



Interictal and Ictal Patterns

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& Best Practices

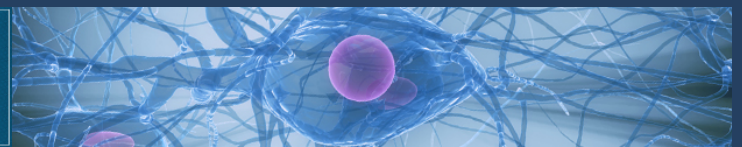
DISCLOSURES

- **Disclosure of Financial Relationships:
None related to the current talk**

Interictal Epileptiform Discharges

- Distinctive waveforms or complexes resembling those recorded in a proportion of human subjects suffering from epileptic disorders and in animals rendered epileptic experimentally”.
 - *The International Federation of Societies for Electroencephalography and Clinical Neurophysiology (1)*
- EEG abnormalities associated with a predisposition (i.e. association is not absolute) to experiencing or developing epileptic seizures (2).
- Detection of epileptiform abnormalities increases the likelihood of an epileptic seizure disorder.
- Need to be taken together with the clinical history and other diagnostic test results

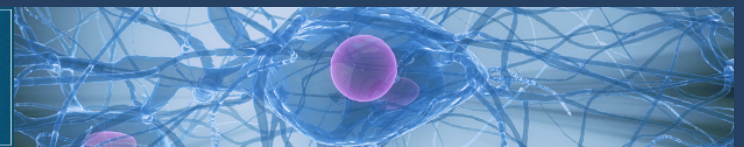
(1) (1974) A glossary of terms most commonly used by clinical electroencephalographers. *Electroencephalogr Clin Neurophysiol* 37:538-548. (2) Sam MC, So EL (2001). *Epilepsia* 42:1273-1278.



EEG of asymptomatic first-degree relatives of patients with JME, CAE, and rolandic epilepsy

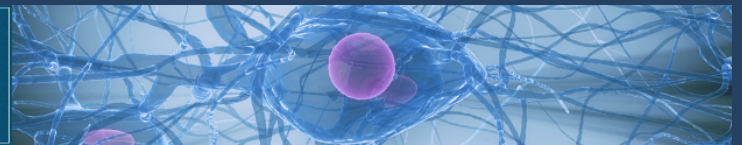
- Possible genetic roles in all three syndromes, yet genes remain unknown
- Metanalysis: 15 studies, a total of 3,858 asymptomatic relatives.
- Prevalence of 'abnormal' EEG waves :
 - 42% for CAE
 - 33% for RE
 - 21% for JME
- Close to what would be expected based on Mendelian inheritance
- However, EEG signature traits were as low as 5%

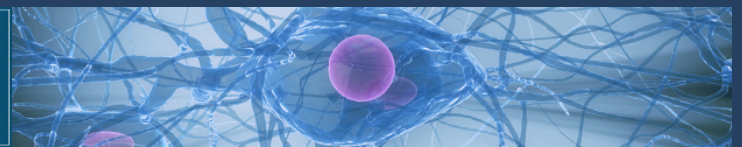
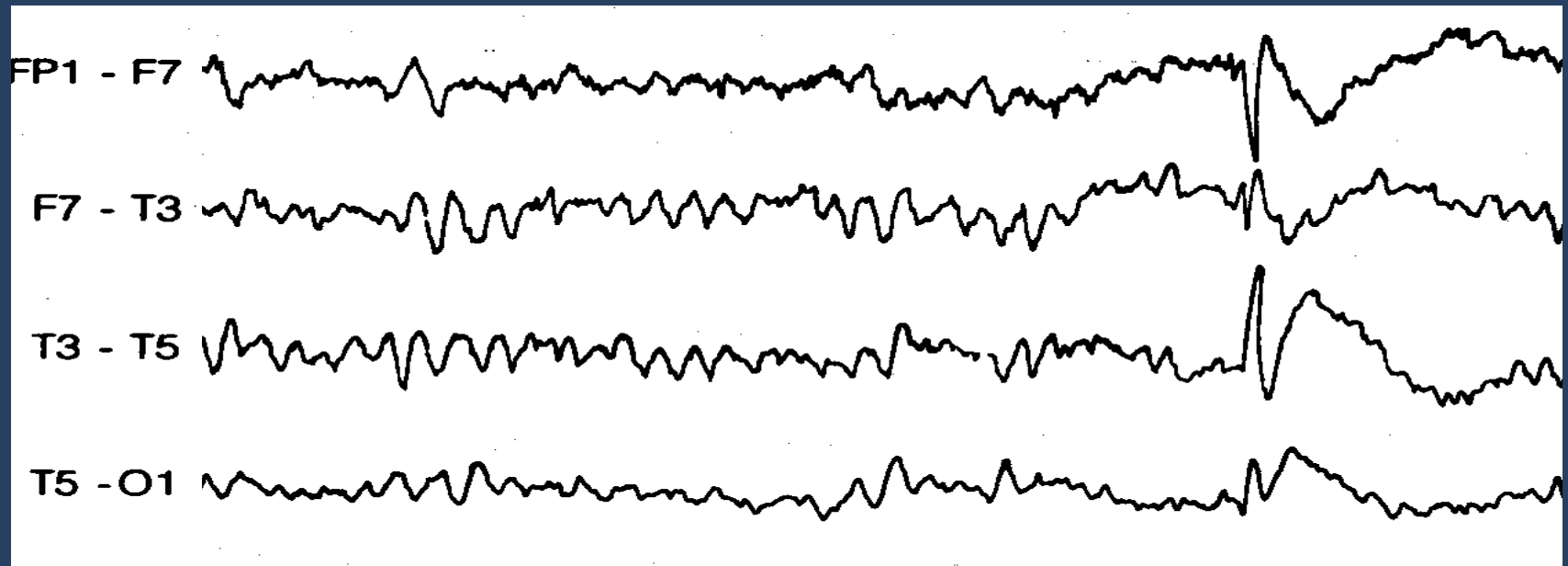
Tashkandi et al. (2019) *Epileptic Disord* 21(1):30-41

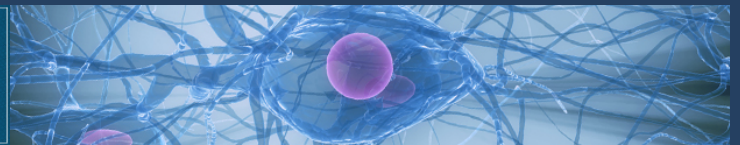
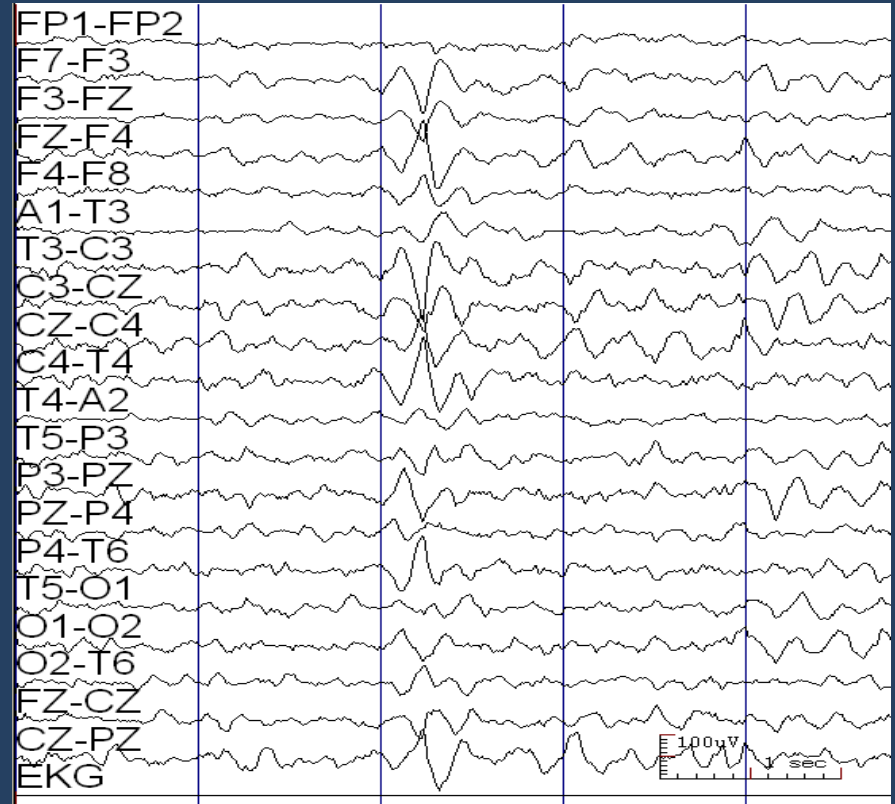
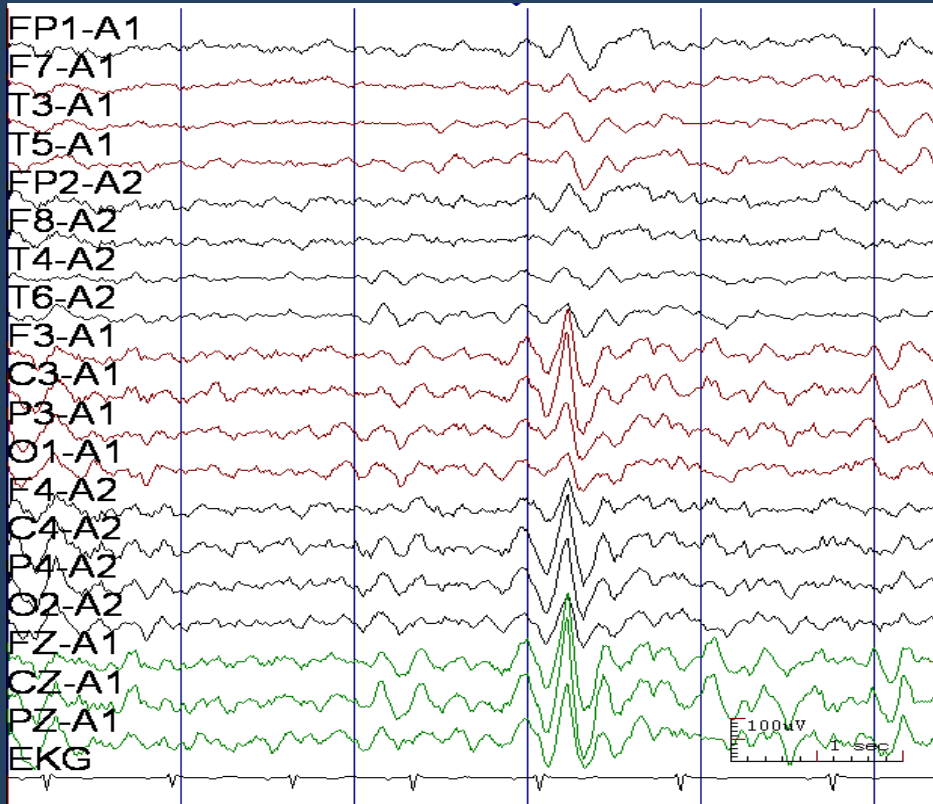


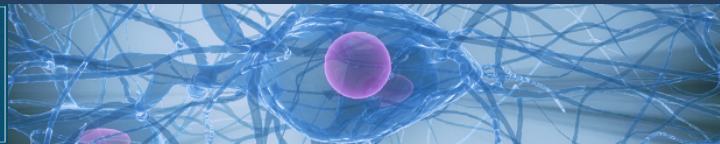
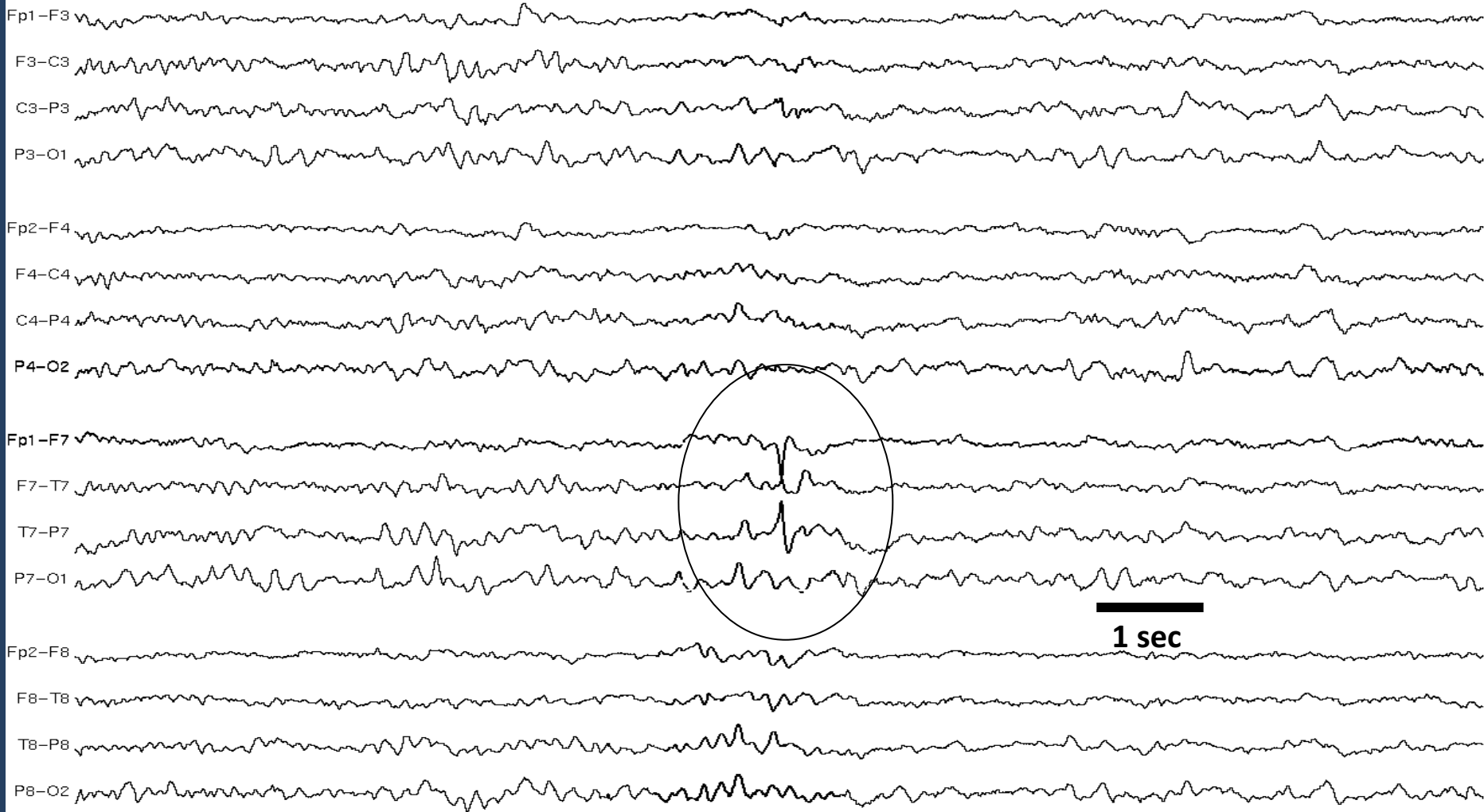
Spikes/Sharp Waves

- Have pointed peaks when recorded at 30 mm per second.
 - Spike duration = 20 to 70 msec
 - Sharp wave duration = 70 to 200 msec
- Both types of waves often occur in the same clinical disorder or the same patient.
- Distinct from the background
- Disrupt the background
- Polyphasic
- Main component is surface negative
- Often followed by a slow wave with variable amplitude
- Have a field
- Asymmetrical slopes









Spike/Sharp Wave Locations

- Temporal > Frontal > Centrotemporal > Parietal > Occipital > Central /paracentral.
- Association with epilepsy is better for temporal than rolandic or occipital spikes (1)

