



MAPPING THE HUMAN BODY

SPATIAL REASONING AT THE INTERFACE BETWEEN
HUMAN ANATOMY AND GEOGRAPHIC INFORMATION
SCIENCE

April 16-17, 2005, University at Buffalo

Adjacency and Maps

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The OBO Relation Ontology

We now propose the first version of the OBO Relation Ontology:

Foundational relations:

is_a

part_of

Spatial relations (connecting one entity to another in terms of relations between the spatial regions they occupy):

located_in

contained_in

adjacent_to

Temporal relations (connecting entities existing at different times):

transformation_of

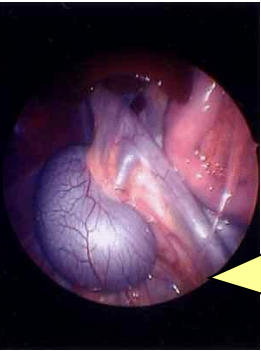
derives_from

preceded_by

Participation relations (connecting processes to their bearers):

has_participant

has_agent



Reality

Language

Adjacency

Maps



FIGURE 13-6. The dose volume histogram shows what volume (in cc or in percent to total volume) receives a given dose of radiation. Three treatment delivery scenarios are considered for the patient shown in Figure 13-4: a collimated stereotactic delivery method,⁶¹ conventional intensity modulated radiation therapy (IMRT) at 1.0 cm resolution, and high-resolution IMRT at 0.5 cm resolution. As was visually apparent in Figures 13-4 and 13-5, IMRT can significantly reduce the dose to a critical structure, such as the brainstem adjacent to the target volume in this case.

A potentially aggressive variant of mesoblastic nephroma is identified by foci of hemorrhage and necrosis, involvement of adjacent structures, and high cellularity and mitotic index. It is associated with invasion of adjacent structures or organs, multiple recurrences, and metastases.¹⁵² This lesion probably represents an intermediate form between congenital mesoblastic nephroma and clear cell sarcoma of the kidney in the spectrum of infantile renal mesenchymal tumors originating from the premetanephric stromagenic stage of renal blastema.¹⁵³

Transfer of prodrug-metabolizing genes may not require all the tumor cells to be transduced for benefit to be seen. One of the most puzzling features of the original thymidine kinase-retrovirus system was that it worked so well in many preclinical tumor models. Even when fewer than 10% of tumor cells were transduced, ganciclovir destroyed nearly 100% of the tumor cell population.^{61,63} This advantage over the tumor correction protocols described earlier appears due to a bystander effect. That is, cells that lack the PDME gene can be killed if they are a

Adjacency

- Geography

- Buffalo is adjacent to lake Erie



- Alexandra Peak is adjacent to Margherita Peak



- Holborn station is adjacent to Covent Garden station



- Anatomy

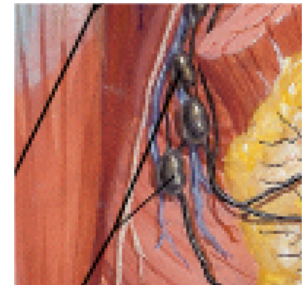
- My elbow is adjacent to my forearm



- A (retrocecal) appendix can be adjacent to an ureter



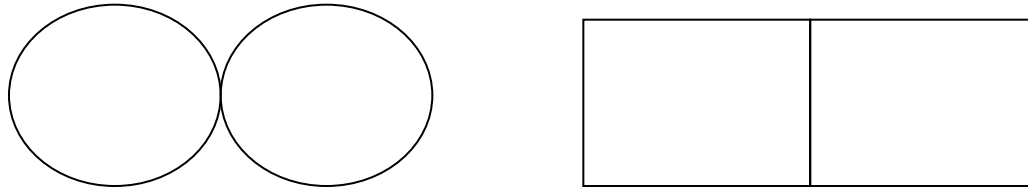
- The tumor infiltrates adjacent lymph nodes



“adjacent” (WordNet)

1. **adjacent**, next, side by side (predicate) –
nearest in space or position; immediately adjoining
without intervening space;
"had adjacent rooms"; "in the next room"; "the person sitting next to me"; "our rooms
were side by side"
2. abutting, **adjacent**, adjoining, conterminous,
contiguous, neighboring (prenominal) –
having a common boundary or edge; touching;
"abutting lots"; "adjoining rooms"; "Rhode Island has two bordering states;
Massachusetts and Connecticut"; "the side of Germany conterminous with France";
"Utah and the contiguous state of Idaho"; "neighboring cities"
3. **adjacent**
near or close to but not necessarily touching;
"lands adjacent to the mountains"; "New York and adjacent cities"

Adjacency in (Mereo)Topology



- External Connection, Touching, Abutting
 - Dependent on notions of *space* and *boundary*
 - sharing of boundaries with no sharing of common (non-boundary) parts (Smith)
 - Connected without overlap (RCC):
 - $\forall x \forall y: (EC(x,y) \leftrightarrow (C(x,y) \wedge \neg O(x,y)))$
 - $\forall x \forall y: (O(x,y) \leftrightarrow (\exists z (P(z,x) \wedge P(z,y))))$
 - $\forall x \forall y: (P(x,y) \leftrightarrow (\forall z (C(z,x) \rightarrow C(z,y))))$
- (applied to the structure of space, rather than to objects located in space)
- Inclusion of boundaries requires distinction between variants of *C* to maintain consistency (Cohn, Varzi)

Connection relation (**C**) as
topological primitive

Adjacency in Medicine :

Case Study

Case study: Medical Textbooks (Books@Ovid collection)
107 M tokens, 8000 matches of **adjacen***

Domains:

Gross Anatomy:

"middle cerebellar peduncle adjacent to the fourth ventricle"

Pathologic Anatomy:

"Osteosarcoma characteristically involves the long tubular bones, especially adjacent to the knee joint"

Molecular biology:

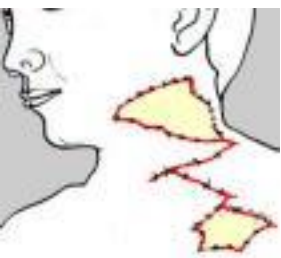
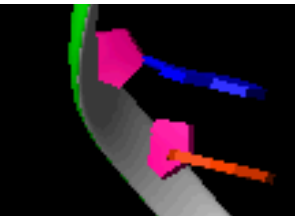
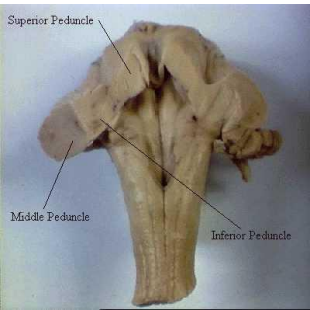
Methylation of cytosine residues in genomic DNA is quite common and usually occurs at cytosine residues adjacent to guanosine (CpG sites).

Medical Imaging:

"A lateral chest radiograph demonstrating an approximately 2-cm rounded opacity adjacent to the right hemidiaphragm"

