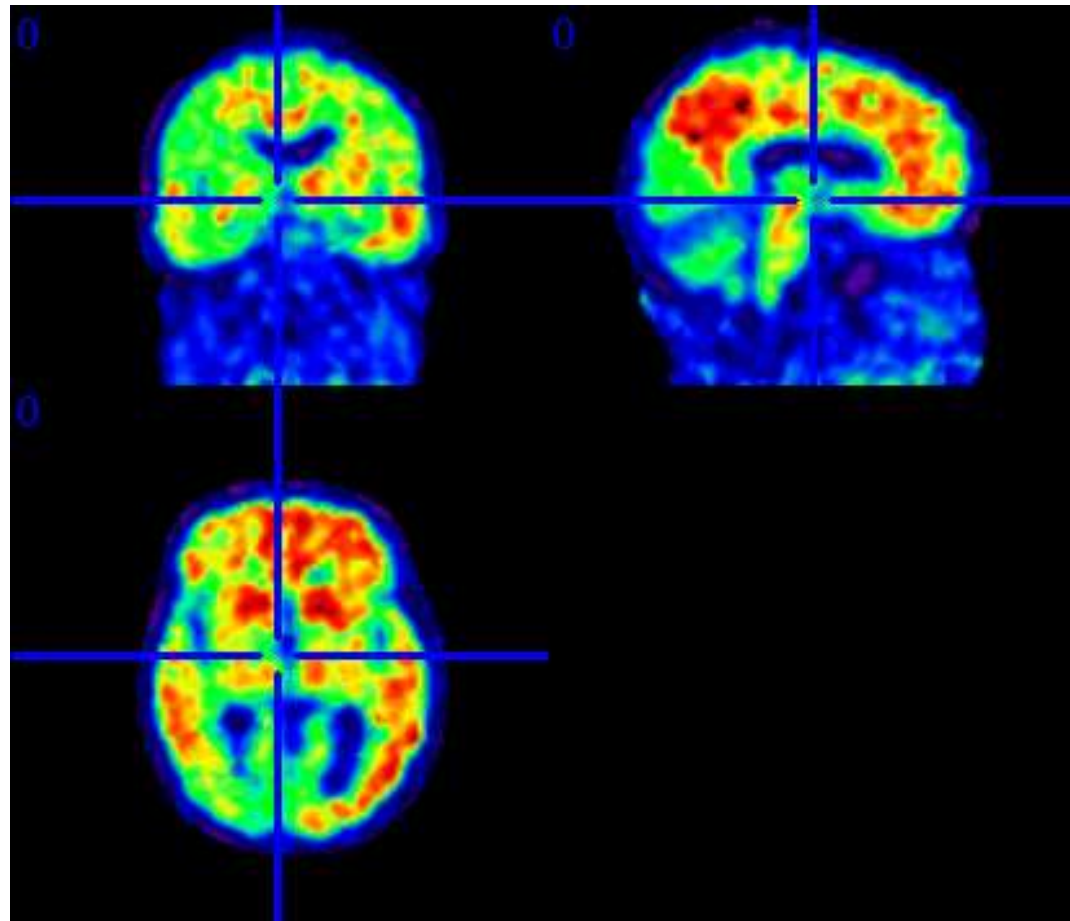


Beautiful PET

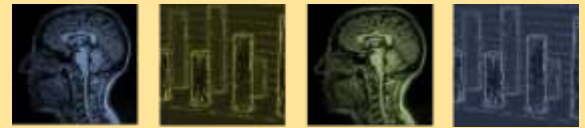


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In particular, “seeing” the inside of the brain is crucial for diagnosing, monitoring or studying mechanisms of diseases (e.g., Alzheimer’s Disease, Parkinson’s Disease)