Anterior Temporal Spikes



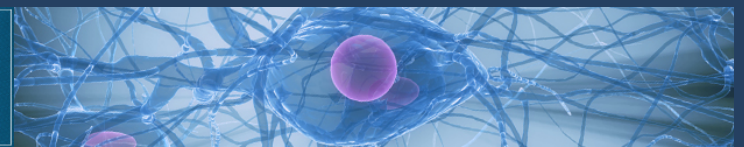
90% Epilepsy

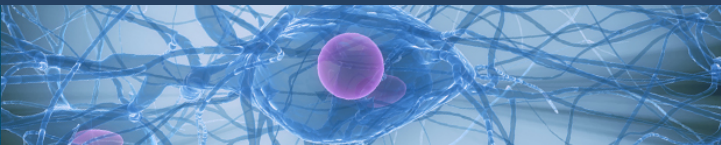
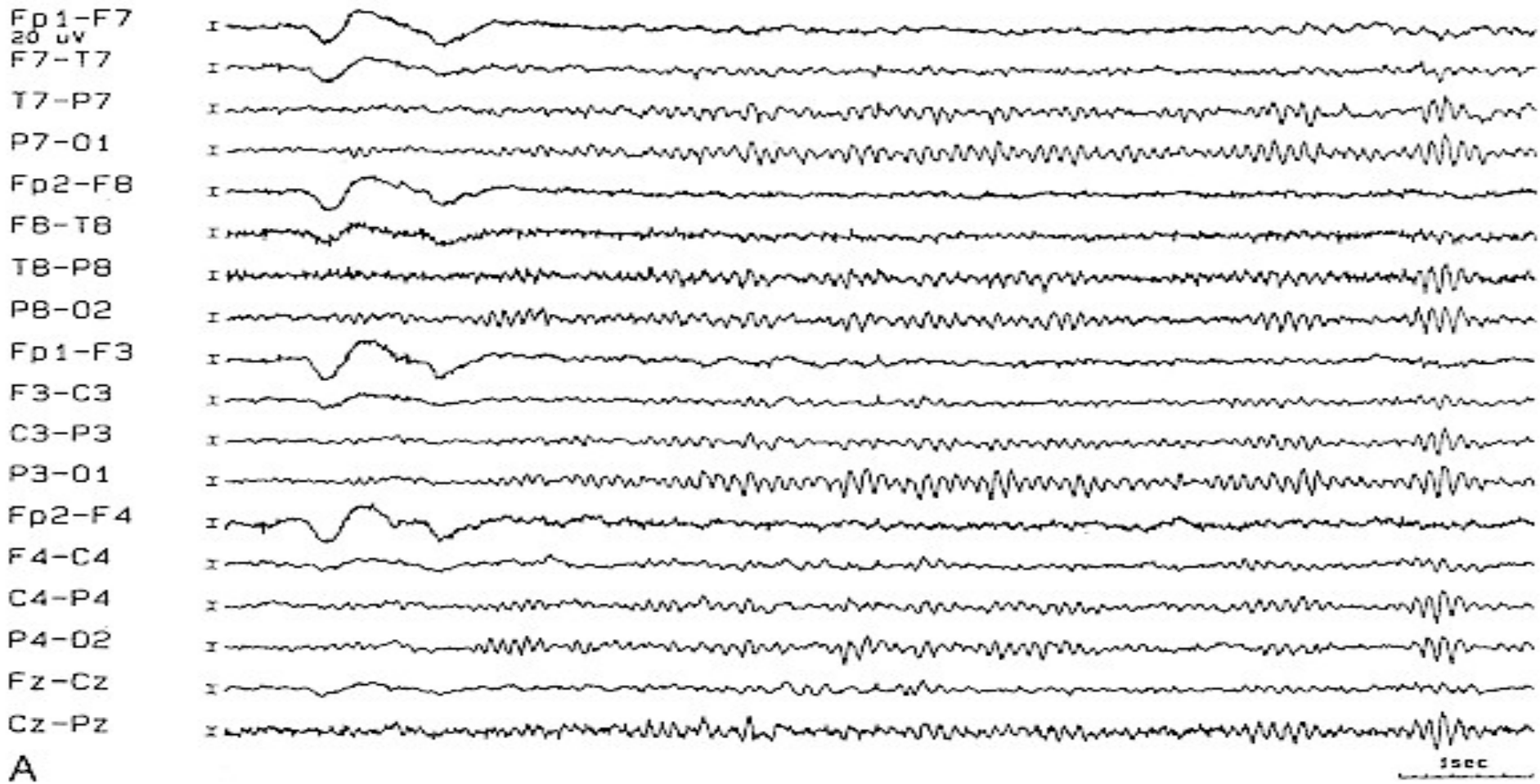
Rolandic Spikes

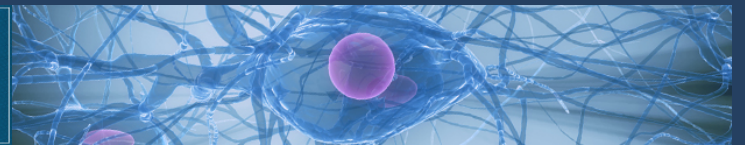
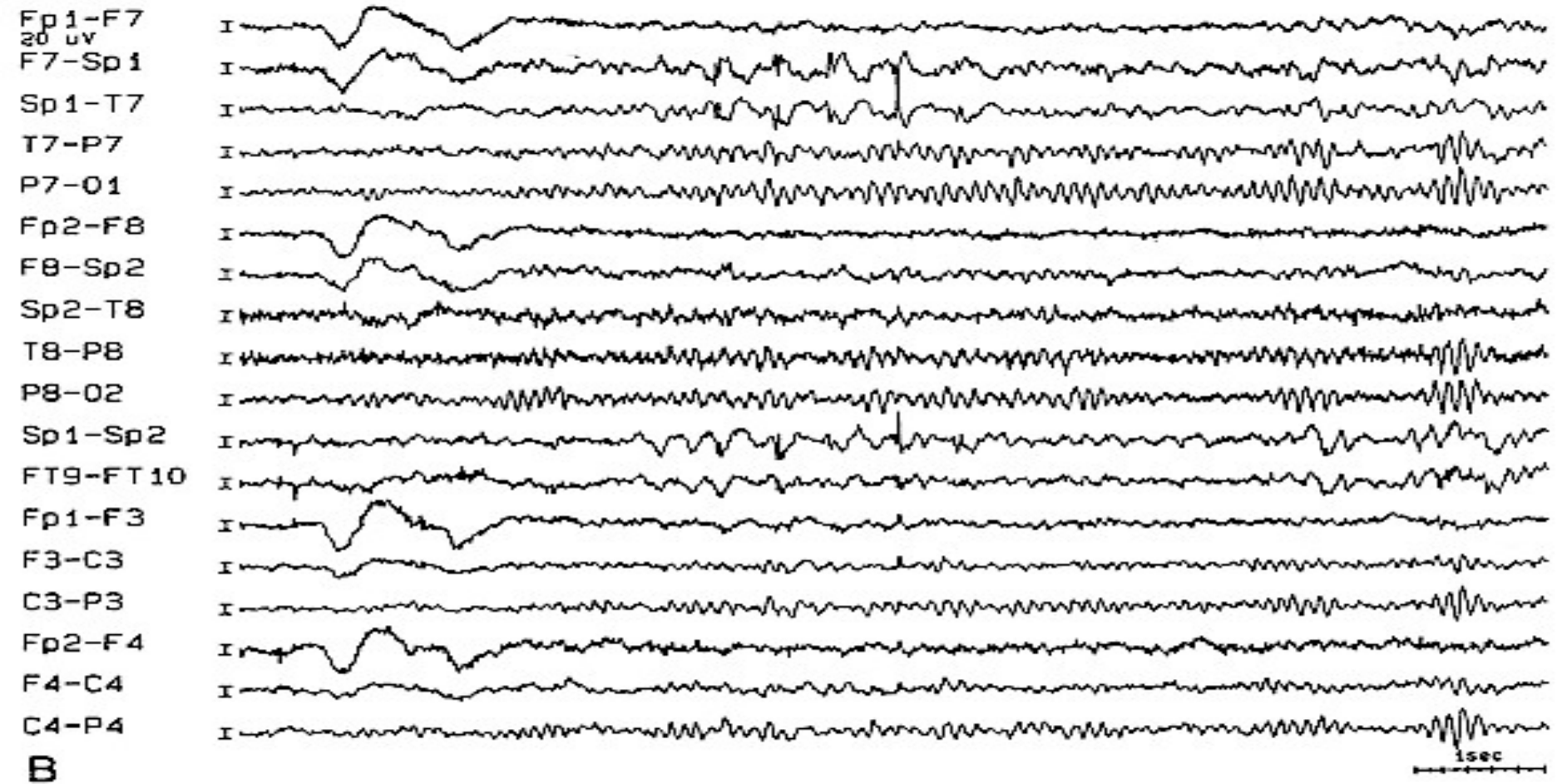


38% Epilepsy

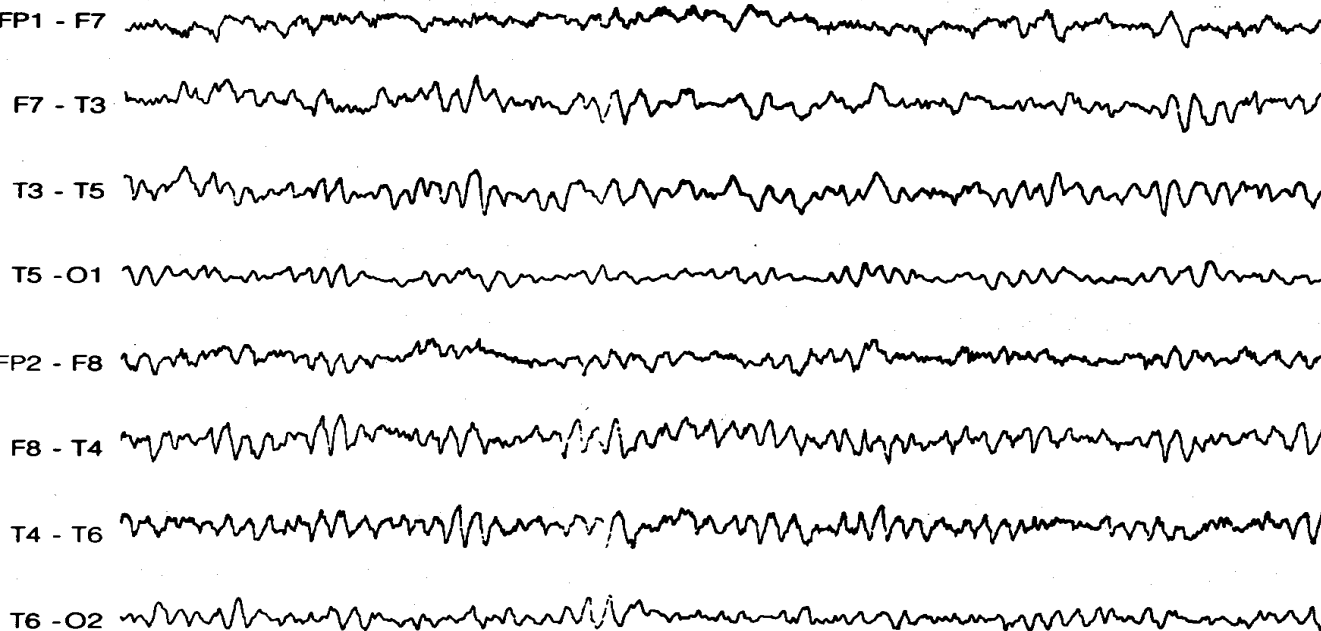
(1) Fois A et al. (1988) Epilepsia 29:620-623



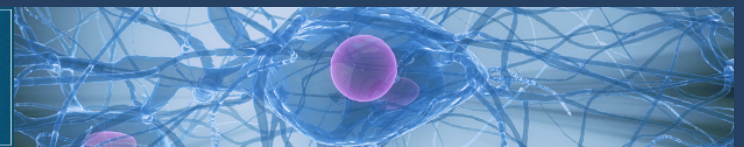


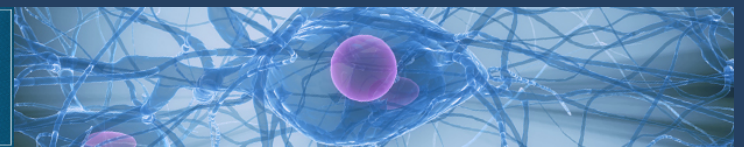
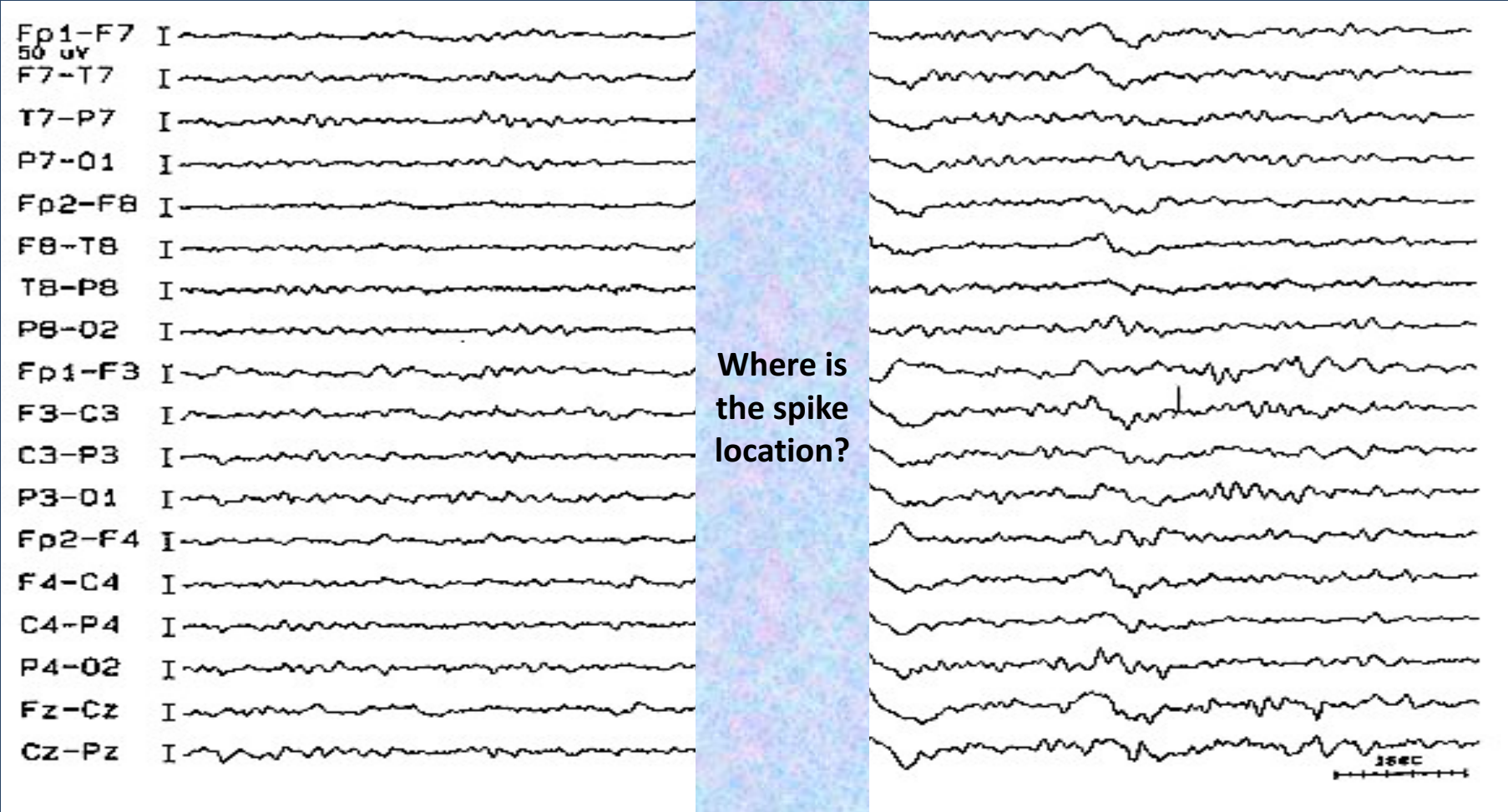


Hyperventilation in a 63 year old woman



There is a spike hidden under this panel. Can you guess its location?

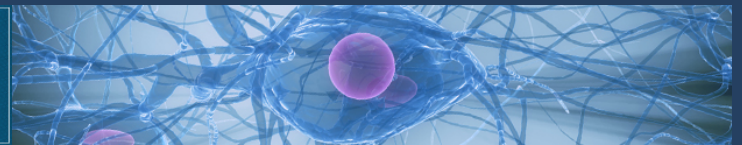




Spike/Sharp Wave Locations

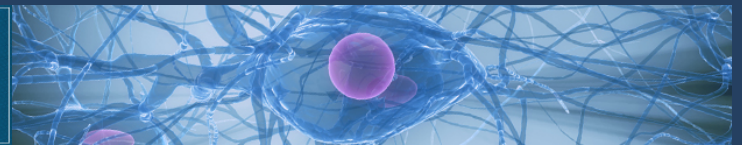
- Occipital IED are encountered in migraine (1)
- About 60% of children with occipital spikes do not have epilepsy.
- Occipital “Needle spikes” are seen in the EEG of children with congenital blindness, but no seizures (2).

