

Einführung

Allgemeine mikroskopische Neuropathologie

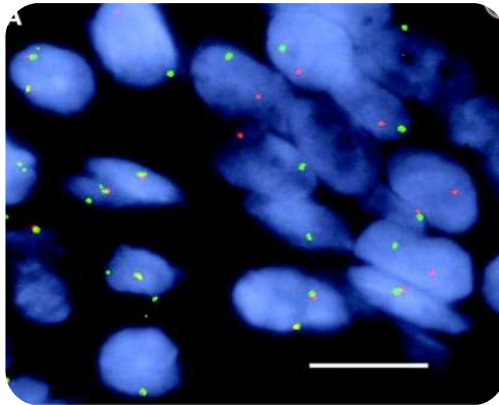
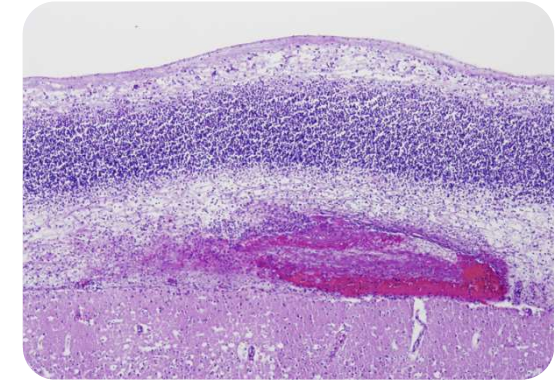
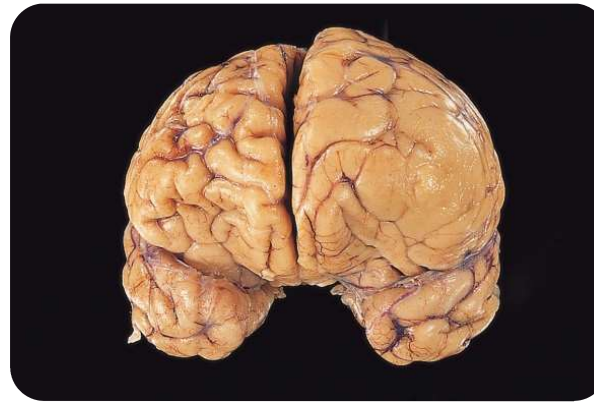
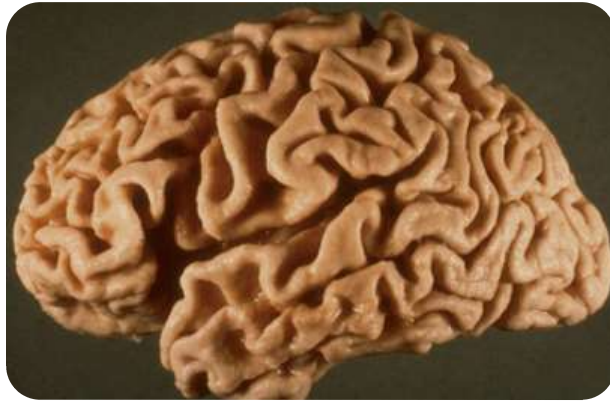
Hirndruck

Dr. Maria Lehning

Ärztin in Weiterbildung

Paul-Flechsig-Institut für Neuropathologie

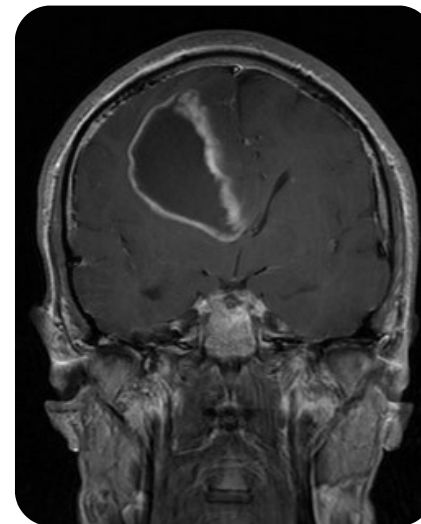




Neuropathologie

Vorlesungsplan Dezember 2024

1. Einführung, Hirndruck
2. Entzündungen
3. Hirnblutungen und Ischämie
4. Tumoren in der Neuropathologie
5. Einführung molekulare Marker
6. Neurodegenerative Erkrankungen



<https://neuropathology-web.org/chapter9/chapter9bAD.html>
<https://neuropathology-web.org/chapter4/chapter4aSubduralepidural.html>
<https://neuropathology-web.org/chapter5/chapter5aSuppurative.html>
<https://radiopaedia.org/articles/glioblastoma?lang=us>

Lernziele

- Aufgabenbereich der Neuropathologie
- Einführung in die mikroskopische Neuropathologie
- Begriff gesteigerter intrakranieller Druck
- Pathophysiologie Hirnödem
- Klinische Zeichen des gesteigerten intrakraniellen Drucks, Herniationen

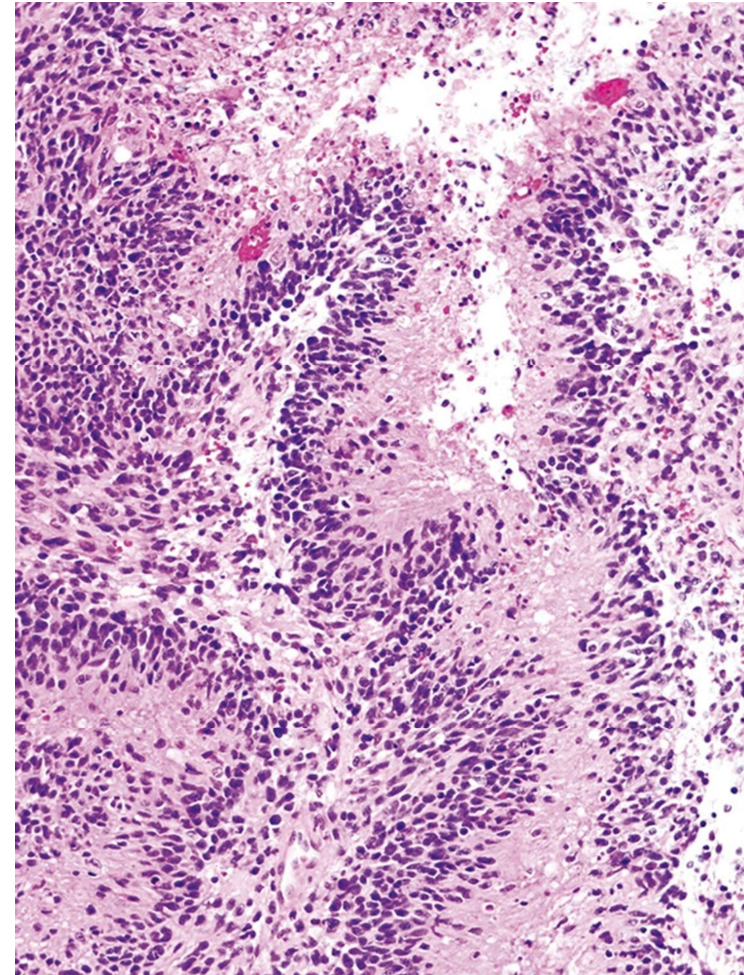
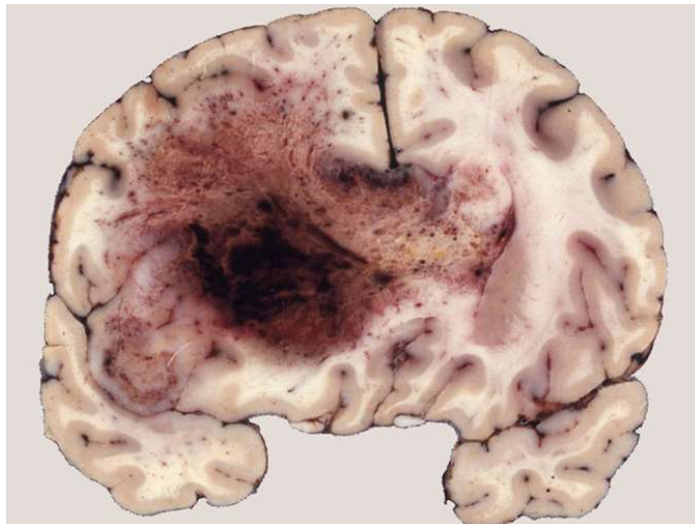
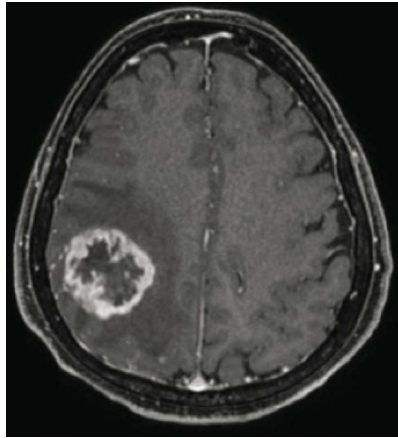
EINFÜHRUNG IN DIE NEUROPATHOLOGIE

- ☛ Krankhafte Veränderungen des ZNS und PNS sowie der Muskulatur
- ☛ Untersuchung von Gewebeproben, die bei (neurochirurgischen) Operationen gewonnen werden
- ☛ Ziel: definitive Diagnosestellung → neuropathologische Gewebediagnose wesentlich für anschließende Therapie

- ☞ **Ursachen des Todeseintritts** und Vergleich mit den klinischen (neuro-psychiatrischen) Diagnosen
- ☞ **Forensische** Fragestellungen
- ☞ Instrument der **Qualitätssicherung**

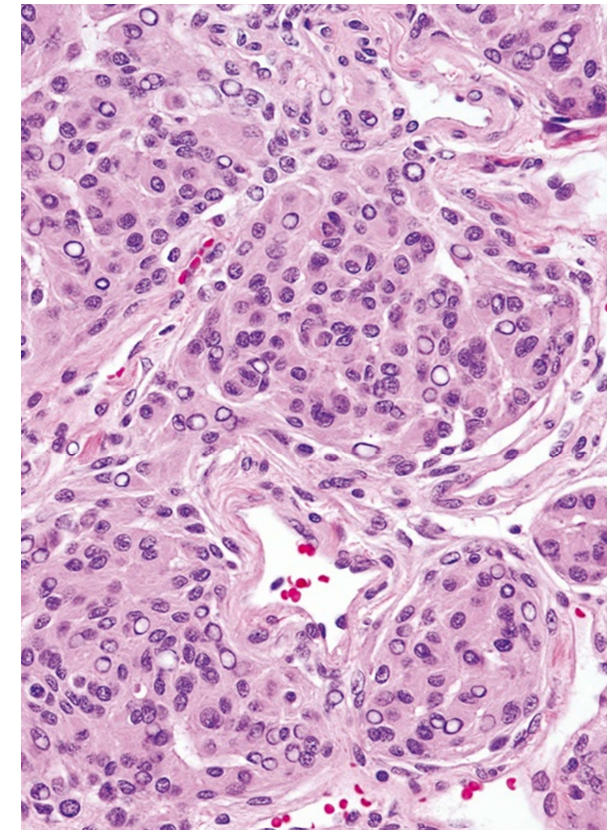
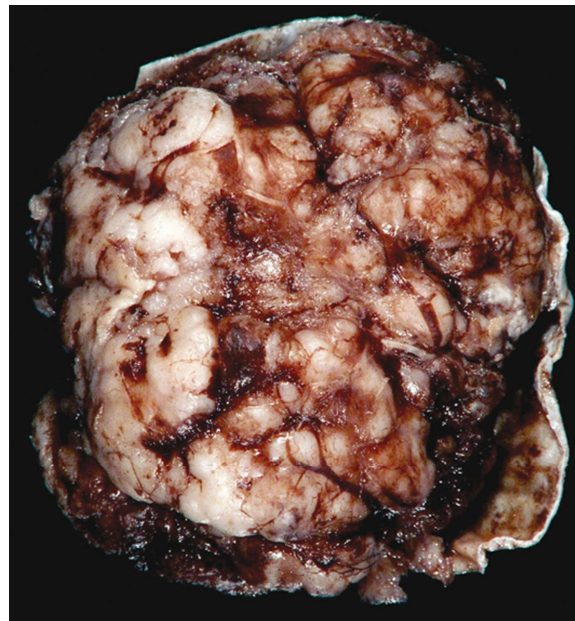
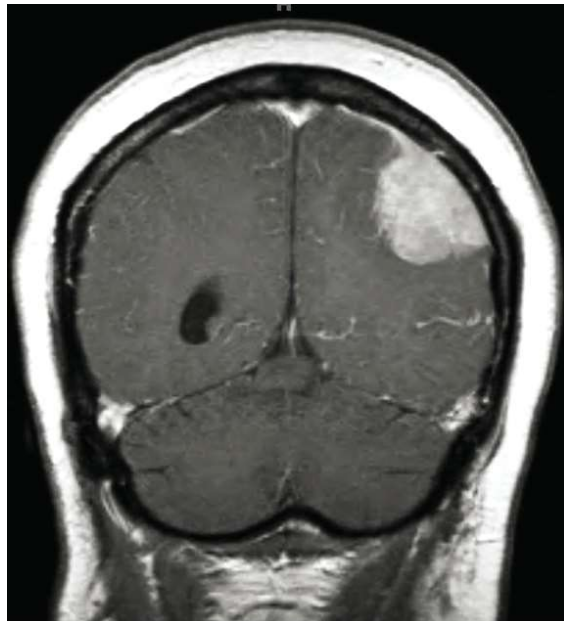
- ☞ Eigene Facharztweiterbildung
- ☞ Insgesamt 6 Jahre
- ☞ 24 Monate Basisweiterbildung in der Pathologie
- ☞ 12 Monate können in Neurochirurgie, Neurologie, Neuropädiatrie, Neuroradiologie und/oder Psychiatrie angerechnet werden

- ☛ Störungen der Liquorzirkulation, Hydrocephalien
- ☛ Physiologische Hirnalterung und Altersdemenzen
- ☛ Pathologie der Epilepsien
- ☛ Entwicklung des Nervensystems: Prä- und Perinataleschäden, Kernikterus
- ☛ Entzündliche Erkrankungen, Multiple Sklerose und verwandte Syndrome
- ☛ Übertragbare spongiforme Enzephalopathien
- ☛ Systematrophien
- ☛ Mechanische und andere physikalische Traumen des ZNS und PNS
- ☛ Forensische Neuropathologie
- ☛ **Tumoren des Nervensystems**
- ☛ Intoxikationen und Alkoholschäden
- ☛ Spongiose Dystrophien und mitochondriale Enzephalopathien
- ☛ Genetische (Stoffwechsel-) Erkrankungen von neuropathologischer Relevanz
- ☛ Pathologie des Peripheren Nervensystems, der Skelettmuskulatur und des Auges



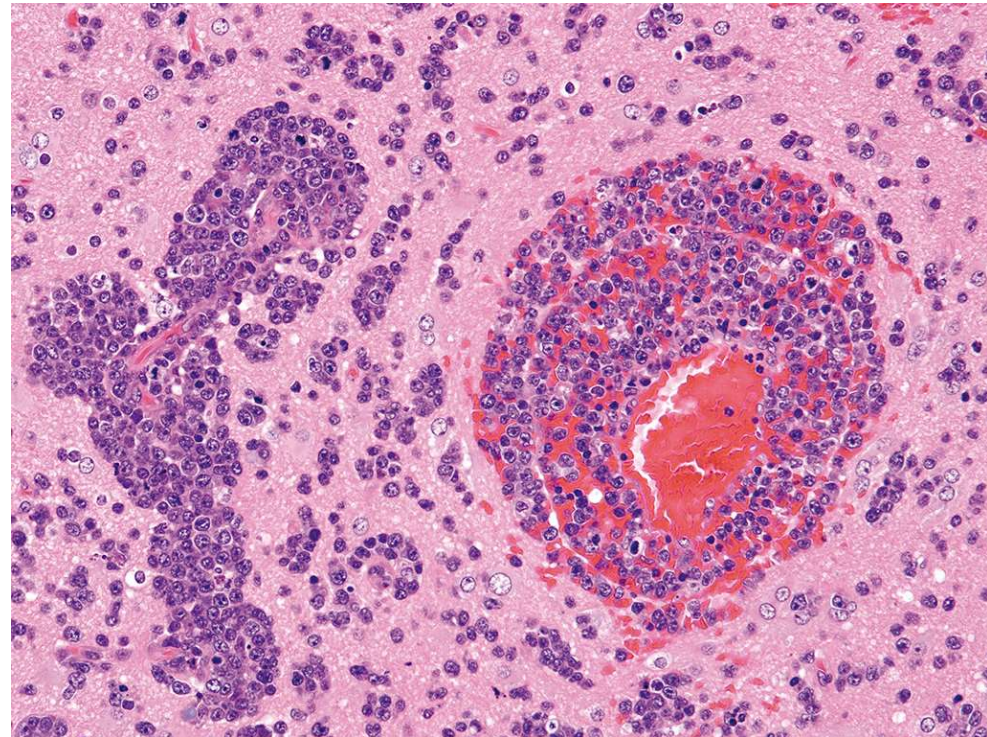
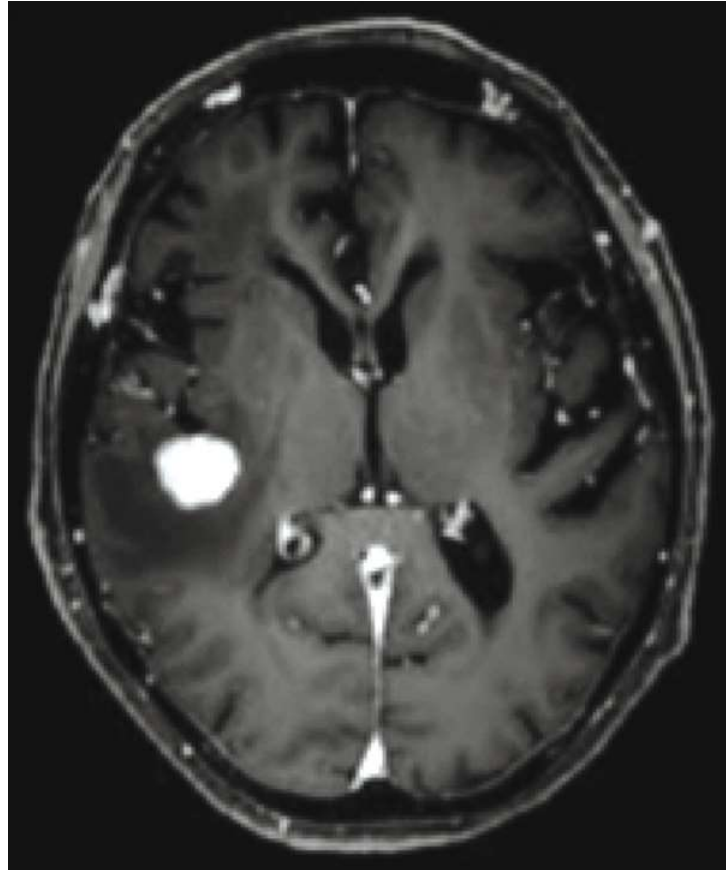
Glioblastom, IDH-Wildtyp, WHO Grad 4

<https://tumourclassification.iarc.who.int/chaptercontent/45/7>



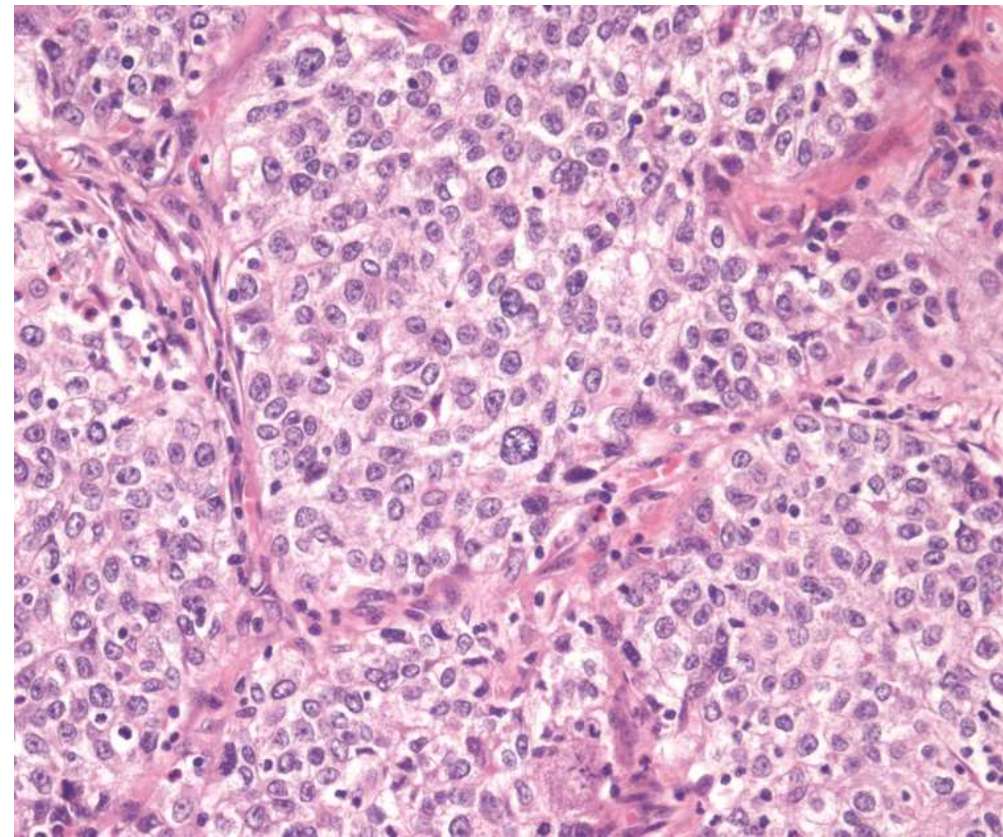
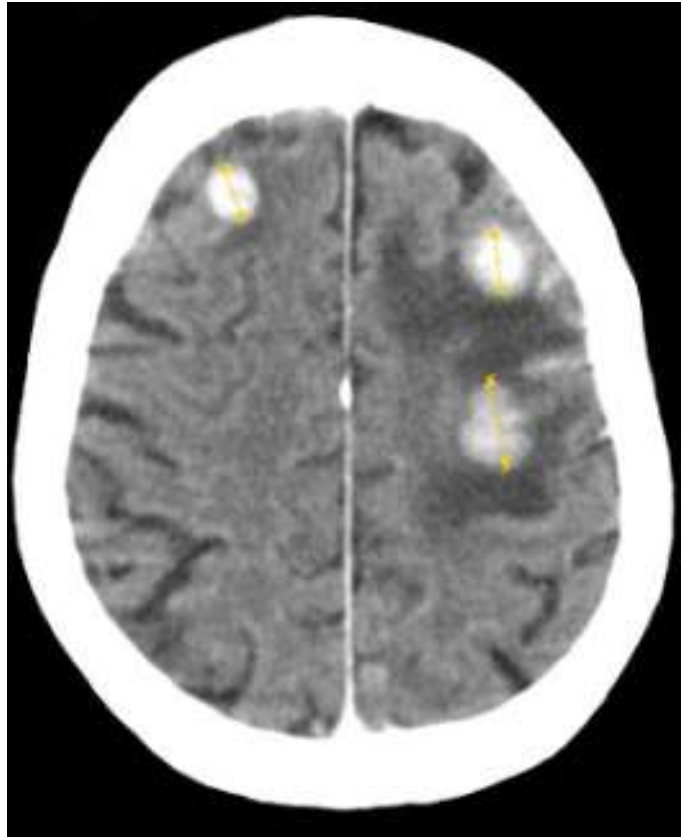
Meningeom WHO-Grad 1, meningotheiomatöser Subtyp

<https://tumourclassification.iarc.who.int/chaptercontent/45/91>



Primäres diffus großzelliges ZNS-Lymphom

<https://tumourclassification.iarc.who.int/chaptercontent/45/162>

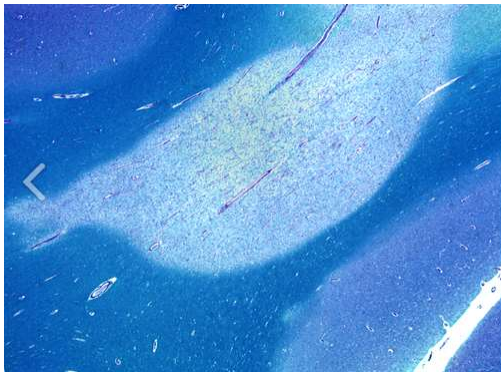


Karzinometastase eines nicht kleinzelligen Adenokarzinoms der Lunge

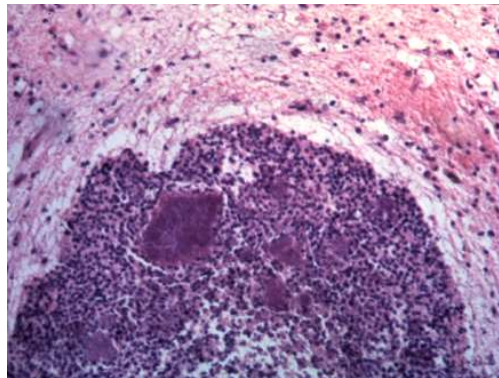
<https://tumourclassification.iarc.who.int/chaptercontent/35/23>
[BrainMetastasisFromBreastCancer - Hirnmetastase - Wikipedia](#)

... und noch vieles mehr.