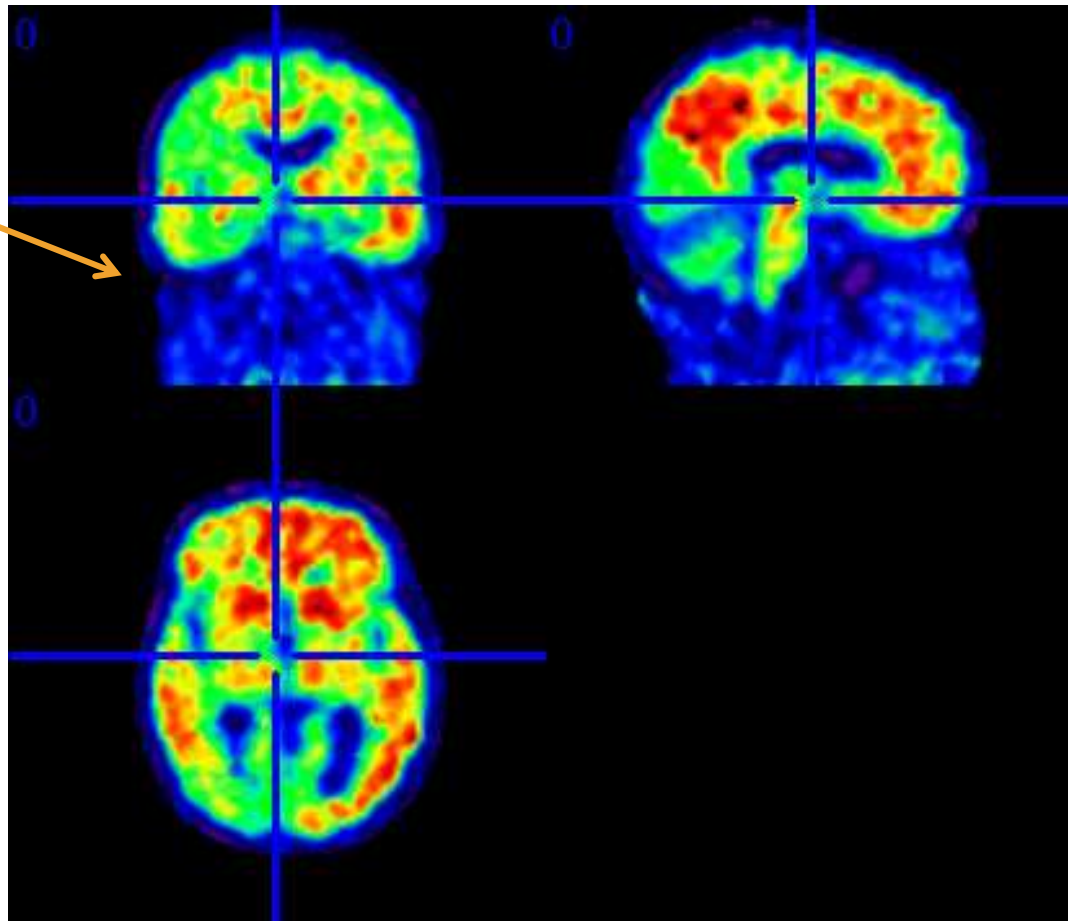
Dissecting a PET image is beautiful



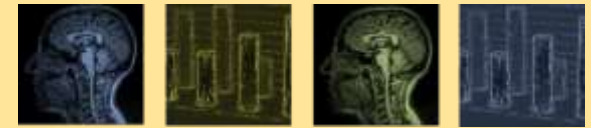
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What's in an image? Like Feynman would, let's take it apart!