(1) Slatter KH (1968). Brain 91:85-98. (2) Kellaway P (1955) Electroencephalogr Clin Neurophysiol Suppl Suppl. 4:212-213.



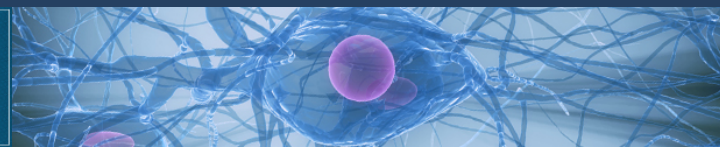
Focal Spikes

- Scalp surface-positive IED can be seen
 - After brain surgery
 - In newborns with periventricular hemorrhage or leukomalacia
 - In young children with multifocal IED and global encephalopathy





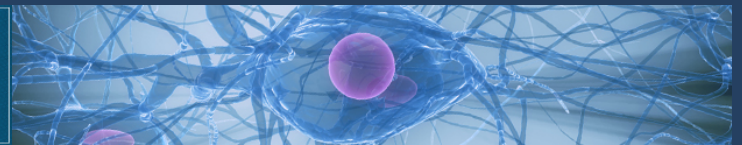
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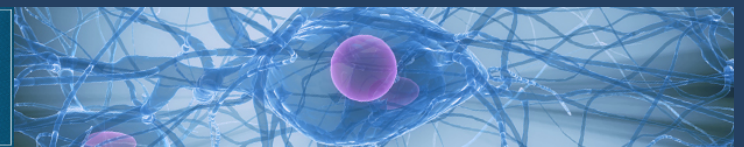
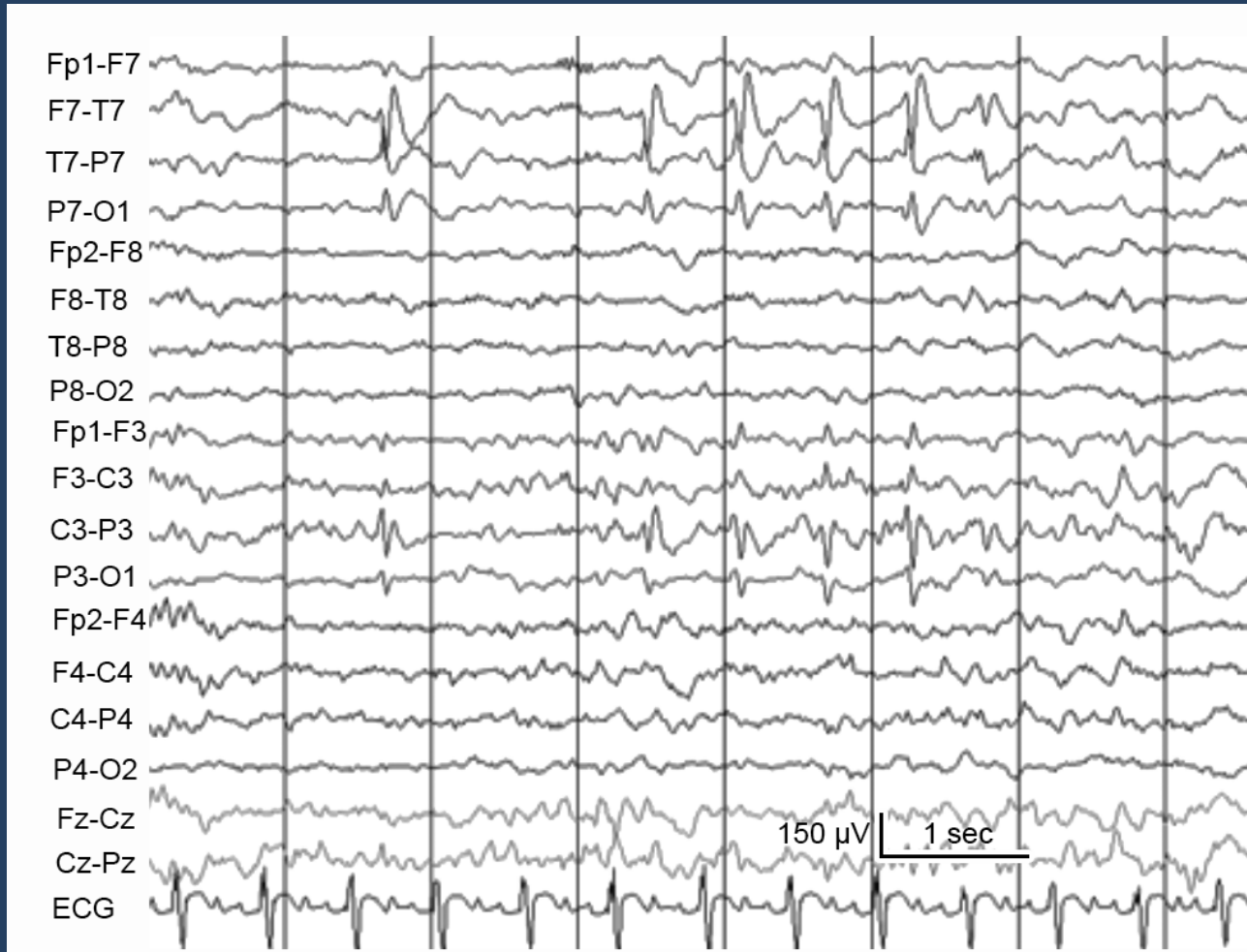
Focal Spikes

- Spikes have typical features in
 - Benign Epilepsy with Centrotemporal Spikes
 - Negative over T and C
 - Positive end of the dipole over frontal regions
 - Benign Childhood Epilepsy with Occipital Paroxysms
 - Early-onset Childhood Seizures with Occipital Spikes (Panayiotopoulos syndrome) (1)

(1) Caraballo R et al (2000) Neurology 55:1096-1100.

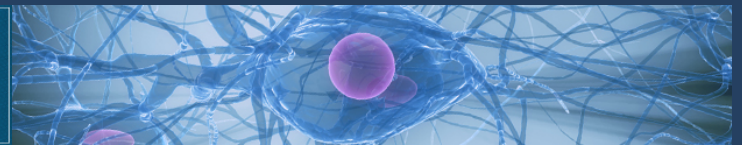


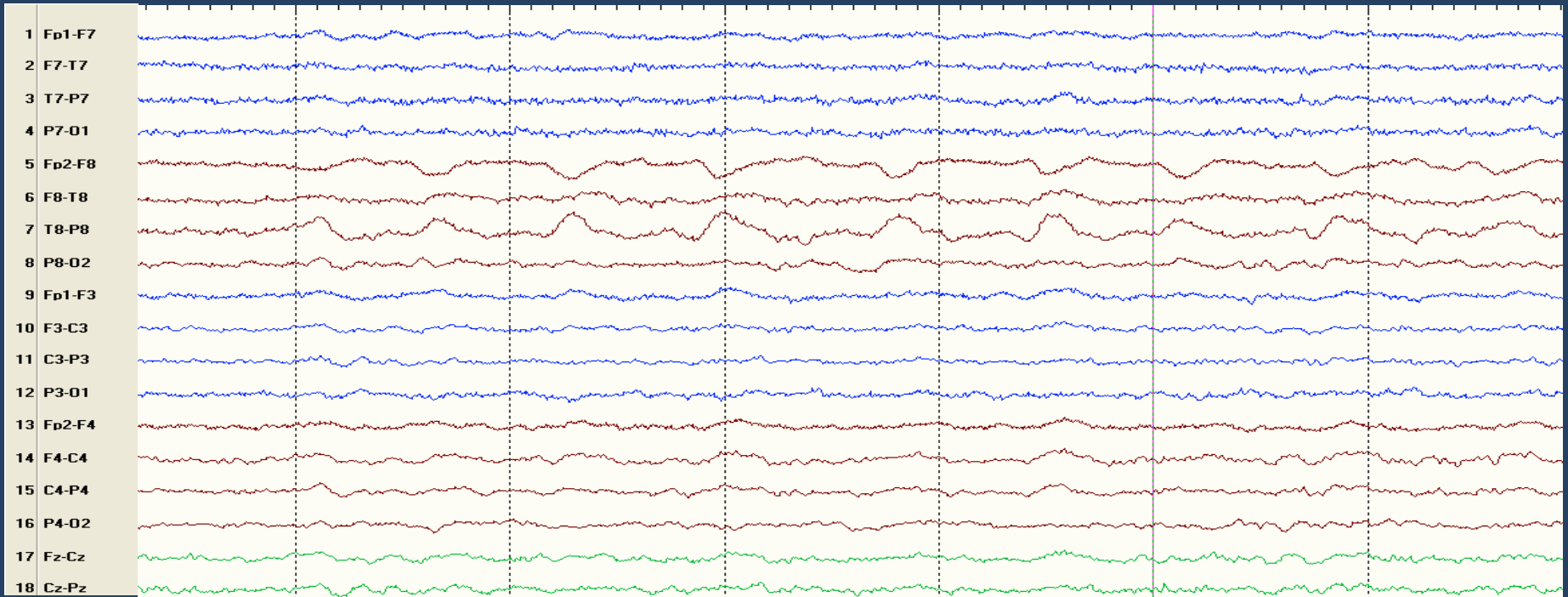
BECTS



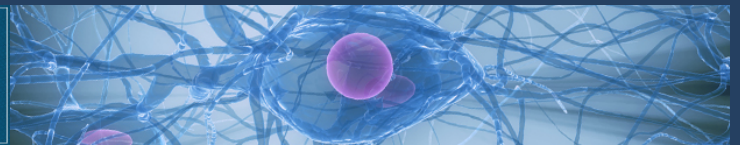
Temporal Intermittent Rhythmic Delta Activity (TIRDA)

- Intermittent sinusoidal trains of rhythmic 1 to 4 Hz waves at the temporal lobe, lasting for about 5 seconds
- Most commonly 2 to 3 Hz
- Appears either during wake or drowsiness and sleep.
- Highly correlated with temporal lobe seizures
- Temporal depth electrode recording during TIRDA showed active spiking activity in mesial temporal structures
- Two-thirds of the patients had a pathological lesion at the temporal lobe.



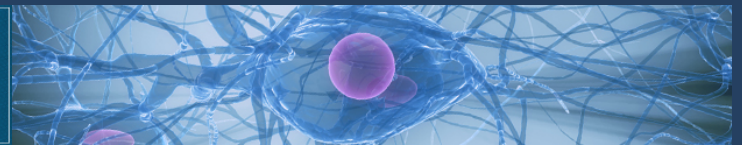


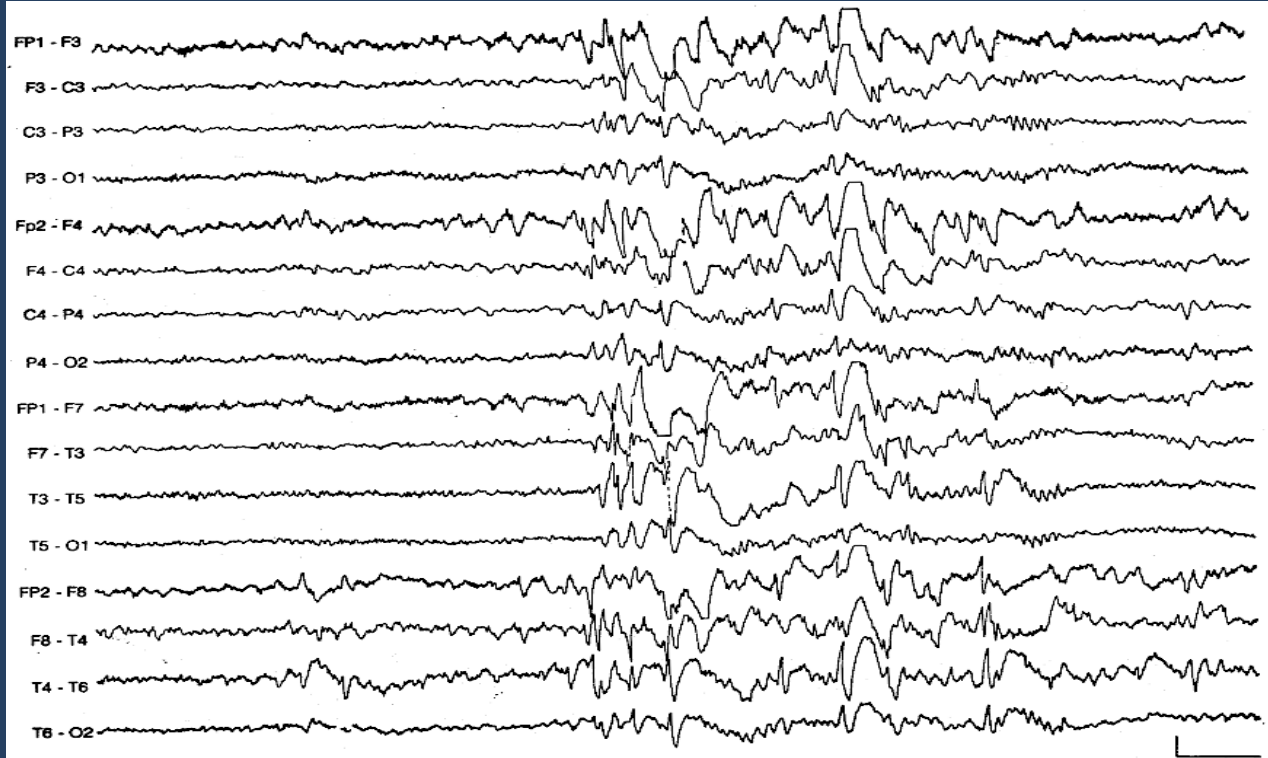
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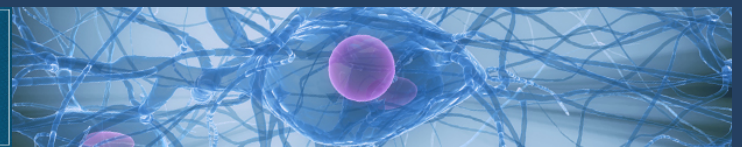
Secondary Bilateral Synchrony

- Focal or regional spikes leading directly to bisynchronous spikes and/or spike-waves.
- Focal interparoxysmal abnormality in same region.