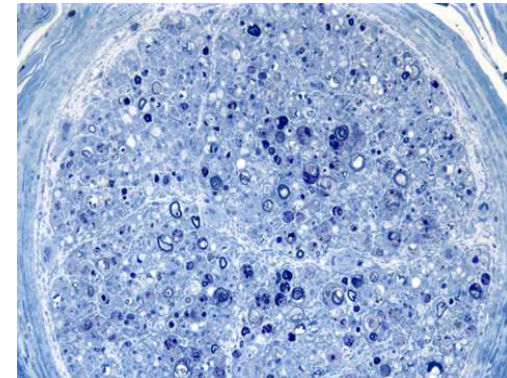
Multiple Sklerose



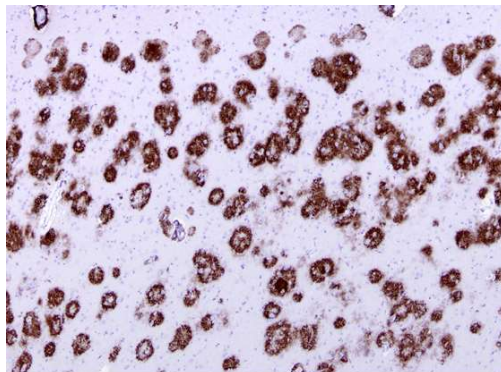
Hirnabszess



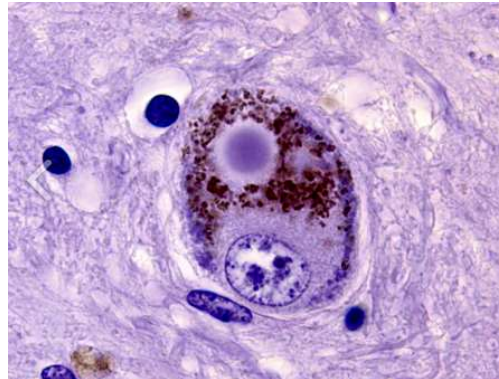
Neuropathien



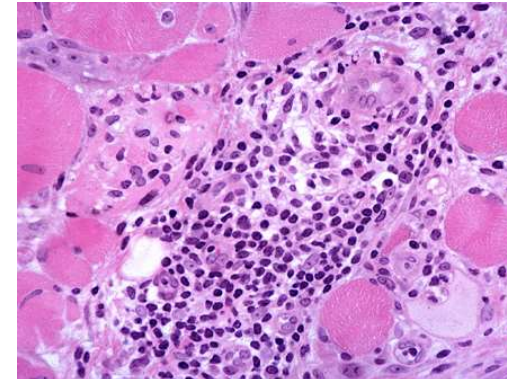
Mb. Alzheimer



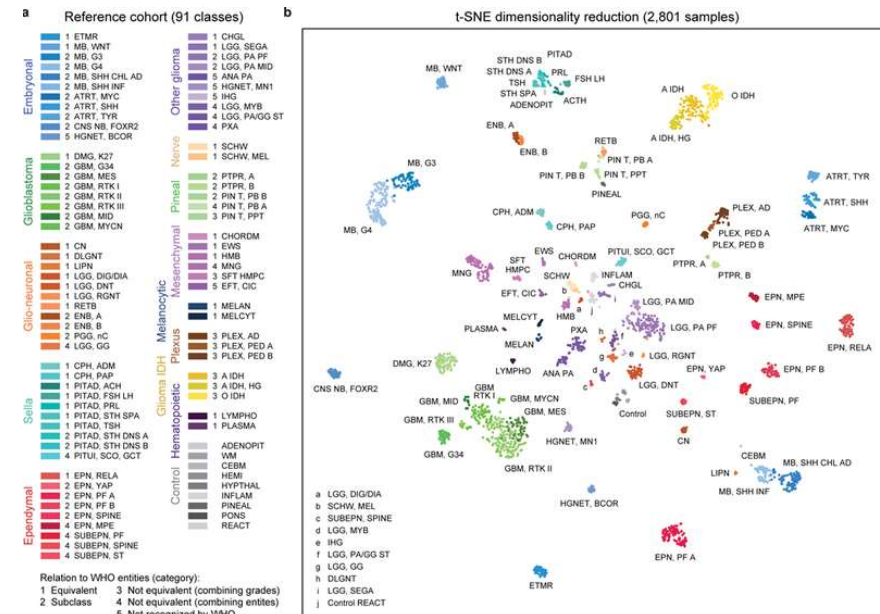
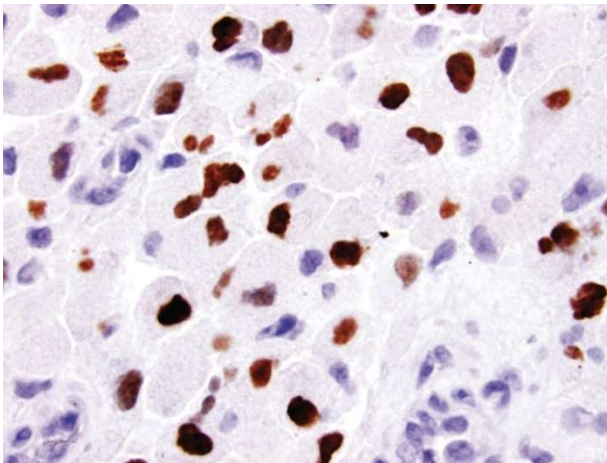
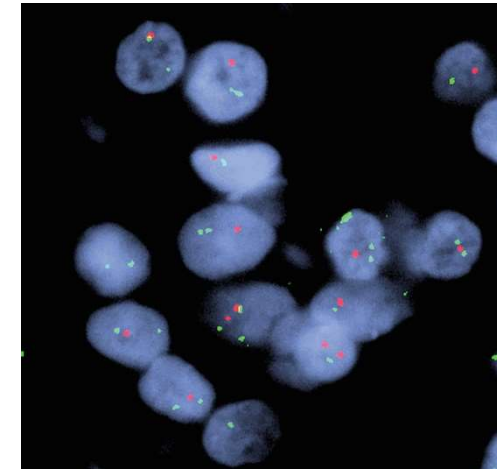
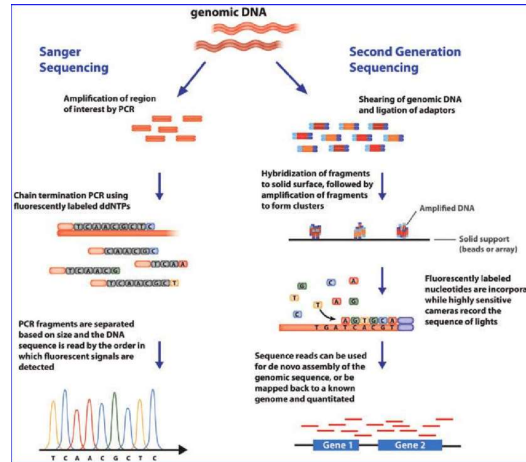
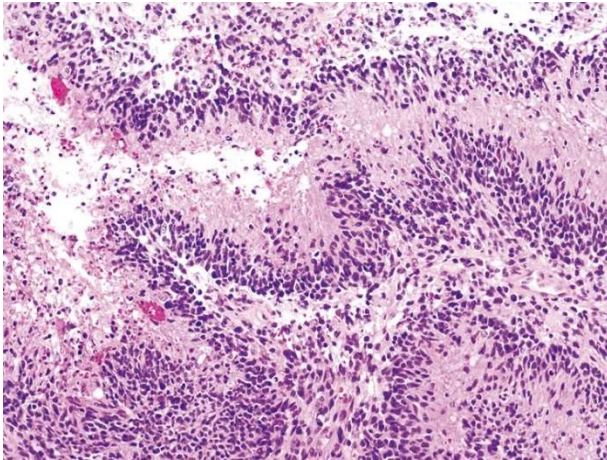
Mb. Parkinson



Myositiden



Methodenspektrum




An Introduction to Functional Genomics and Systems Biology,
<https://doi.org/10.1089/wound.2012.0379>

Nature. 2018 Mar 22; 555(7697): 469–474.

<https://tumourclassification.iarc.who.int/chaptercontent/45/7>

Published: 14 March 2018

DNA methylation-based classification of central nervous system tumours

David Capper, David T. W. Jones, Martin Sill, Volker Hovestadt, Daniel Schrimpf, Dominik Sturm, Christian Koelsche, Felix Sahm, Lukas Chavez, David E. Reuss, Annekathrin Kratz, Annika K. Wefers, Kristin Huang, Kristian W. Pajtler, Leonille Schweizer, Damian Stichel, Adriana Olar, Nils W. Engel, Kerstin Lindenberg, Patrick N. Harter, Anne K. Braczynski, Karl H. Plate, Hildegard Dohmen, Boyan K. Garvalov, ... Stefan M. Pfister  + Show authors

Nature 555, 469–474 (2018) | Cite this article

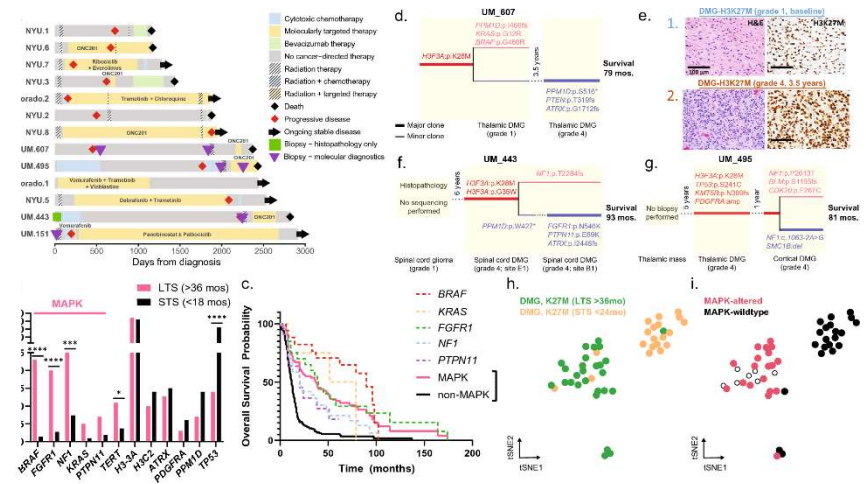
87k Accesses | 1536 Citations | 499 Altmetric | Metrics

<https://www.nature.com/articles/nature26000>

Myelin insulation as a risk factor for axonal degeneration in autoimmune demyelinating disease

Erik Schäffner ^{# 1 2}, Mar Bosch-Queralt ^{# 2}, Julia M Edgar ^{1 3}, Maria Lehning ², Judith Strauß ⁴, Niko Fleischer ², Theresa Kungl ⁵, Peter Wieghofer ^{5 6}, Stefan A Berghoff ^{1 7}, Tilo Reinert ^{2 8}, Martin Krueger ⁵, Markus Morawski ⁹, Wiebke Möbius ¹, Alonso Barrantes-Freer ², Jens Stieler ⁹, Ting Sun ¹, Gesine Saher ¹, Markus H Schwab ², Christoph Wrede ¹⁰, Maximilian Frosch ¹¹, Marco Prinz ^{11 12 13}, Daniel S Reich ¹⁴, Alexander Flügel ⁴, Christine Stadelmann ¹⁵, Robert Fledrich ^{16 17}, Klaus-Armin Nave ¹⁸, Ruth M Stassart ^{19 20}

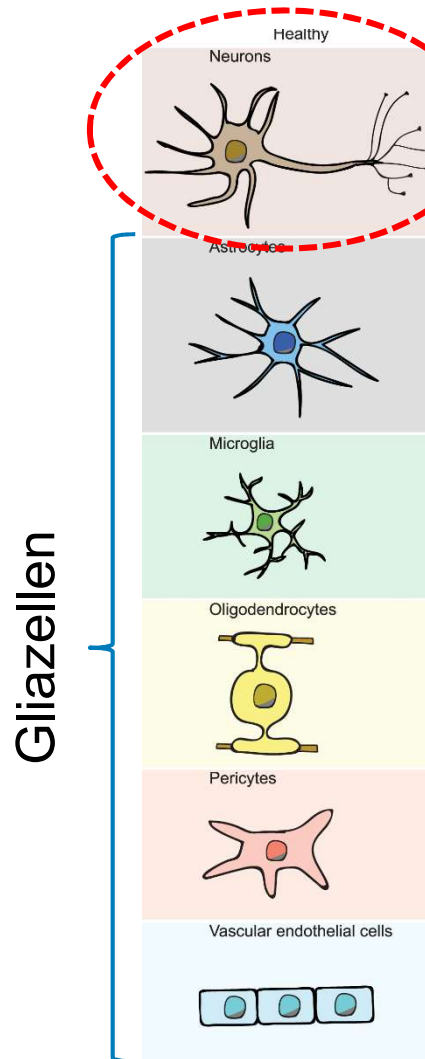
Schäffner et al. Myelin insulation as a risk factor for axonal degeneration in autoimmune demyelinating disease. Nat Neurosci. 2023 Jul;26(7):1218-1228. doi: 10.1038/s41593-023-01366-9. Epub 2023 Jun 29. PMID: 37386131; PMCID: PMC10322724.



Roberts et al. Clinical, genomic, and epigenomic analyses of H3K27M-mutant diffuse midline glioma long-term survivors reveal a distinct group of tumors with MAPK pathway alterations. Acta Neuropathol 146, 849–852 (2023). <https://doi.org/10.1007/s00401-023-02640-7>

Es besteht eine große Nähe
zu
grundlagenwissenschaftlicher
und diagnostischer Forschung

ALLGEMEINE MIKROSKOPISCHE NEUROPATHOLOGIE

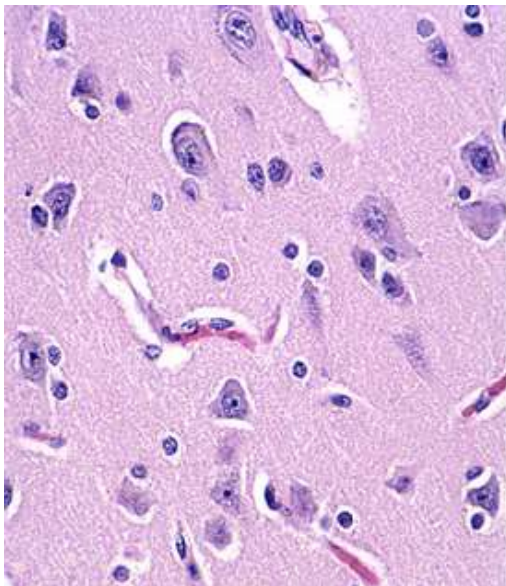


- Die verschiedenen Zelltypen des Gehirns können morphologisch und immunhistochemisch unterschieden werden.
- Sie können sich – teils pathognomonisch – im Rahmen einer ZNS-Pathologie verändern.
- Diese Veränderungen als auch die Überschneidungen mit den ursprünglich „gesunden“ Zellen zu detektieren sind entscheidend für die richtige Diagnose.

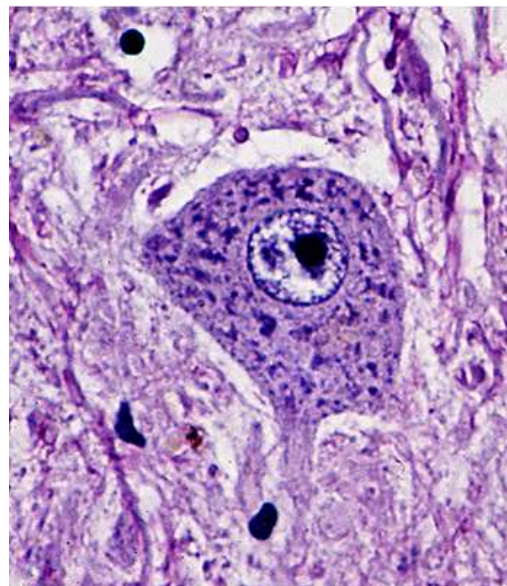
Penney, J., Ralvenius, W.T. & Tsai, L.H. Modeling Alzheimer's disease with iPSC-derived brain cells. *Mol Psychiatry* **25**, 148–167 (2020). <https://doi.org/10.1038/s41380-019-0468-3>

Zelltypen im ZNS: Neurone

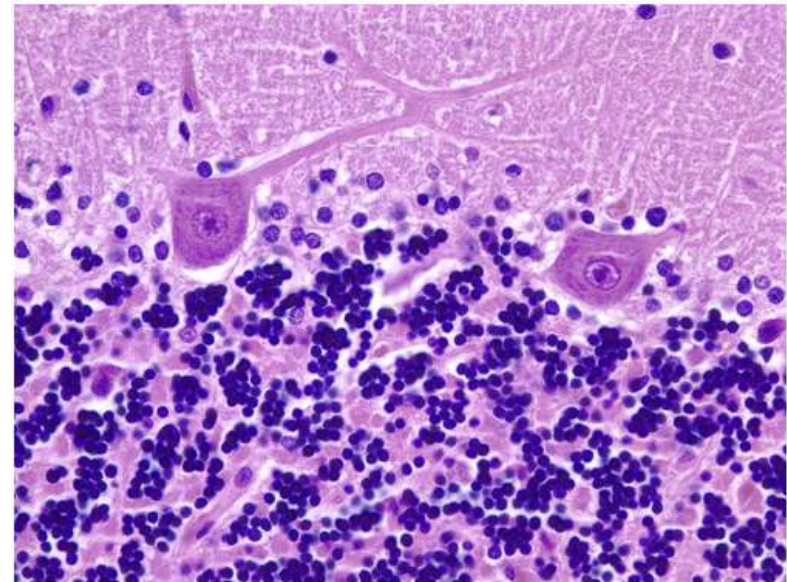
Kortex



Spinales
Motoneuron

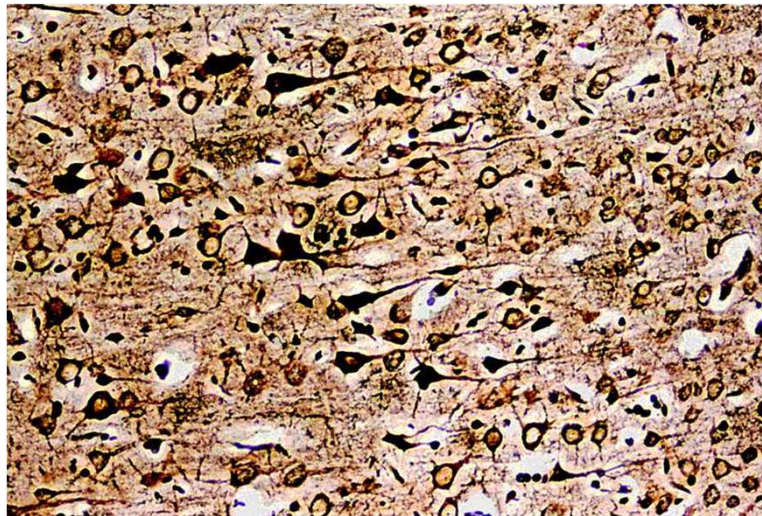


Purkinjezellen und
Granularzellschicht



<https://neuropathology-web.org/chapter1/chapter1aNeurons.html>

Zelltypen im ZNS: Neurone

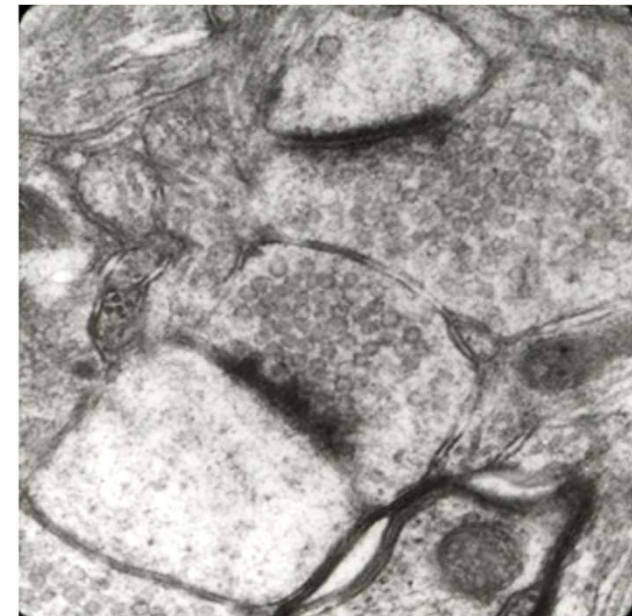
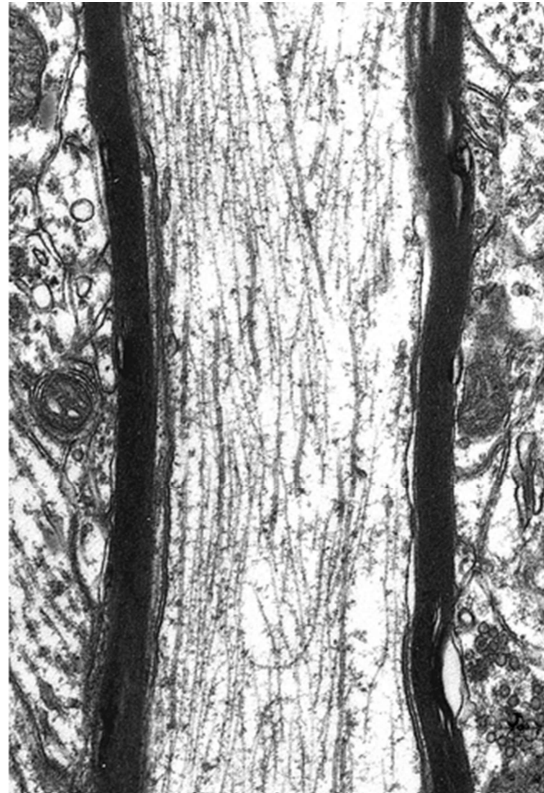
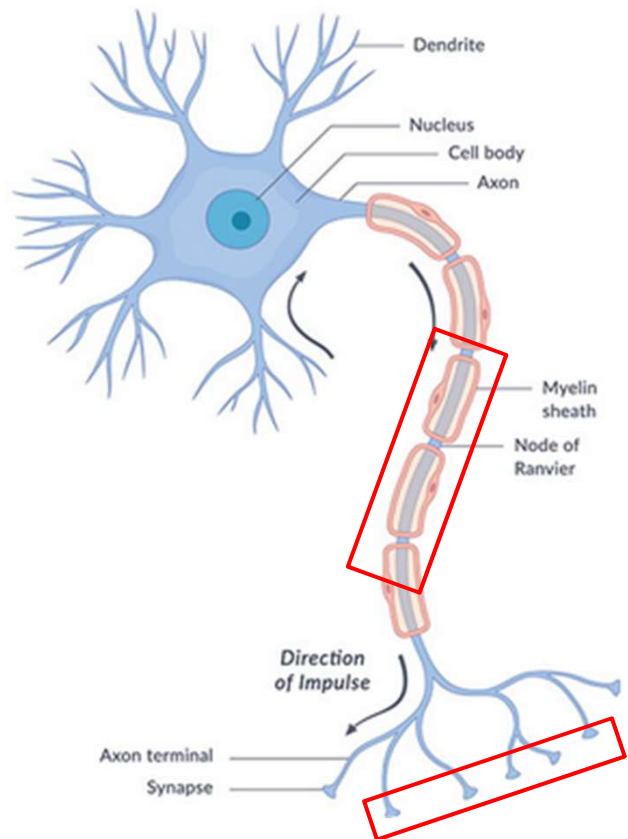