Within each voxel, the colour translates the concentration of tracer



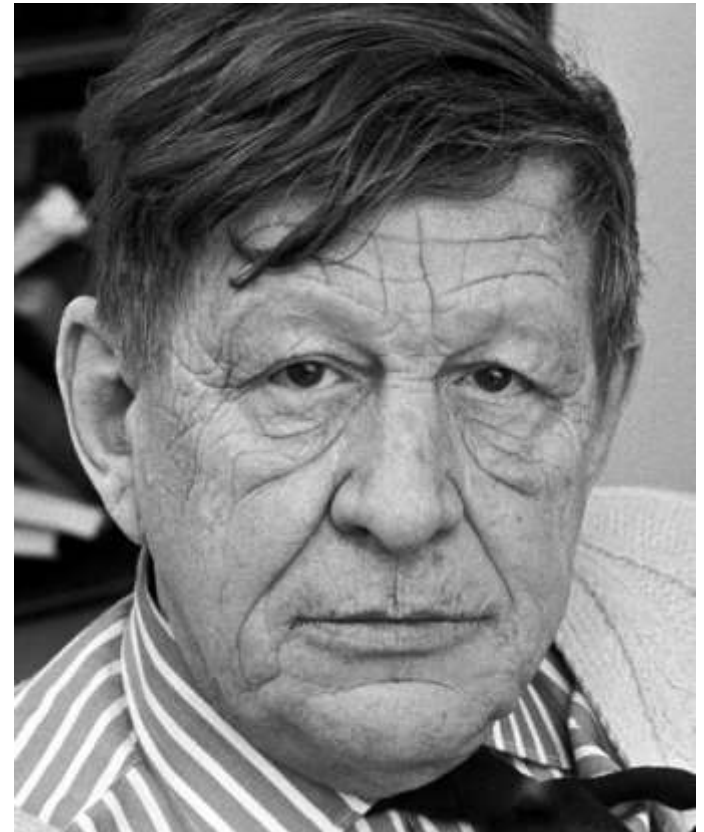
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What's in an voxel? Like Feynman would, let's take it apart!

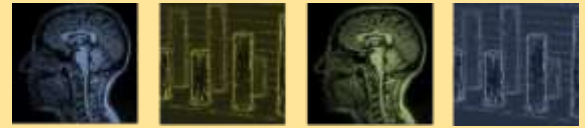
“There is always another story,
there is more than meets the eye”



W. H. Auden

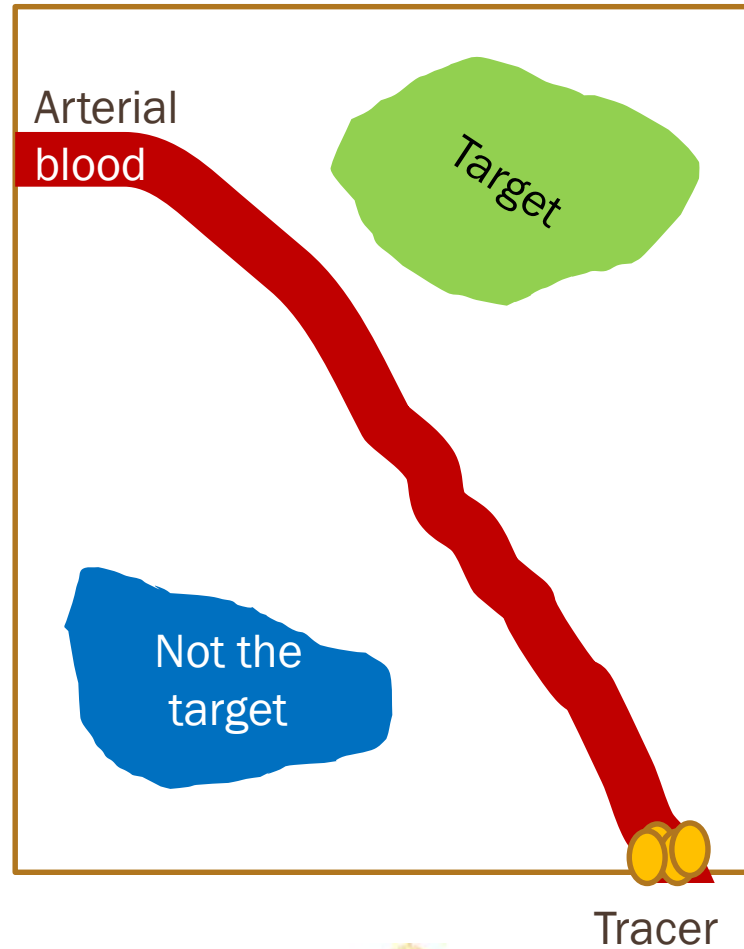


What's in a voxel?