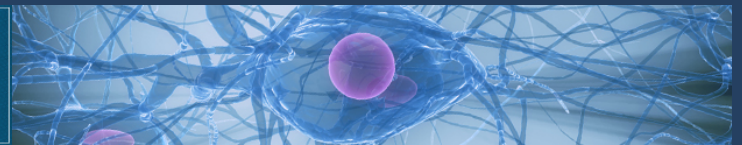


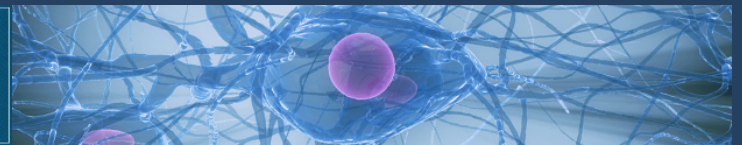
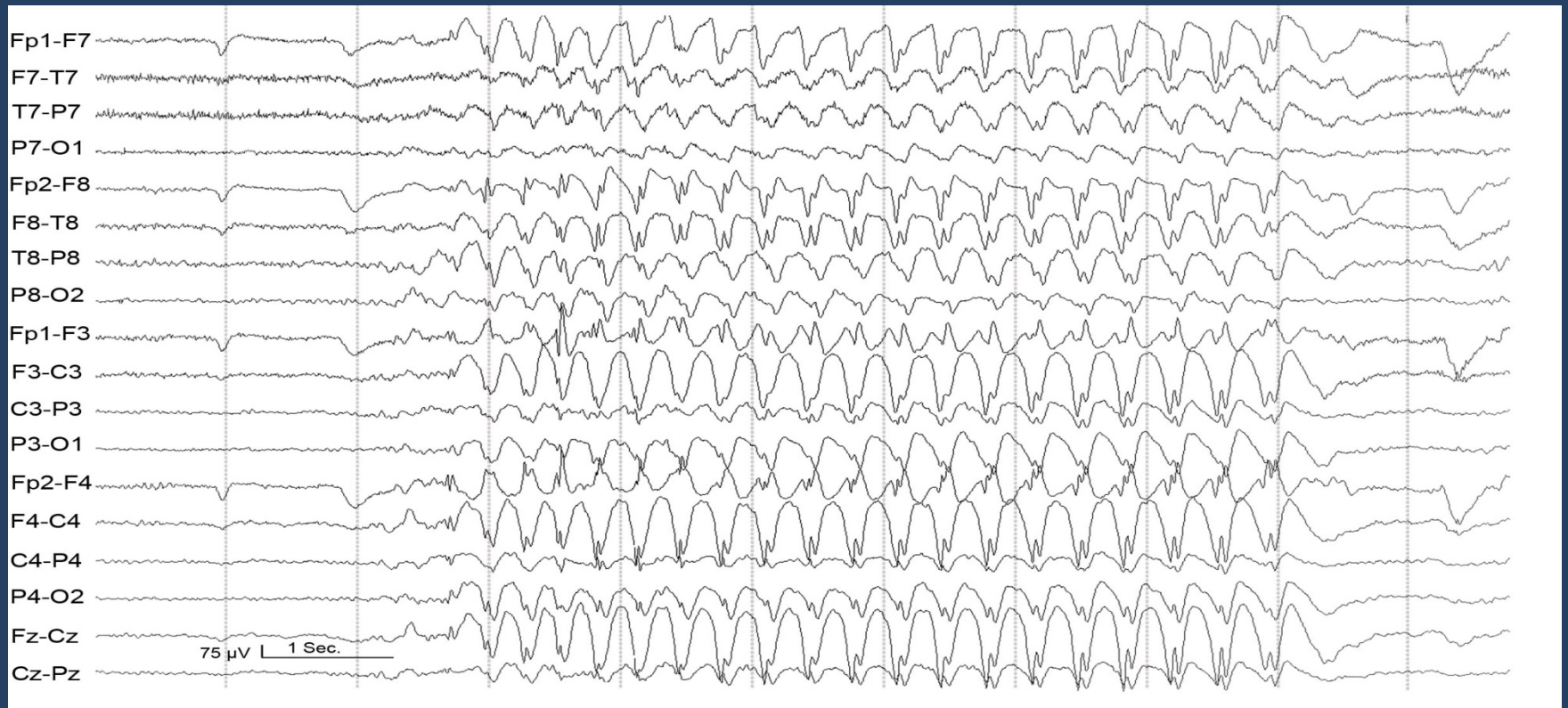
Secondary bilateral synchrony. 33 years. Sequential 3 Hz theta with intermingled electropositive spikes at F8-T4 lead into irregular spike-wave discharges whose durations occasionally extend to 500 msec. These are followed by regional theta and right hemisphere-accentuated spikes. All of these features are characteristic of secondary bisynchrony and satisfy the definition of "a bilaterally synchronous discharge which can be shown to arise from a unilateral cortical focus." Calibration signal 1 sec, 70uV.



Generalized IEDs.

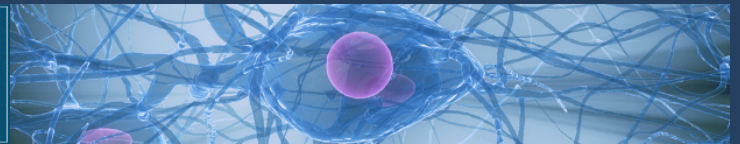
- 3-Hz spike-and-wave discharges
- Bursts last 1-3 seconds, but can be longer
- Activated by hyperventilation or drowsiness
- Synchronous in timing and symmetric in amplitude
- Shifting asymmetries may be seen - usually no more than 20 milliseconds difference
- Maximum over midline frontal region.
- EEG signature of absence epilepsy
- Can interfere with mental functions in a subtle manner







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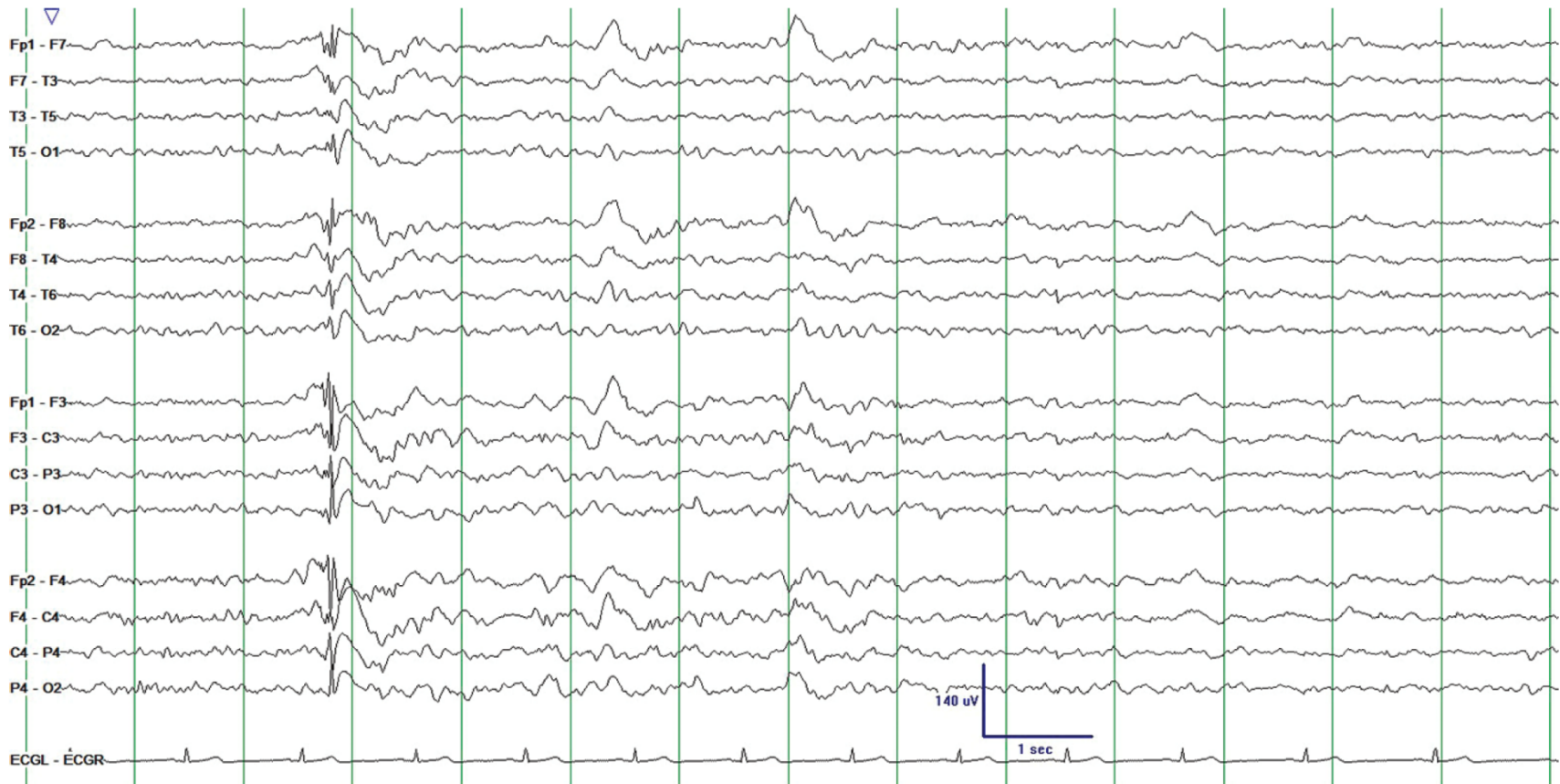
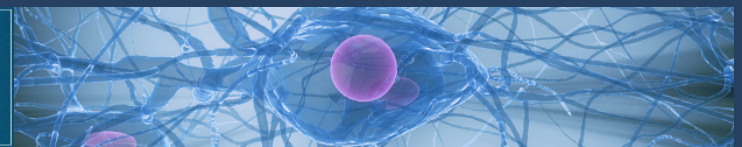
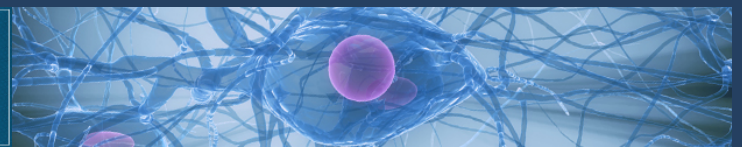
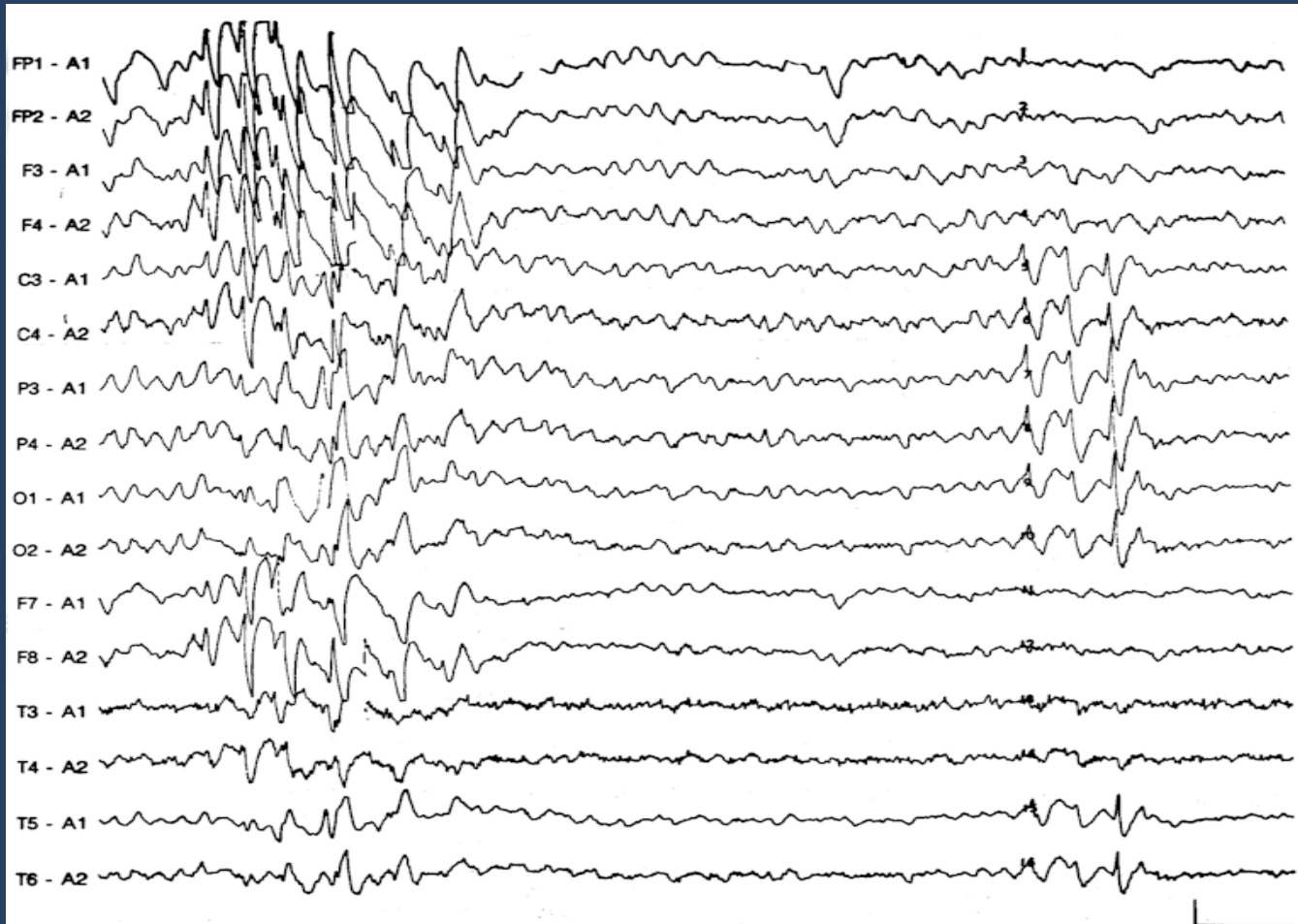


FIGURE 7-8

EEG of a 43-year-old man with myoclonic seizures showing diffuse spike discharges. Diffuse spike-and-wave discharges were noted in EEG recordings.

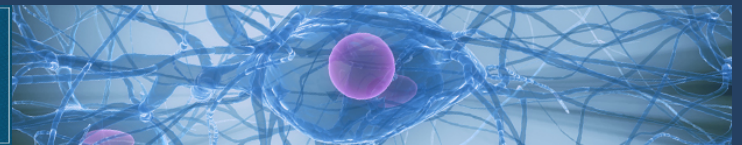
Chen and Koubeissi. 2019. Continuum

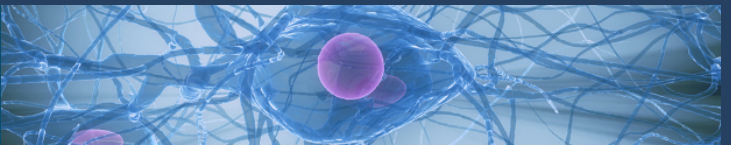
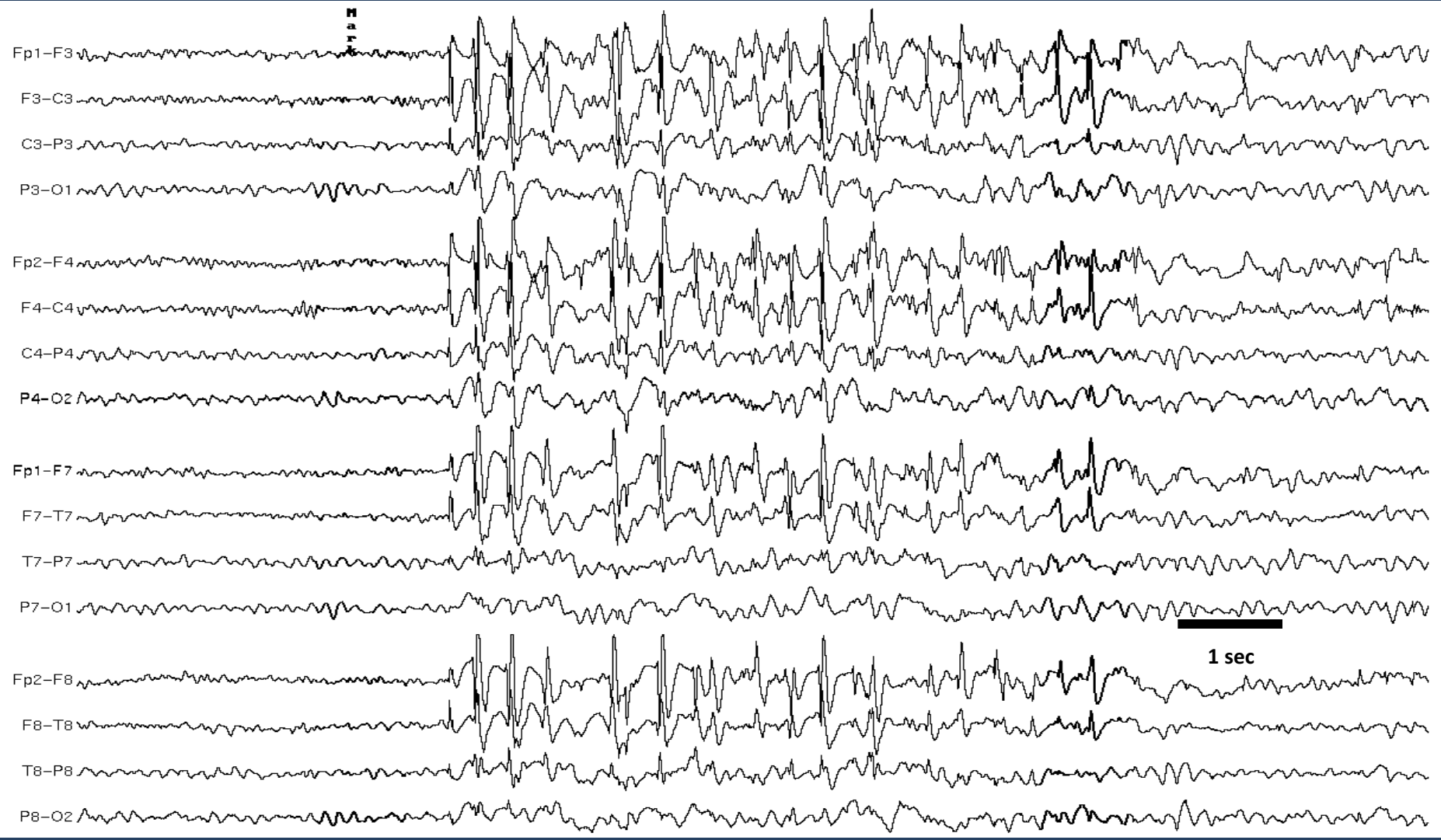




Generalized IEDs.