Bielschowsky-
Silberimprägnierung

Minbay et al., 2009. Rapid Bielschowsky silver impregnation method using microwave heating

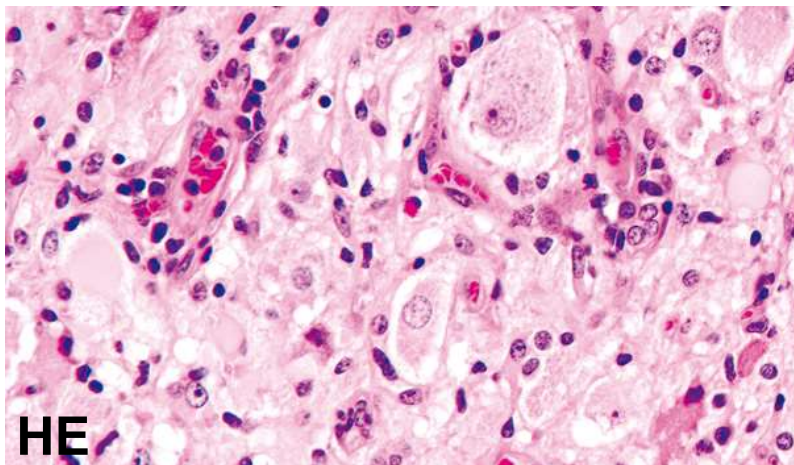
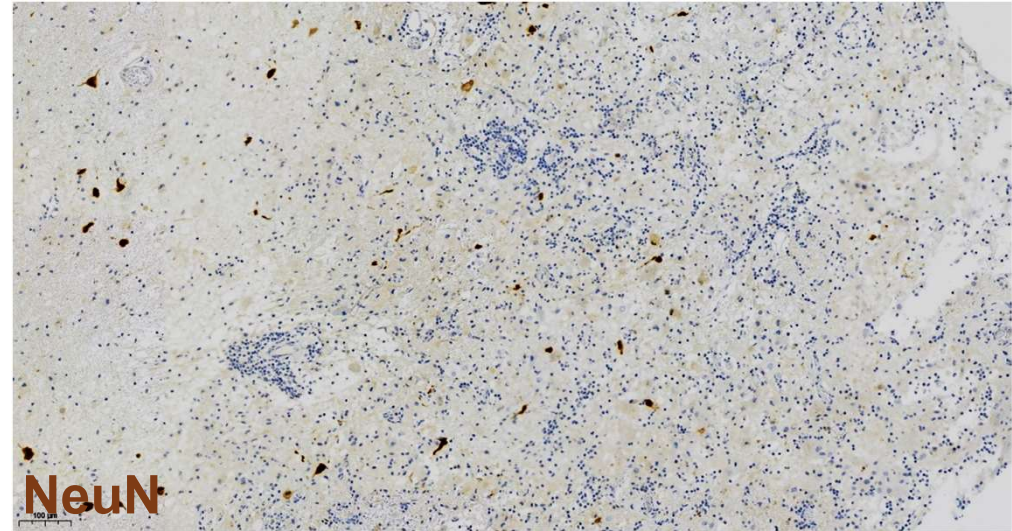
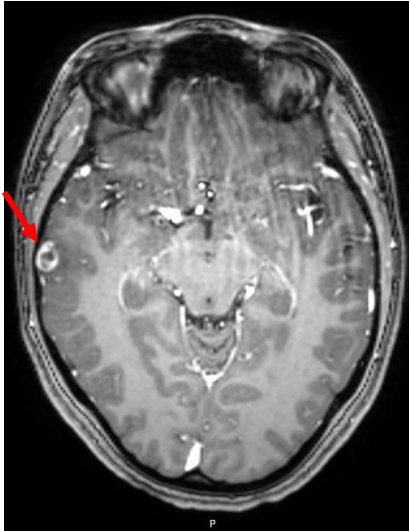
Carolina Gonzalez-Riano et al., 2017. Metabolomics and neuroanatomical evaluation of post-mortem changes in the hippocampus. Brain Structure and Function volume 222, pages2831–2853 (2017)

Zelltypen im ZNS : Neurone

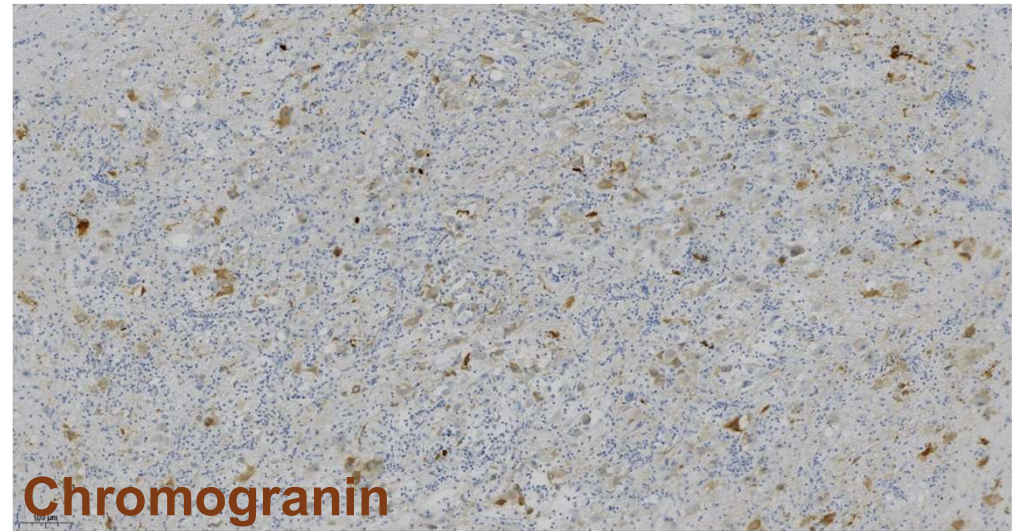


Neurofilamente und Mikrotubuli bilden das neuronale Zytoskelett

Fallbeispiel: 28 Jahre alte Patientin, rechts temporale Raumforderung.



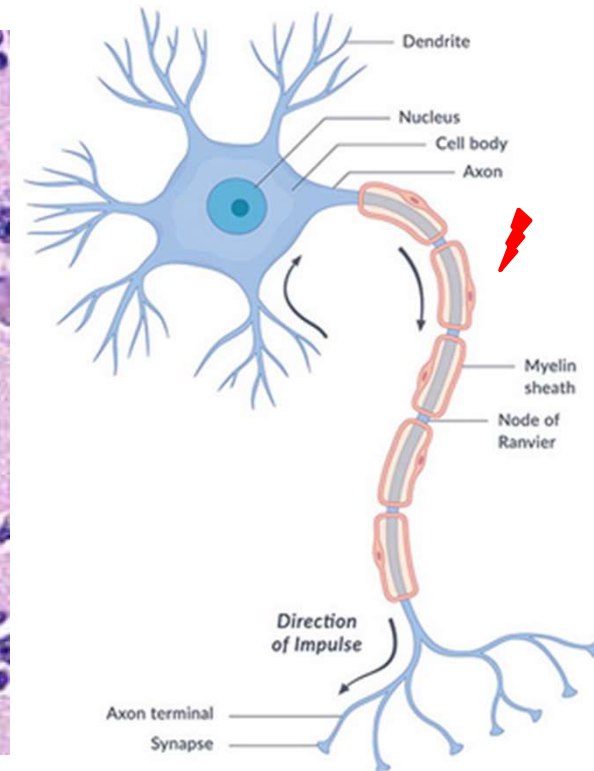
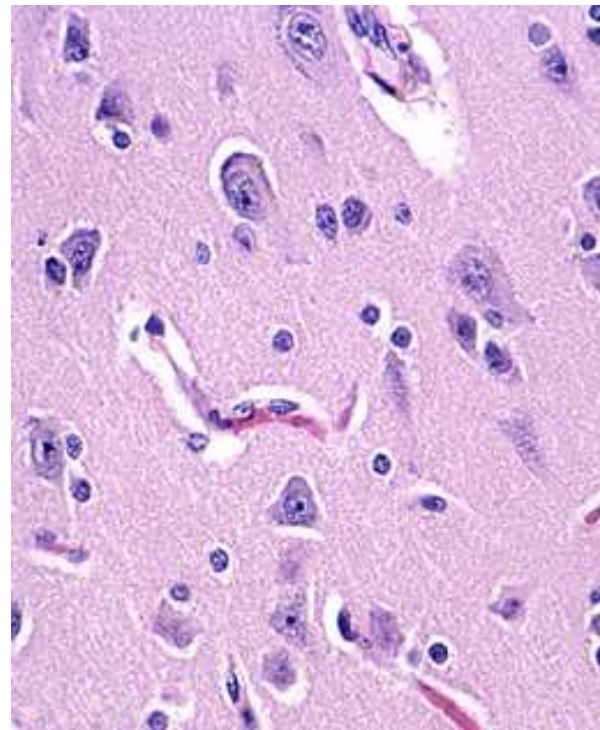
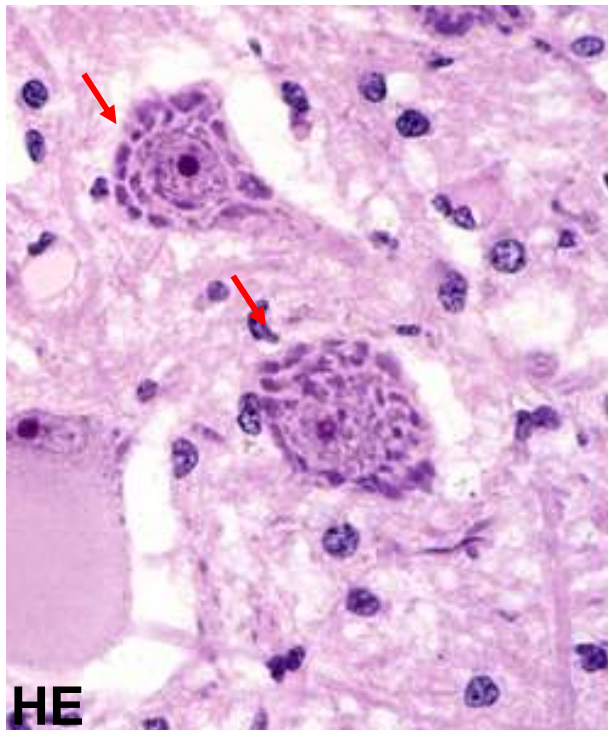
HE
Gangliogliom, ZNS WHO-Grad 1



Chromogranin

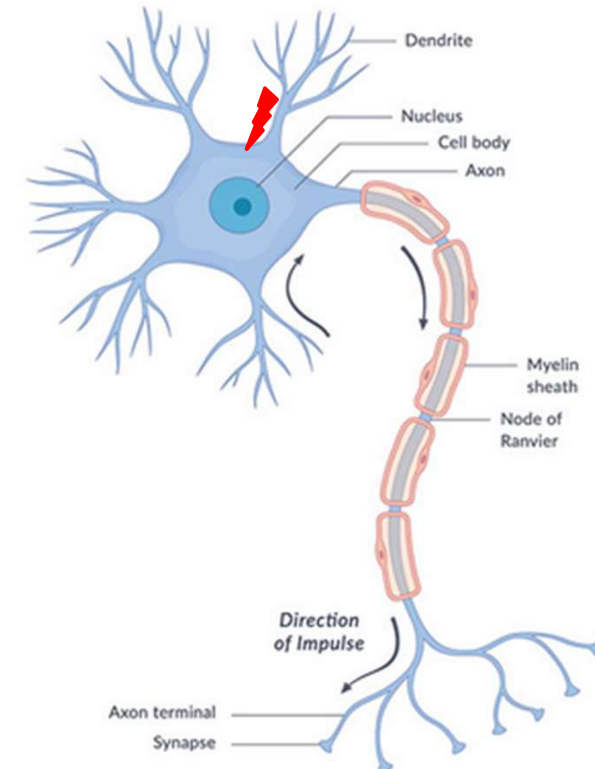
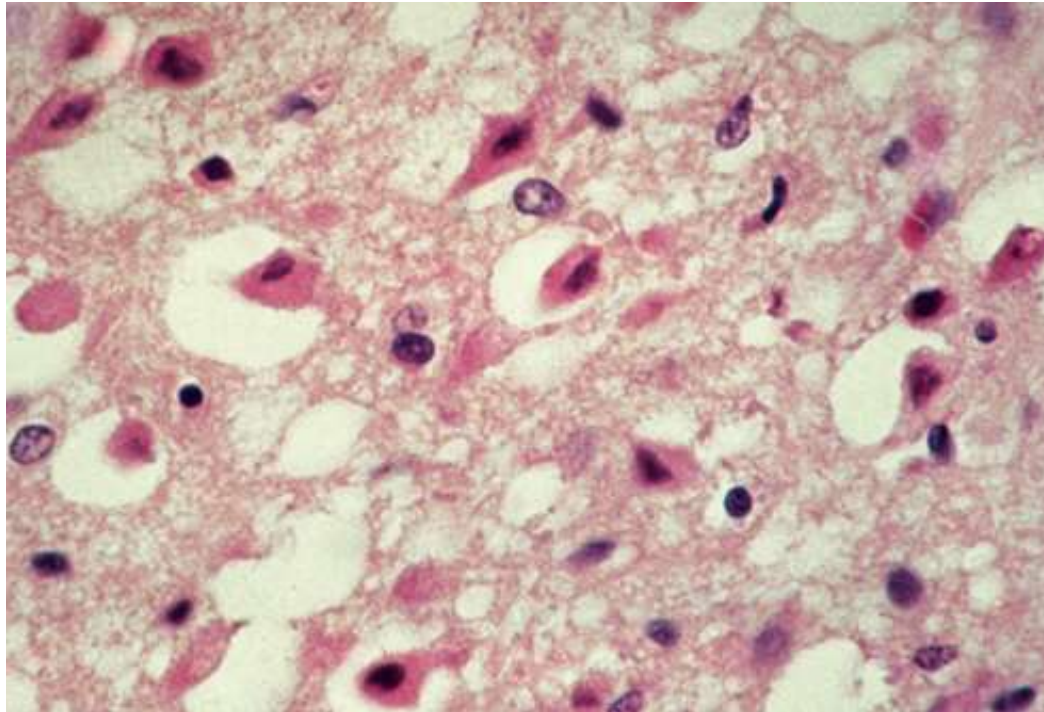
<https://tumourclassification.iarc.who.int/chaptercontent/45/35>

Zelltypen im ZNS: Neurone

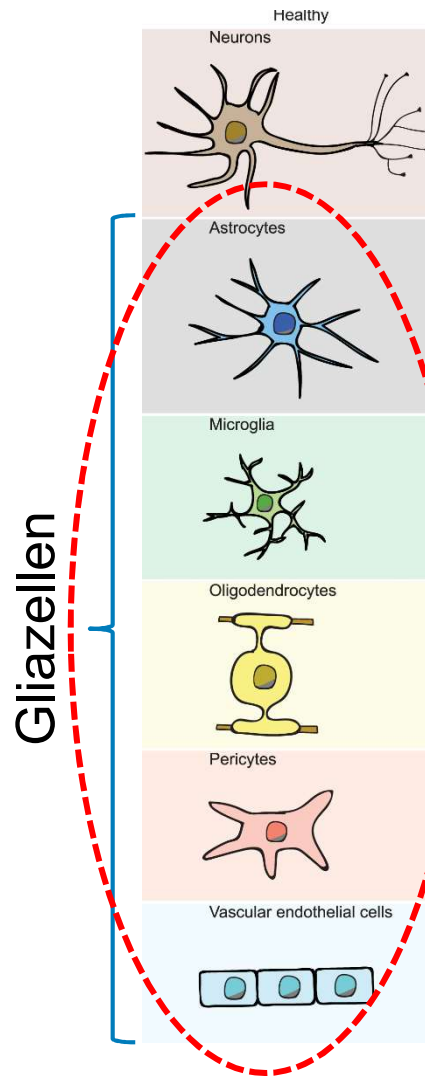


- Neuron mit zentraler Chromatolyse. Das RER disaggregiert und das neuronale Soma balloniert
- Folge einer Diskonnektion zwischen Target und Neuron

Hypoxisch/anoxische Neurone



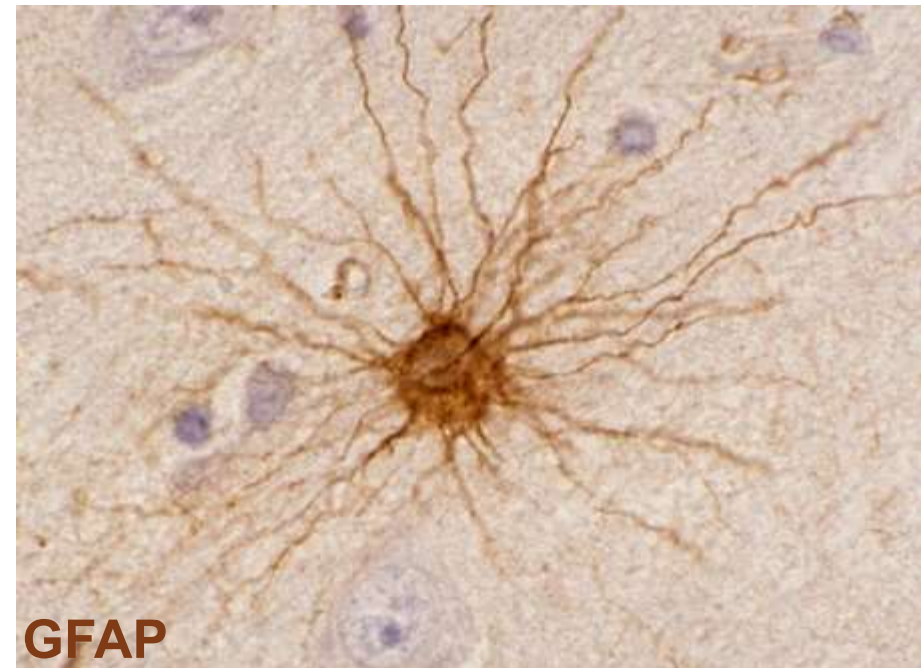
- Eosinophiles, geschrumpfte Zytoplasma durch Kondensation der Mitochondrien
- Z.n. Reanimation oder frischer Hirninfarkt



- Die verschiedenen Zelltypen des Gehirns können morphologisch und immunhistochemisch unterschieden werden.
- Sie können sich – teils pathognomonisch – im Rahmen einer ZNS-Pathologie verändern.
- Diese Veränderungen als auch die Überschneidungen mit den ursprünglich „gesunden“ Zellen zu detektieren sind entscheidend für die richtige Diagnose.

Penney, J., Ralvenius, W.T. & Tsai, L.H. Modeling Alzheimer's disease with iPSC-derived brain cells. *Mol Psychiatry* **25**, 148–167 (2020). <https://doi.org/10.1038/s41380-019-0468-3>

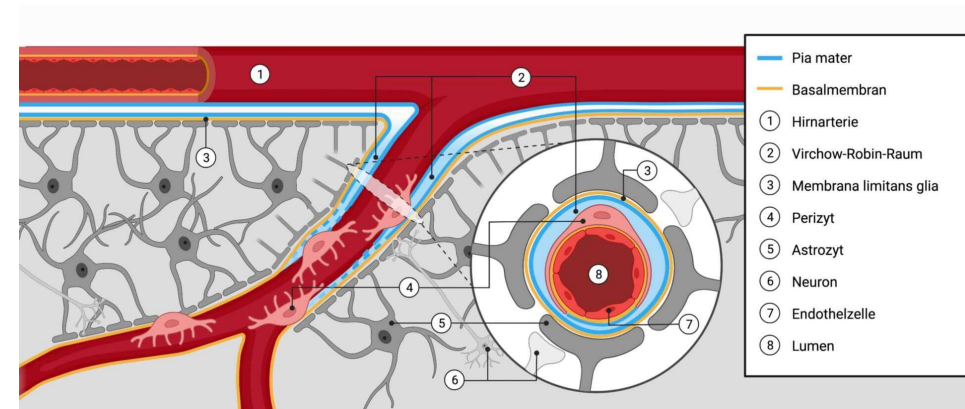
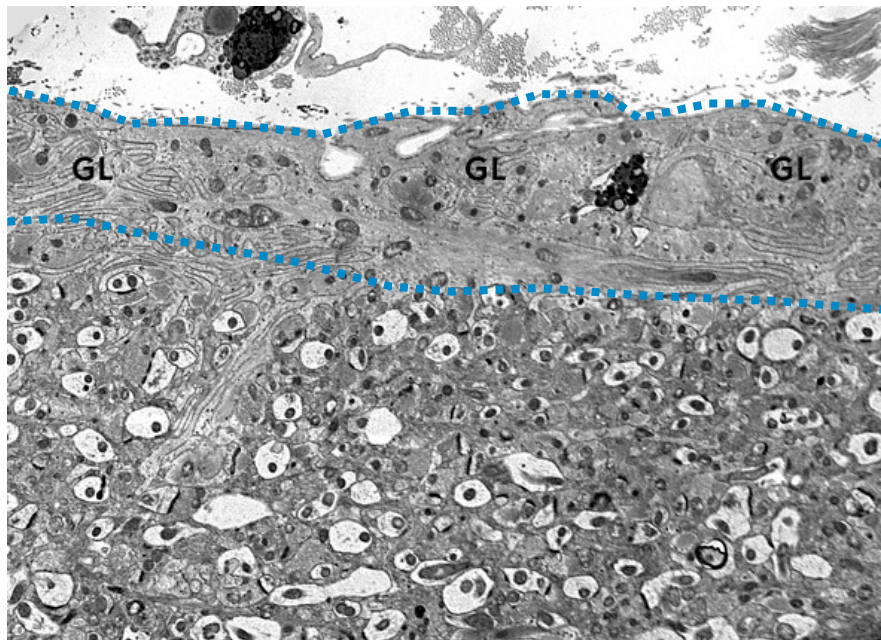
Gliazellen: Astrozyten



<https://neuropathologyatlas.wustl.edu/index.php?album=BASIC%20PROCESSES/Astrocytes%20%26%20Astrocytosis/Astrocytes%2C%20Gray%20vs%20White%20matter%2C%20Cajal%20AuCl&image=1A4+Astrocytes%2C+GM+%28Cerebral+Cortex%29+Cajal+AuCl+stain+3.jpg>

<https://neuropathology-web.org/chapter1/chapter1bAstrocytes.html>

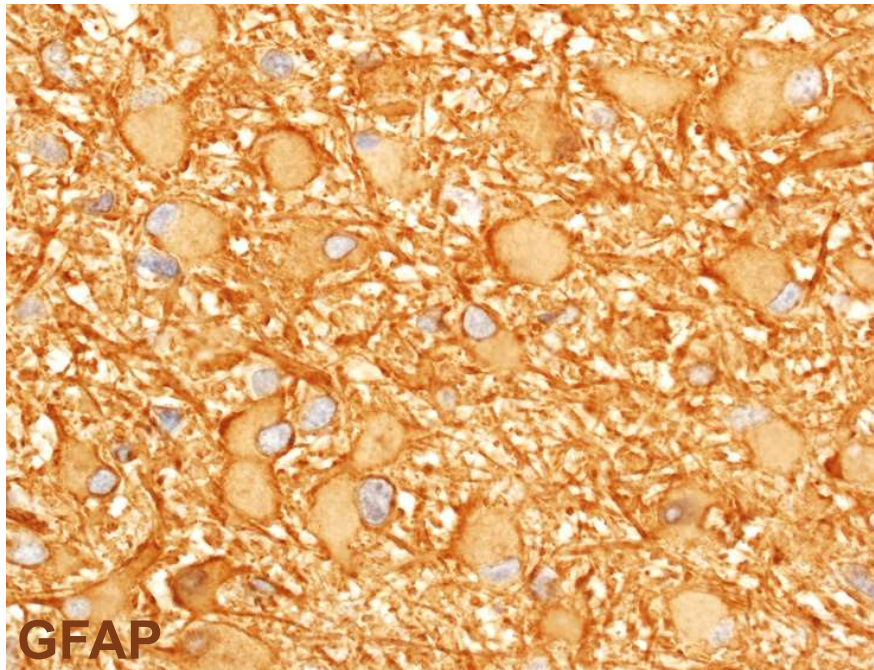
Gliazellen: Astrozyten



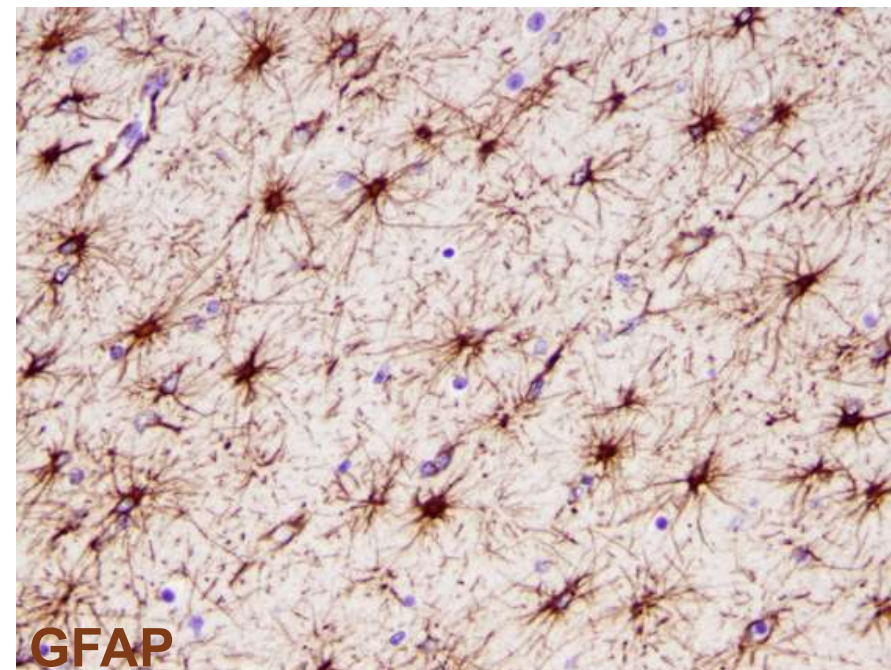
- Ausbildung der Membrana limitans gliae superficialis