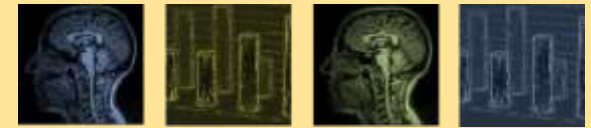


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2D representation of a voxel



Dissecting a PET image is beautiful



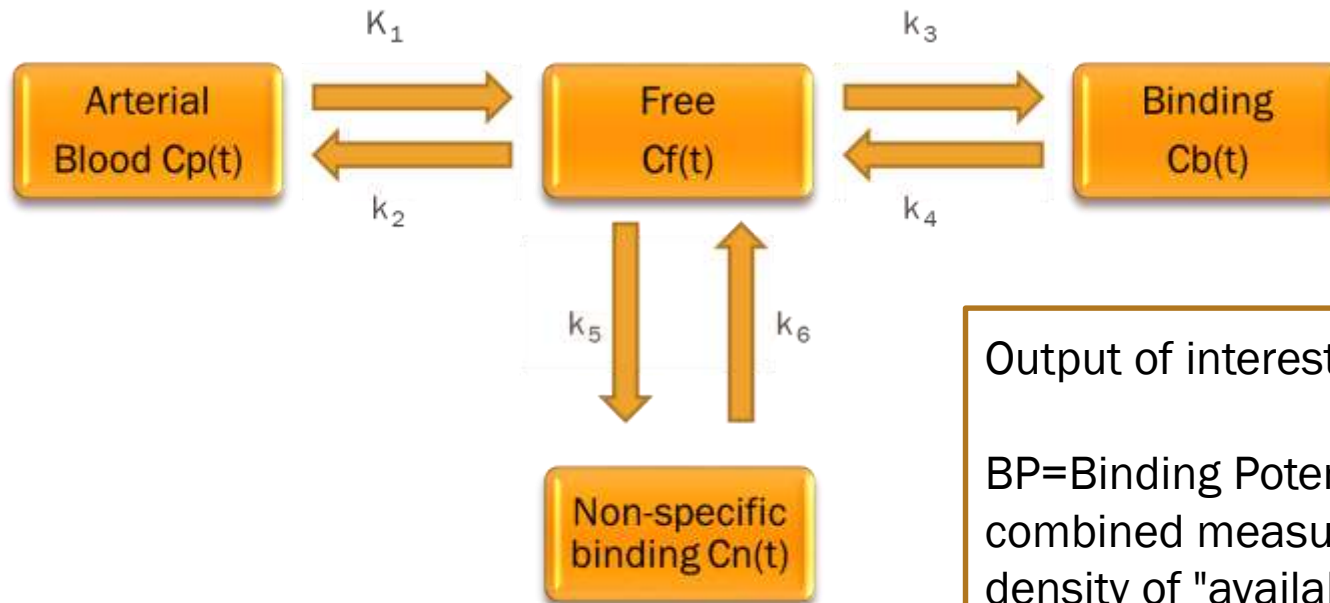
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The concentration of the tracer is not as interesting as how much tracer binds to the target – but how can we obtain the latter?

“The devil is in the detail”



Mathematics to the rescue



Output of interest: $BP = k_3/k_4$

BP=Binding Potential, a combined measure of the density of "available" neuroreceptors and the affinity of a drug to that neuroreceptor

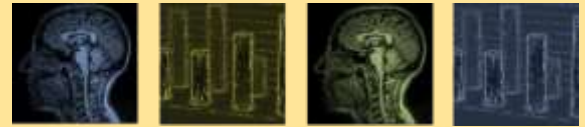
https://en.wikipedia.org/wiki/Binding_potential

$$\frac{dC_b(t)}{dt} = k_3C_f(t) - k_4C_b(t)$$

$$\frac{dC_f(t)}{dt} = K_1C_p(t) + k_6C_n(t) + k_4C_b(t) - (k_2 + k_3 + k_5)C_f(t)$$

$$\frac{dC_n(t)}{dt} = k_5C_f(t) - k_6C_n(t)$$

Dissecting a PET image is beautiful



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Richard Feynman:

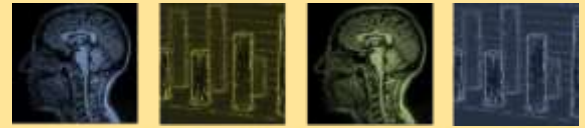
I have a friend who's an artist [...] He'll hold up a flower and say
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"O binómio de Newton é tão belo como a Vénus de Milo. O que há é pouca gente para dar por isso (...)"