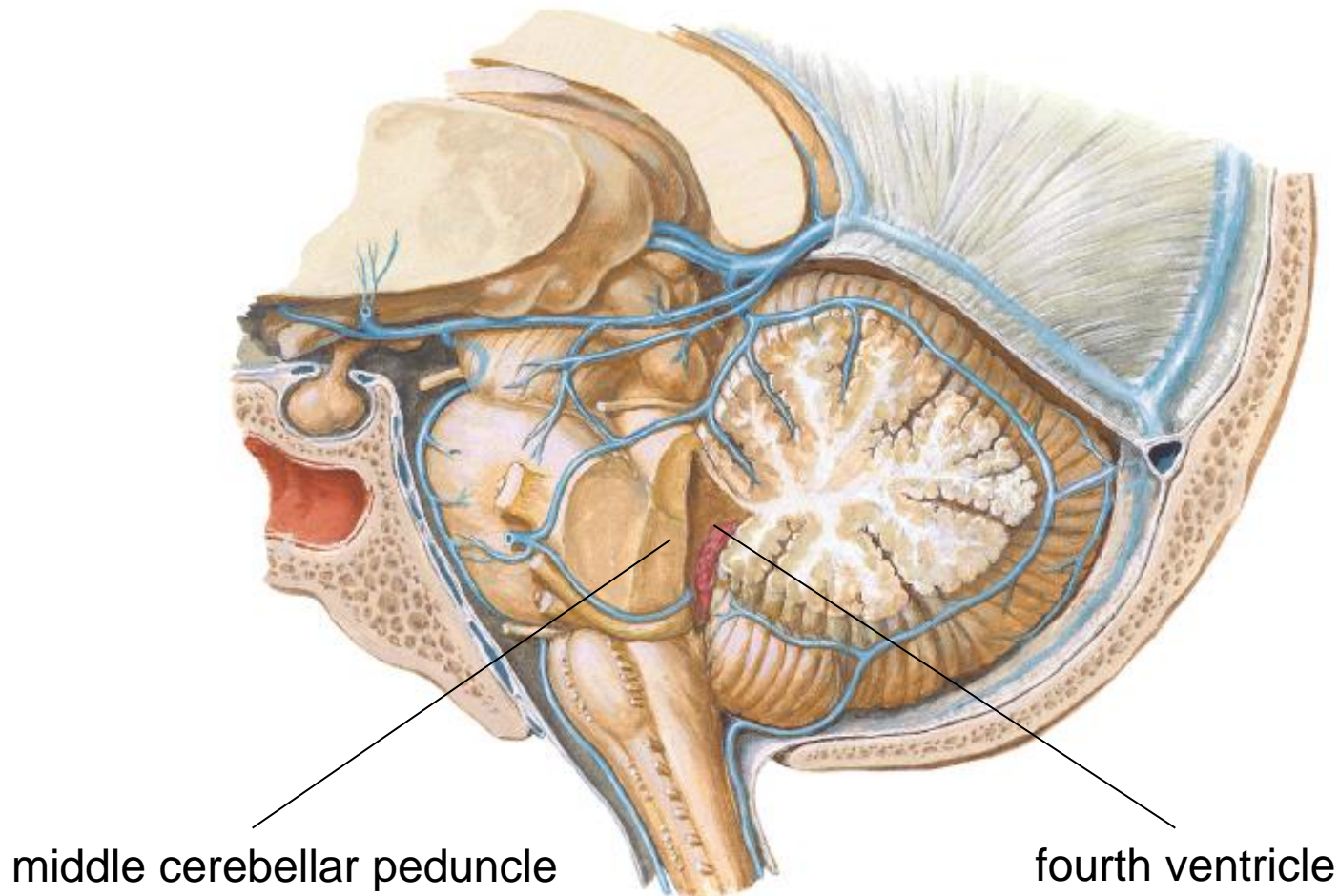
Surgical Technique:

"The edges of the flap are usually irregular and fit together with adjacent wound edges, like a jigsaw puzzle"