- Im Bereich der Gefäße Fortsetzung als Membrana limitans gliae perivascularis fort

Gliazellen: Astrozyten

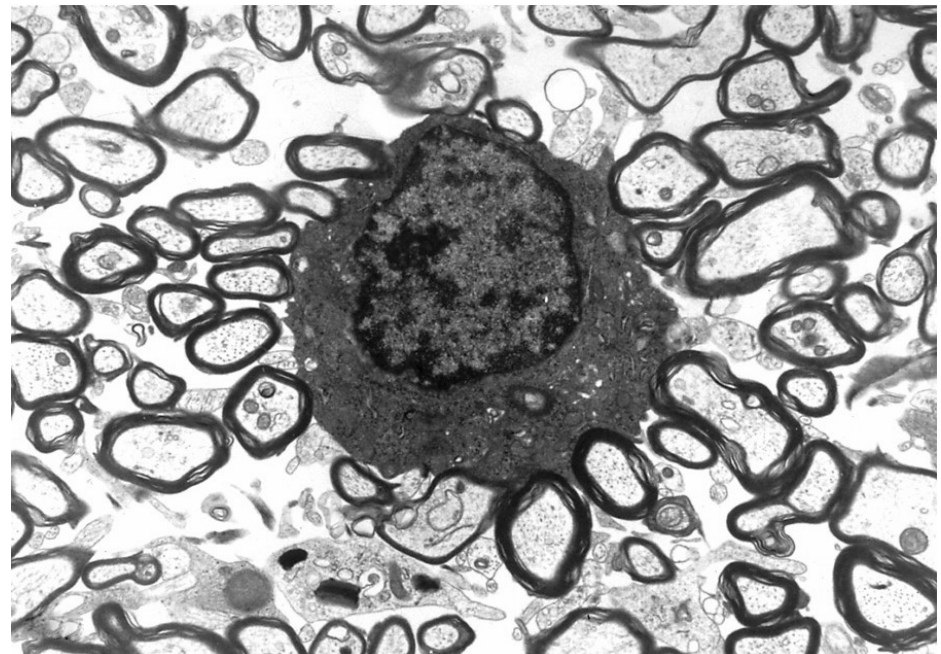
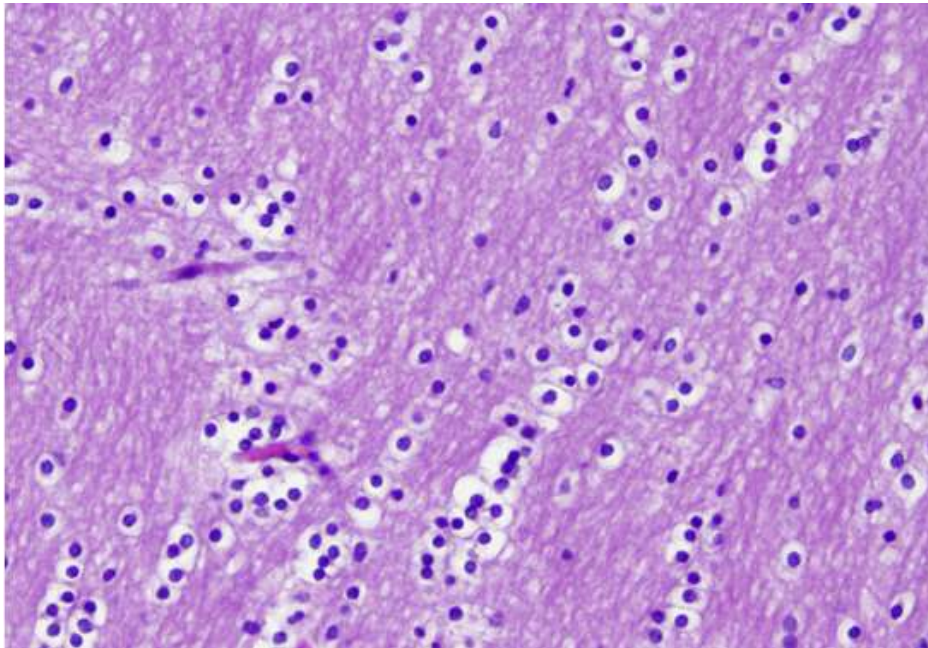


- wichtiger Marker in der Tumordiagnostik (astrogliale Liniendifferenzierung)



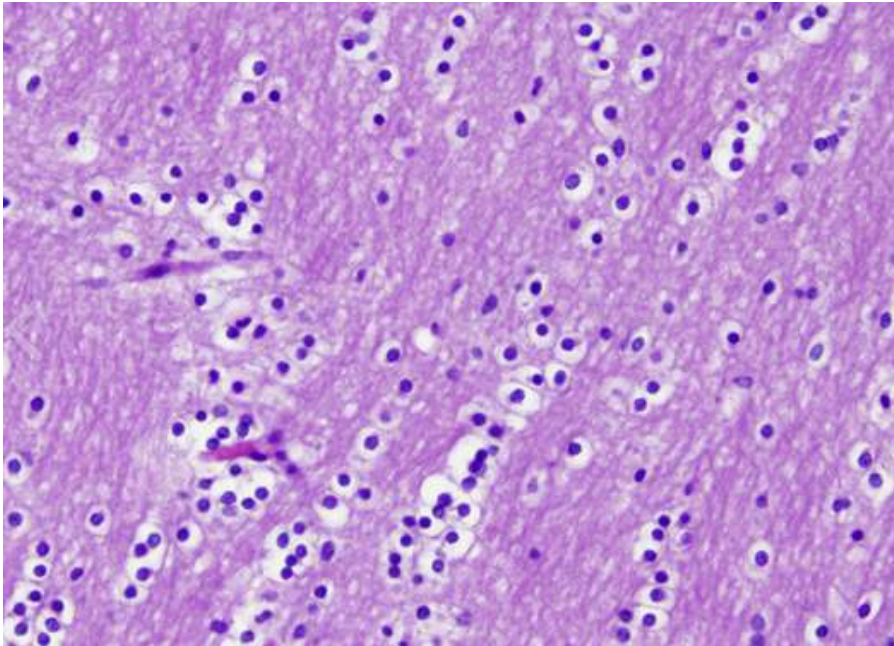
- **Astrogliose:** Proliferation und Hypertrophie von Astrozyten bei Schädigung von ZNS-Gewebe

Gliazellen: Oligodendrozyten

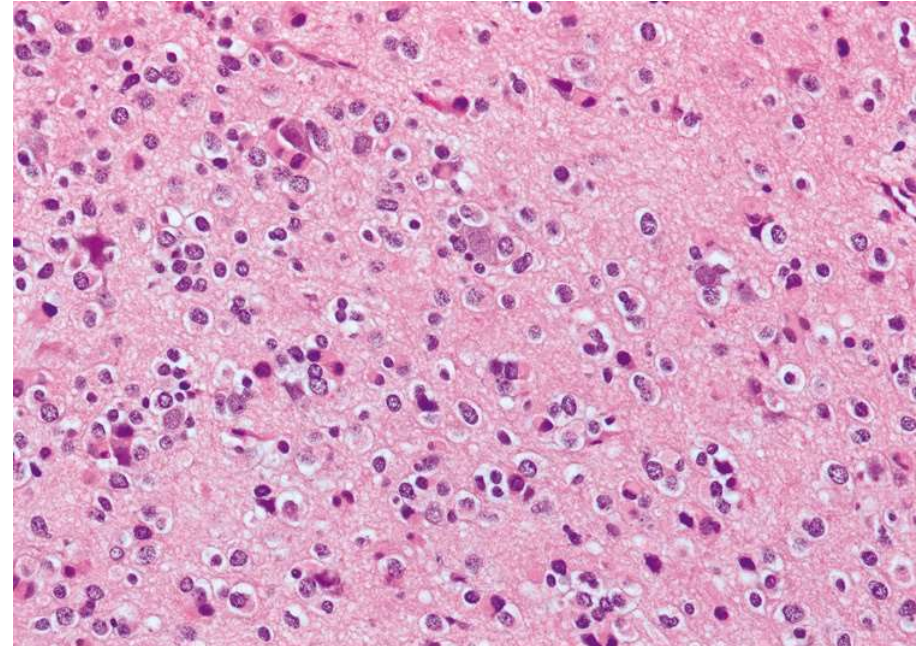


- herausgelöste Zytoplasma, der sogenannte „Spiegelei“-Aspekt
- Myelinsynthese im ZNS

Normalgewebe

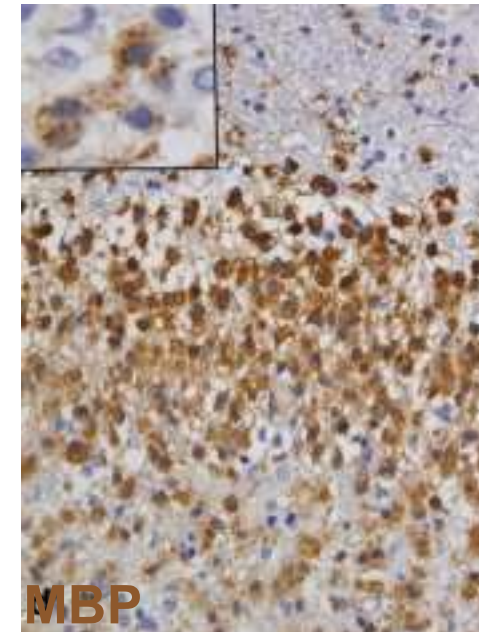
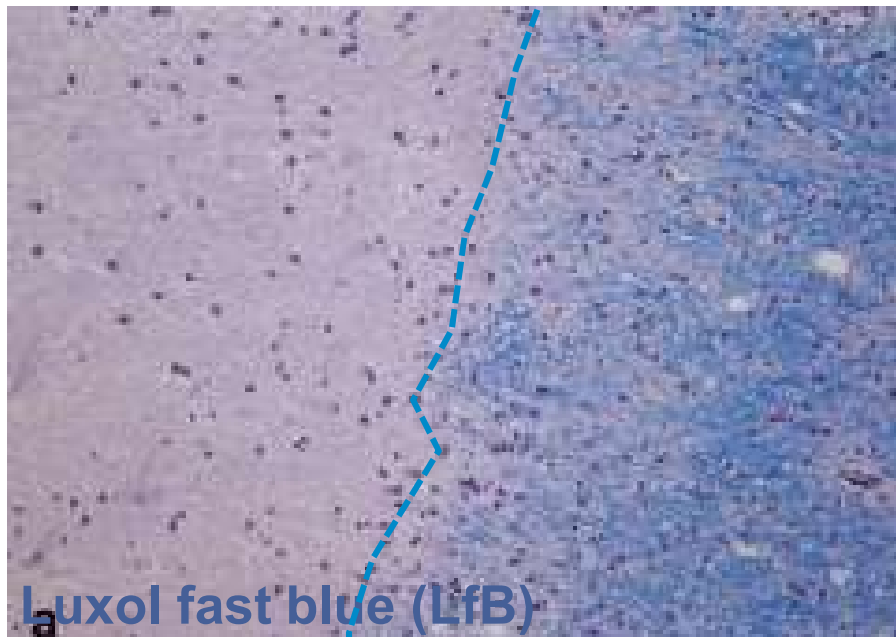


Oligodendrogliom



- sog. „Spiegelei“-Aspekt von Oligodendrozyten

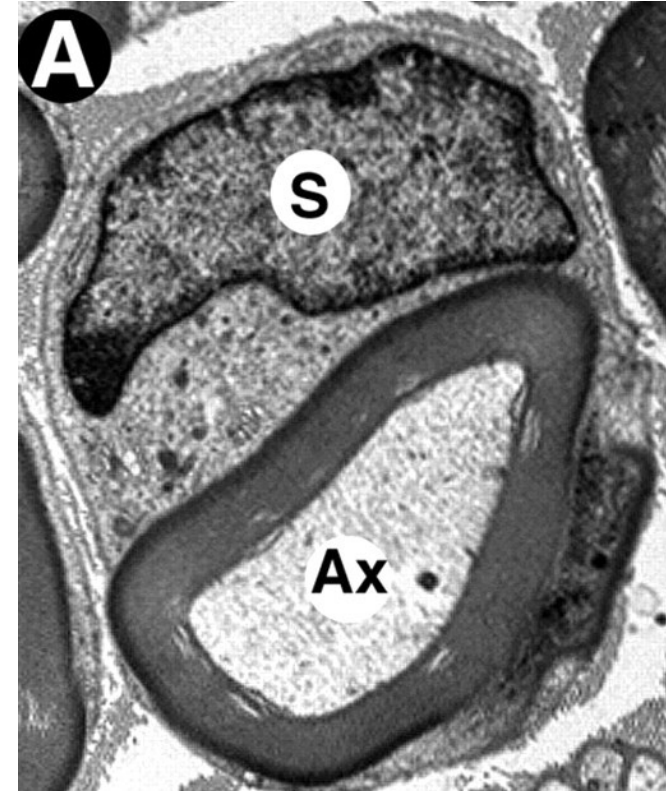
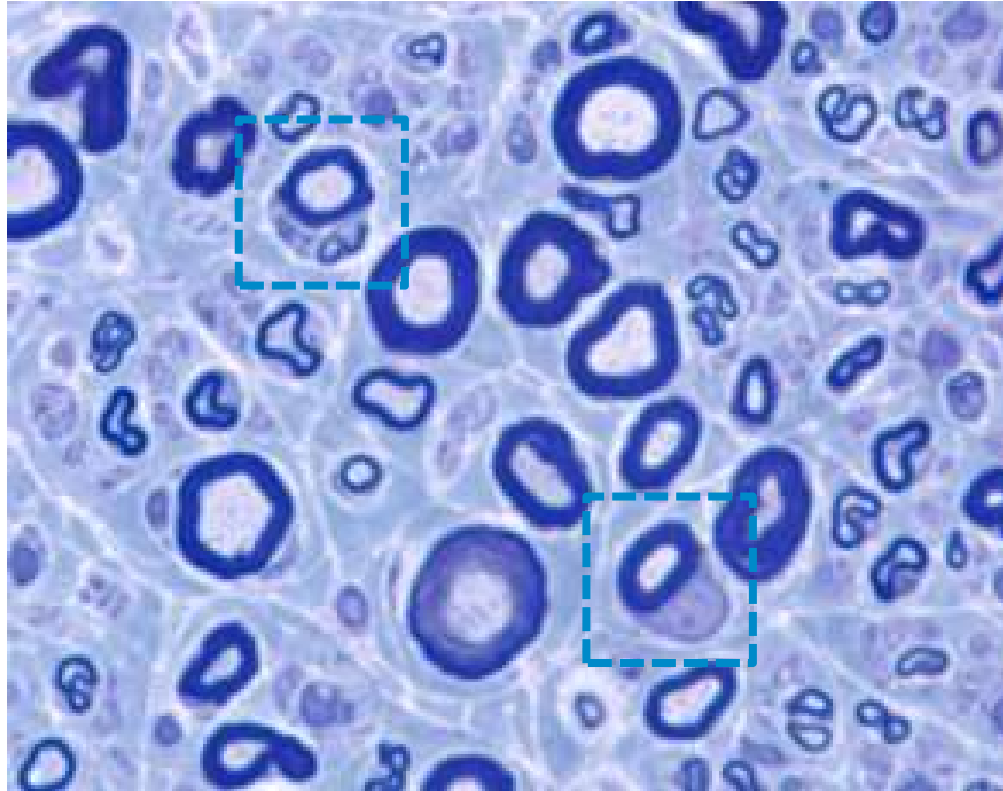
Scharfe Grenze in MS-Läsionen



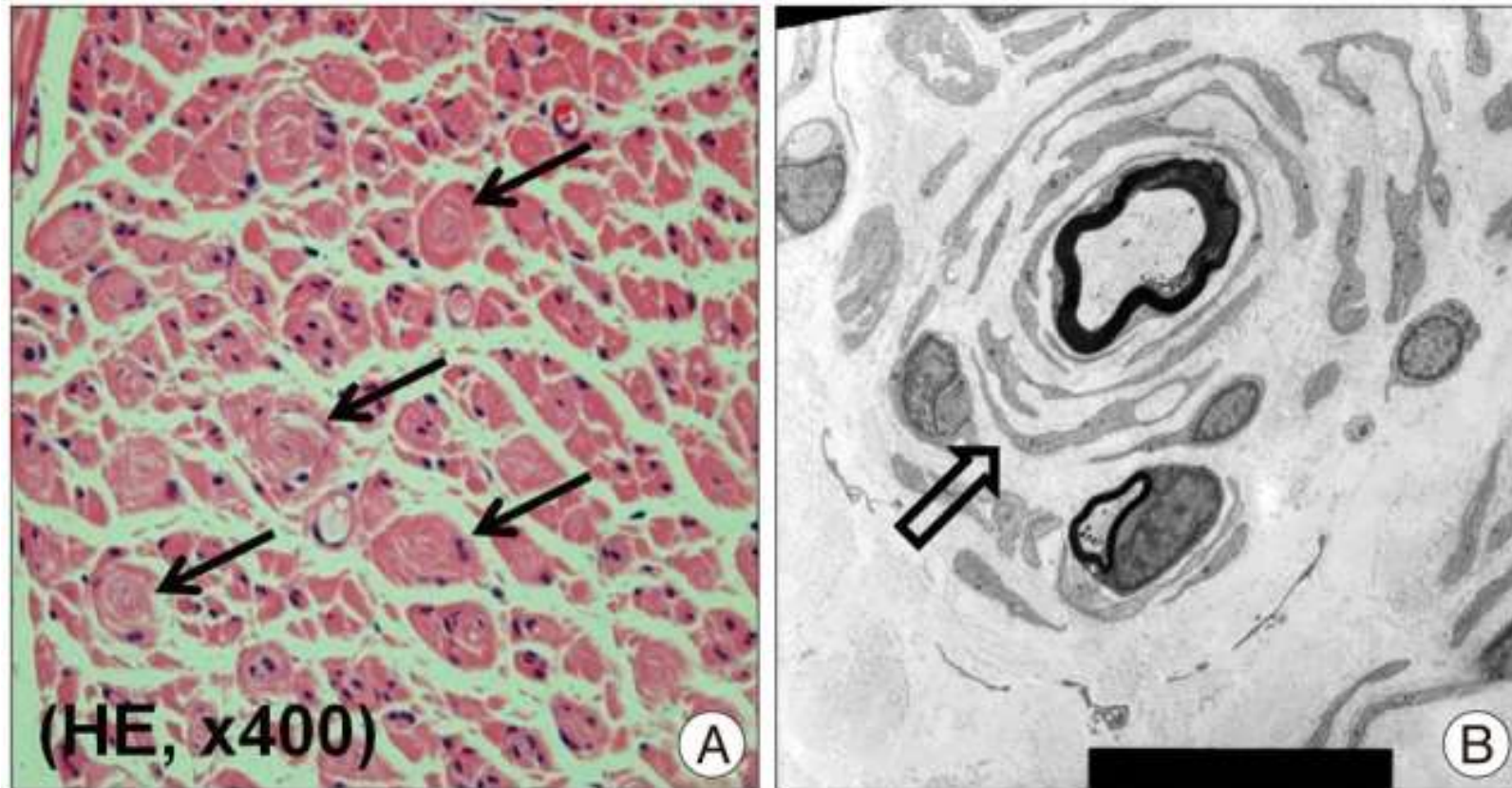
- **Verlust der Myelinscheiden bei Erhalt der neuronalen Fortsätze** aus.