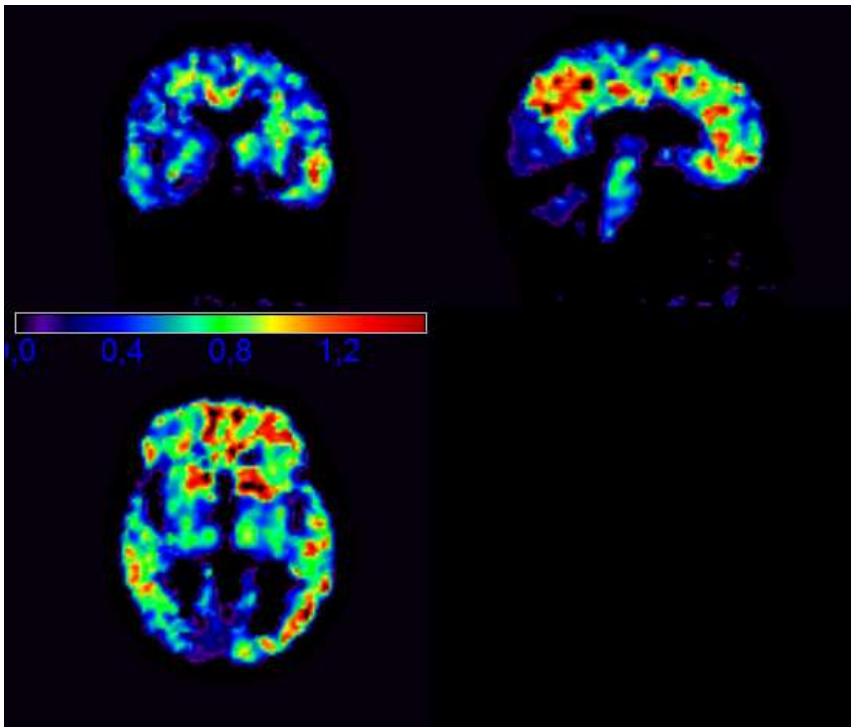
Álvaro de Campos

What use is what the model gives?

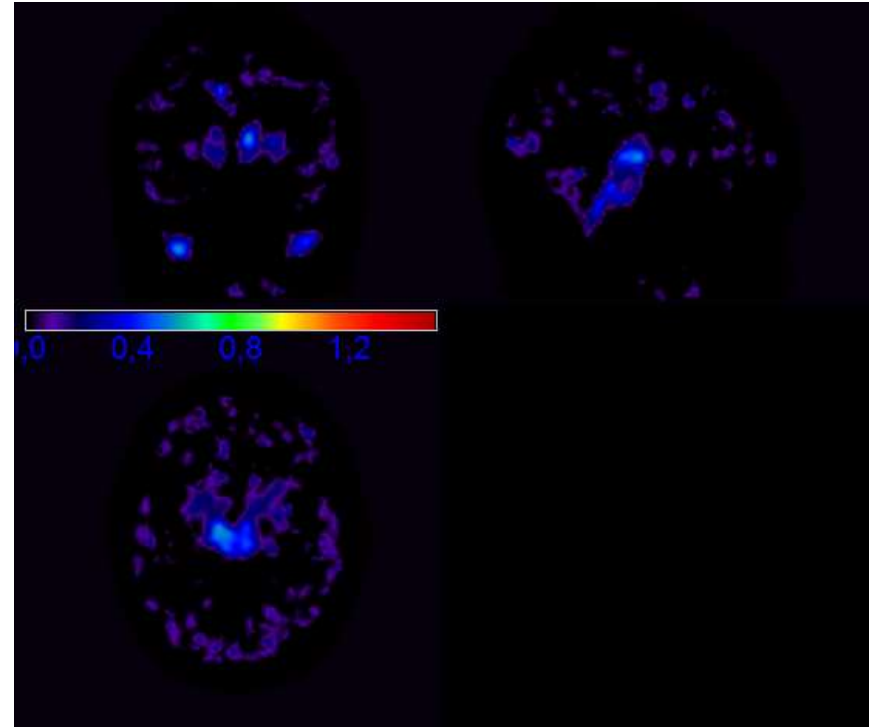


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Patterns of BP may help in diagnosis