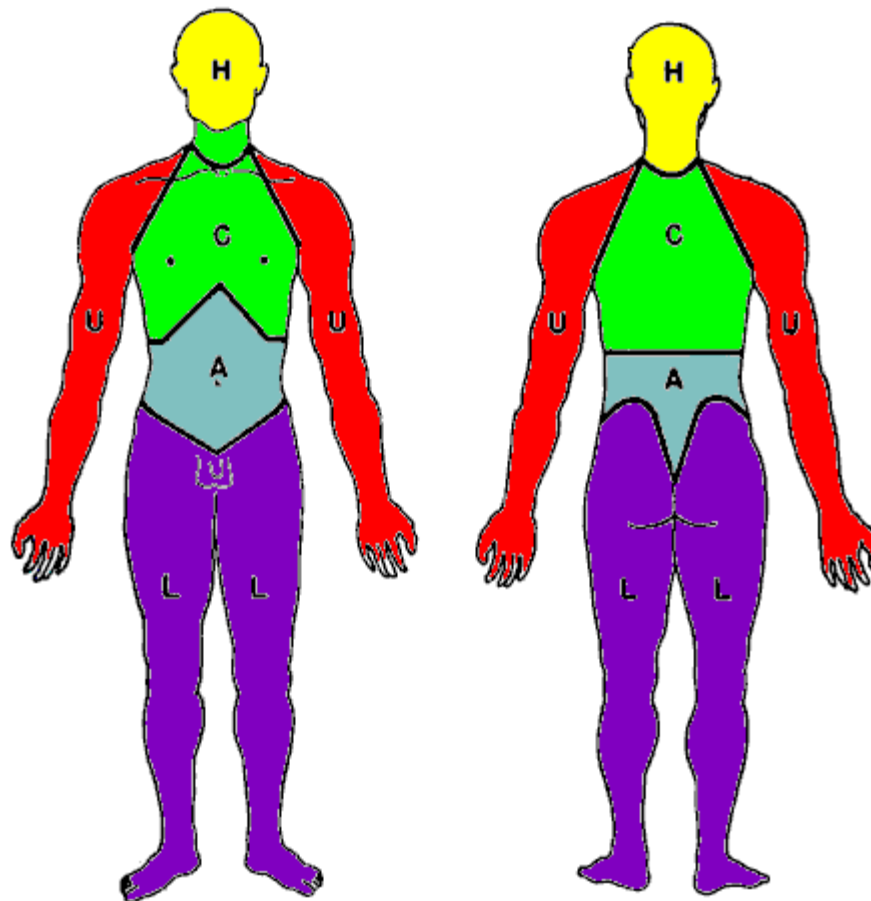
Example 1

*„middle cerebellar peduncle **adjacent to** the fourth ventricle”*



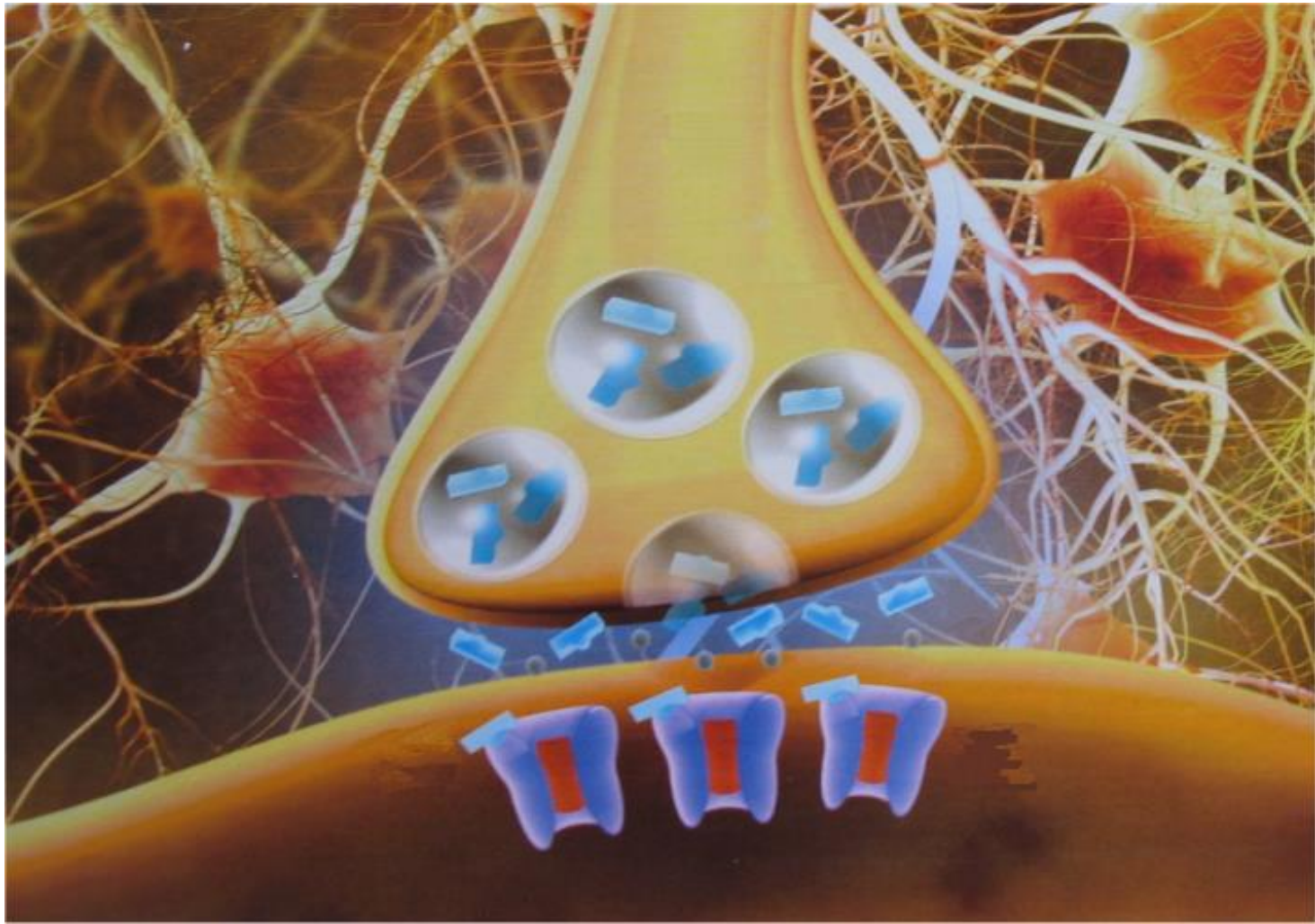
Example 2

*“...spread of paresthesias to the opposite side of **adjacent** body regions”*



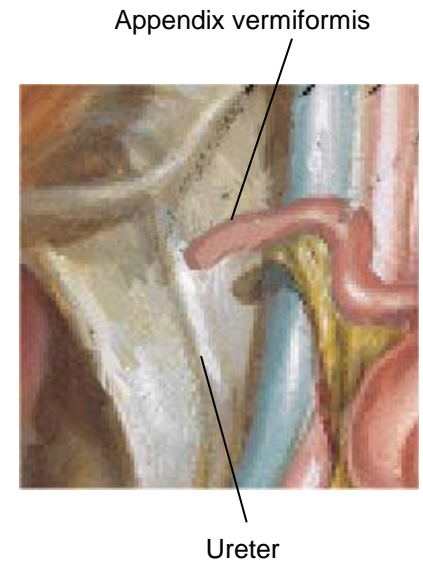
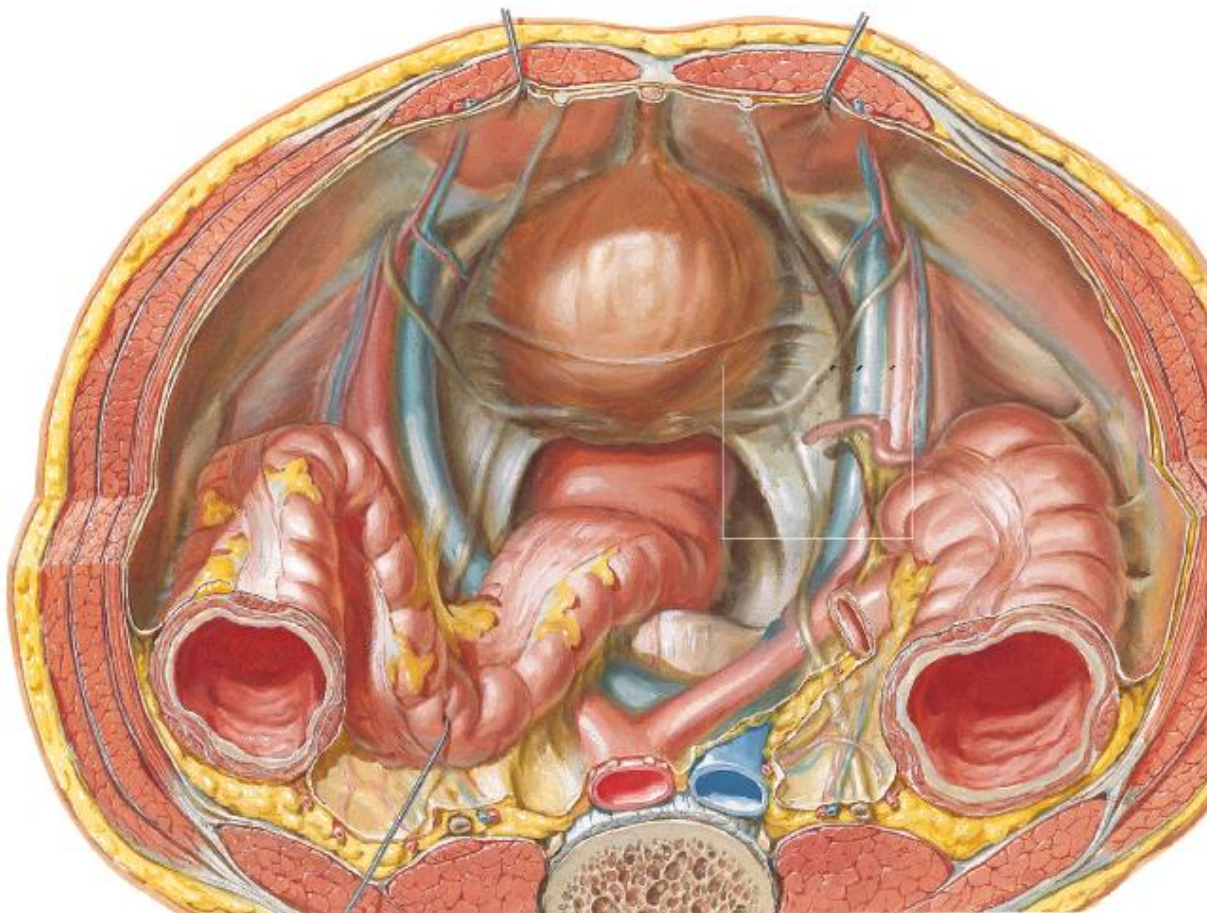
Example 3

„...specific receptors for GABA in the postsynaptic membranes *adjacent to* presynaptic terminals”



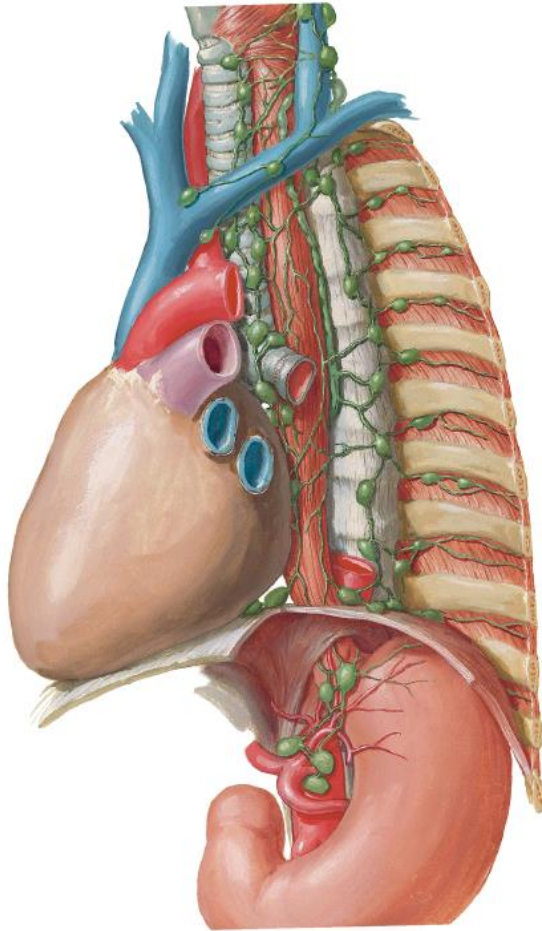
Example 4

*“Retrocaecal appendicitis often causes microscopic haematuria from inflammation of the **adjacent** ureter”*