Kuhlmann et al. Diagnosis of inflammatory demyelination in biopsy specimens: a practical approach. Acta Neuropathol. 2008 Mar;115(3):275-87. doi: 10.1007/s00401-007-0320-8. Epub 2008 Jan 4

Exkurs: myelinisierende Gliazellen im peripheren Nervensystem



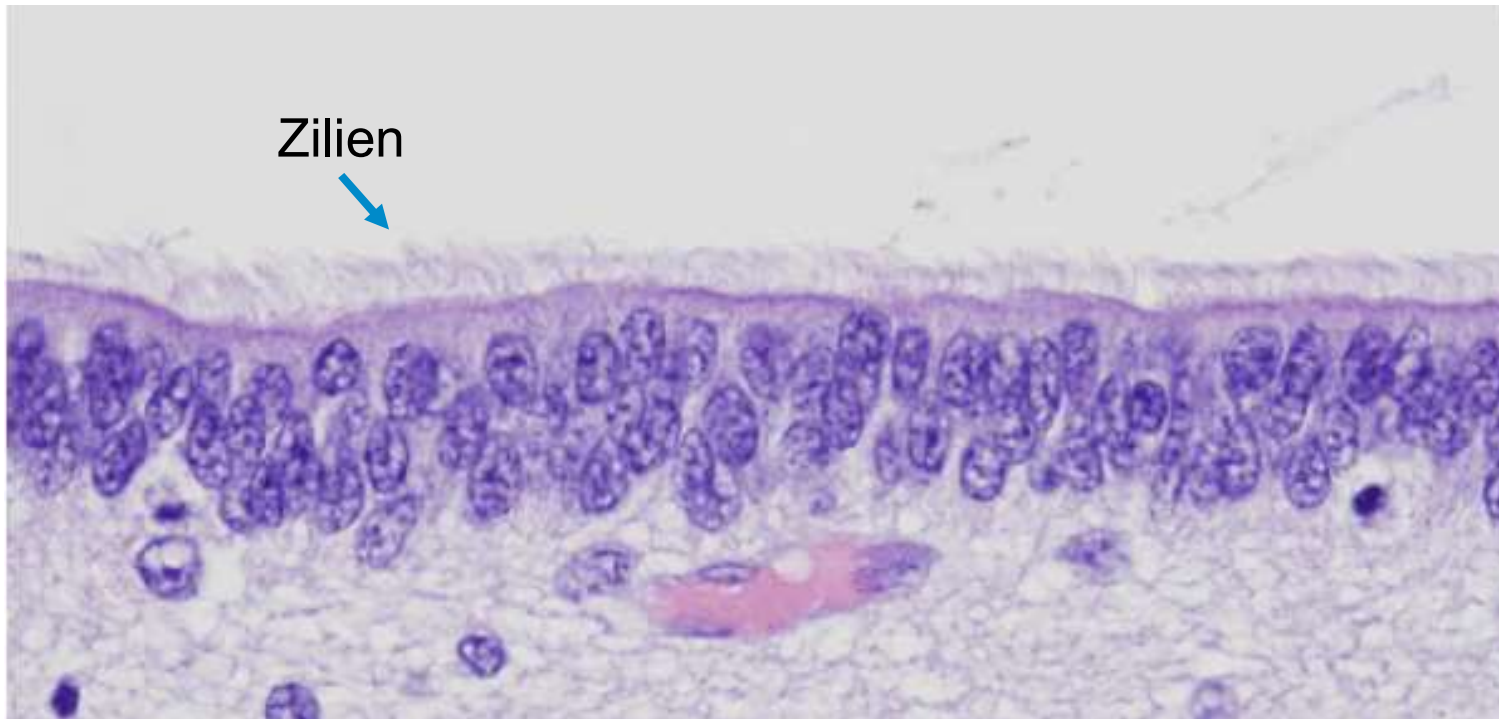
- Myelinisierung im PNS durch **Schwannzellen**



- sog. **Zwiebelschalformationen** in demyelinisierenden Polyneuropathien

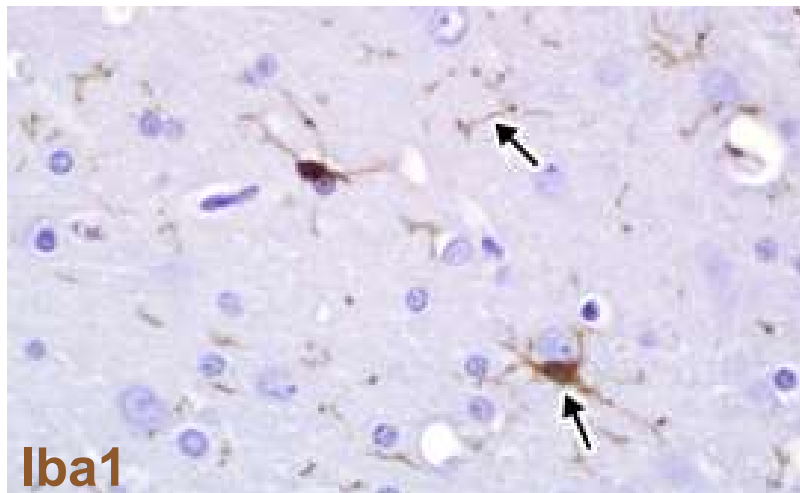
Lee et al. A Case of Cauda Equina Syndrome in Early-Onset Chronic Inflammatory Demyelinating Polyneuropathy Clinically Similar to Charcot-Marie-Tooth Disease Type. <https://doi.org/10.3340/jkns.2014.55.6.370> 1

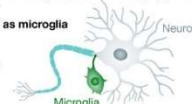
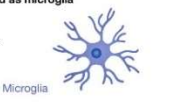
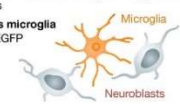
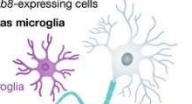
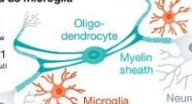

Gliazellen: Ependymzellen



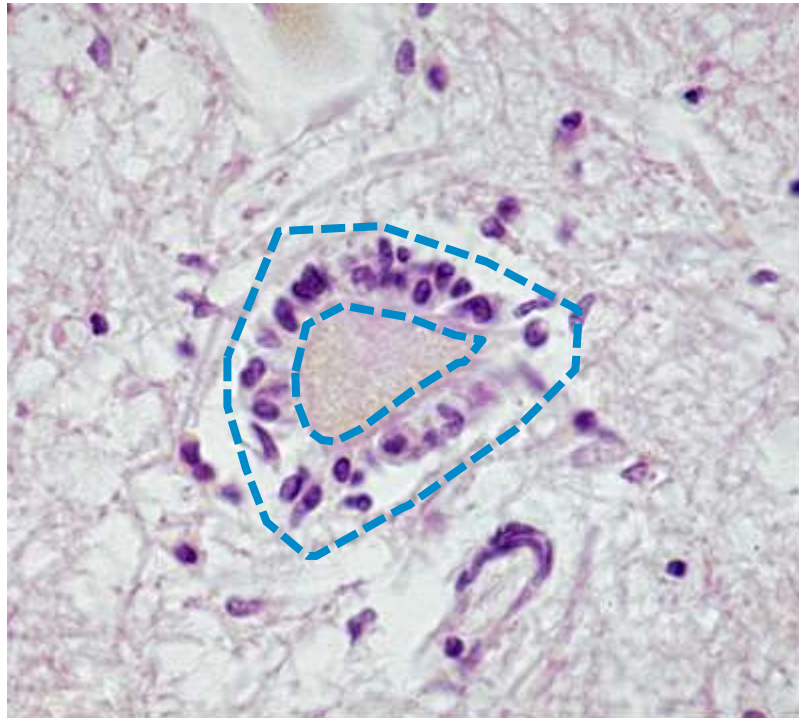
- Ependymzellen kleiden die Ventrikel aus
- spez. Epithel des Choroidplexus zur Liquorproduktion

Gliazellen: Microglia

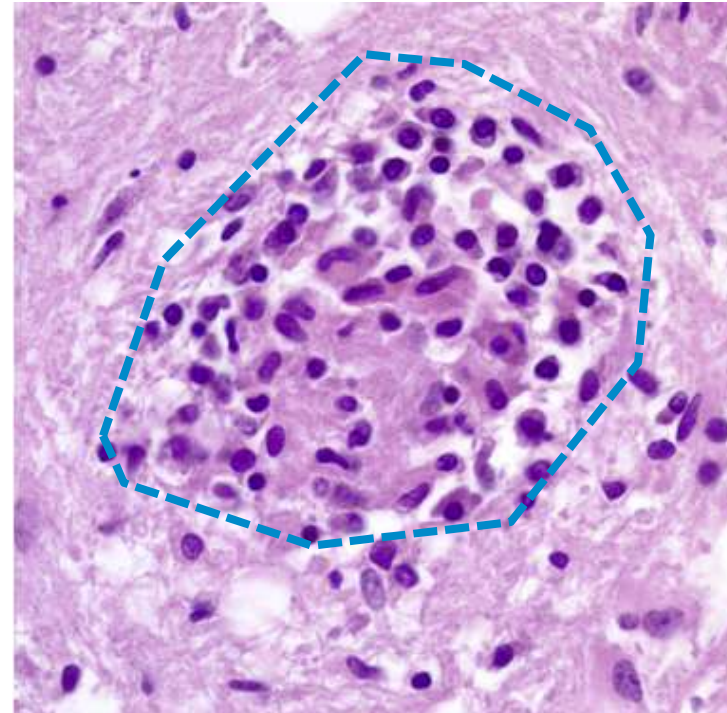


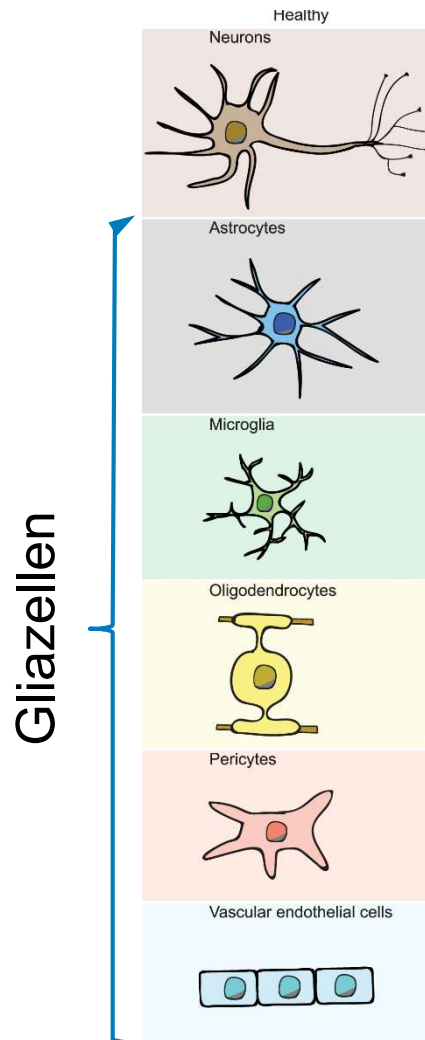
<p>"Satellite microglia"</p> <p>Function Interact with the axon initial segment (AIS) of neurons in the healthy brain. Loss of interaction upon injury.</p> <p>Characteristics Localized to the axonal side of the neuron's cell body exhibit a single process overlapping with the AIS.</p> <p>Defined as microglia IBA1 CD11b CX3CR1</p>  <p>Reference Del Rio Hortega, 1919 Baalman <i>et al.</i>, 2015 Wogram <i>et al.</i>, 2016</p>	<p>KSPG-microglia</p> <p>Function Typical appearance upon different insults, i.e. around motoneurons in ALS; away from brain trauma</p> <p>Characteristics Keratan sulfate positive cells</p> <p>Defined as microglia IBA1 CR3 CD11b</p>  <p>Reference Bertolotto <i>et al.</i>, 1998, 1995 Hirano <i>et al.</i>, 2013 Shinjo <i>et al.</i>, 2014</p>	<p>Microglia supporting neurogenesis</p> <p>Function Essential for neuroblast survival and migration in SVZ/RMS</p> <p>Characteristics IBA1⁻, isolectin B₄⁻, CD68⁻, P2RY12^{low}, pSTAT6⁺ cells, IL4 and IL10-producing cells, less ramified than microglia in neighbouring brain areas</p> <p>Defined as microglia CX3CR1-EGFP</p>  <p>Reference Shigemoto <i>et al.</i>, 2014 Ribeiro Xavier <i>et al.</i>, 2015 Xavier <i>et al.</i>, 2015</p>
<p>Hox8b-microglia</p> <p>Function Absence of Hoxb8 function in microglia impacts on the corticostriatal neuronal circuit, and leads to impaired grooming, anxiety and social behaviors</p> <p>Characteristics YFP-Hoxb8-expressing cells</p> <p>Defined as microglia IBA1 Cd11b</p>  <p>Reference Chen <i>et al.</i>, 2000 Nagrajan <i>et al.</i>, 2017 De <i>et al.</i>, 2018</p>	<p>Cd11c-microglia</p> <p>Function Promote myelination and neurogenesis in the neonatal brain</p> <p>Characteristics CD11c-positive, Igf1-producing cells</p> <p>Defined as microglia IBA1 CD11b CD45^{low} CX3CR1 CCR2^{nat}</p>  <p>Reference Wodarczyk <i>et al.</i>, 2017</p>	<p>"Dark microglia"</p> <p>Function Interact with blood vessels and synapses</p> <p>Characteristics Appear as dark by Electron Microscopy</p> <p>Defined as microglia IBA1^{low} CX3CR1-GFP^{low} CD11b TREM2 4D4</p>  <p>Reference Bisht <i>et al.</i>, 2016 Hui <i>et al.</i>, 2018</p>

Neuronophagie



Microgliaknötchen



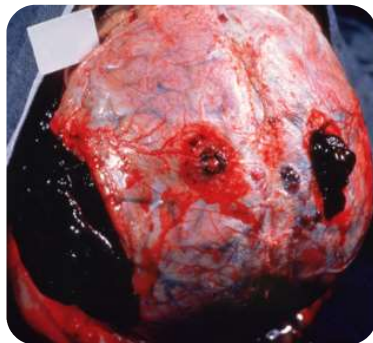
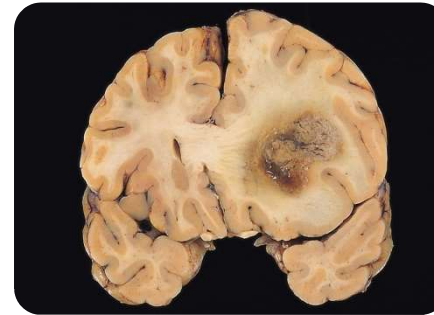
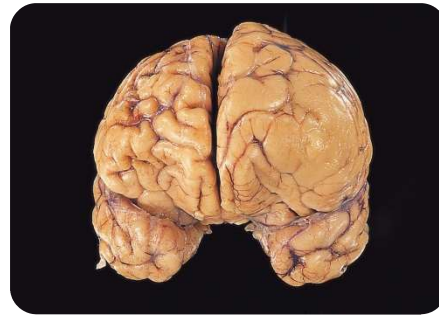
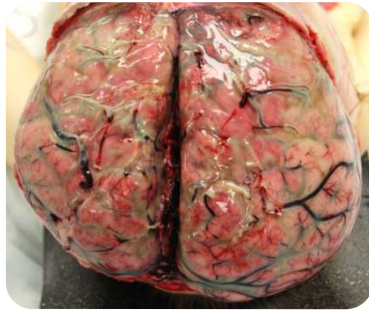


- Die verschiedenen Zelltypen des Gehirns können morphologisch und immunhistochemisch unterschieden werden.
- Sie können sich – teils pathognomonisch – im Rahmen einer ZNS-Pathologie verändern.
- Diese Veränderungen als auch die Überschneidungen mit den ursprünglich „gesunden“ Zellen zu detektieren sind entscheidend für die richtige Diagnose.

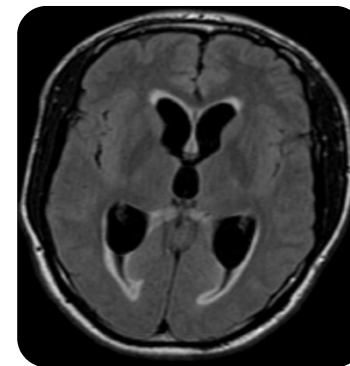
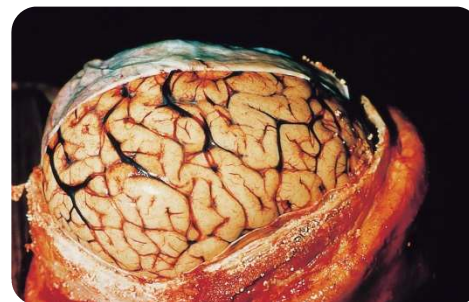
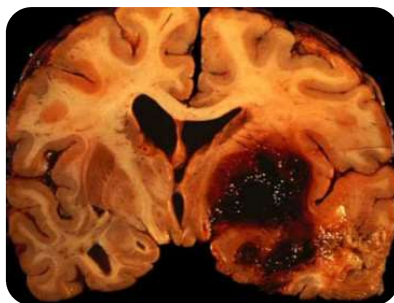
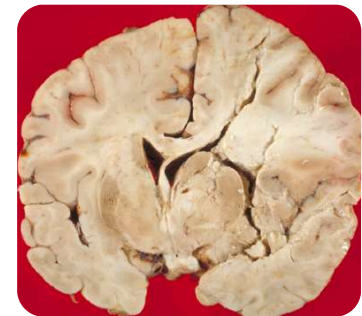
Penney, J., Ralvenius, W.T. & Tsai, L.H. Modeling Alzheimer's disease with iPSC-derived brain cells. *Mol Psychiatry* **25**, 148–167 (2020). <https://doi.org/10.1038/s41380-019-0468-3>

INTRAKRANIELLER DRUCK, HIRNÖDEM UND HERNIATIONEN

Ursachen gesteigerter ICP



Gesteigerter Intrakranieller
Druck (ICP)



Entzündung
Tumor
Ischämie/Hypoxie
Blutung
Hydrocephalus
High altitude cerebral
edema (HACE)

<https://neuropathology-web.org/chapter4/chapter4aSubduralepidural.html>
<https://neuropathology-web.org/chapter2/chapter2bCerebralinfarcts.html>
<https://neuropathology-web.org/chapter5/chapter5aSuppurative.html>

- ☛ Normwert im Liegen: <15 mmHg (Erwachsene und Schulkinder)
- ☛ Zerebraler Perfusionsdruck (CPP): Einschätzung des intrakraniellen Blutflusses, normal ca. 90 mmHg

$$CPP = MAP - ICP$$

- ☛ Eine Steigerung des intrakraniellen Drucks kann die Blutversorgung des Gehirns einschränken und zur Ischämie führen.

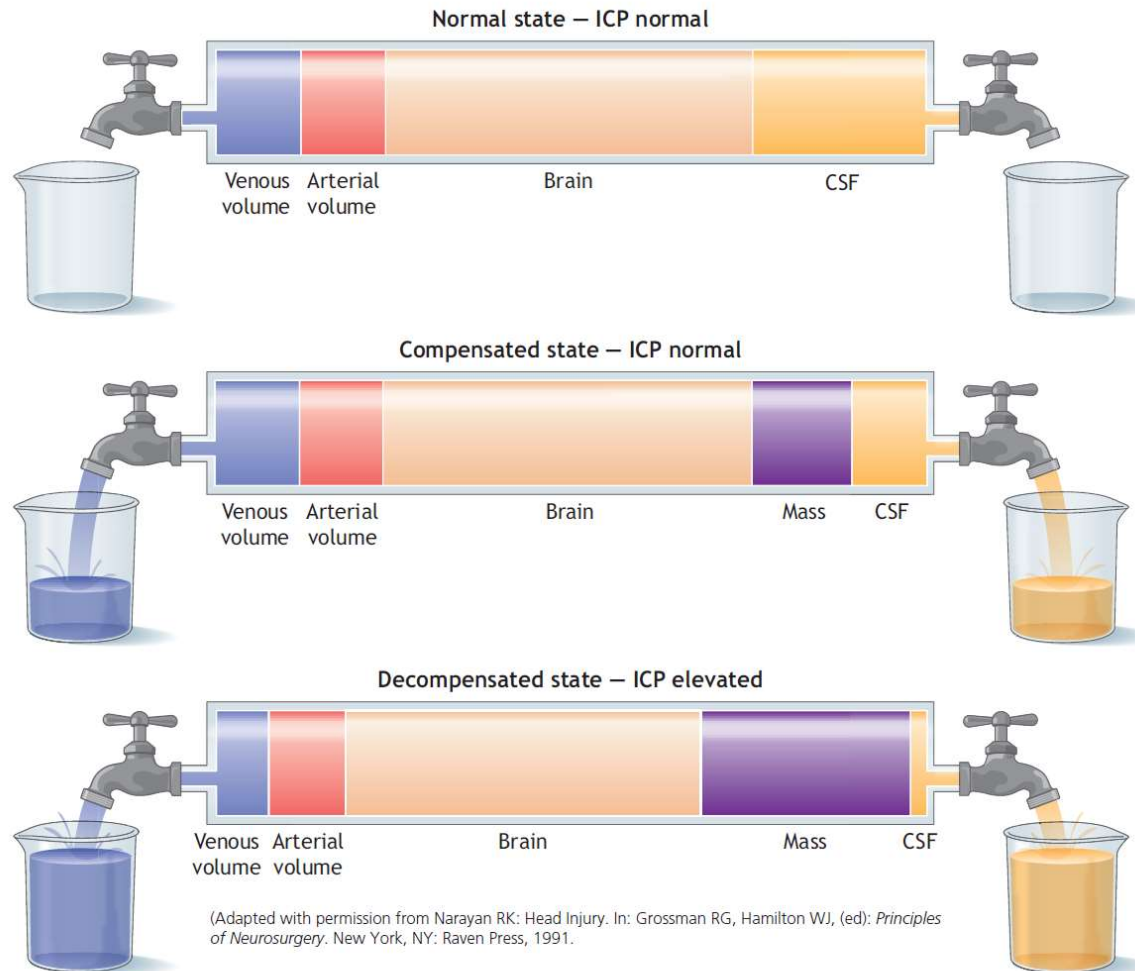
Tan TK, Cheng MH, Sim EY. Options for managing raised intracranial pressure. Proceedings of Singapore Healthcare. 2015;24(3):156-164. doi:10.1177/2010105815598444

Intrakranielle Volumina: Das Monro-Kellie Doktrin

Alexander Monro II.



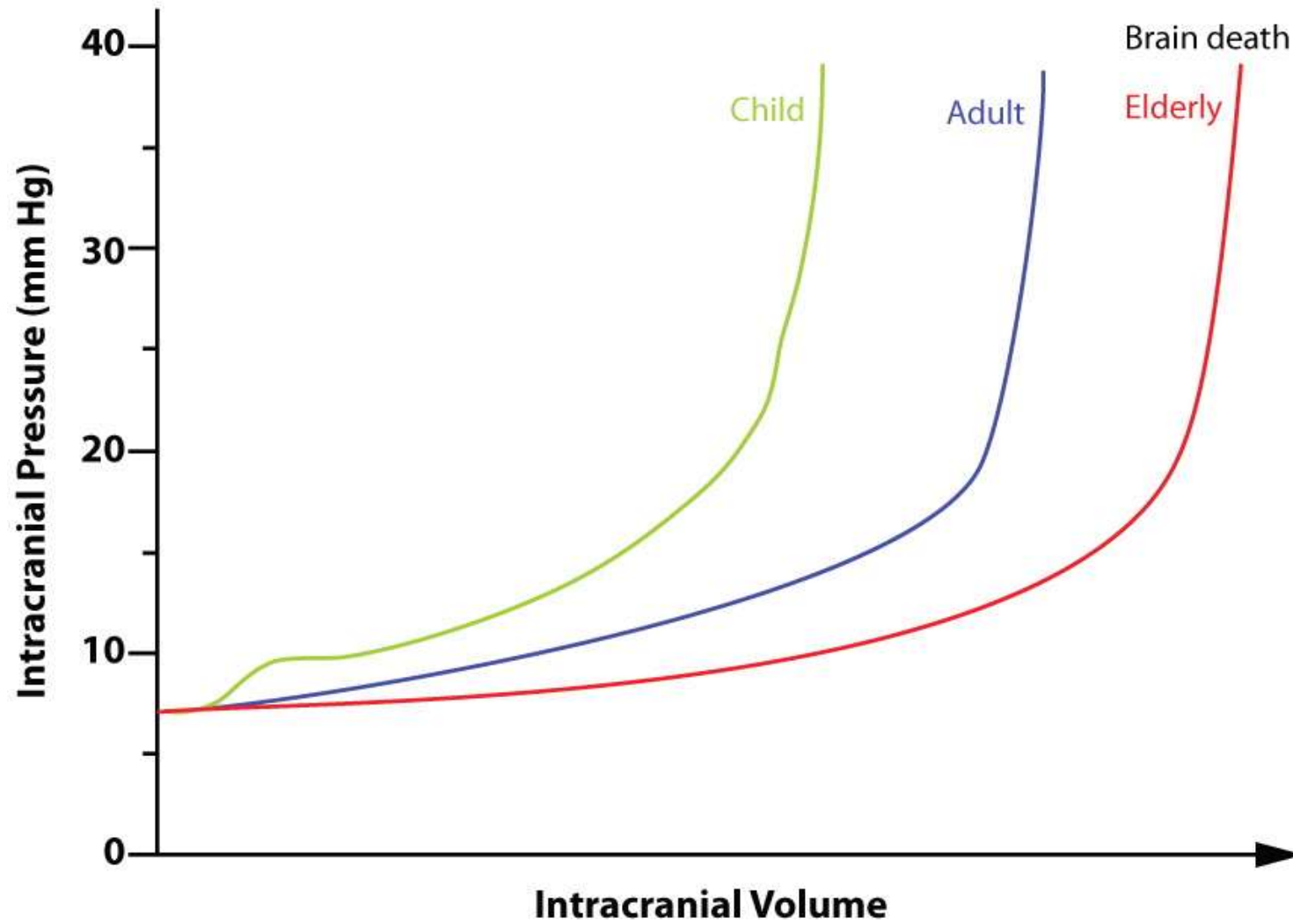
George Kellie



The Monro-Kellie Doctrine Regarding Intracranial Compensation for Expanding Mass.
The volume of the intracranial contents remains constant. If the addition of a mass such as a hematoma results in the squeezing out of an equal volume of CSF and venous blood, the ICP remains normal. However, when this compensatory mechanism is exhausted, there is an exponential increase in ICP for even a small additional increase in the volume of the hematoma.

https://de.wikipedia.org/wiki/Alexander_Monro_II.#/media/Datei:Alexander_Munro_secundus.jpg
<https://litfl.com/george-kellie/>

Intrakranieller Druck (ICP)