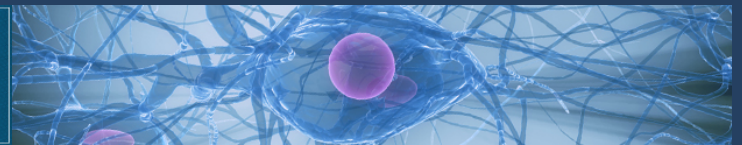
- Generalized Atypical Spike-and-Slow-Waves
- Resemble 3 Hz spike-and-wave discharges, but have variable rates
- Complexes vary in amplitude and morphology
- Enhanced by drowsiness and non-REM sleep
- Correlate with primary generalized epilepsies
- In generalized epilepsies, focal spikes of low amplitude may appear during drowsiness





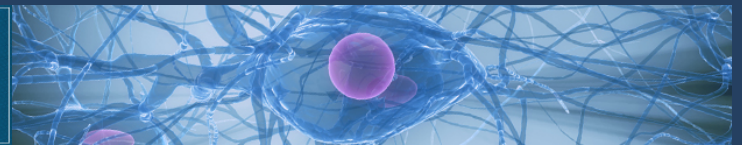
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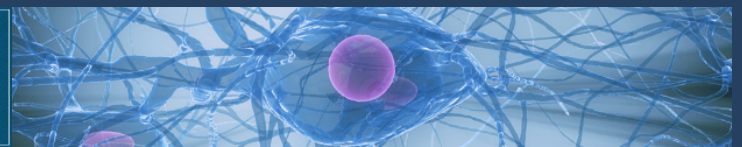
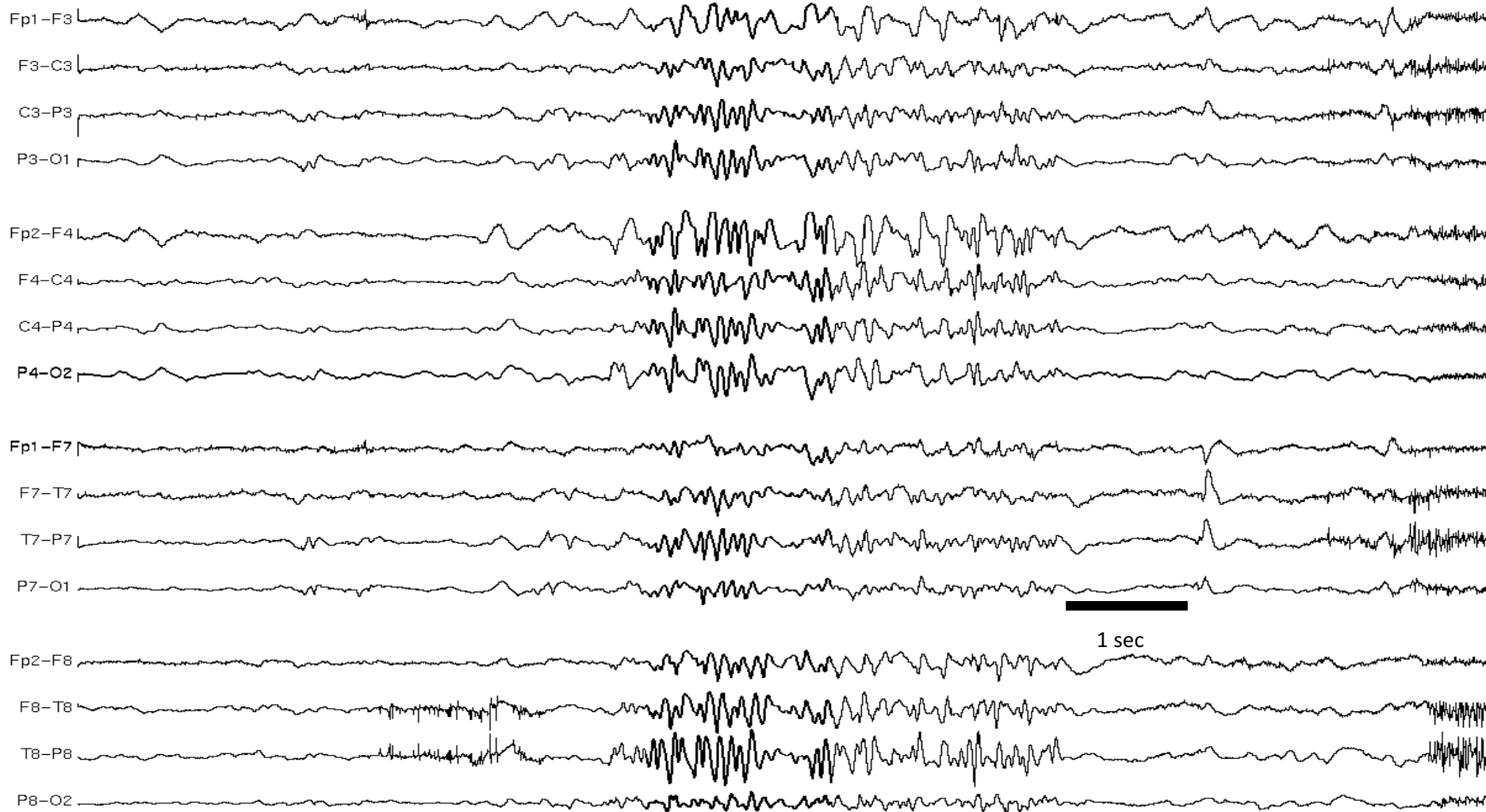
- Slow Spike-and-Waves
- Frequency is around 1.0 to 2.5 Hz
- Not as rhythmic in repetition
- Mostly sharp waves: wide duration and blunt peaks
- Fluctuating asymmetry of amplitude is common
- Drowsiness or Non-REM sleep may activate trains → ESES?
- May be enhanced by hyperventilation, but not photic stimulation
- Seen in Lennox-Gastaut syndrome



Generalized IEDs.

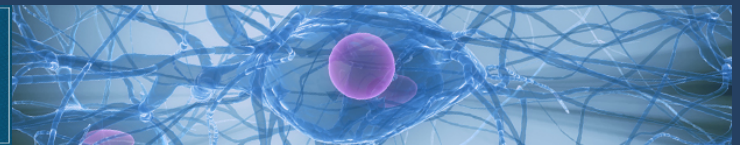
- Generalized Repetitive Fast Discharge (GRFD)
- Also known as paroxysmal fast rhythm, generalized paroxysmal fast activity, or “runs of rapid spikes”
- Alpha or beta frequency range
- Last typically less than 10 seconds
- Electrodecrement consists of very fast and very low amplitude activity
- GRFD may be preceded or followed by generalized slow spike-and-wave discharge
- Often associated with Lennox-Gastaut syndrome
- Most GRFD occur during sleep
- May be an ictal rhythm - could be accompanied by tonic seizures

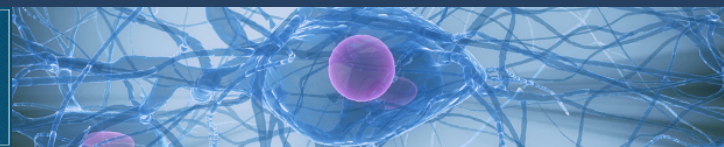
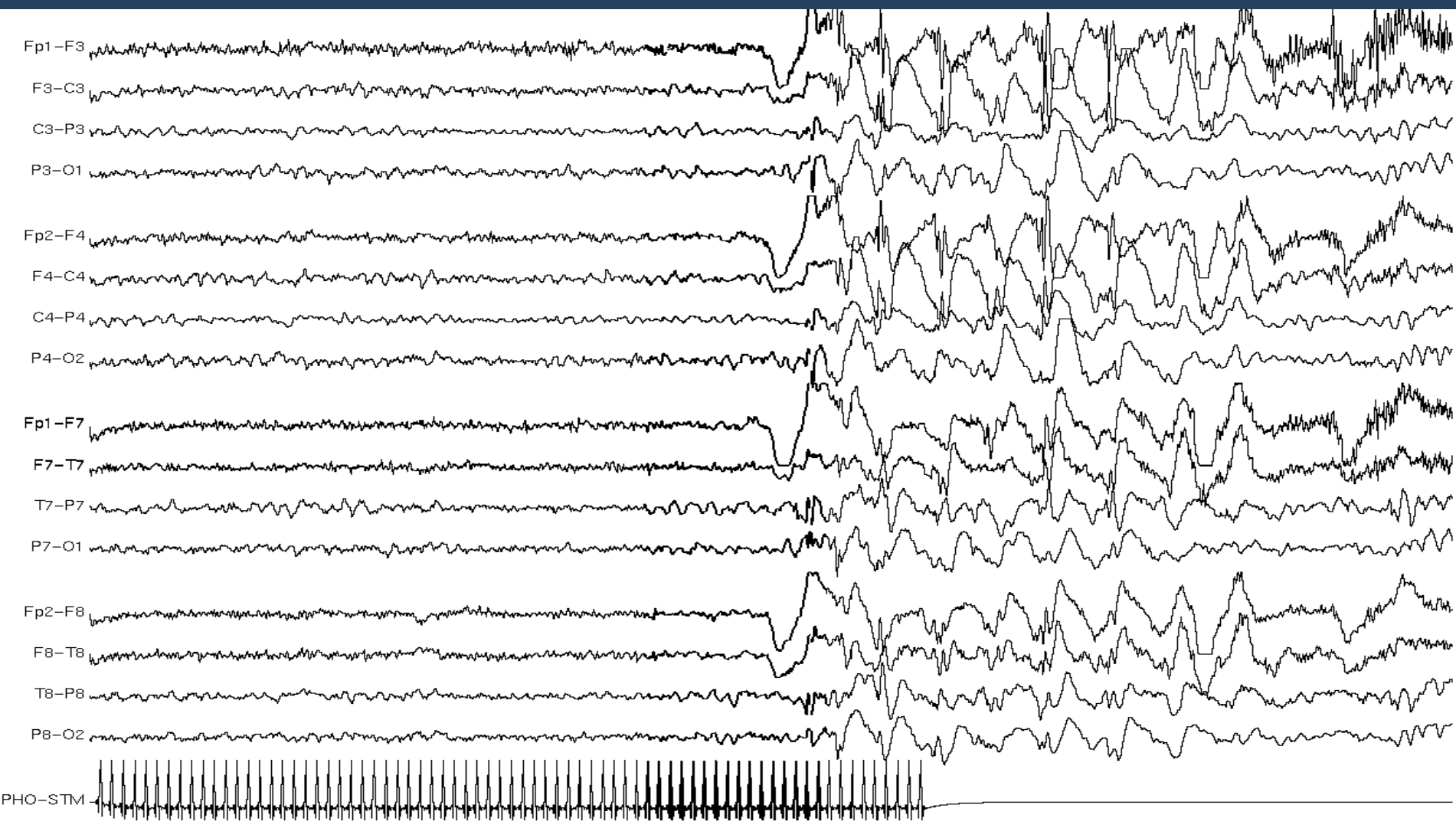




Generalized IEDs.

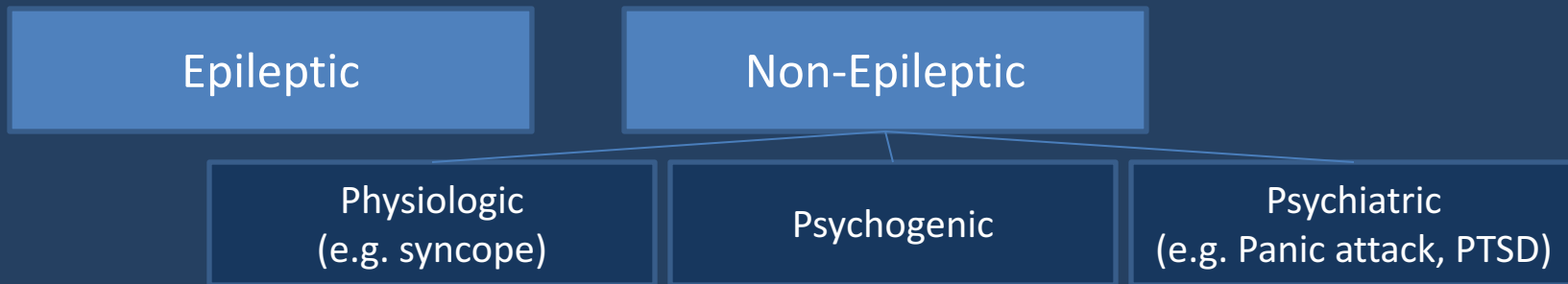
- Photo-epileptiform discharges
- IEDs elicited by intermittent photic stimulation
- Can be self-limited or self-sustaining
- Four types
 - (1) generalized (most common)
 - (2) bilateral posterior dominant
 - (3) bilateral occipital
 - (4) focal unilateral discharge (least common)
- 70 to 77% of generalized photo-epileptiform discharges have seizure disorders, but bilateral occipital photo-epileptiform discharges are less commonly associated with epilepsy.





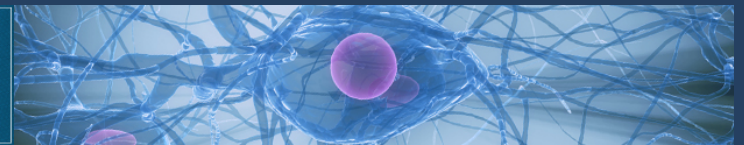
Importance of Ictal Recordings

- Evaluation of paroxysmal episodes



- Characterizing and quantifying each seizure type
- Syndromic classification
- Indispensable for presurgical evaluation

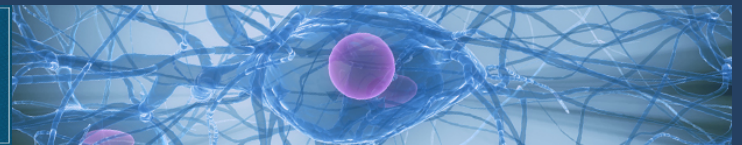
(1) Koubeissi, M. and E. So (2013). Interictal and Ictal EEG. EEG in Clinical Practice. J. a. P. Ebersole, T.



Ictal Discharges – General Considerations

- Seizure patterns can be isomorphic or metamorphic
- An electrographic deviation from the baseline
 - Frequency
 - Morphology
 - Field
 - Amplitude
- The most recognizable EEG seizure pattern consists of rhythmic, organized discharge that may or may not have apiculate waveforms.

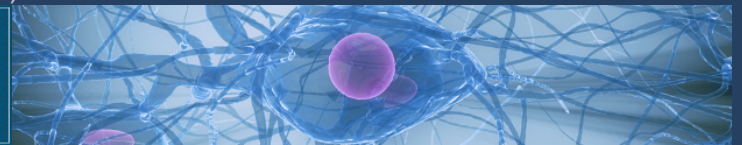
(1) Koubeissi, M. and E. So (2013). Interictal and Ictal EEG. EEG in Clinical Practice. J. a. P. Ebersole, T.



Focal Aware Seizures

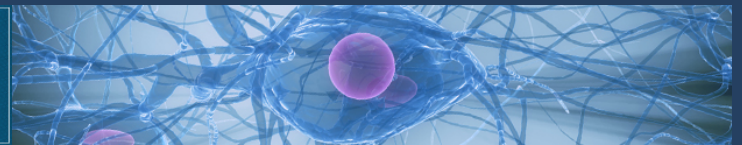
- These can occur without a clear ictal correlate on the EEG
- 6 (or 10) cm² rule
- 21% of seizures are associated with EEG ictal discharge (1)
 - 33% with motor manifestations
 - 15% with no motor manifestations
- Seizures may be motor, sensory, autonomic, or psychic
- Semiology is an important indicator of the area of seizure onset
- When recorded, seizure discharges are not different from focal impaired awareness seizures
- May be focal fast frequency discharge, rhythmic slowing, or repetitive spike discharge. Irregular non-rhythmic delta or theta frequency discharge is less frequent.