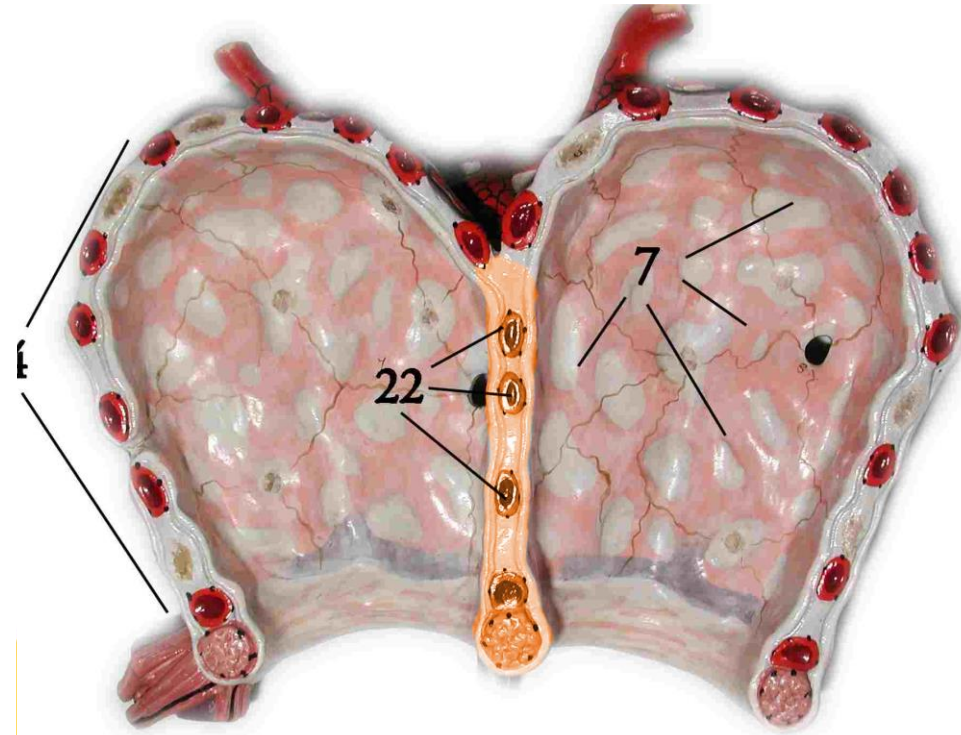
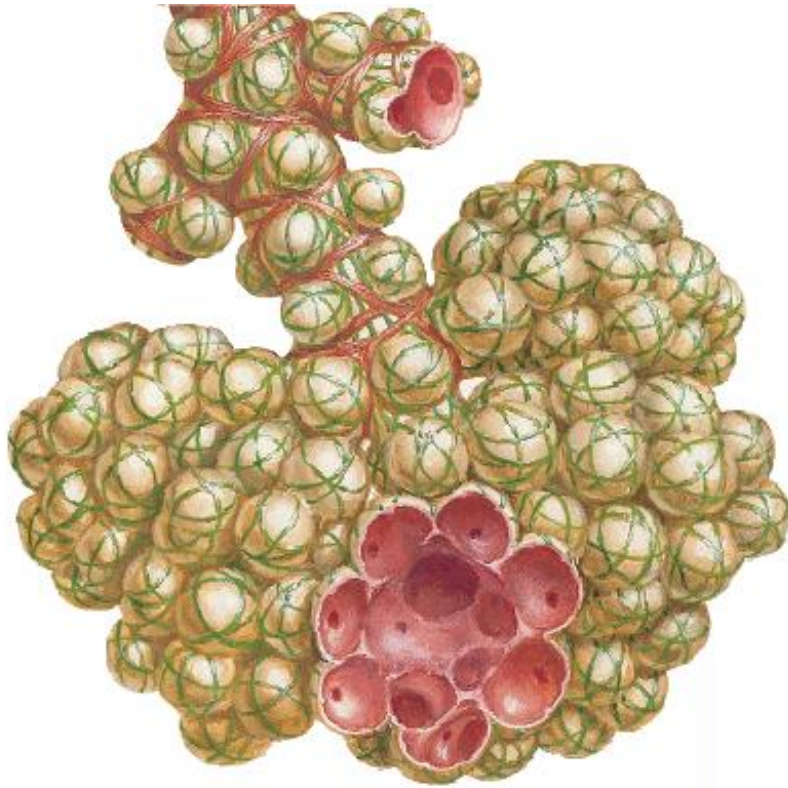
Example 5

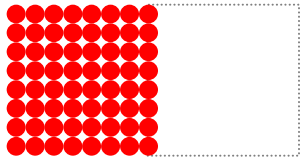
*“Esophageal carcinoma is notorious for its aggressive biologic behavior. It tends to infiltrate locally, involving **adjacent** lymph nodes.”*



Example 6

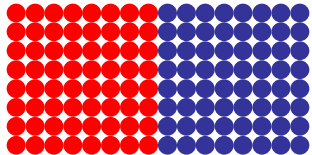
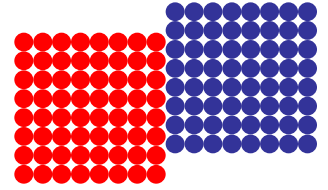
“The alveolar walls contain thin collagen strands that interconnect adjacent alveoli by weaving between capillary segments.”





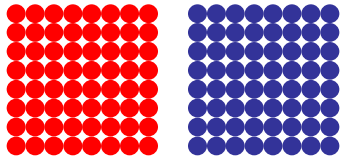
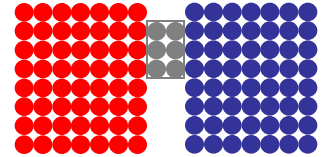
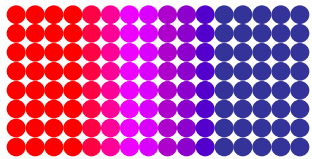
Sharing a boundary
between a solid
and a cavity

Not sharing a
physical boundary,
but possibly
touching



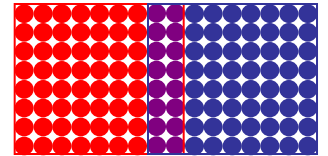
Sharing a
boundary or a
gradual transition

Not touching but
functionally
connected



Close, but not
touching

Sharing physical
parts



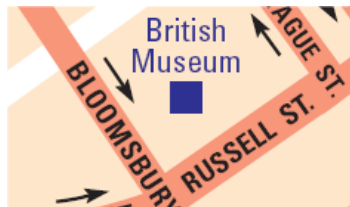
Problem Statement

Is Adjacency a foundational relation
(inferable from reality, without
commitment to a mental
abstraction) ?

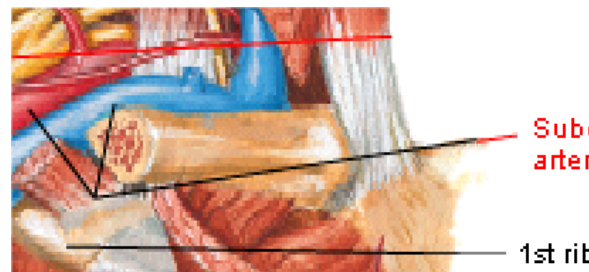
→ **MAPS**

Maps

- A spatial entity a representing another spatial entity b ($Dim(a) \leq Dim(b)$) (Casati, Varzi)
- Maps are projections from reality to a granular partition (Bittner, Smith)
- (Formal) Maps consist of regions and predications on regions (using colors, labels, conventional signs), e.g.



building (BM)



vein (SV)



interchange station (SV)

Types of Maps

- Image (by photography, radiography etc.):
 - Format: raster
 - Granularity: depends on imaging technique
 - Scale: defined