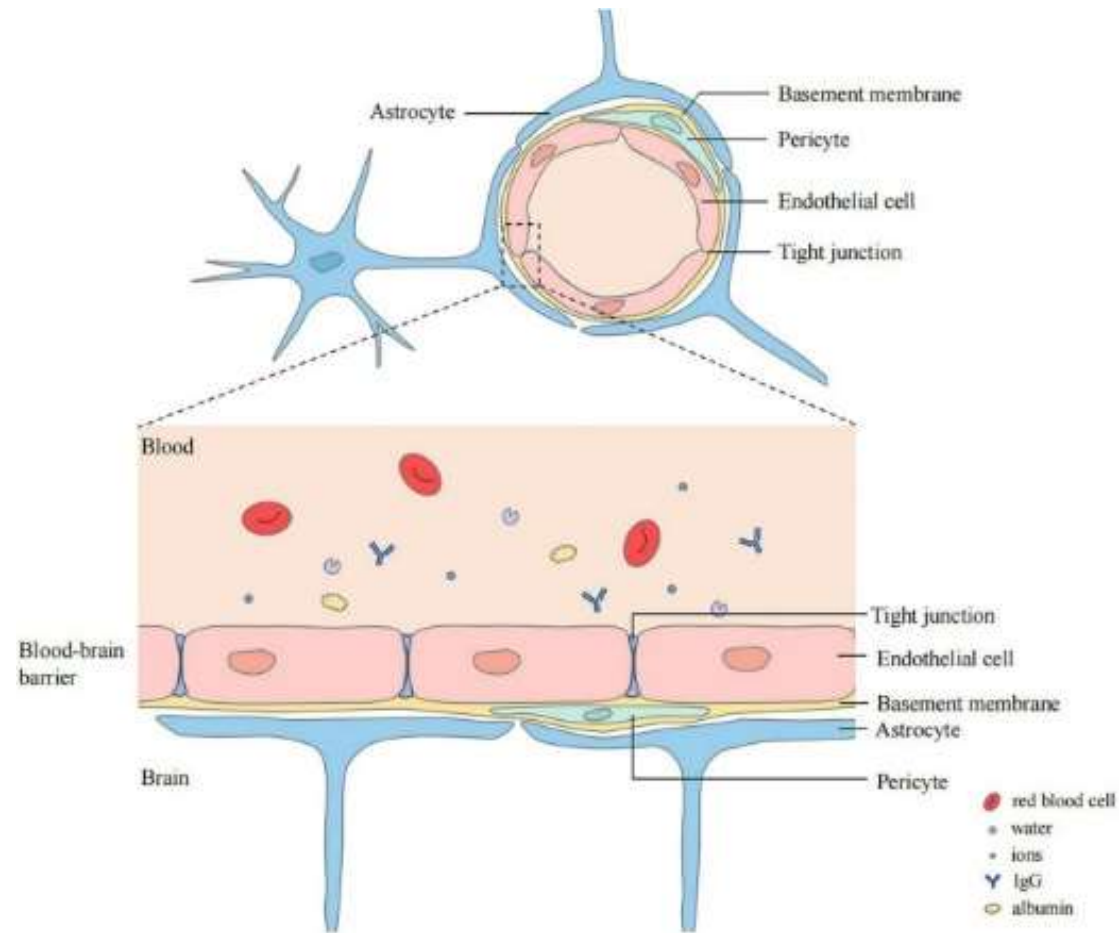
Tan TK, Cheng MH, Sim EY. Options for managing raised intracranial pressure. Proceedings of Singapore Healthcare. 2015;24(3):156-164. doi:10.1177/2010105815598444

☞ Vermehrte Flüssigkeitseinlagerung, u.a. bei gestörter Bluthirnschranke

☞ Formen

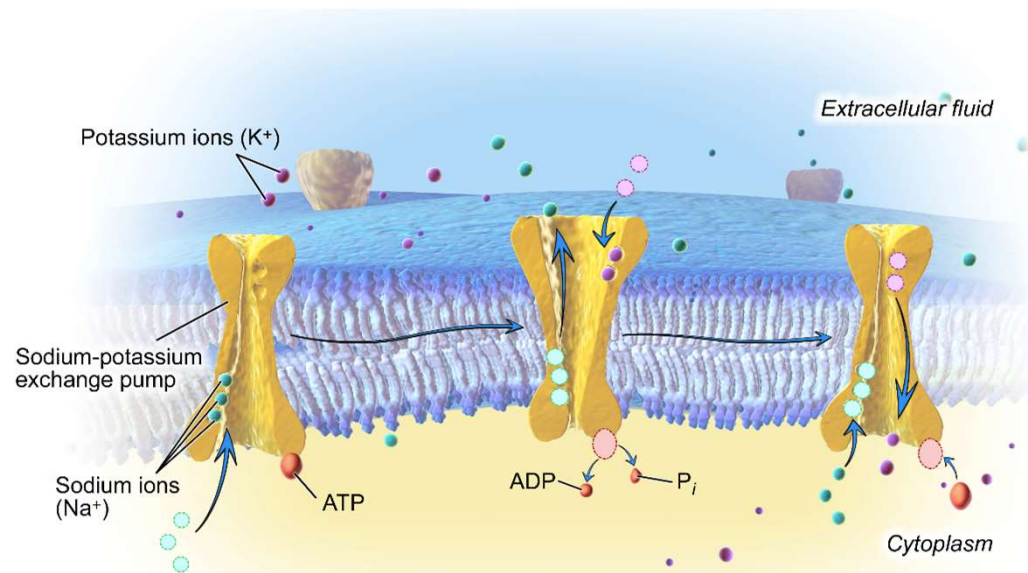
- Zytotoxisch
- (Ionen)
- Vasogen
- Interstitiell

Bluthirnschranke

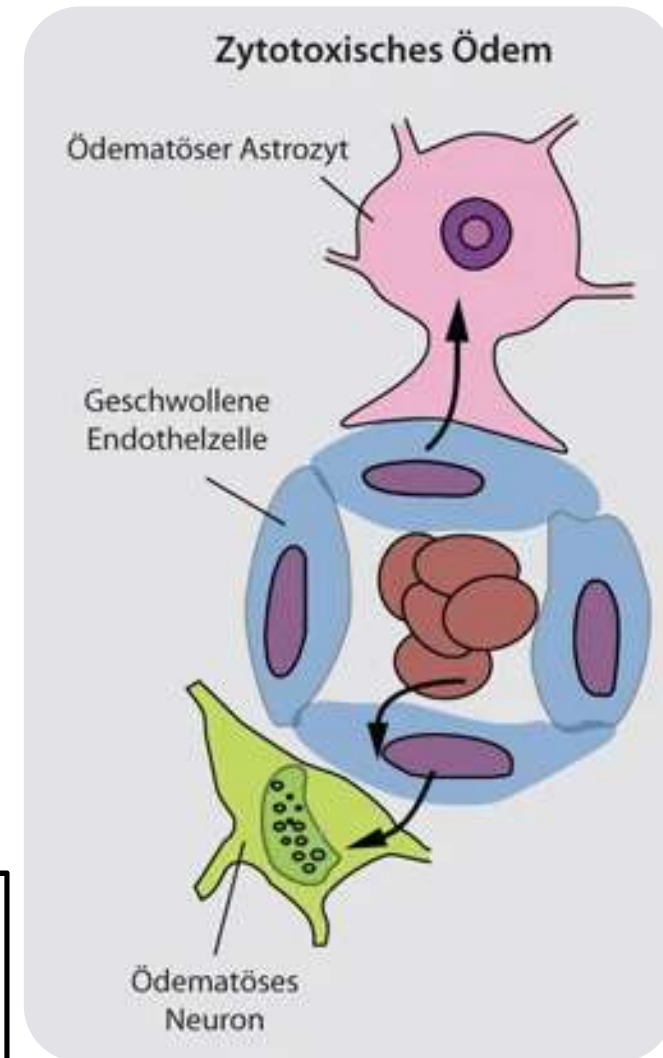


Formen des Hirnödems: I Zytotoxisch

Zytotoxisches Hirnödem:
 Störung Na⁺/K⁺ ATPasen u.a. bei
 Hypoxie, Flüssigkeit im IZR↑



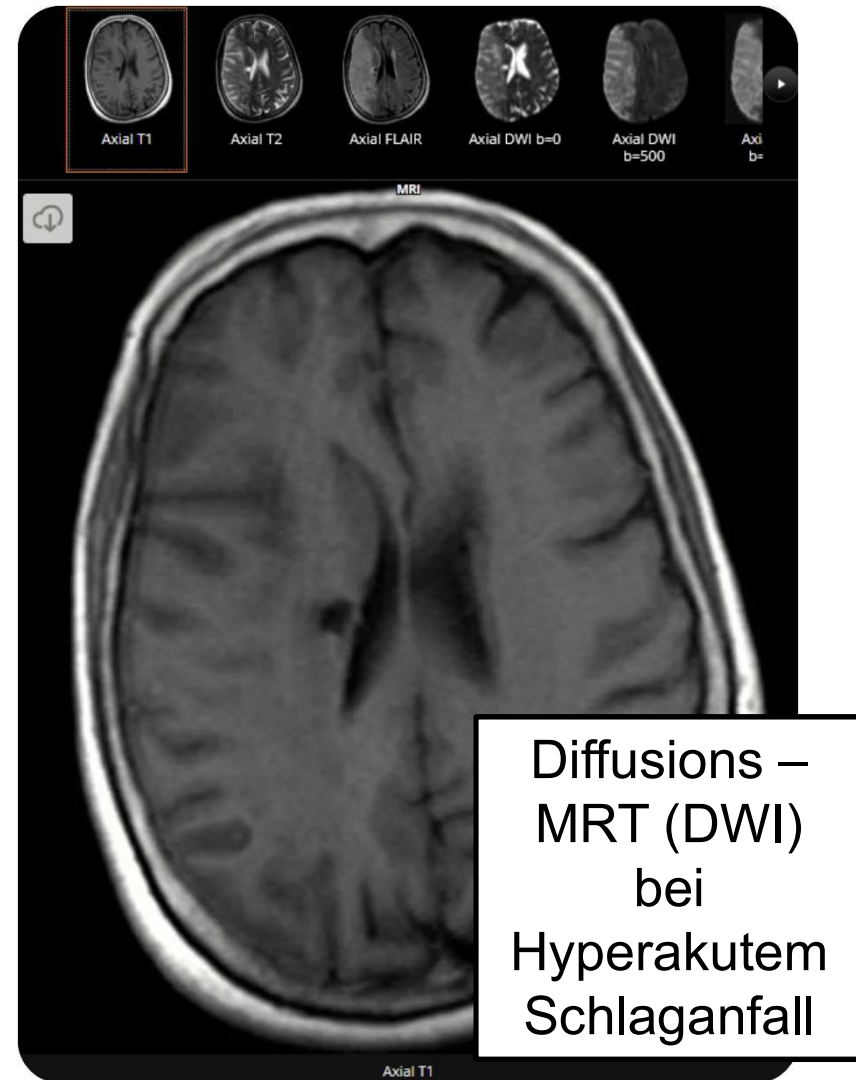
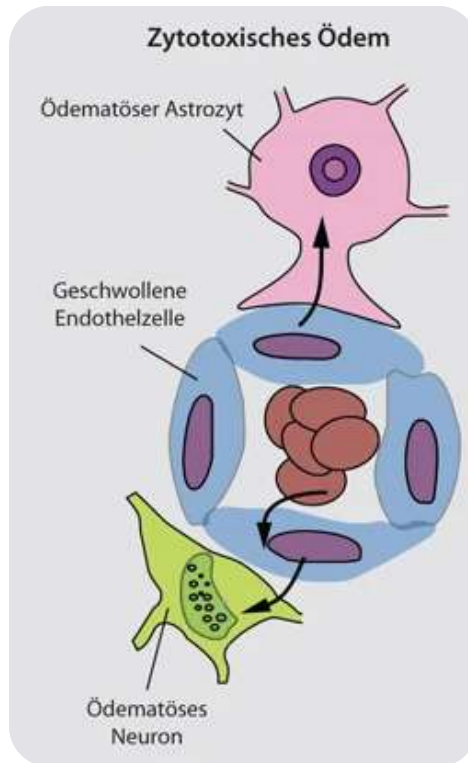
z.B. generalisierte Hypoxie
 Schlaganfall
 metabolisch/toxisch



<https://www.khanacademy.org/science/biology/human-biology/neuron-nervous-system/a/the-membrane-potential>
<https://link.springer.com/article/10.1007/s00101-014-2337-4>

Formen des Hirnödems: I Zytotoxisch

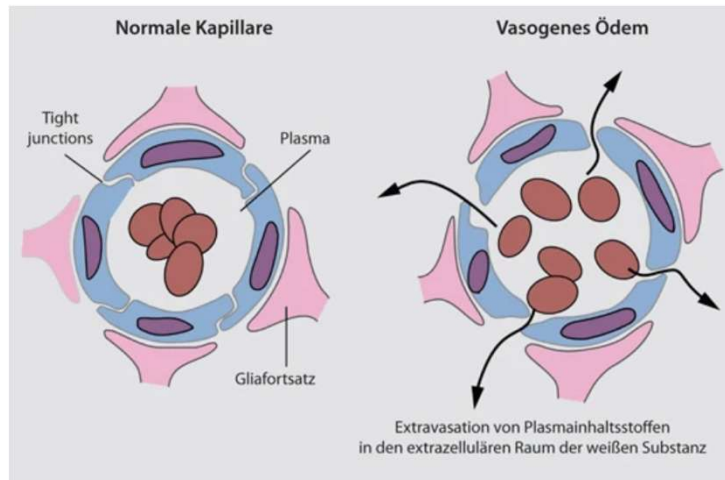
Zytotoxisches Hirnödem:
Störung Na⁺/K⁺ ATPasen u.a. bei
Hypoxie, Flüssigkeit im IZR↑



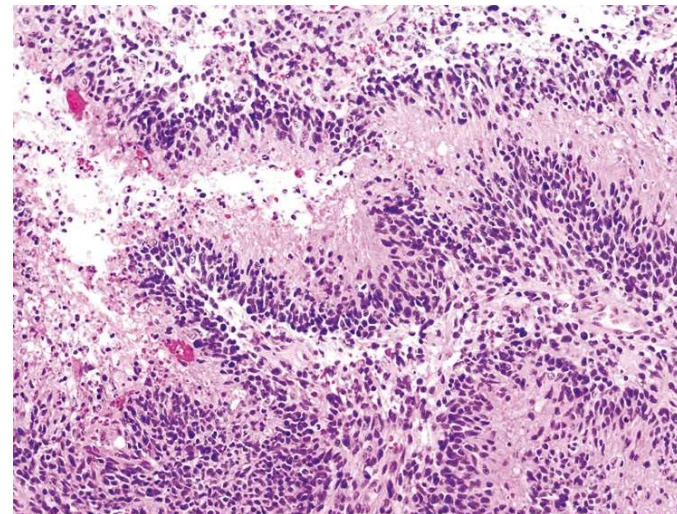
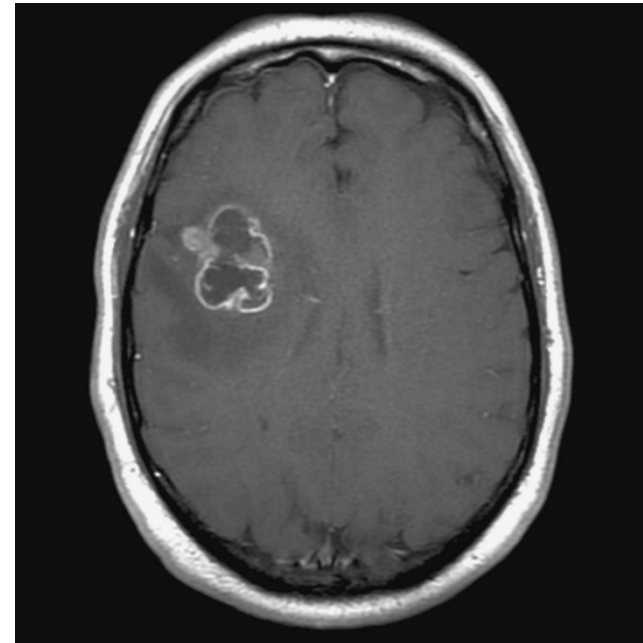
<https://radiopaedia.org/cases/mri-in-hyperacute-stroke-1?lang=us>
<https://link.springer.com/article/10.1007/s00101-014-2337-4>

Formen des Hirnödems: II Vasogen

Vasogenes Hirnödem:
Kapillarpermeabilität↑,
Flüssigkeit im EZR↑,
v.a. Marklager



Hirntumor
Hirnabszess/
Infektion
posttraumatisch

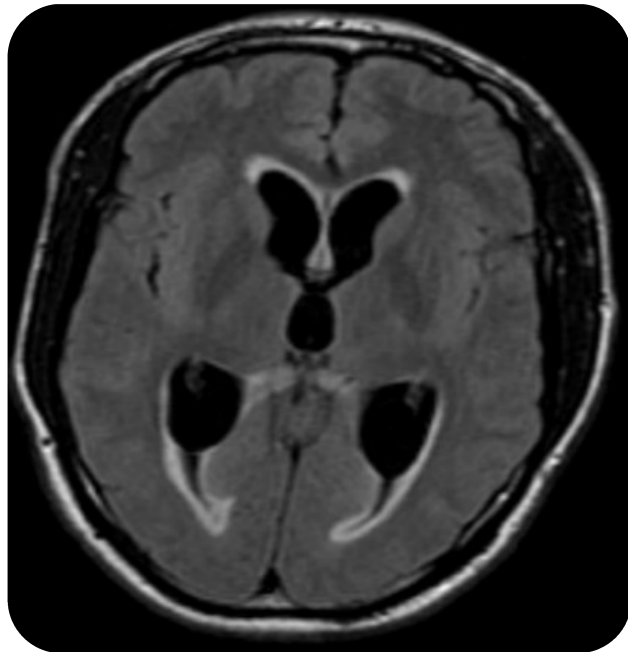


<https://link.springer.com/article/10.1007/s00101-014-2337-4>

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 10223
<https://tumourclassification.iarc.who.int/chaptercontent/45/7>

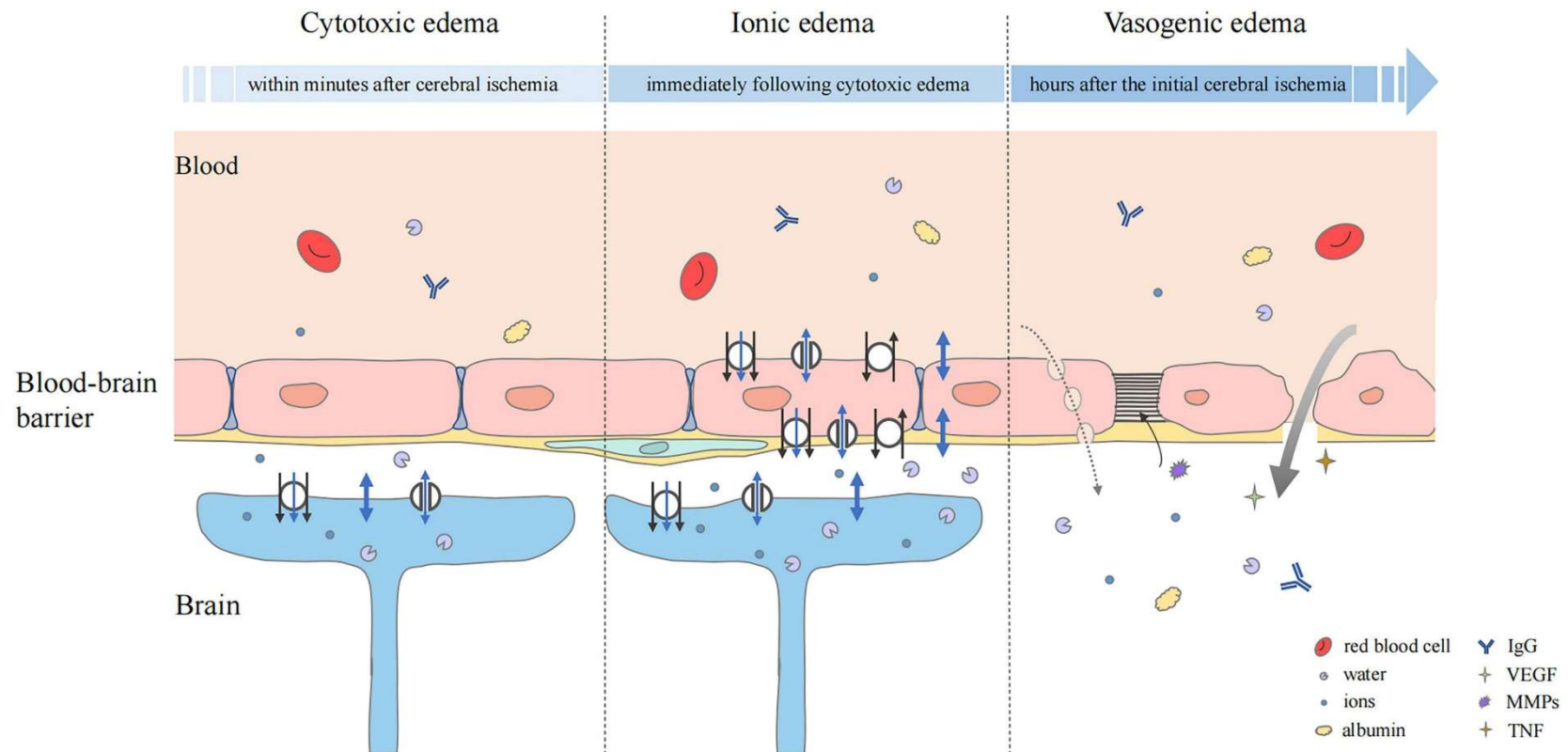
Formen des Hirnödems: Interstitiell

Interstitiell
Liquordruck \uparrow Liquor gelangt passiv
transependymal
ins Hirn



<https://radiopaedia.org/articles/transependymal-oedema?lang=us>
<https://radiopaedia.org/articles/transependymal-oedema>

Ein Kontinuum ist möglich.



Gu et al, Front Neurosci. 2022; 16: 988283.