(1) Devinsky, et al NEUROLOGY 1988;38:1347-1352



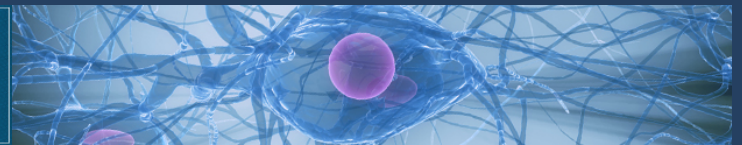
Focal Impaired Awareness Seizures

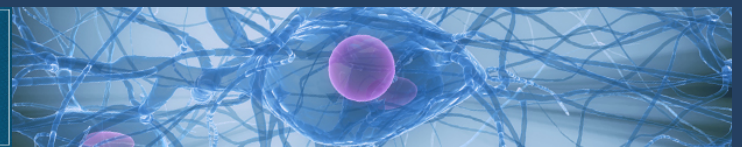
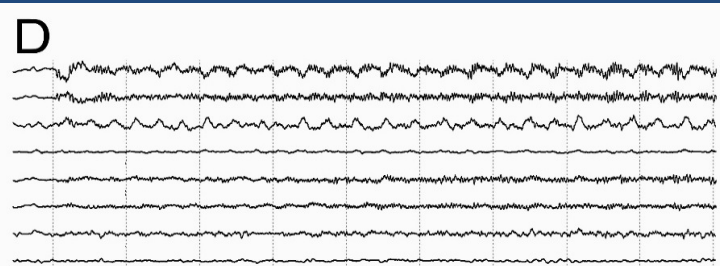
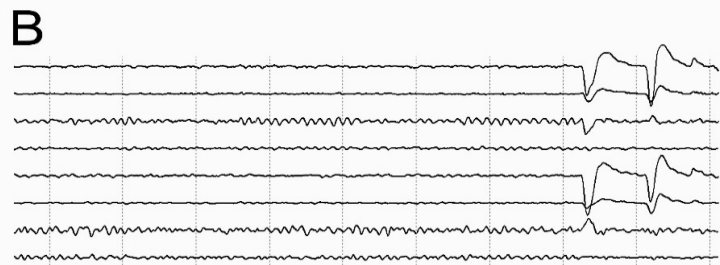
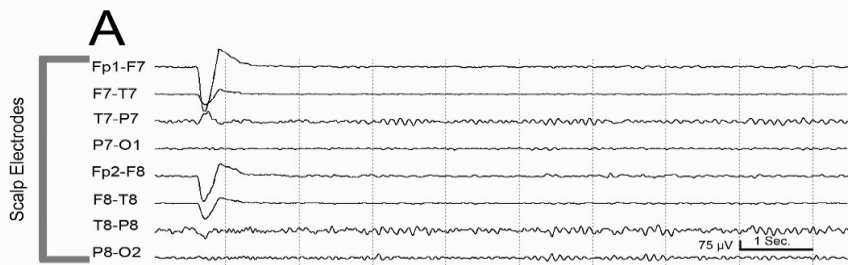
- EEG changes occur almost always – Exceptions: some frontal or parietal lobe seizures
- Mesial temporal: Often theta-range temporal ictal discharge
- Classic Teaching:
 - Closer to ictal onset zone → higher frequency
 - Deep or far generators → slower frequency
- Common evolving discharge is that of rhythmic discharge, then developing into higher voltage and slower frequency discharge, then regular slow waves increasing in frequency

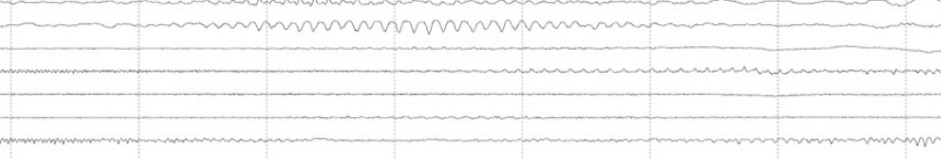
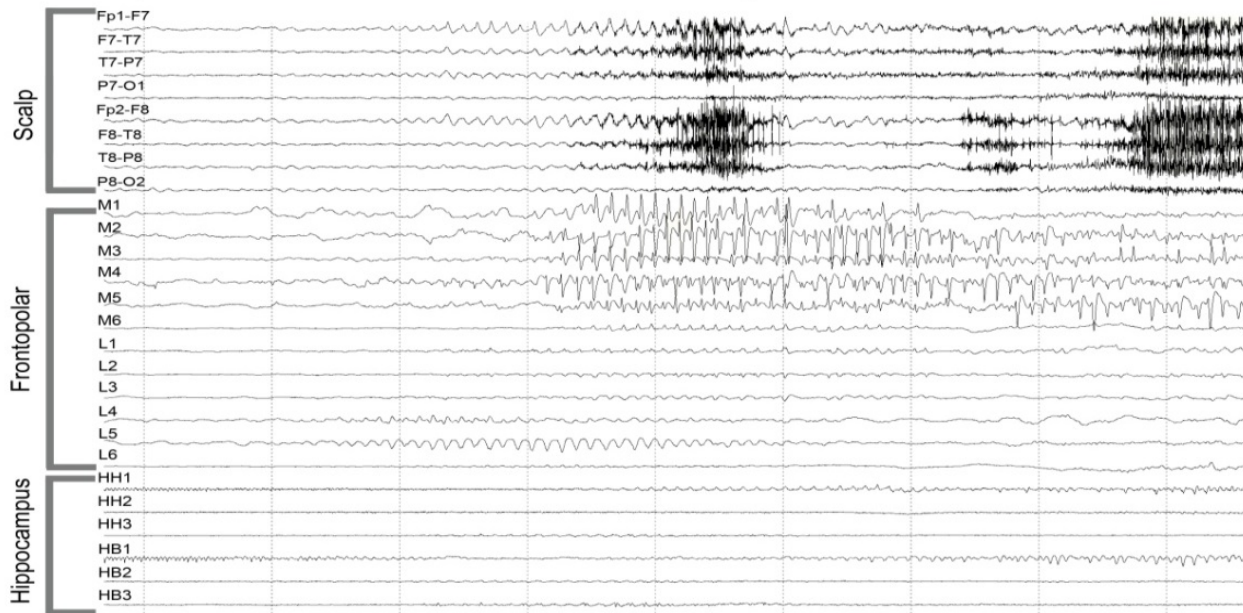
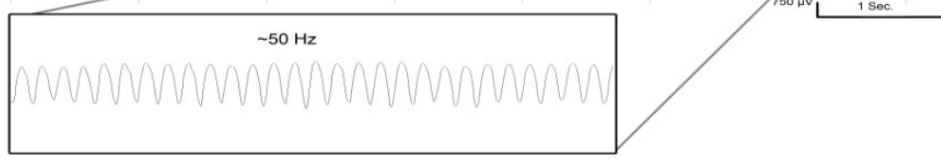
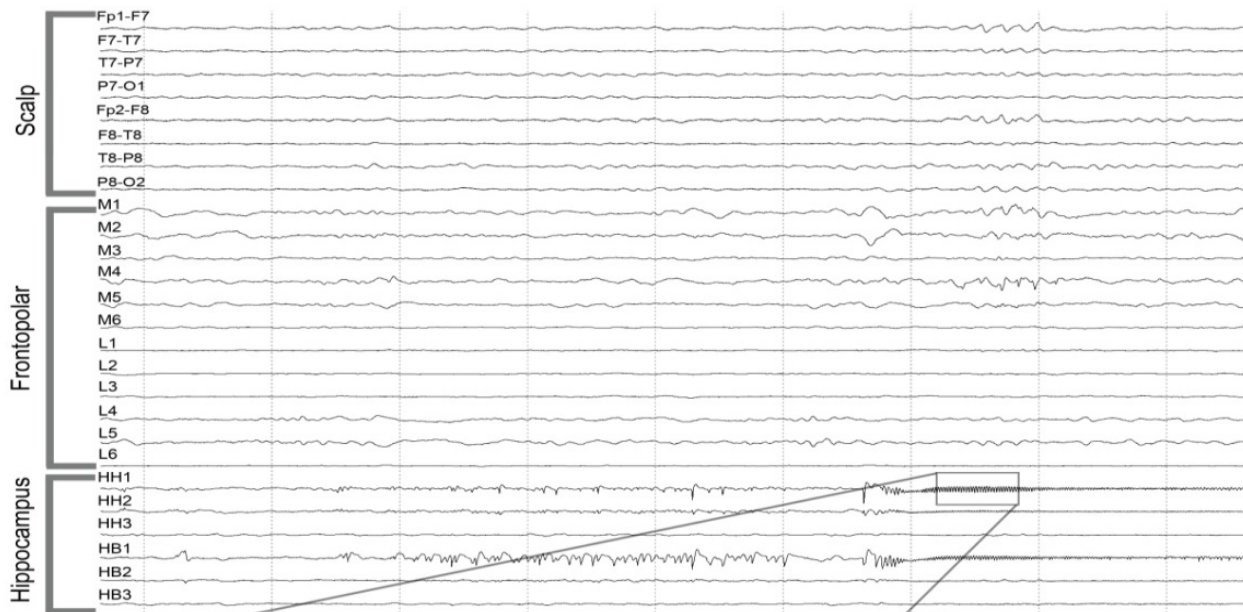


Temporal Lobe Seizures

- Most common focal epilepsy
- Originate from the hippocampus or other mesial temporal structures and propagate to involve the basal and lateral temporal lobe cortices, as well as frontal lobe regions.
- If limited to the hippocampus, non scalp discharge
- Workup of non-lesional cases
- Extratemporal may look temporal
- Temporal may look extratemporal





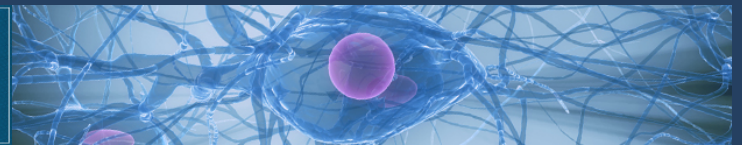


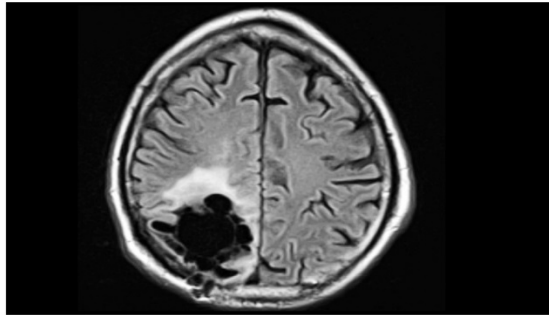
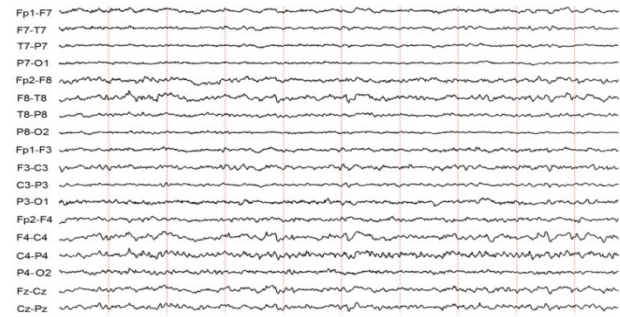
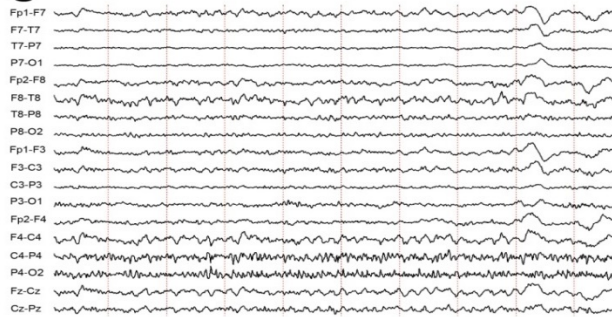
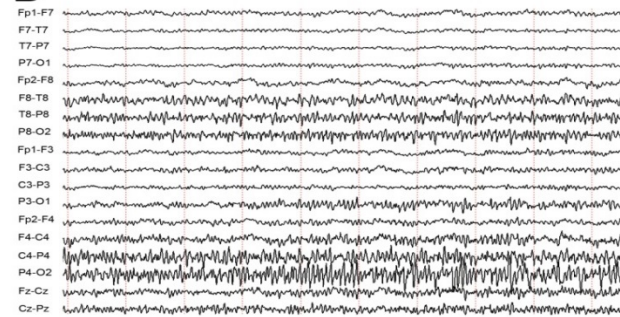
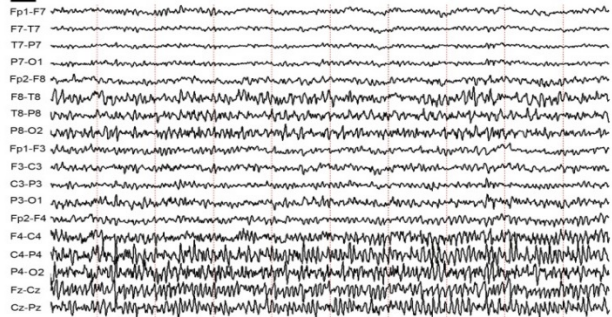
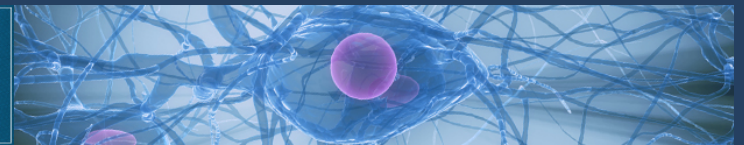
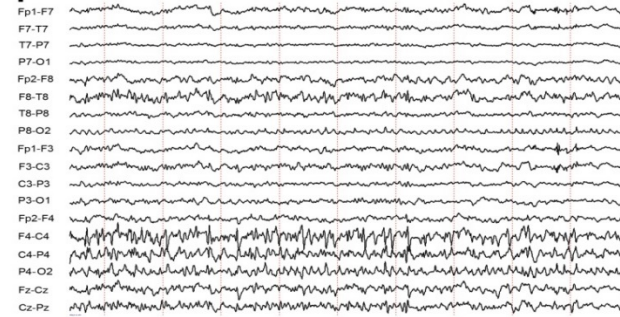
*