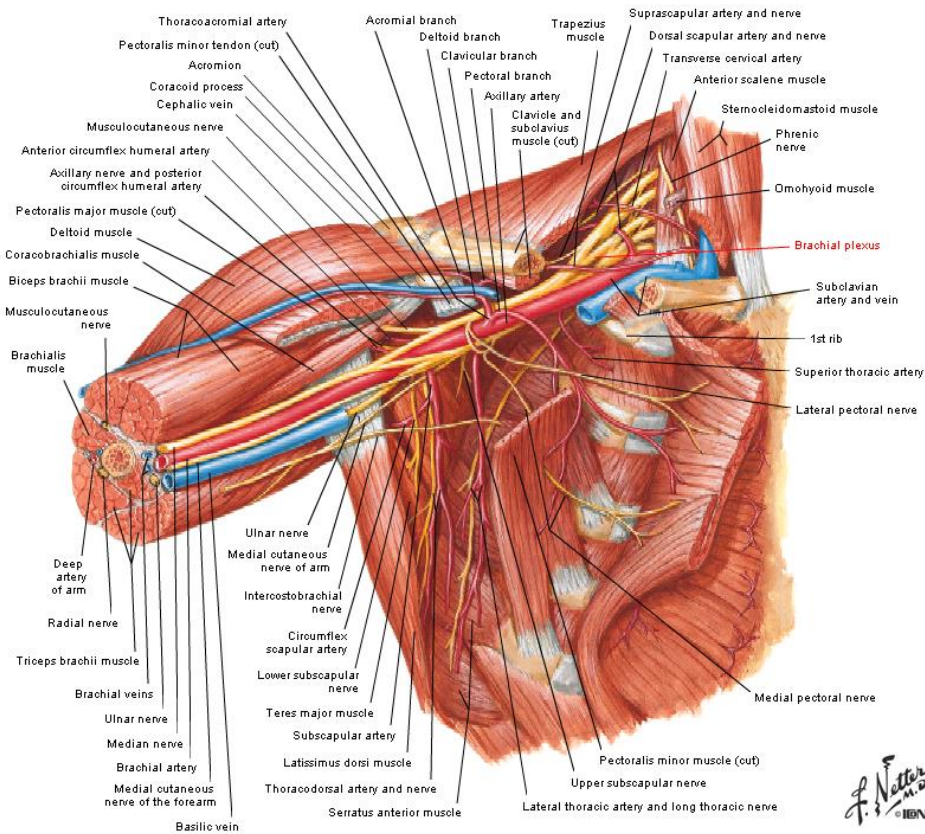
Image Map



Types of Maps

- Image (by photography, radiography etc.):
 - Format: raster
 - Granularity: depends on imaging technique
 - Scale: defined
- Scaled map (manual, digital):
 - Format: raster or vector
 - Granularity : variable, depends on purpose
 - Scale: defined

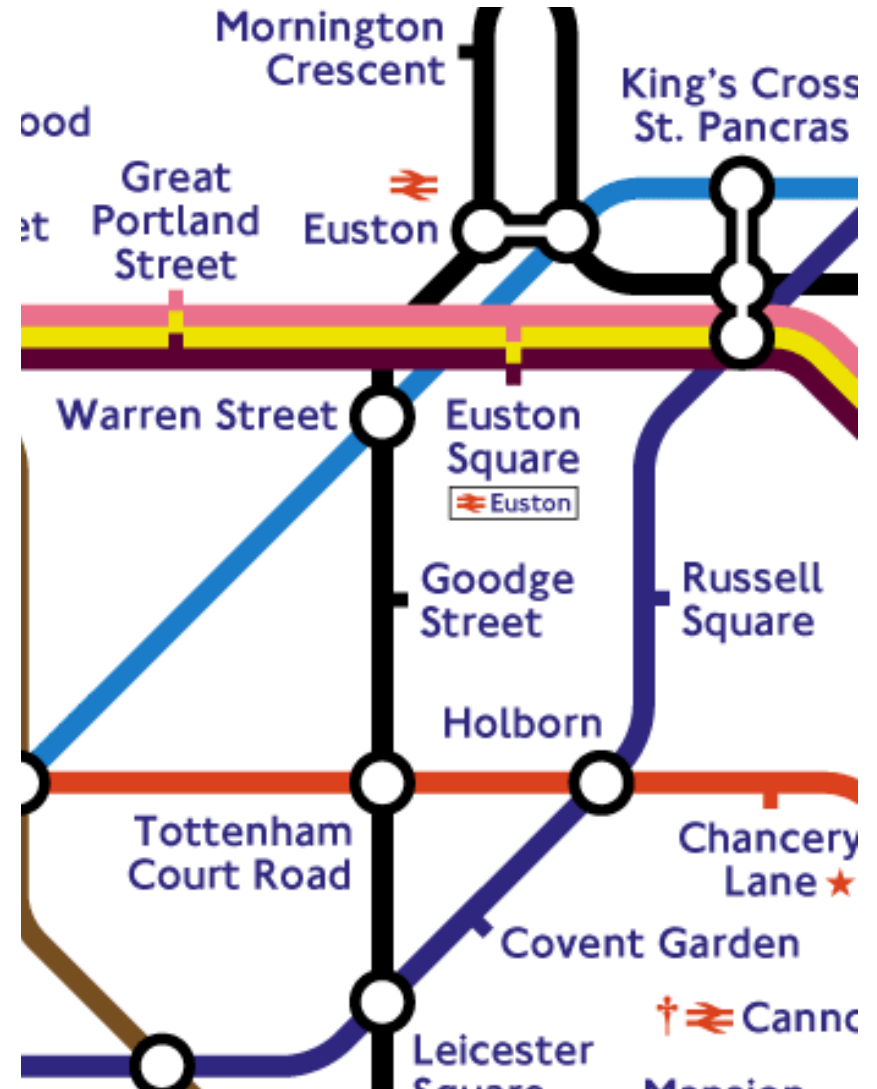
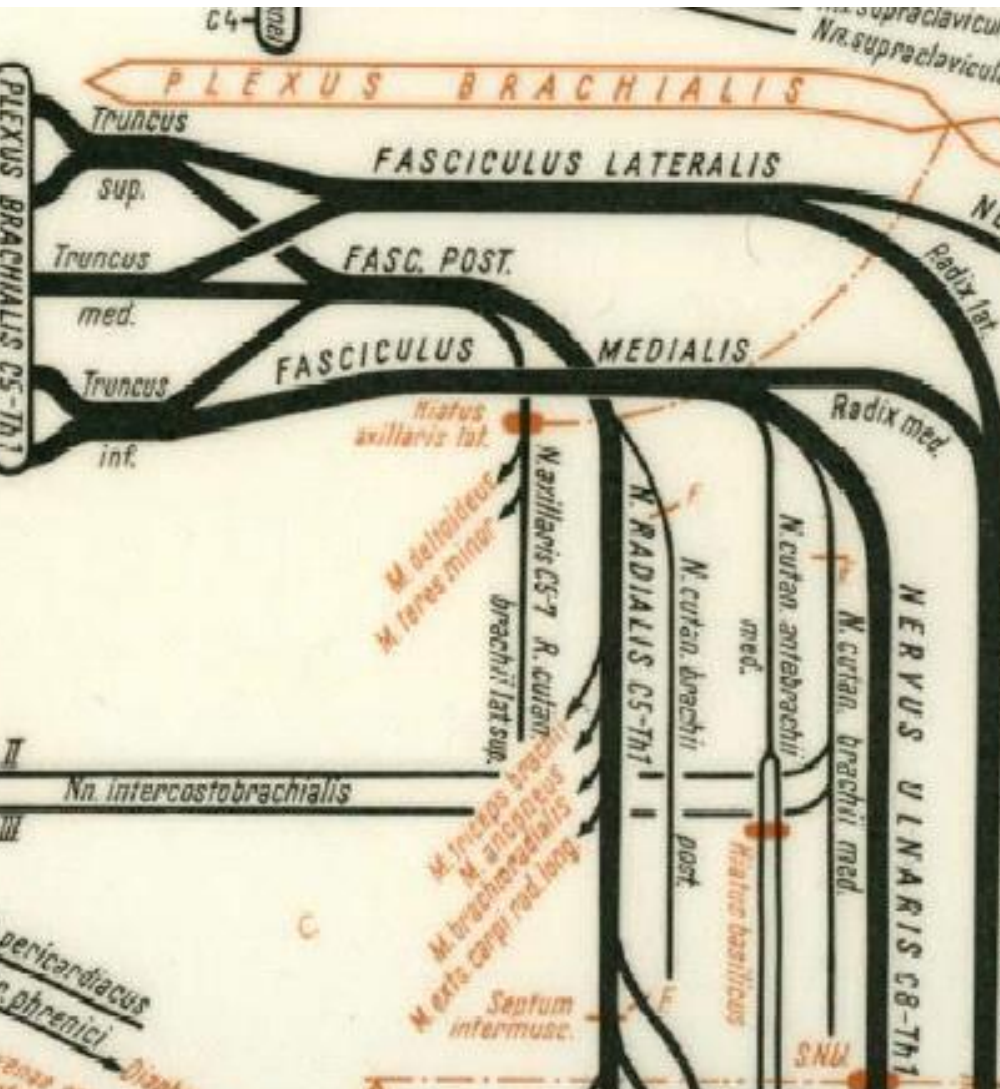
Scaled Maps