AD patient

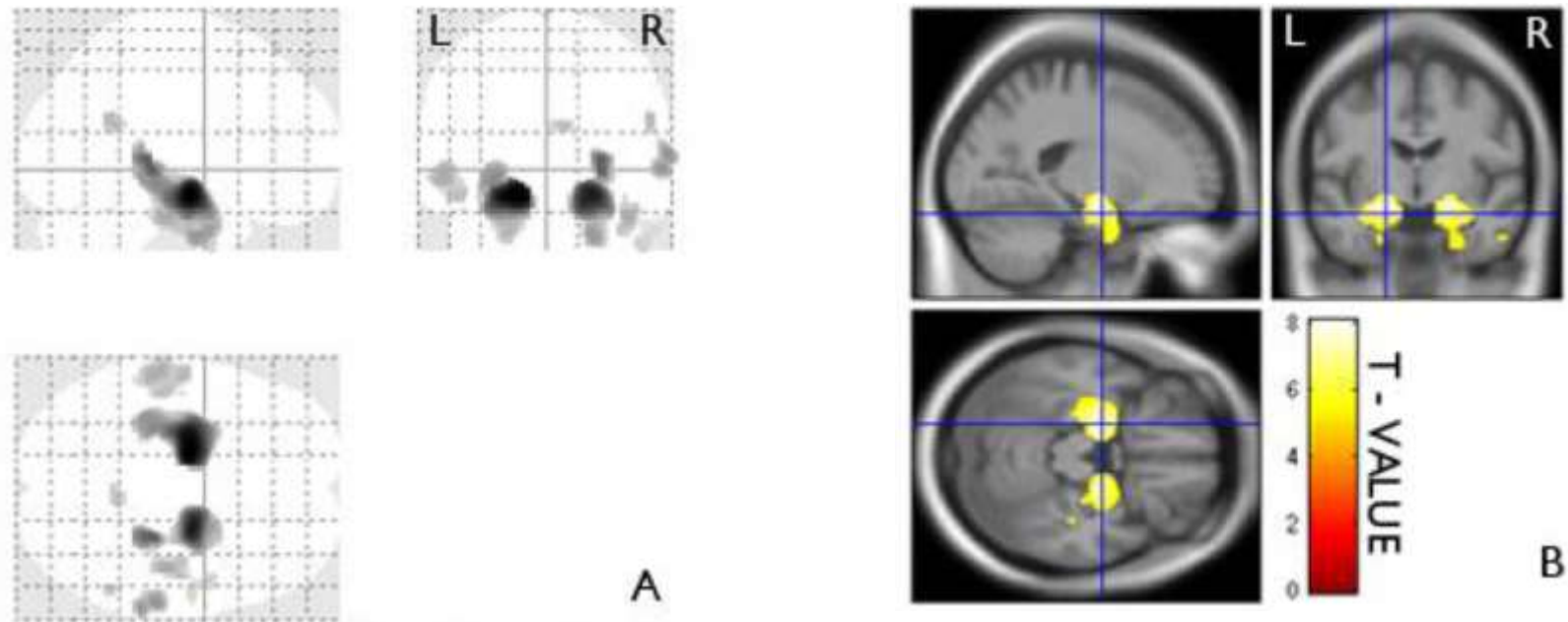


Healthy control



What use is what the model gives?