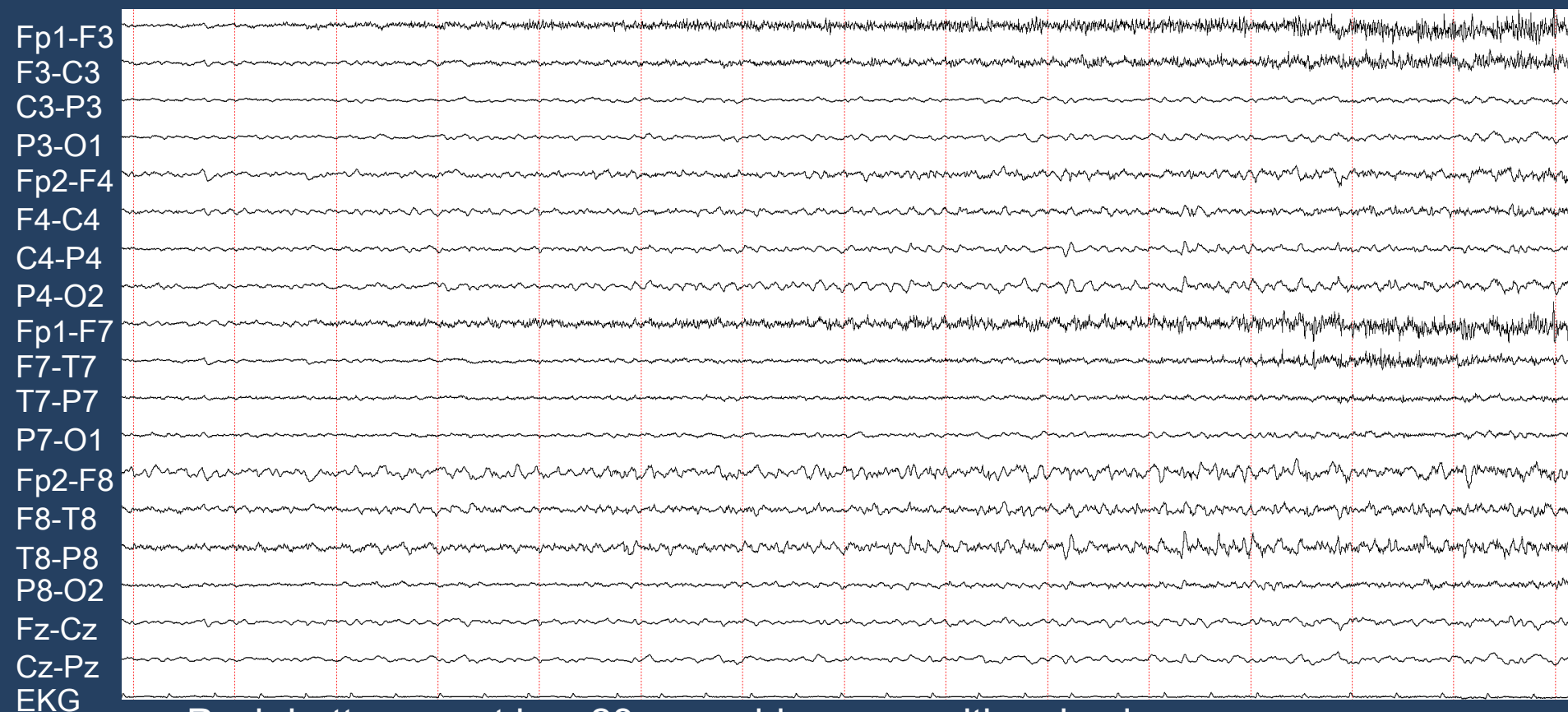


EEG in Extratemporal Epilepsy

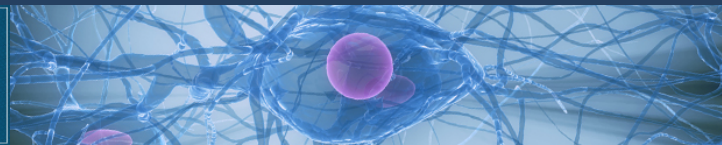
- In general, ETLE is less commonly associated with ictal discharges
- A fast, beta-range ictal discharge may be more common
- FLE tend to have abrupt hypermotor activity and rapid propagation
- Only about half of FLE will have localizing EEG pattern
- In 25% of FLE, ictal beta discharge is present: 90% of the patients becoming seizure-free
- EEG of parietal lobe seizures often do not show localizing findings
- Occipital lobe seizures may propagate to ipsilateral or contralateral temporal lobe

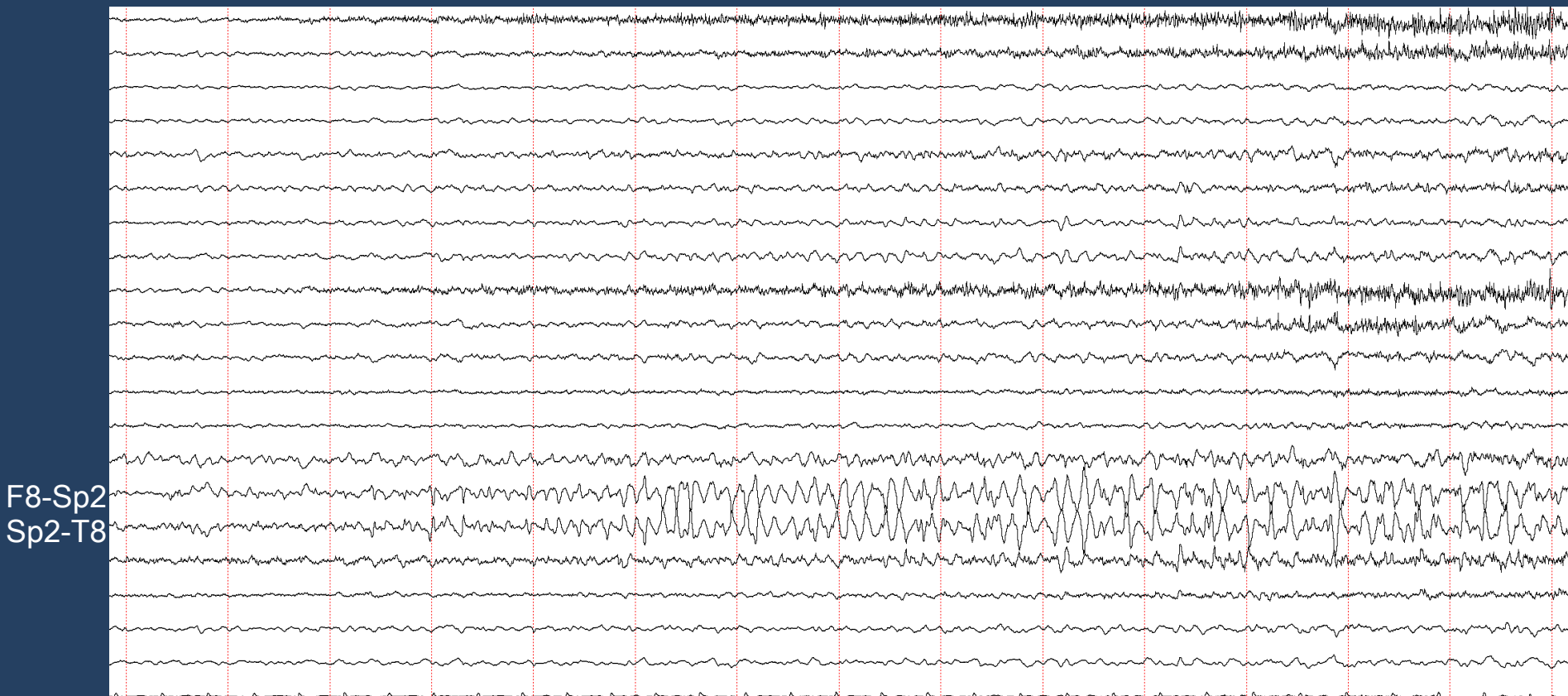


A**B****C****D****E****F**

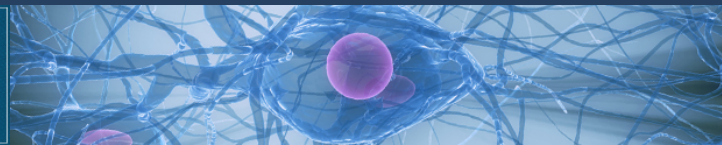


Push button event in a 28 year old woman with episodes of confusion and “weird thoughts”

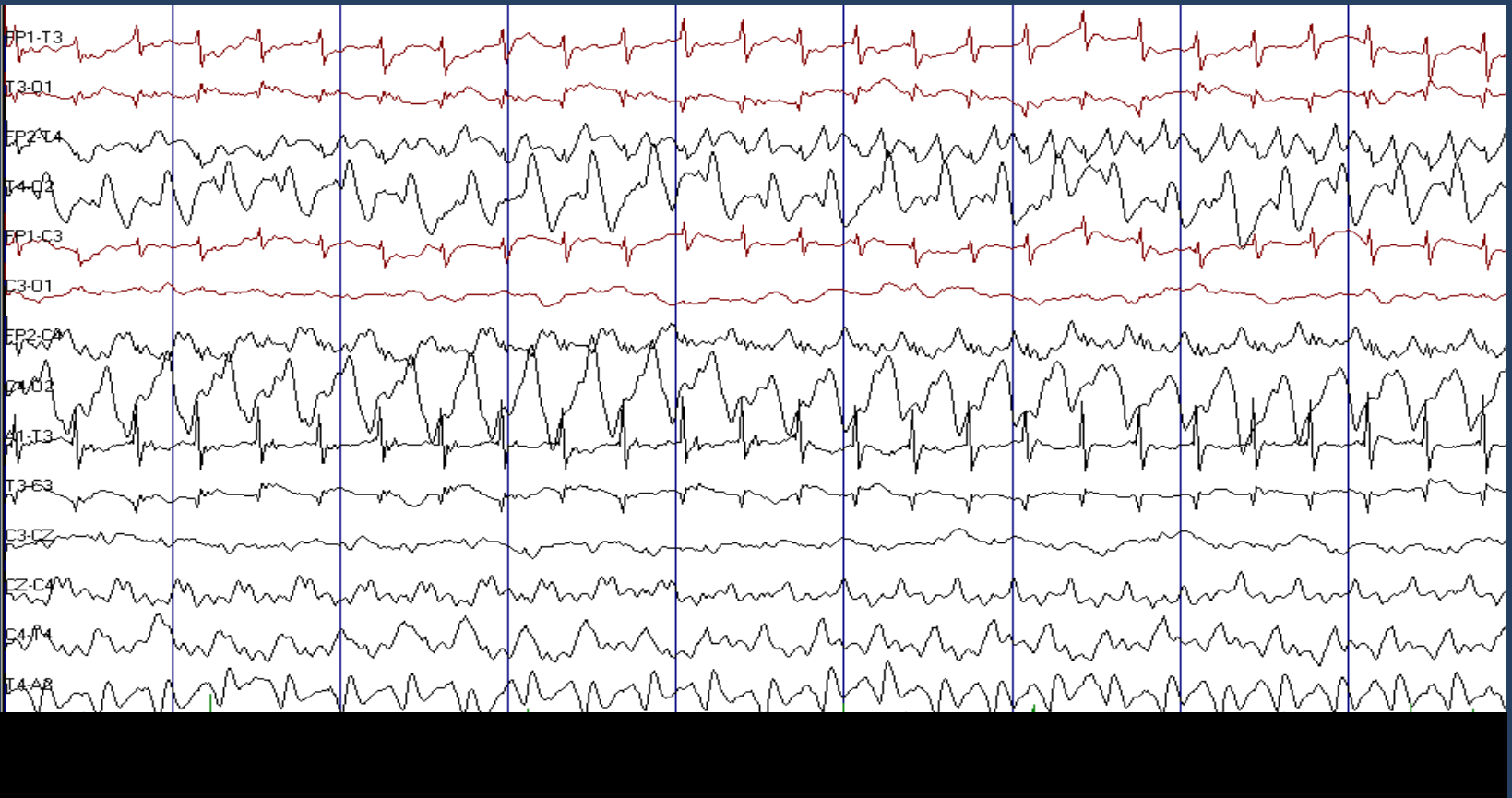




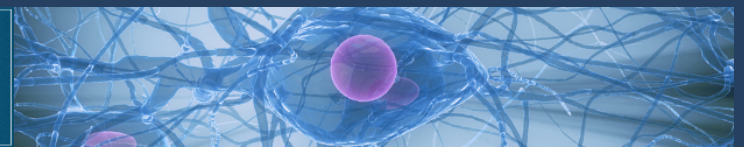
Same page with Sp2 included in montage



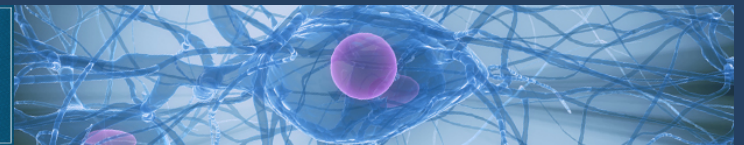
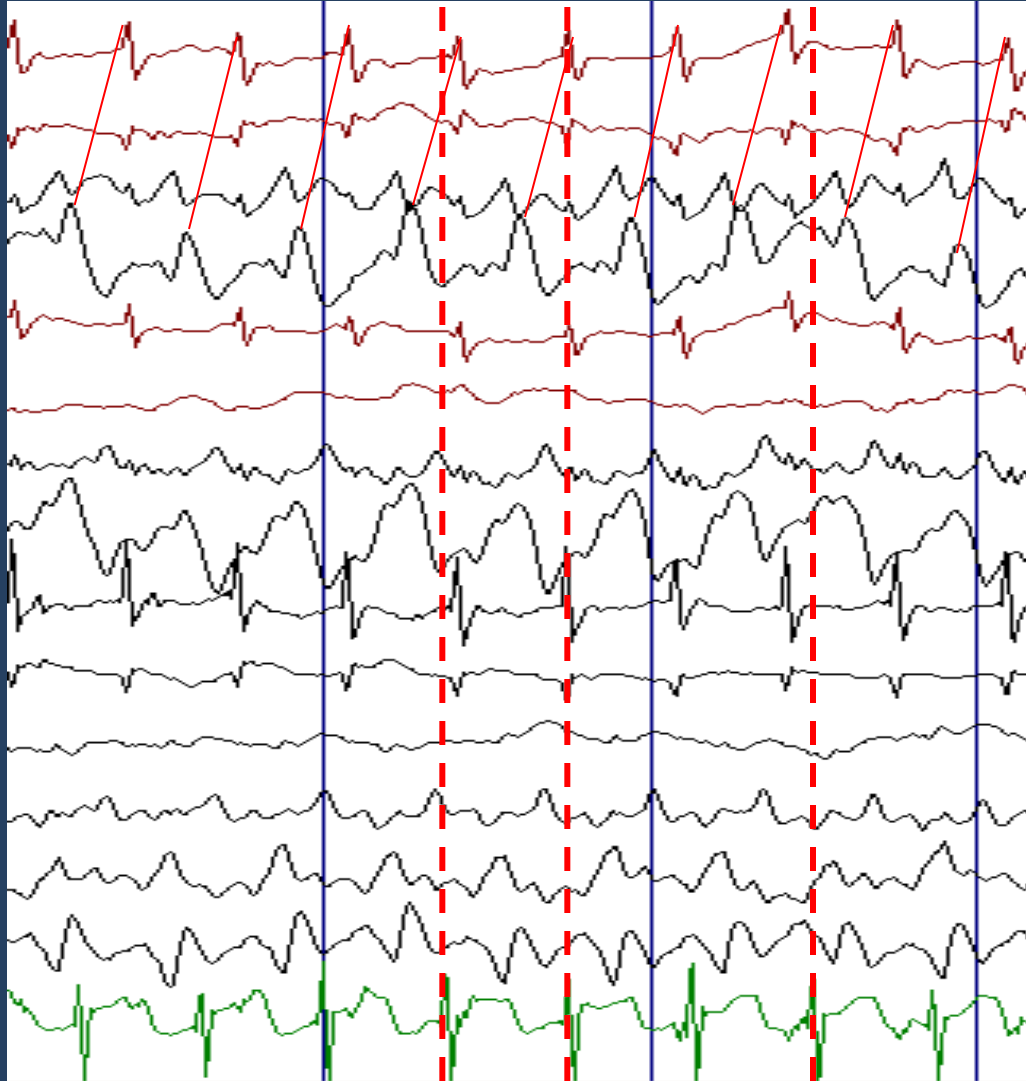
Fp1-T3
T3-O1
Fp2-T4
T4-O2
Fp1-C3
C3-O1
Fp2-C4
C4-O2
A1-T3
T3-C3
C3-Cz
Cz-C4
C4-T4
T4-A2
EKG

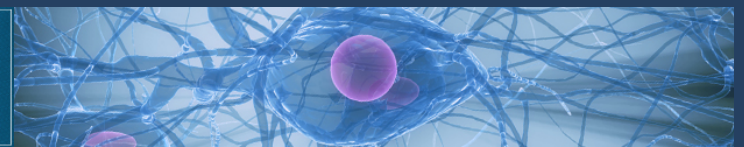


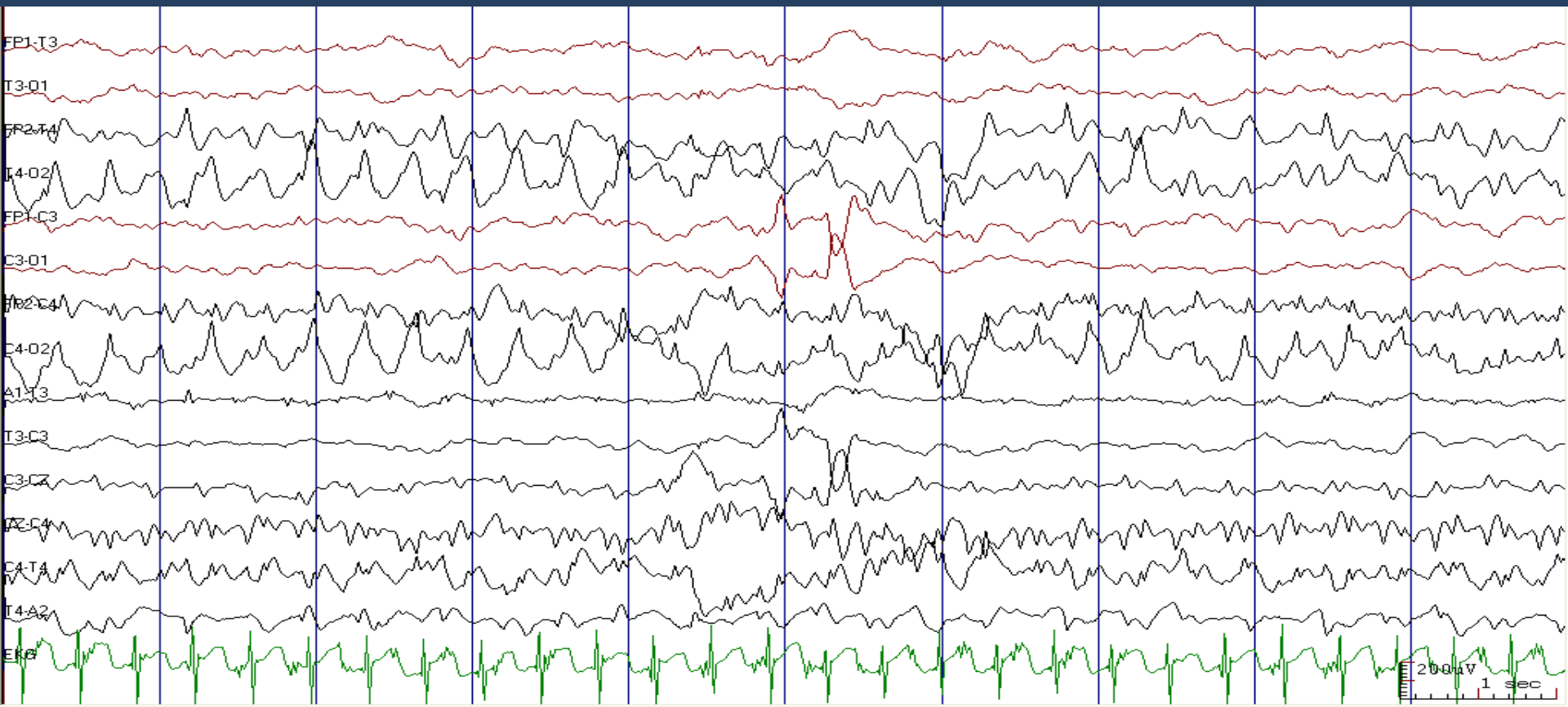
3 mo AAM with propionic acidemia, normal development, with 2 episodes of mouth twitching.