Types of Maps

- Image (by photography, radiography etc.):
 - Format: raster
 - Granularity: depends on imaging technique
 - Scale: defined
- Scaled map (manual, digital):
 - Format: raster or vector
 - Granularity : variable, depends on purpose
 - Scale: defined
- Schematic map:
 - Format: vector, graph-like
 - Granularity : selective
 - Scale: highly distorted

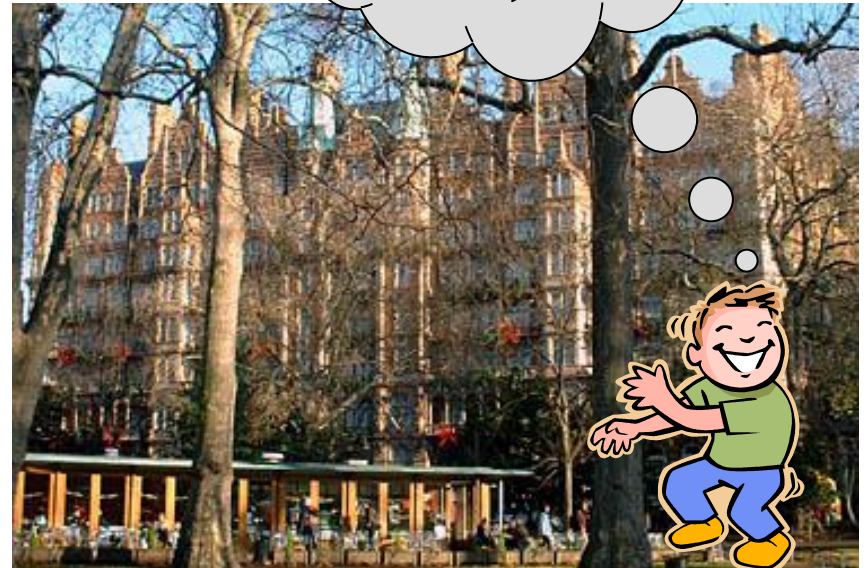
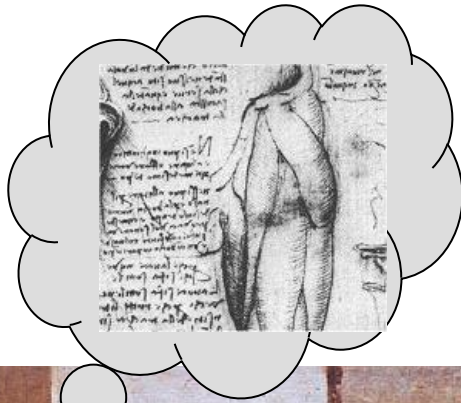
Schematic Maps



Types of Maps

- Image (by photography, radiography etc.):
 - Format: raster
 - Granularity: depends on imaging technique
 - Scale: defined
- Scaled map (manual, digital):
 - Format: raster or vector
 - Granularity : variable, depends on purpose
 - Scale: defined
- Schematic map:
 - Format: vector, graph-like
 - Granularity : selective
 - Scale: highly distorted
- Mental map:
 - Format: memory / cognition
 - Granularity : selective, focused
 - Scale: implicit

“Mental” Maps



Formal Semantics for Maps

Region R , Interpretation function f

Formal map m has model $M = \langle R, f \rangle$

For each map region m_i , $f(m_i)$ is a world / body region in R .

For any pair m_i, m_j :

(i) $P(m_i, m_j) \text{ iff } P(f(m_i), f(m_j))$

(ii) $C(m_i, m_j) \text{ iff } C(f(m_i), f(m_j))$

Varzi & Casati: Parts and Places

Extending to RCC relations:

(iii) $O(m_i, m_j) \text{ iff } O(f(m_i), f(m_j))$

(iv) $EC(m_i, m_j) \text{ iff } EC(f(m_i), f(m_j))$

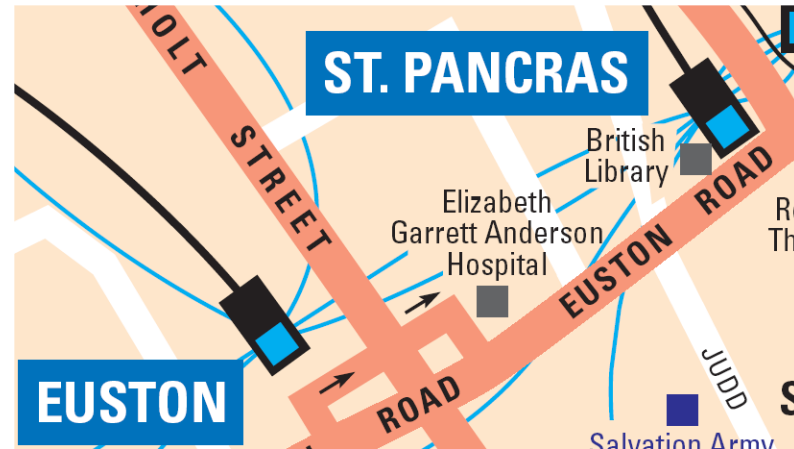
Formal Semantic for Maps

- Conclusion (interpreting adjacency as external connection):
 - Entities which are adjacent in reality are also adjacent on maps (and vice versa)
 - Entities which overlap in reality also overlap on maps (and vice versa)

Does this always hold true ?

Adjacency in Geo Map

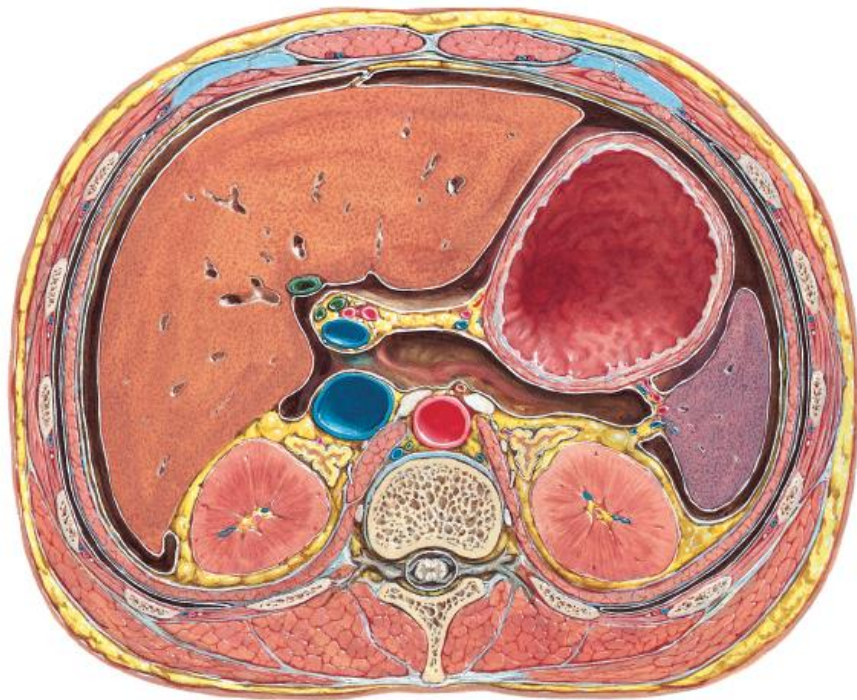
- Is St. Pancras Station adjacent to British Library?
- Is St. Pancras Station adjacent to Euston Station?