Volumenzunahme in Kompartimenten:

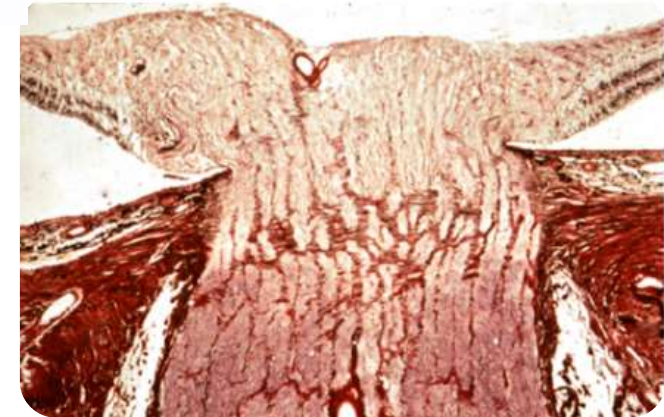
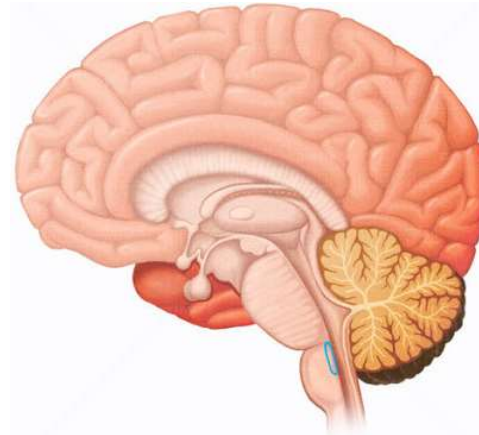
Hirn, Blut, Liquor



Intracranial pressure (ICP)↑

Normwerte	5-15 mmHg
Moderat	30 mmHg
Ausgeprägt	37,5 mmHg
Letal	60 mmHg

Symptomatik, Klinik



Akut:

Kopfschmerz
Übelkeit, Erbrechen
Vigilanz↓

Chronisch:

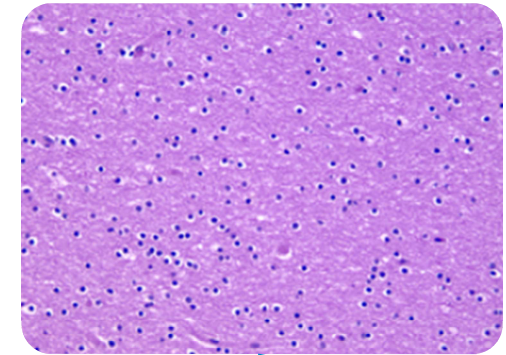
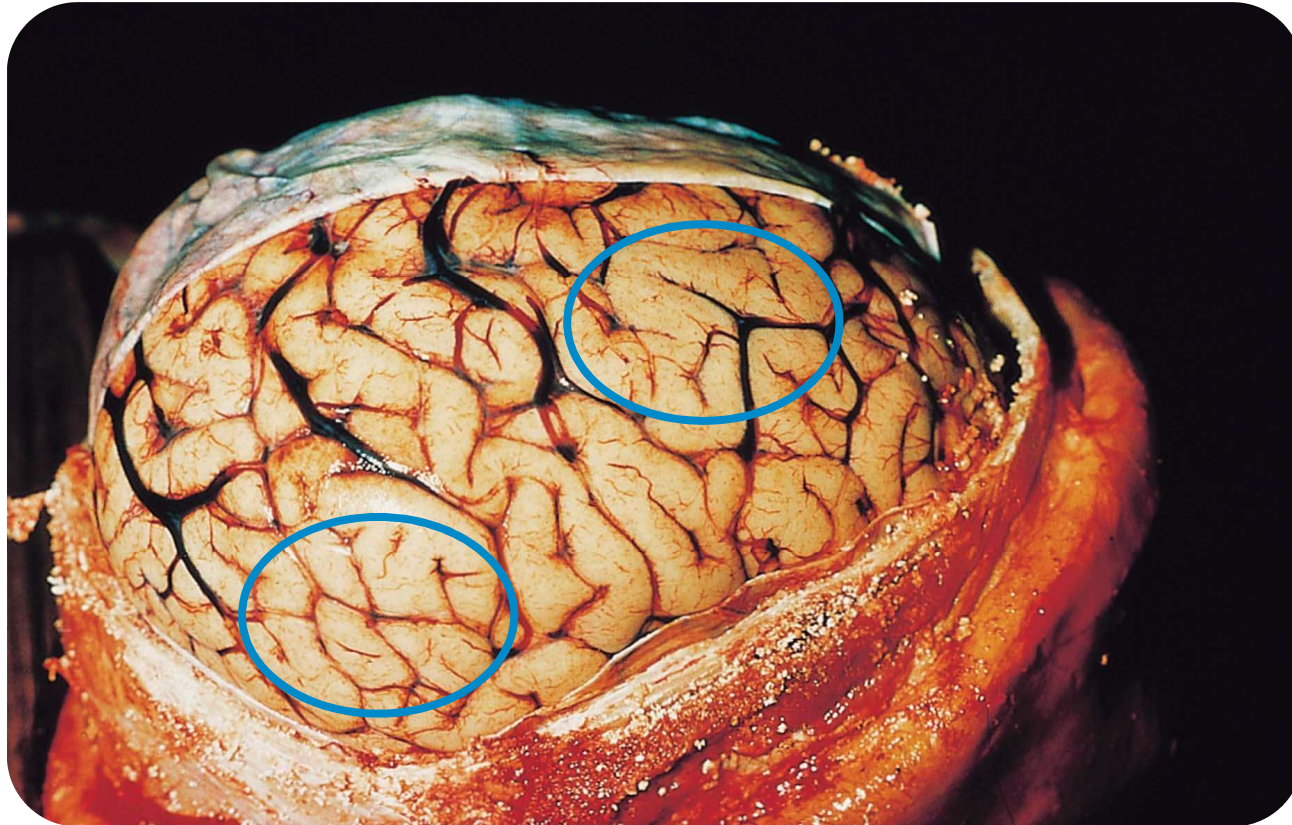
Antriebslosigkeit,
neurologische Defizite wie
Gangstörung etc.

https://www.researchgate.net/figure/Infant-with-huge-hydrocephalus-and-sunset-sign-in-both-eyes_fig1_315794002
<https://neuropathology-web.org/chapter4/chapter4cHerniations.html#edema>
<http://atlas.centralx.com/p/image/area-postrema/>

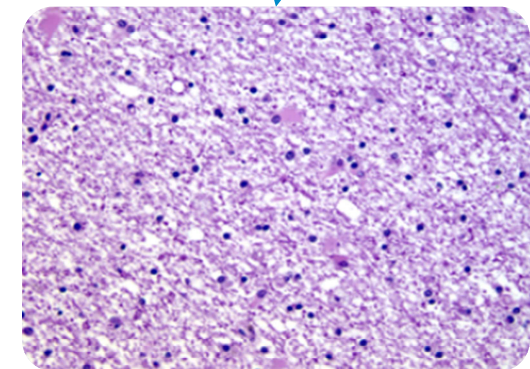
Fallbeispiel: Hirnödem



Fallbeispiel Hirnödem



Ödem

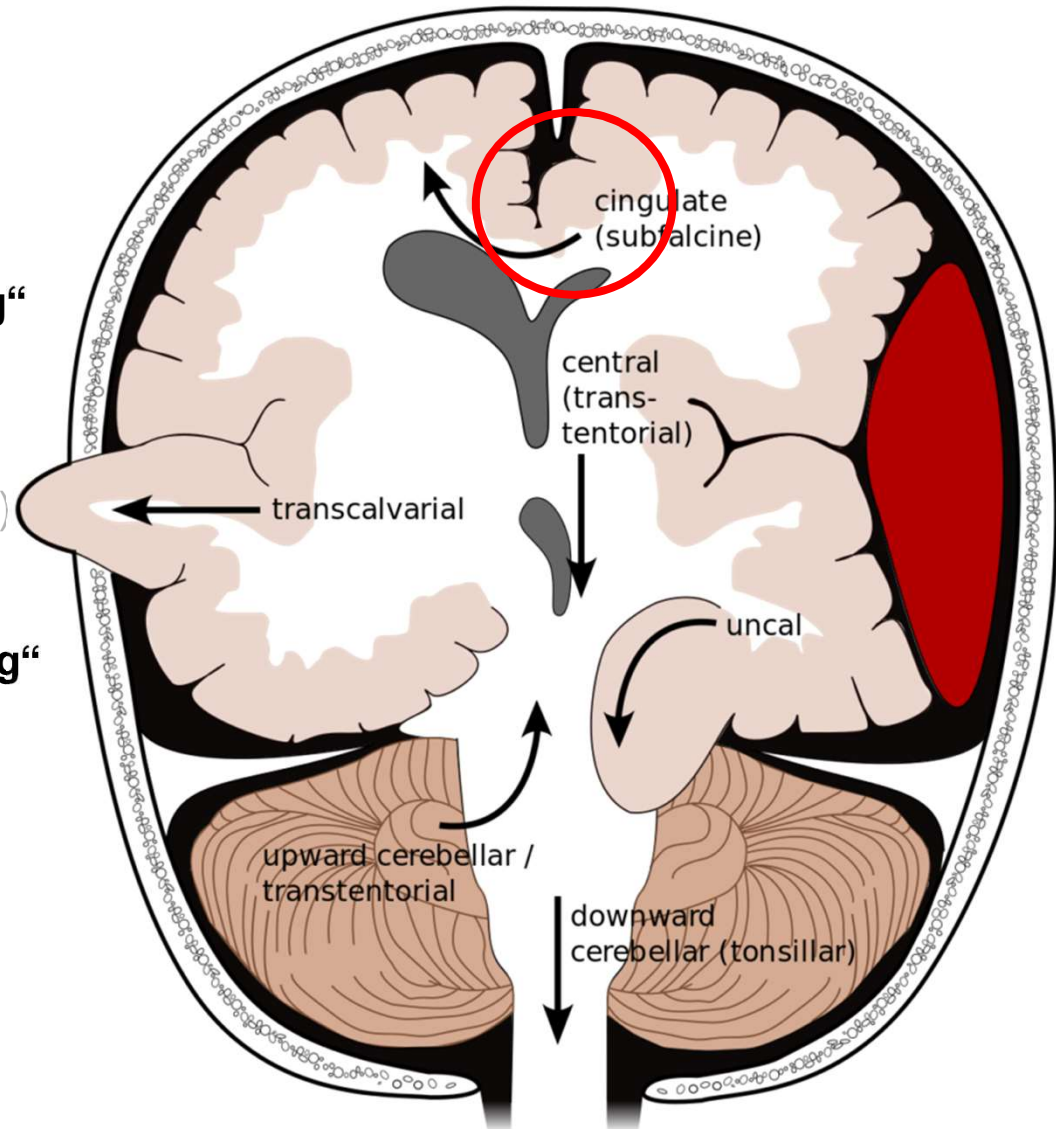


1. **Subfalxial**
(Gyrus cinguli)
2. **Transtentoriell „obere Einklemmung“**
(Uncus parahippocampalis)

absteigend uncal
 absteigend zentral (Hirnstamm)
 aufsteigend (Zerebellum)

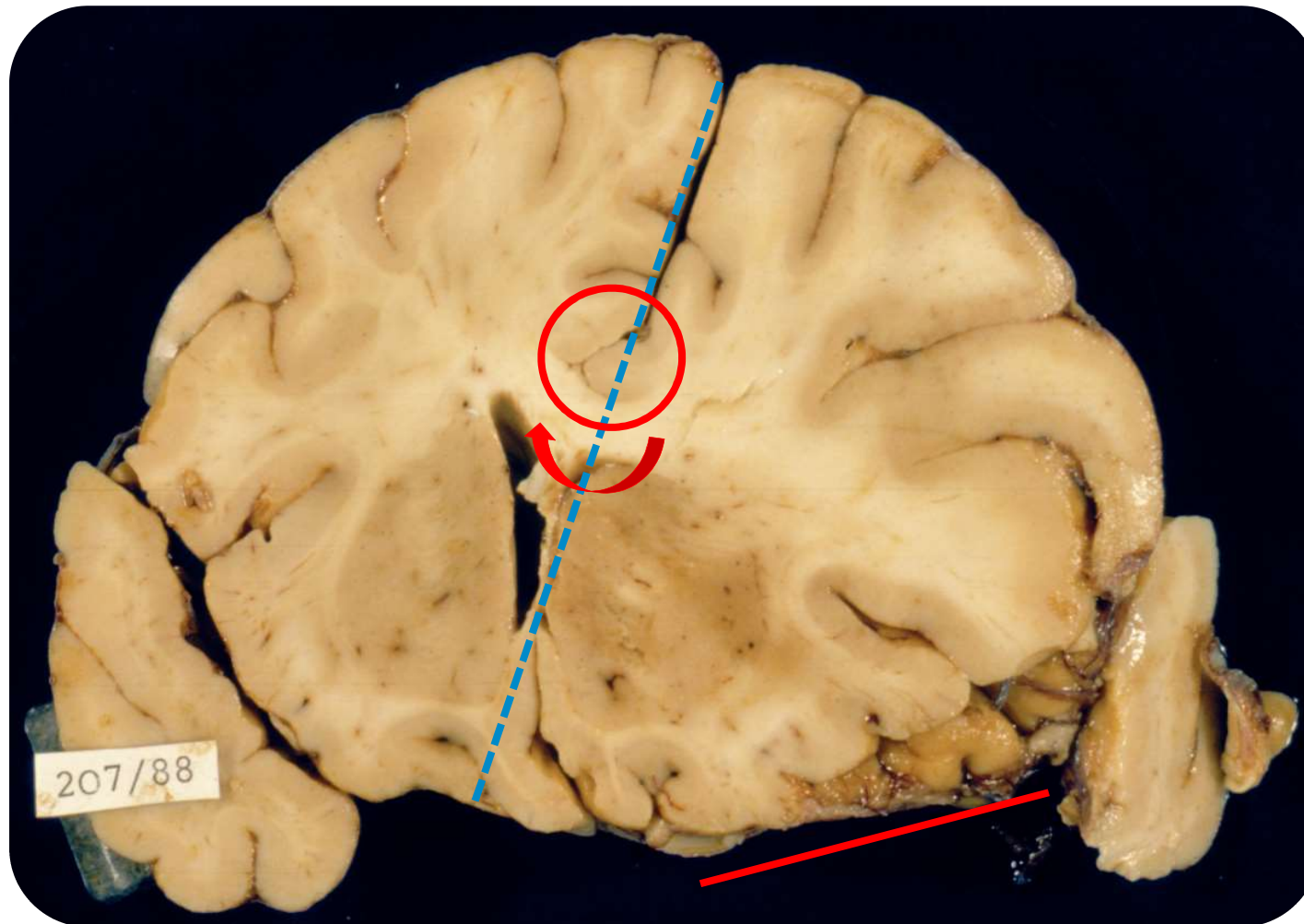
3. **Transforaminal „untere Einklemmung“**
(Kleinhirntonsillen)

4. **Extrakraniell**



<https://canadiem.org/tiny-tips-ich-for-ich-brain-herniation/>

Herniation: subfalxial



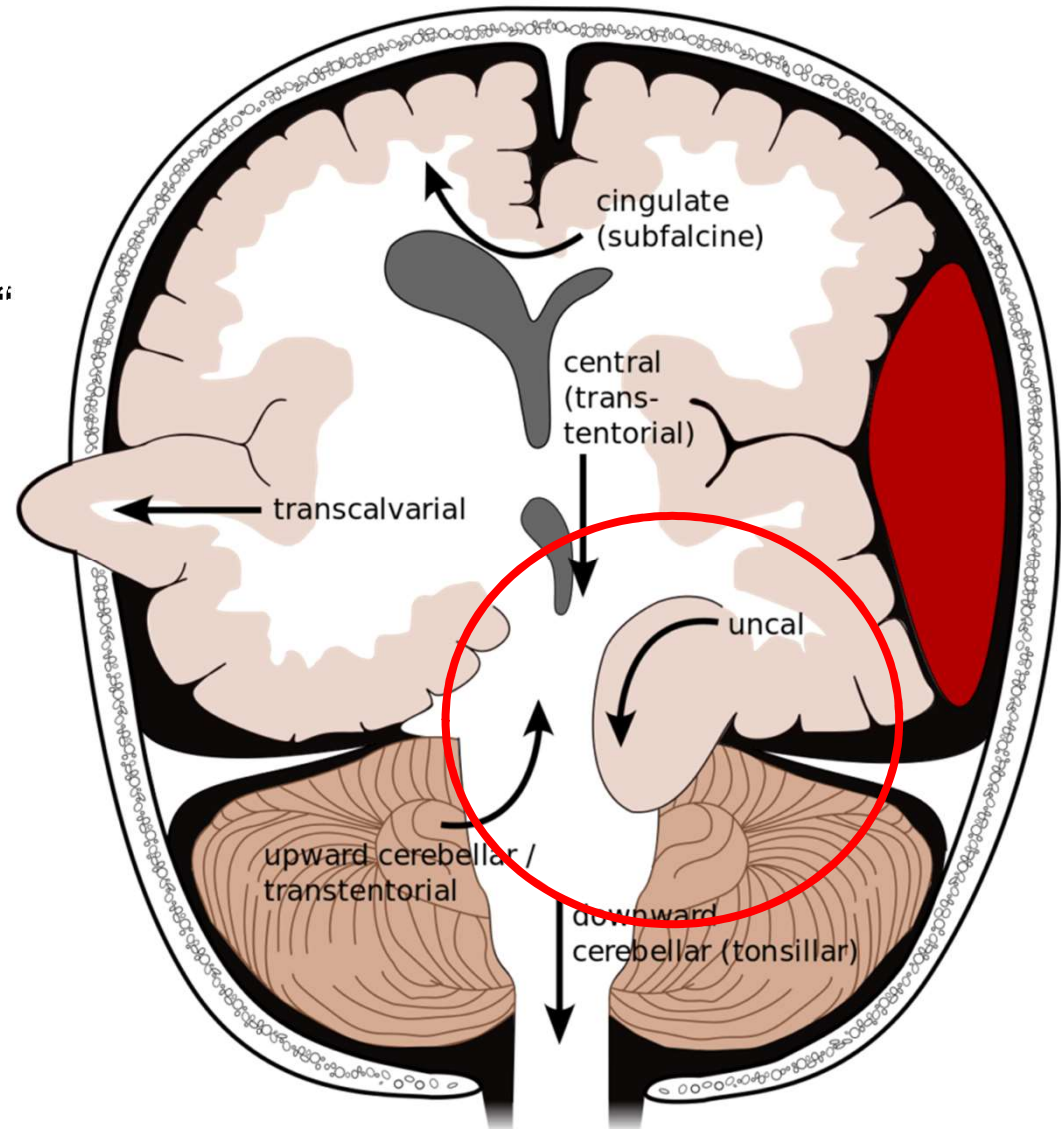
Herniationsformen

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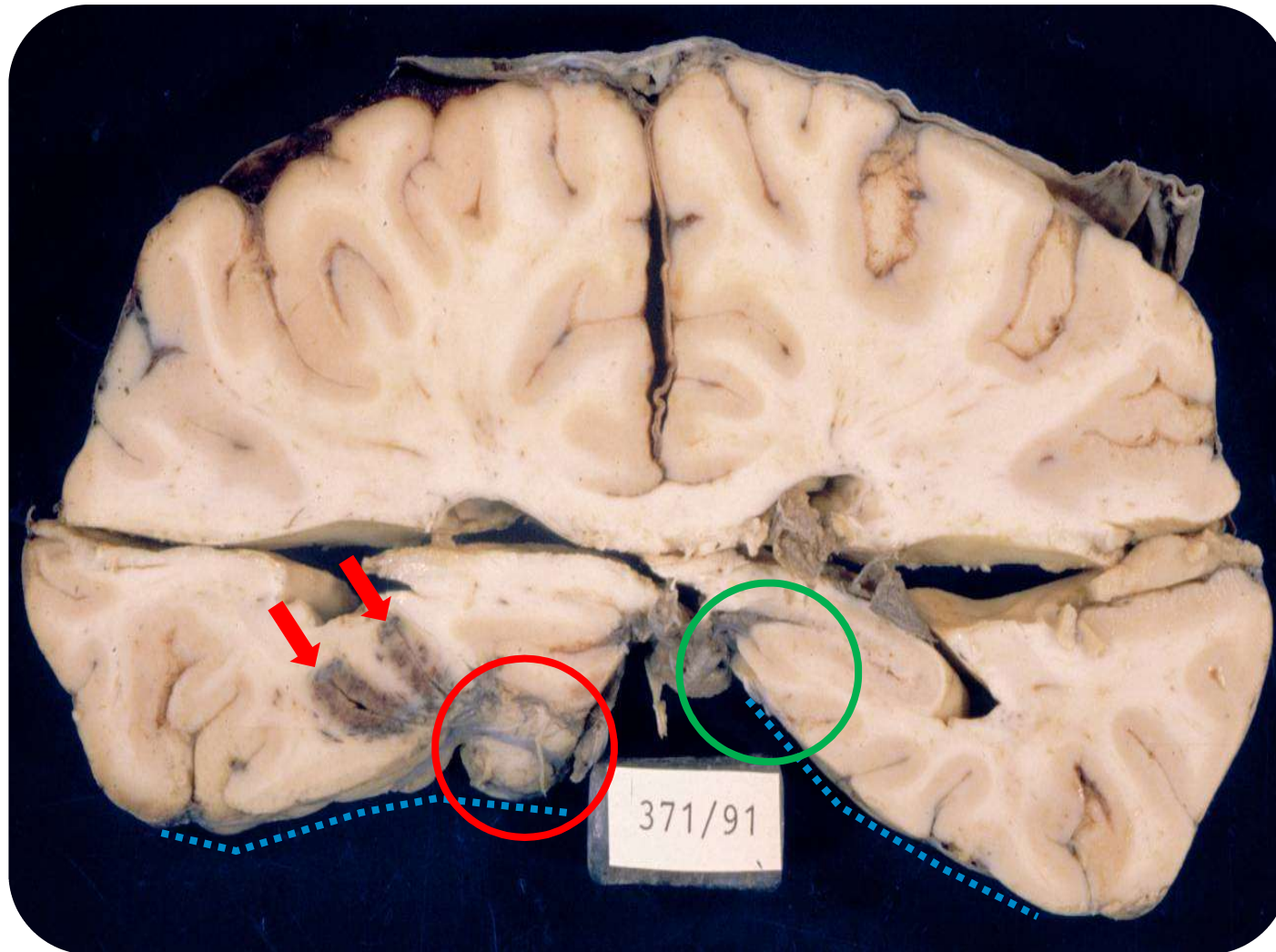
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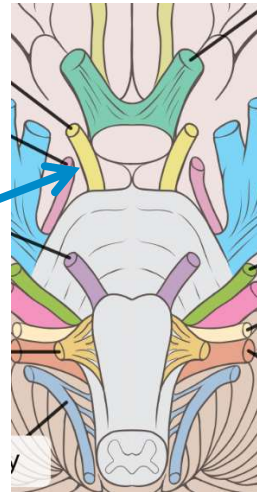
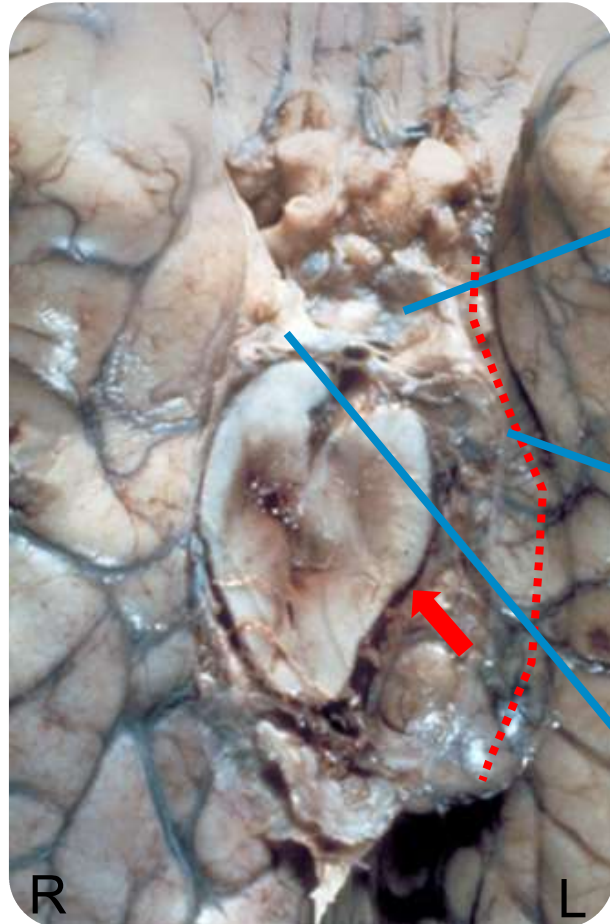


<https://canadiem.org/tiny-tips-ich-for-ich-brain-herniation/>

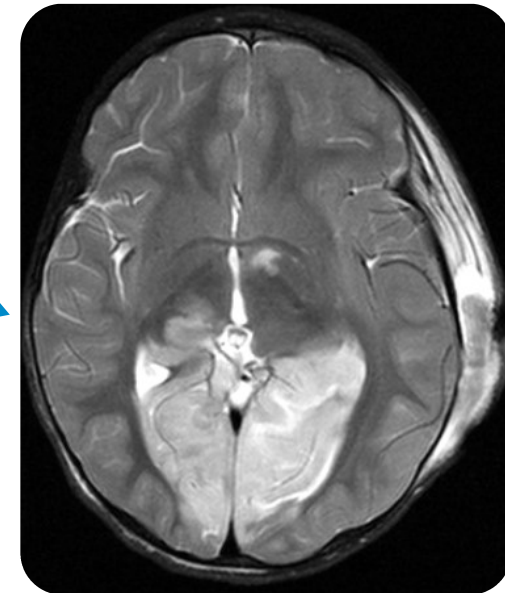
Herniation: transtentoriell



Herniation: transtentoriell



- Kompression
- Hirnschenkel kontralateral
 - N. oculomotorius ipsilateral
 - A. cerebri posterior ipsilateral



<https://neuropathology-web.org/chapter4/chapter4cHerniations.html#edema>
https://en.wikipedia.org/wiki/Oculomotor_nerve#/media/File:Brain_human_normal_inferior_view_with_labels_en.svg
<https://de.wikipedia.org/wiki/Anisokorie#/media/Datei:Anisokoria.JPG>
<https://schlaganfallbegleitung.de/folgen/hemiparese>