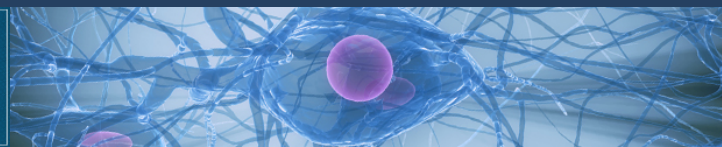
Fp1-T3
T3-O1
Fp2-T4
T4-O2
Fp1-C3
C3-O1
Fp2-C4
C4-O2
A1-T3
T3-C3
C3-Cz
Cz-C4
C4-T4
T4-A2
EKG

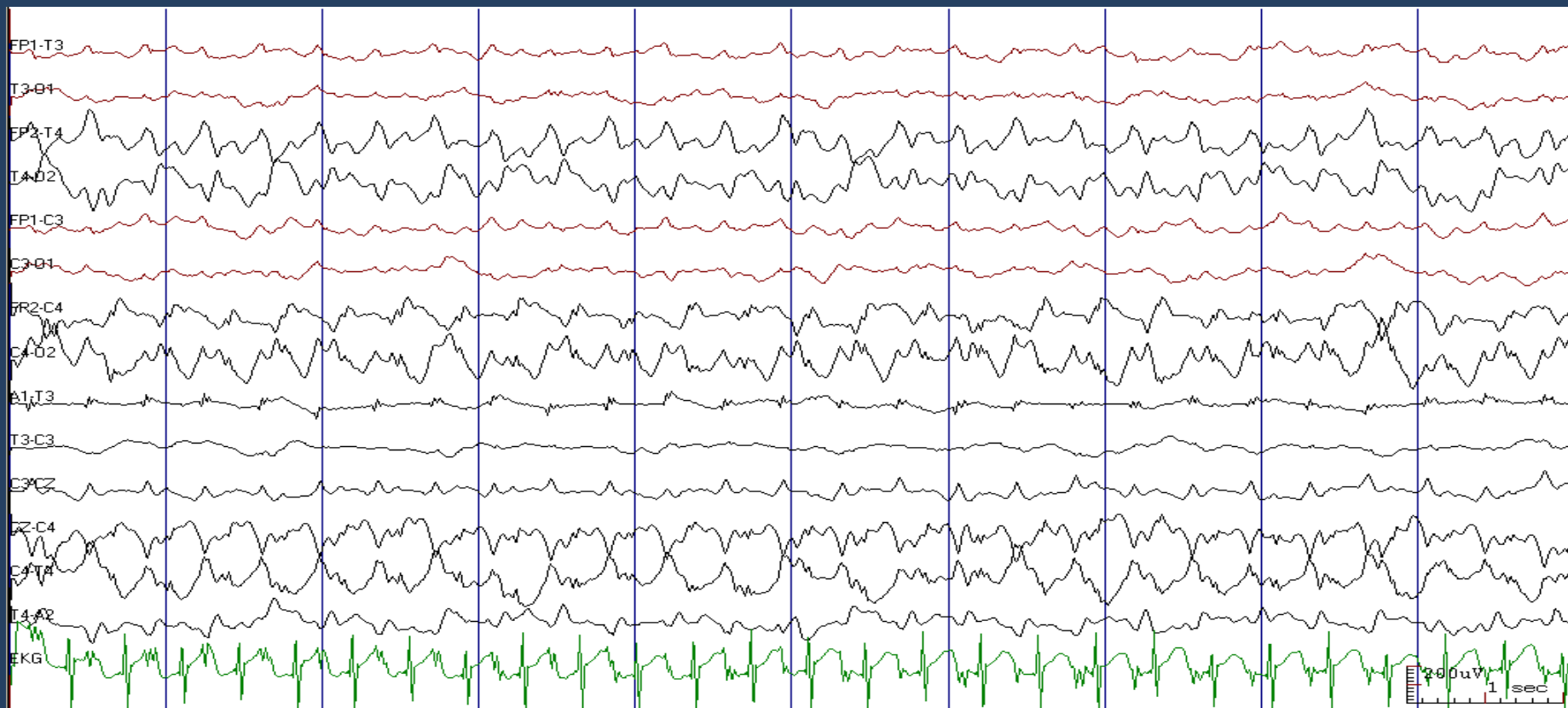




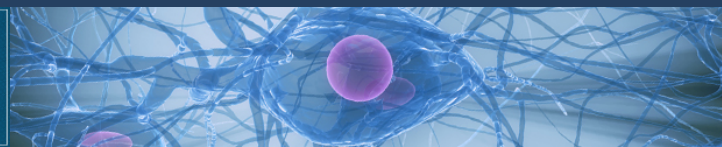


20 MORE SECONDS LATER

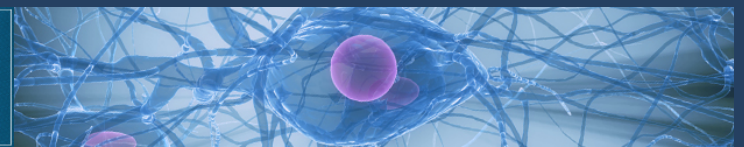
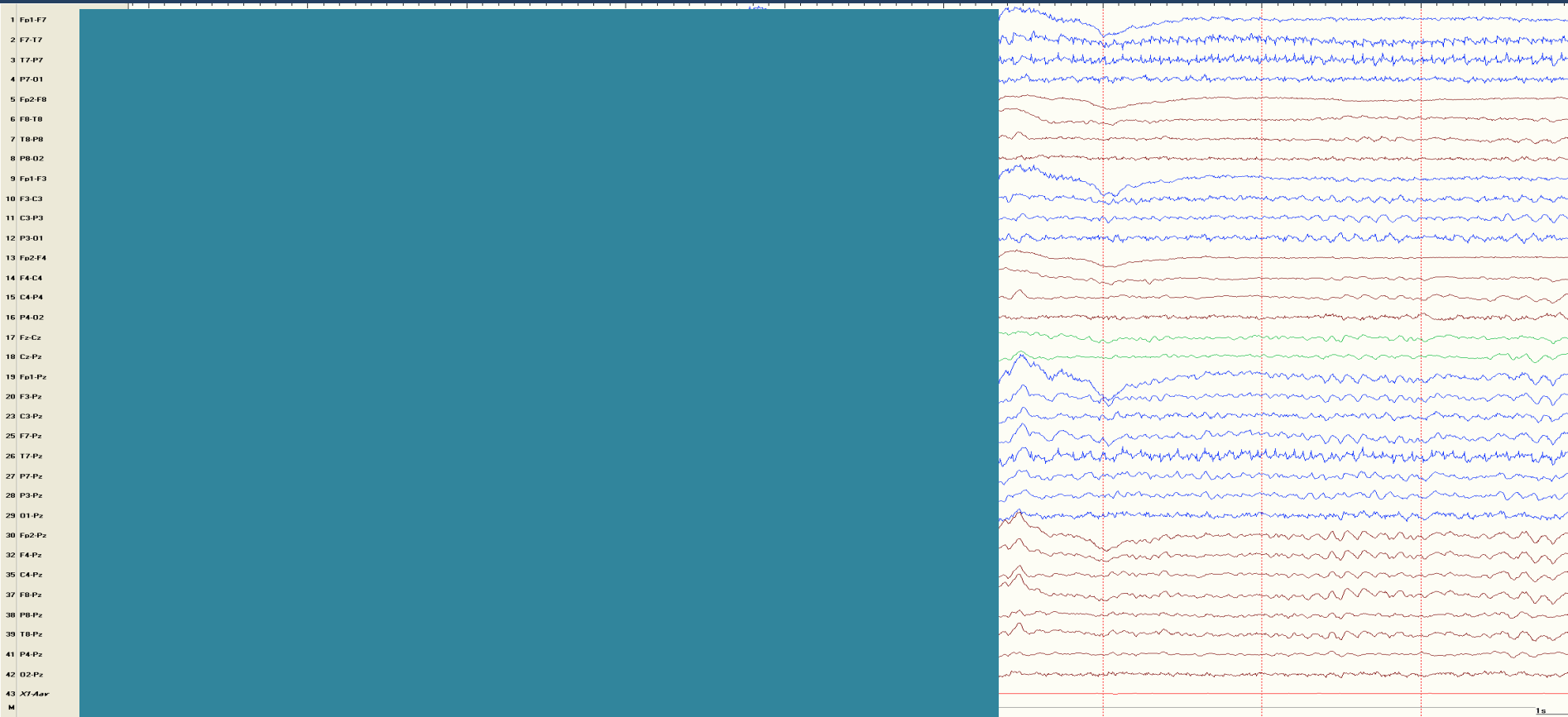




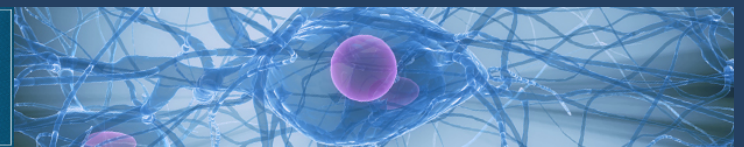
20 MORE SECONDS LATER



What's under the panel?

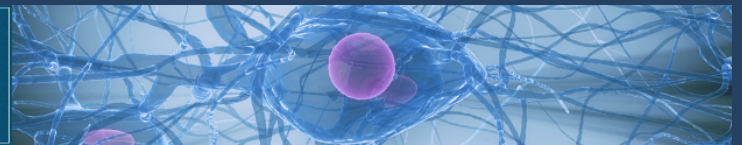


RH Seizure after Stroke



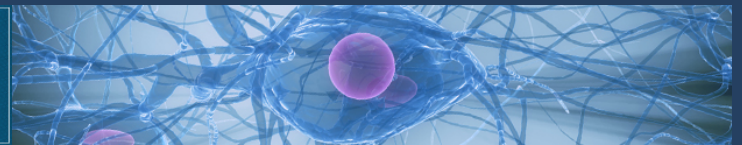
Generalized Epilepsy

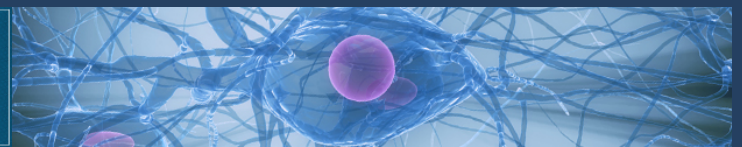
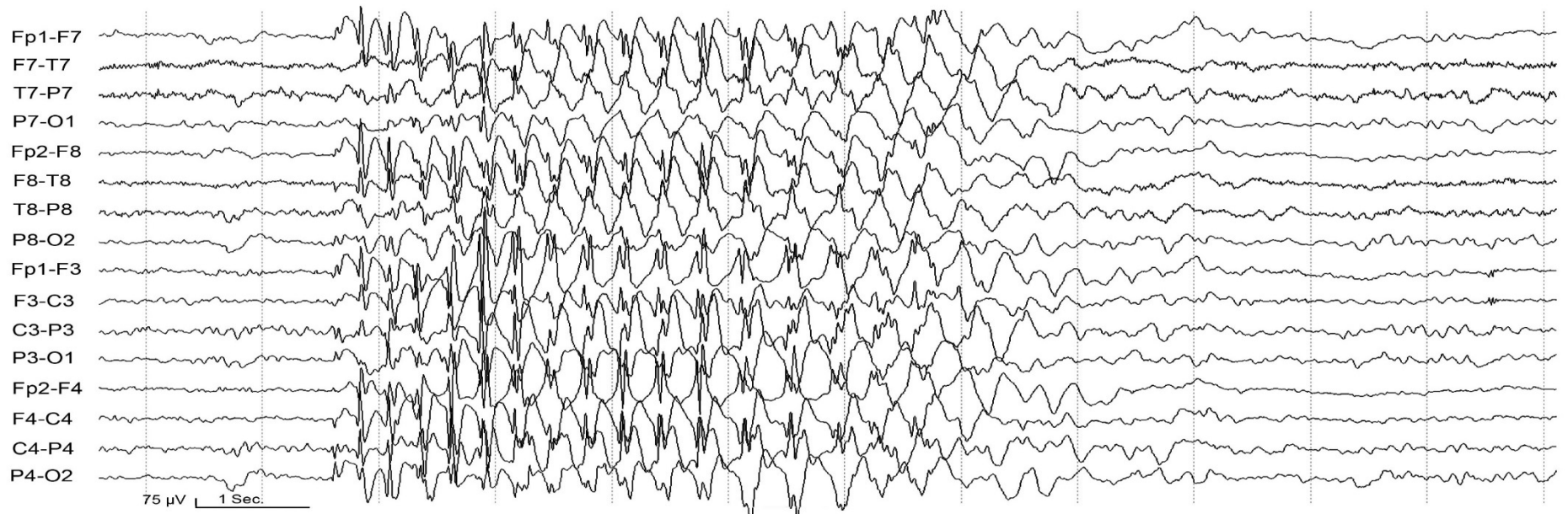
- Absence epilepsy:
 - Discharges that last longer than 3 seconds will often have clinical correlates
 - Abrupt onset and offset, with no postictal slowing
 - Average frequency of 3 Hz, starting at approximately 3.5 Hz, and slowing down to 2.5 Hz
 - Some ictal discharges may include polyspike components.
 - Occasionally, the spikes may be more posteriorly prominent



Generalized Epilepsy

- Juvenile myoclonic epilepsy (JME):
 - Bursts of bilateral frontal-maximum polyspike-and-slow-wave discharge
 - Discharges may have irregular morphology and frequency
 - Shortly after arousal or during photic stimulation
 - One third of the patients will have a generalized photoepileptiform discharges
 - During myoclonic seizures, 10-16 Hz spike discharge
 - Some absence seizures seen in JME have an ictal 3-Hz discharge





Conclusions

- There is **no evidence** that the slower patterns result from propagation
- Several patterns were associated with each pathology
- All pathologies were associated with multiple SOPs
- Polyspikes followed by LVFA was found only with MCD, but in only 20% of MCD
- Impossible to assign a unique significance to any pattern