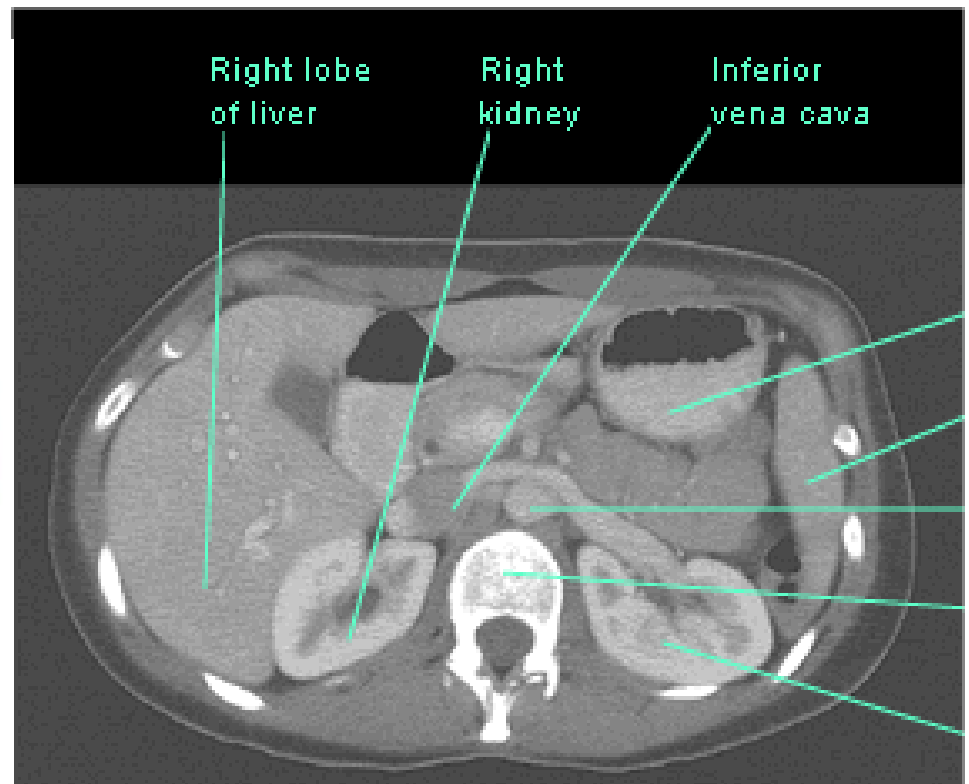
Adjacency in Body Map

- Is the kidney adjacent to the liver?

map1 (high resolution)



map2 (image, low resolution)



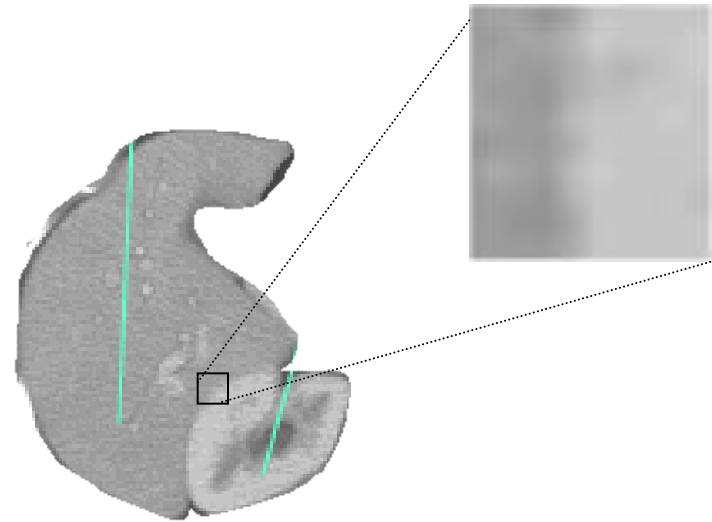
Adjacency in Body Map

- Is the kidney adjacent to the liver?

map1 (high resolution)

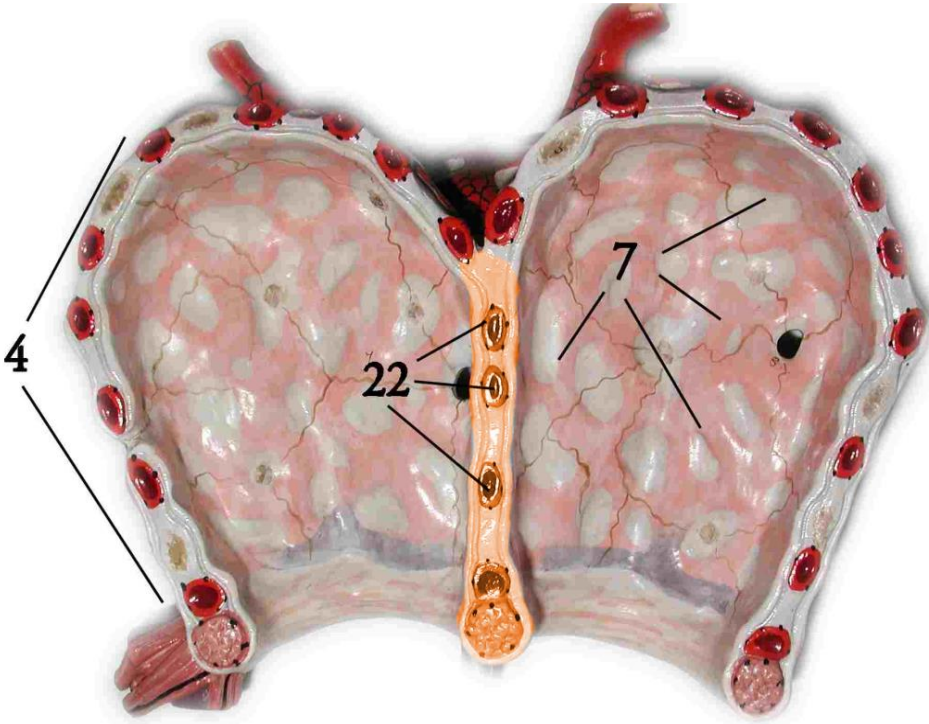


map2 (image, low resolution)

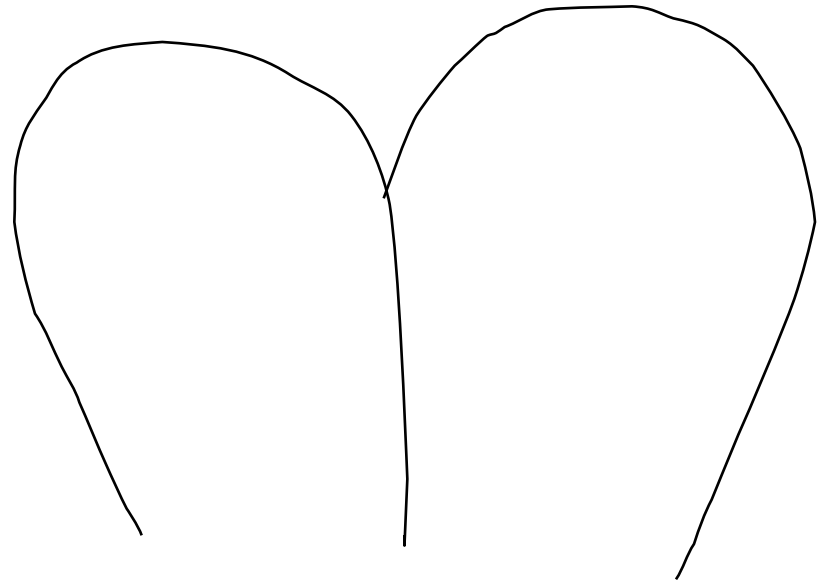


Overlap in Reality, Adjacency in Map

map1 (high resolution)



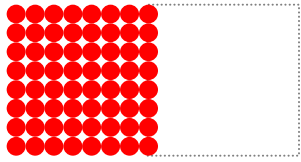
map2 (schematic)



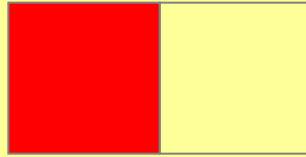
Adjacency and Maps: Main Argument

Two spatially relevant objects are adjacent, when their representations on a map are externally connected (on raster or vector maps) or are neighboring nodes (on graph-like schematic maps)

Reality



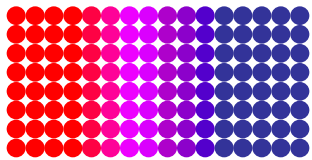
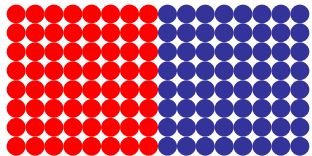
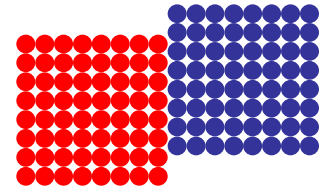
Map