Herniation: transtentoriell



Paramediane Verschiebeblutungen in Mittelhirn und Brücke

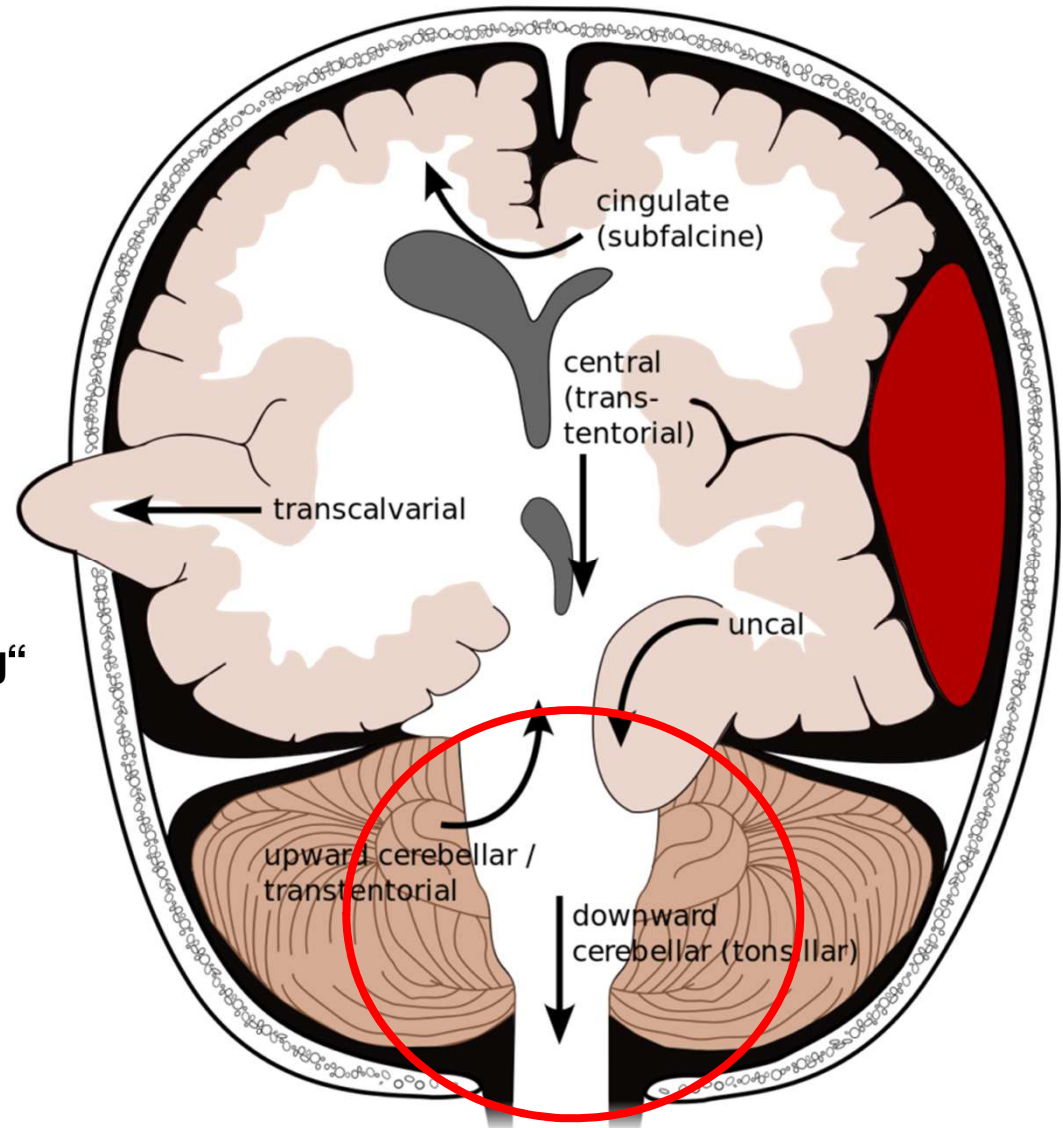
Herniationsformen

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(Uncus parahippocampalis)

absteigend uncal
absteigend zentral (Hirnstamm)
aufsteigend (Zerebellum)

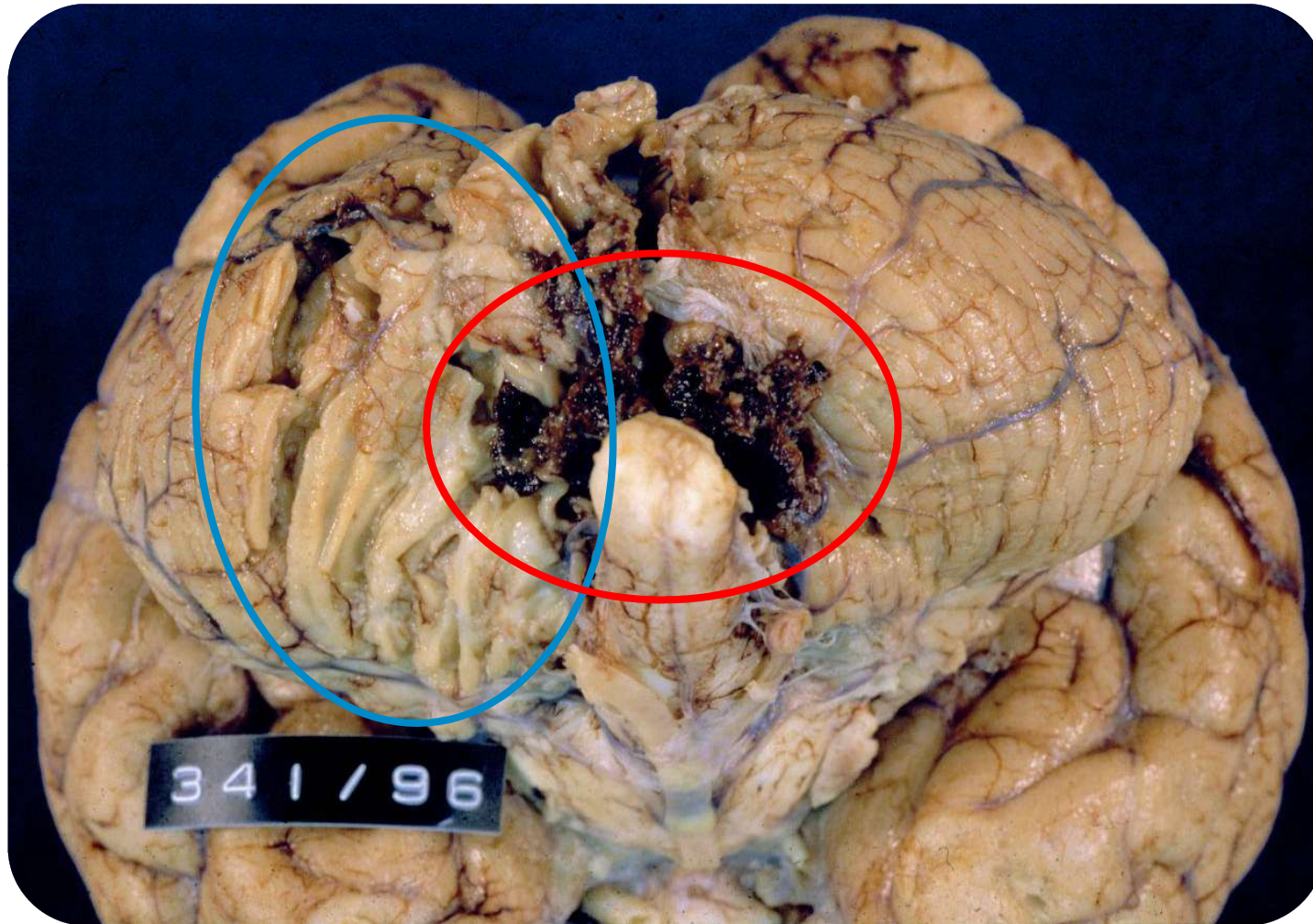
3. **Transforaminal „untere Einklemmung“**
(Kleinhirntonsillen)

4. Extrakraniell

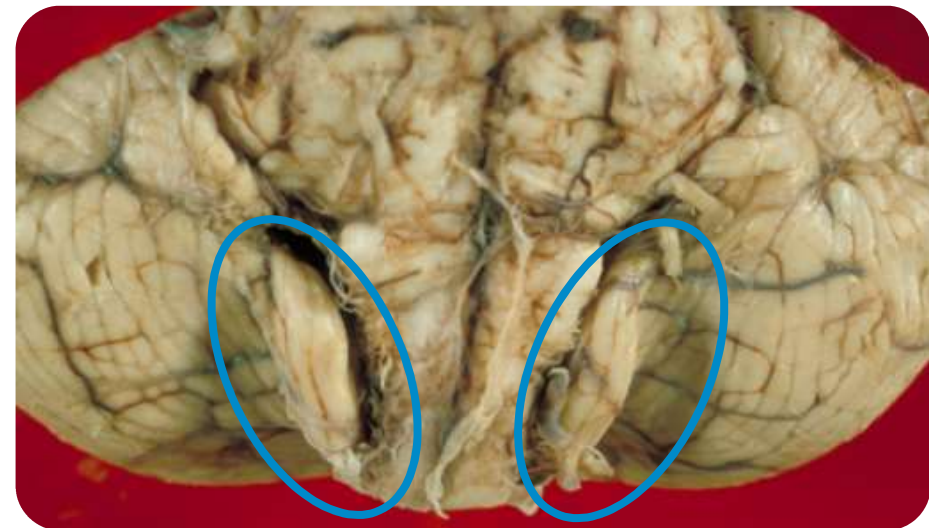
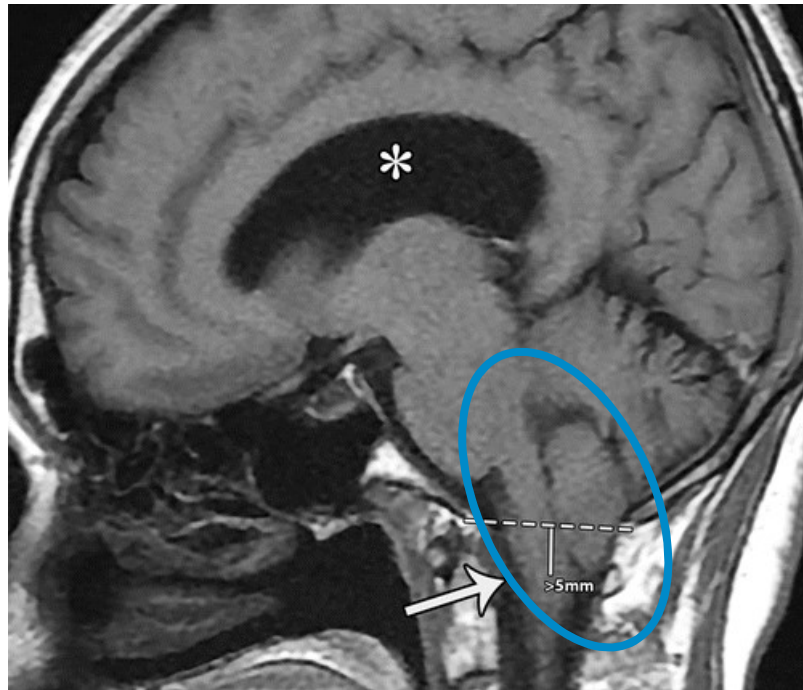


<https://canadiem.org/tiny-tips-ich-for-ich-brain-herniation/>

Herniation: transforaminal



Herniation: transforaminal



Druckkonus

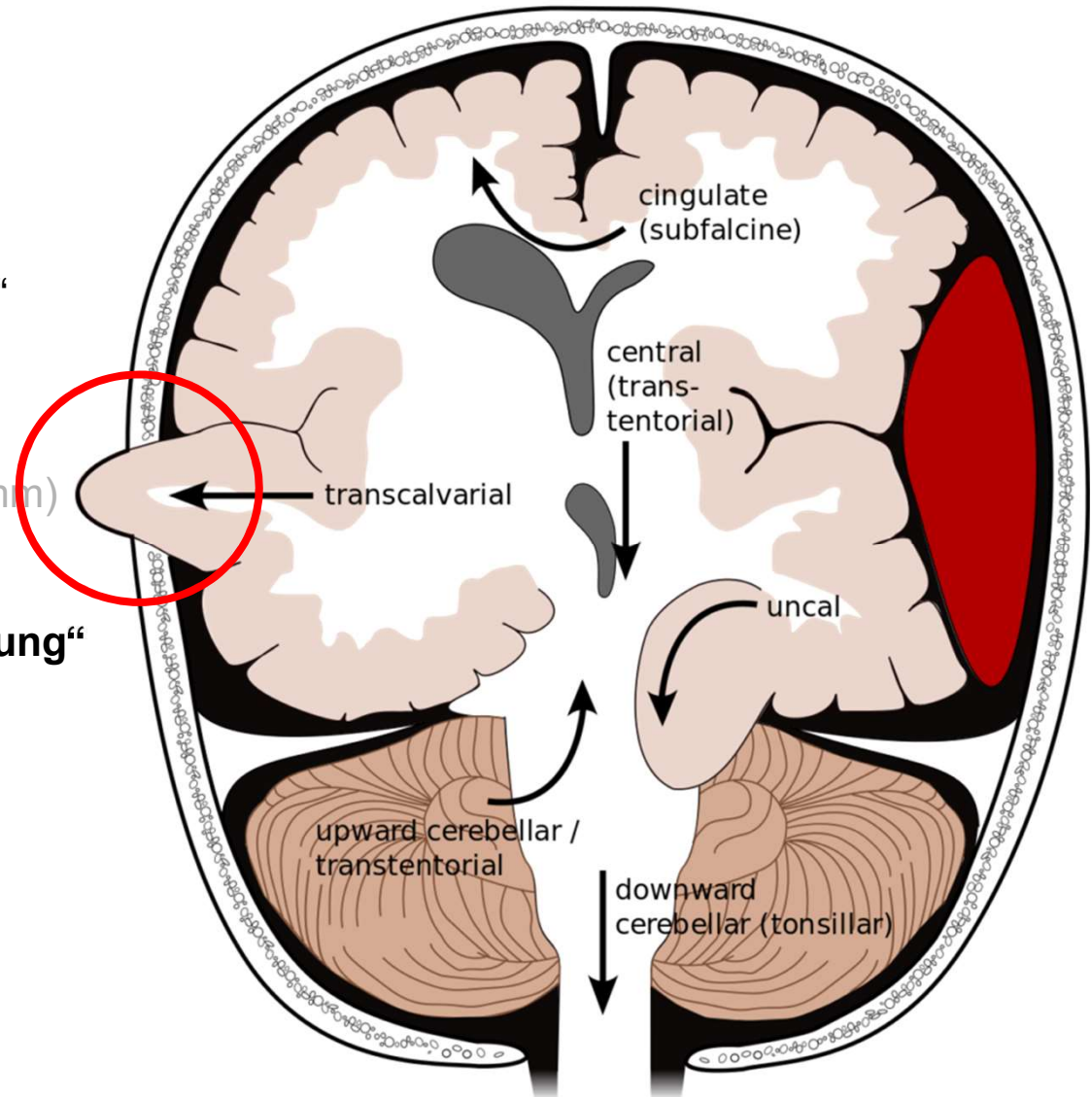
<https://neuropathology-web.org/chapter4/chapter4cHerniations.html#edema>
Gilardi et al, 2019, RadioGraphics, /10.1148/rg.2019190018

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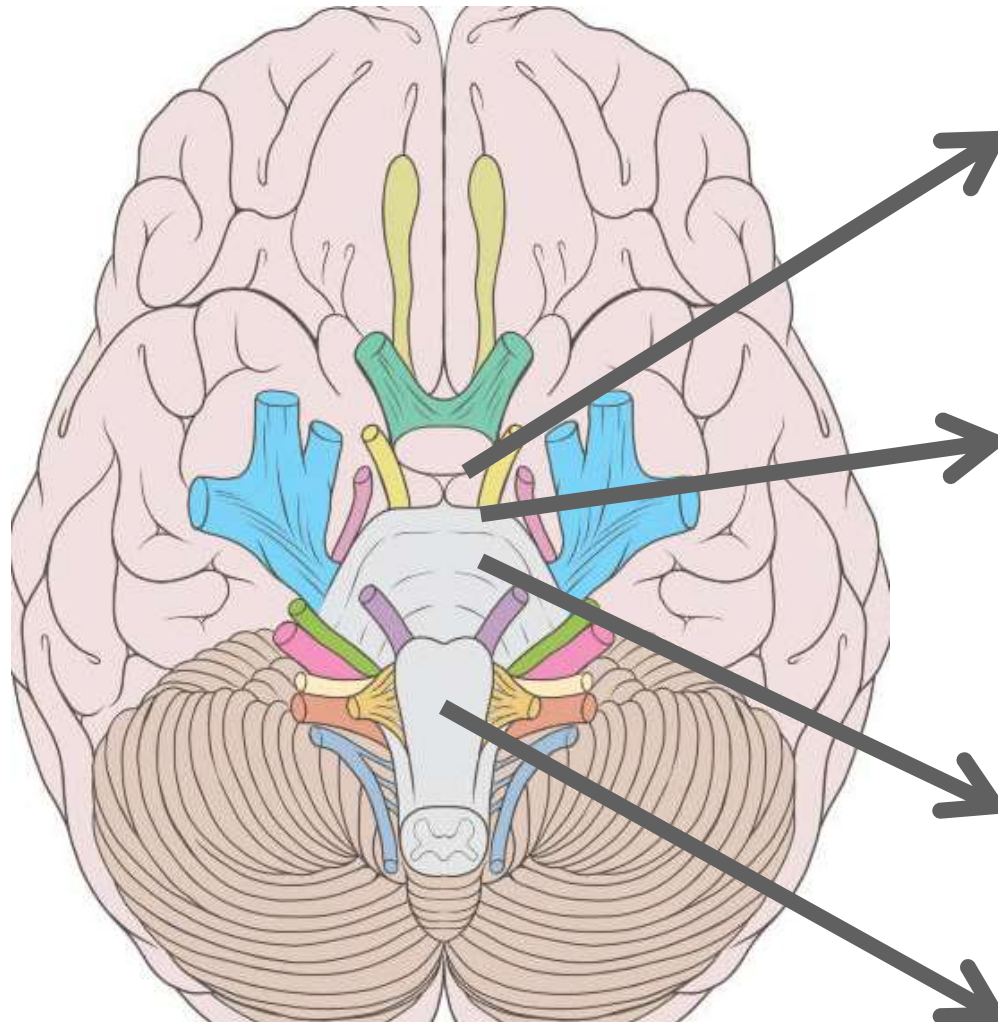
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 absteigend zentral (Hirnstamm)
 aufsteigend (Zerebellum)

3. **Transforaminal „untere Einklemmung“**
(Kleinhirntonsillen)

4. Extrakraniell



<https://canadiem.org/tiny-tips-ich-for-ich-brain-herniation/>



Zwischenhirnsyndrom

Vigilanz ↓, gesteigerter
Muskeltonus

Mittelhirnsyndrom

Kompression N.Oculomotorius:
Pupillenreflex ↓
weite, nicht lichtreagible
Pupille

Pontines Syndrom

Kornealreflex ↓

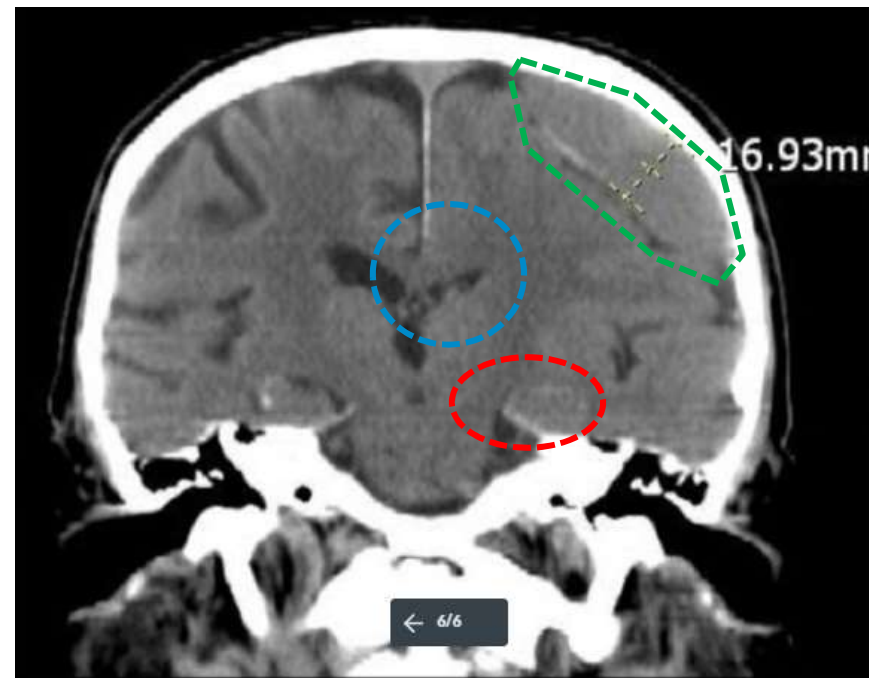
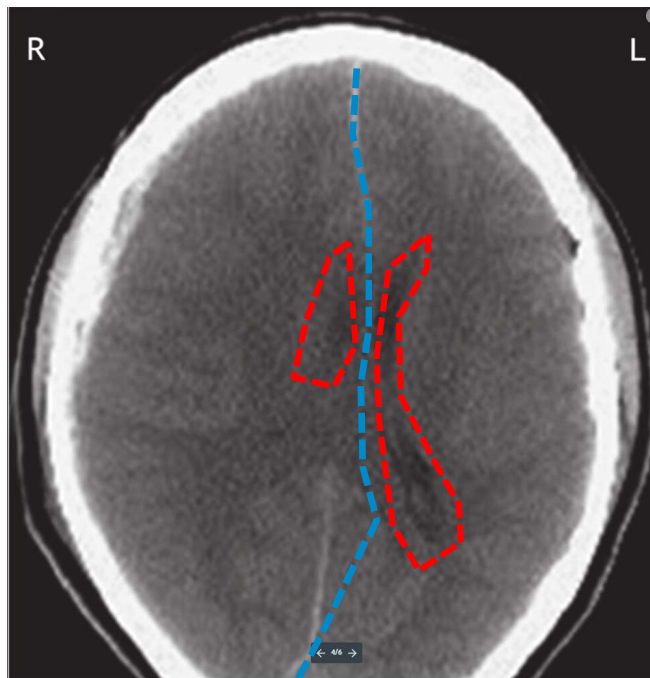
Bulbäres Syndrom

Spontanatmung ↓

<https://flexikon.doccheck.com/de/Hirnnerven>

Herniation: Diagnostik

- ☞ Klinische Untersuchung
- ☞ Bildgebung
- ☞ Invasives ICP-Monitoring



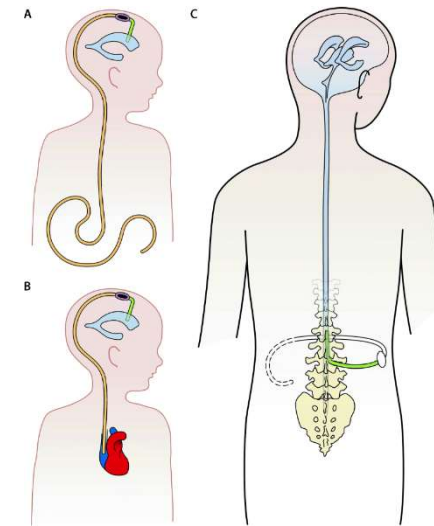
<https://next.amboss.com/de/article/r70fMh?q=hirnodem#Za82b584662d979808976001ddb1b299e>

Herniation: Therapie

Lagerung?



Beatmung
Hyperventilation \rightarrow $CO_2 \downarrow$ Vasokonstriktion



Shunt?

Therapie $ICP \uparrow \uparrow$ –
Ursache?

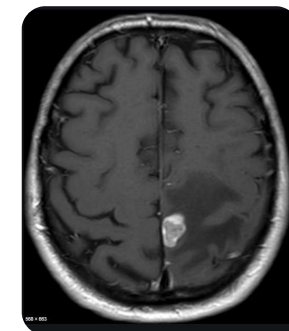
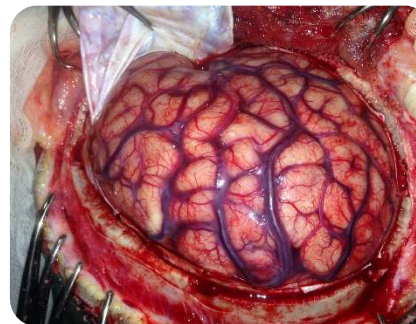


Osmotherapie?

Gerinnung? RR?



OP? Intervention?



Glucocorticoide?

<https://www.mcguiffmedical.com/mannitol-25-125gm/vial-sdv-50ml/vial>
https://link.springer.com/chapter/10.1007/978-3-662-48700-6_24
<https://www.medicalexpo.de/prod/fritz-stephan/product-68464-424807.html>
CNE.online

Take Home

- Mikroskopische Charakteristika der hirneigenen Zellpopulationen
- Formen des Hirnödems (vasogen, zytotoxisch, interstitiell)
- Herniationen mit Klinik
- Therapieoptionen des gesteigerten ICP

Vielen Dank für Ihre Aufmerksamkeit



Bei Fragen, Anmerkungen, Lob/ Kritik:

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