Using methods such as voxel based morphometry one may investigate which brain areas are altered by a disease



Voxel-based morphometry analyses in Alzheimer's disease;
AM Matos, P Faria, M Patrício (2013)

Pressing challenge

Alternatives to arterial cannulation are sought

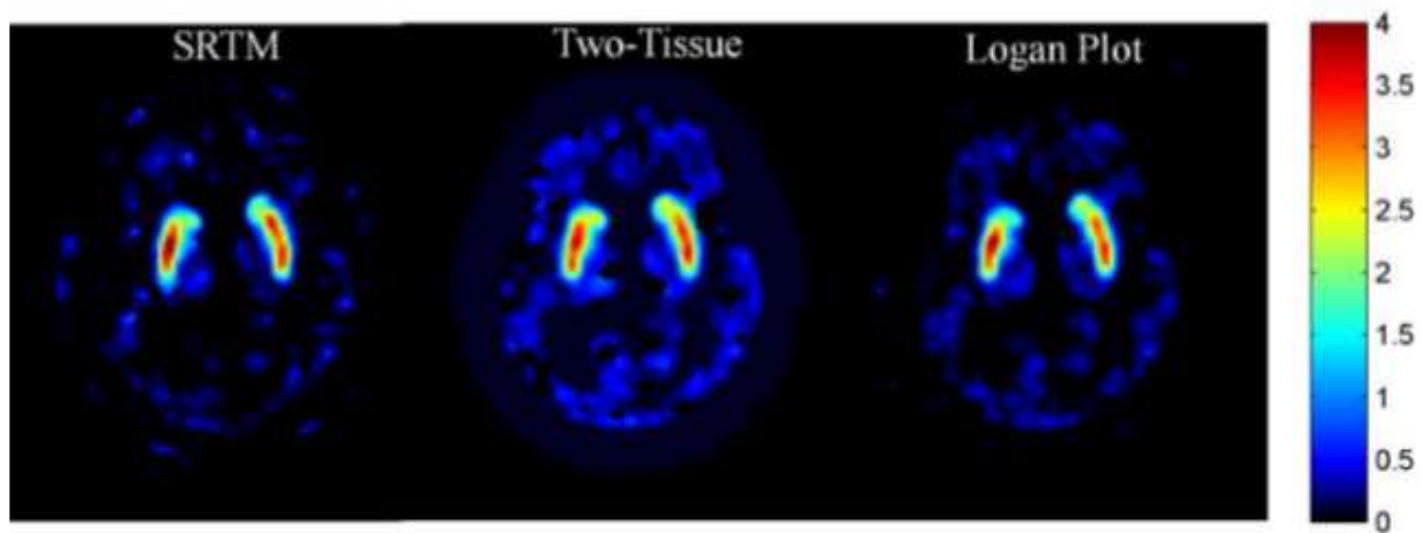
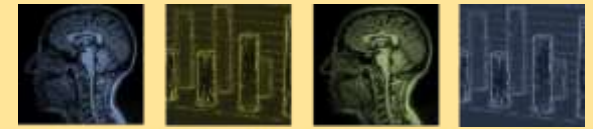


Image-derived input function for brain PET quantification;
A Gorgulho, F Caramelo, M Patrício (2015)

Dissecting a PET image is beautiful



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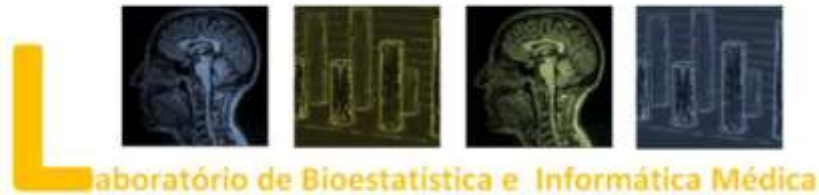
- "I as an artist can see how beautiful this is but you as a scientist take this all apart and it becomes a dull thing" [...]

I think that he's kind of nutty [...]. All kinds of interesting questions which the science knowledge [raises] only adds to the excitement, the mystery and the awe of a flower. It only adds. I don't understand how it subtracts.



Richard Feynman

Acknowledgments



- ✘ Projecto GAI “Image Derived Input Function for quantitative PET studies”
- ✘ Projecto GAI “Radiation dosimetry assessment based on tracer biokinetic models”
- ✘ Portuguese Foundation for Science and Technology grant: UID/NEU/04539/2013