Map

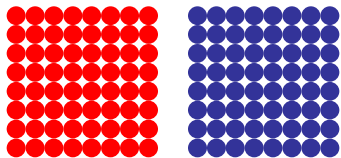
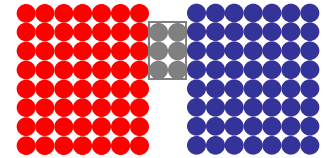
Not sharing a physical boundary, but possibly touching

Reality



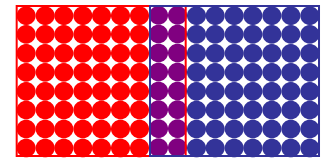
Sharing a boundary or a gradual transition

Not touching but functionally connected

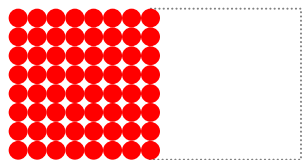


Close, but not touching

Sharing physical parts



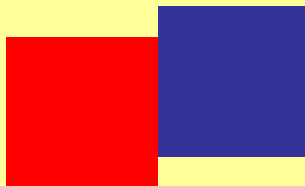
Reality



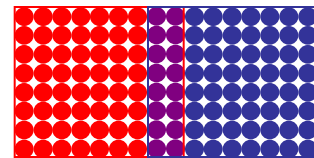
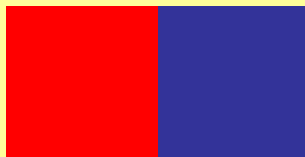
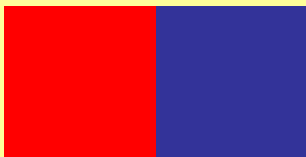
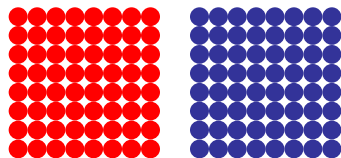
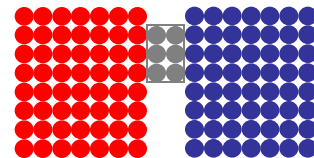
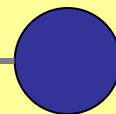
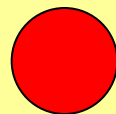
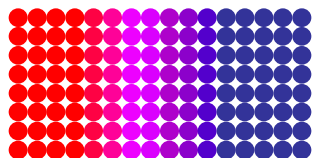
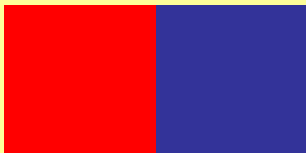
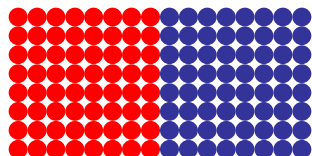
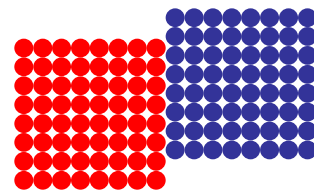
Map



Map

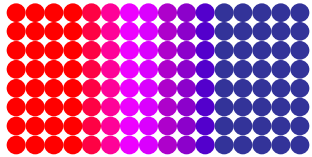
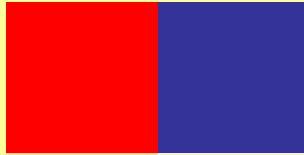
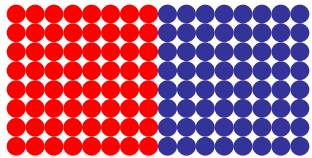
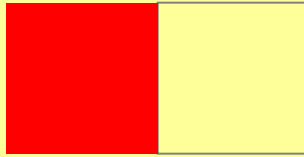
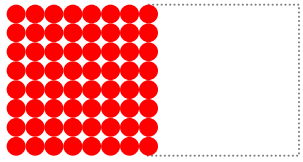


Reality



Reality

Map



**Adjacency as a
foundational relation
describing reality**

Reality

Map

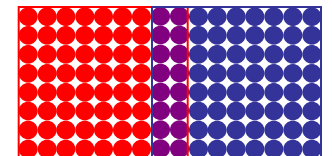
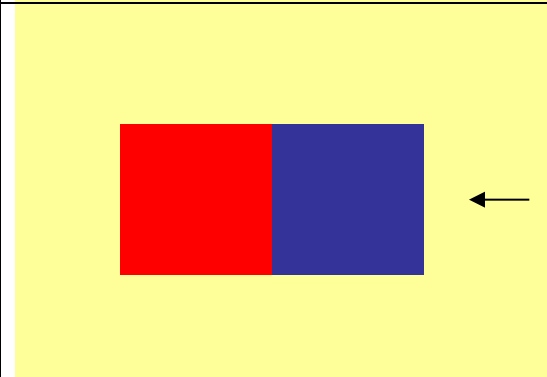
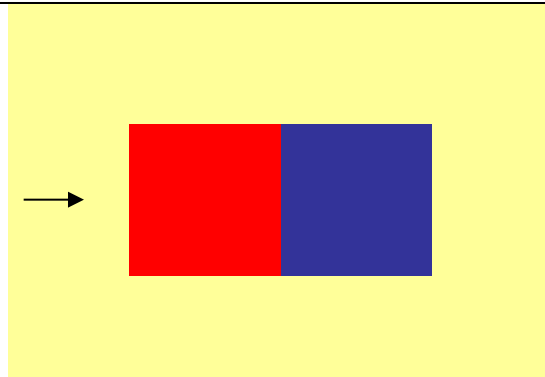
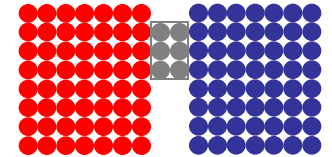
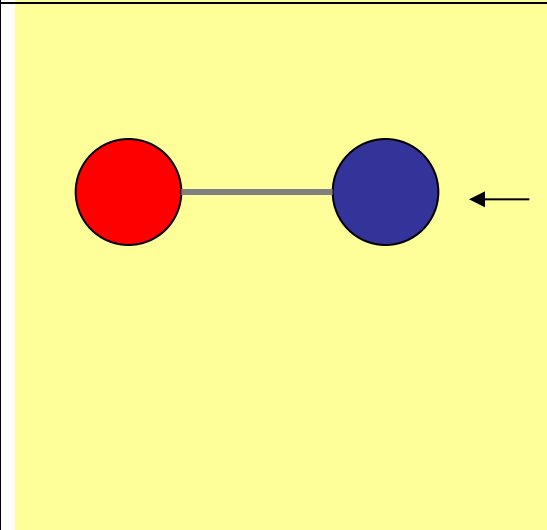
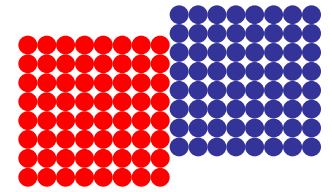
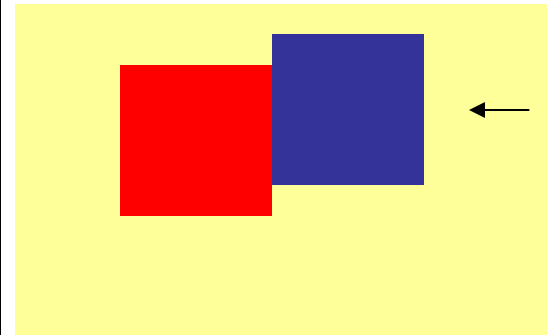
**Adjacency as a
contextual relation
dependent on maps**

Map m with $M = \langle R, f \rangle$

$$adjacent_m(a, b) =_{def} ec(f^{-1}(a), f(b))$$

Map

Reality



Conclusion

- The notion of adjacency in geo an biosciences goes beyond the topological external connection
- It includes external connection and neighborhood on maps which have no exact correlate in reality
- Maps are artifacts or concepts produced and used by cognition
- Hence, adjacency cannot be ascribed the status of a foundational relation in most cases