

1-MSS (Merkezi Sinir Sistemi-CNS)

2-PSS (Perifer Sinir Sistemi-PNS)

# SİNİR DOKUSU

## (Yapısal Elemanları)

### 1-Sinir Hücresi (Nöron, nörosit)

- Sitoplazması:Nöroplazma
- Gövdesi(Perikaryon)

-Uzantıları:

#### a.Dendrit (=ağaç)

- Sitoplazması:Dendroplazma

#### b.Akson

- Sitoplazması:Aksoplazma
- Membranı: Aksolemma
- Akson tepeciği:Perikaryondan çıkış yeri
- Kılıfları:Miyelin kılıf

Nörolemma (Schwann kılıfı)

Miyeli içersin ya da içermesin, kılıflanmış aksonlara “sinir teli” denir.

### 2-Hücrelerarası madde

#### A-Glia Dokusu (MSS’de)

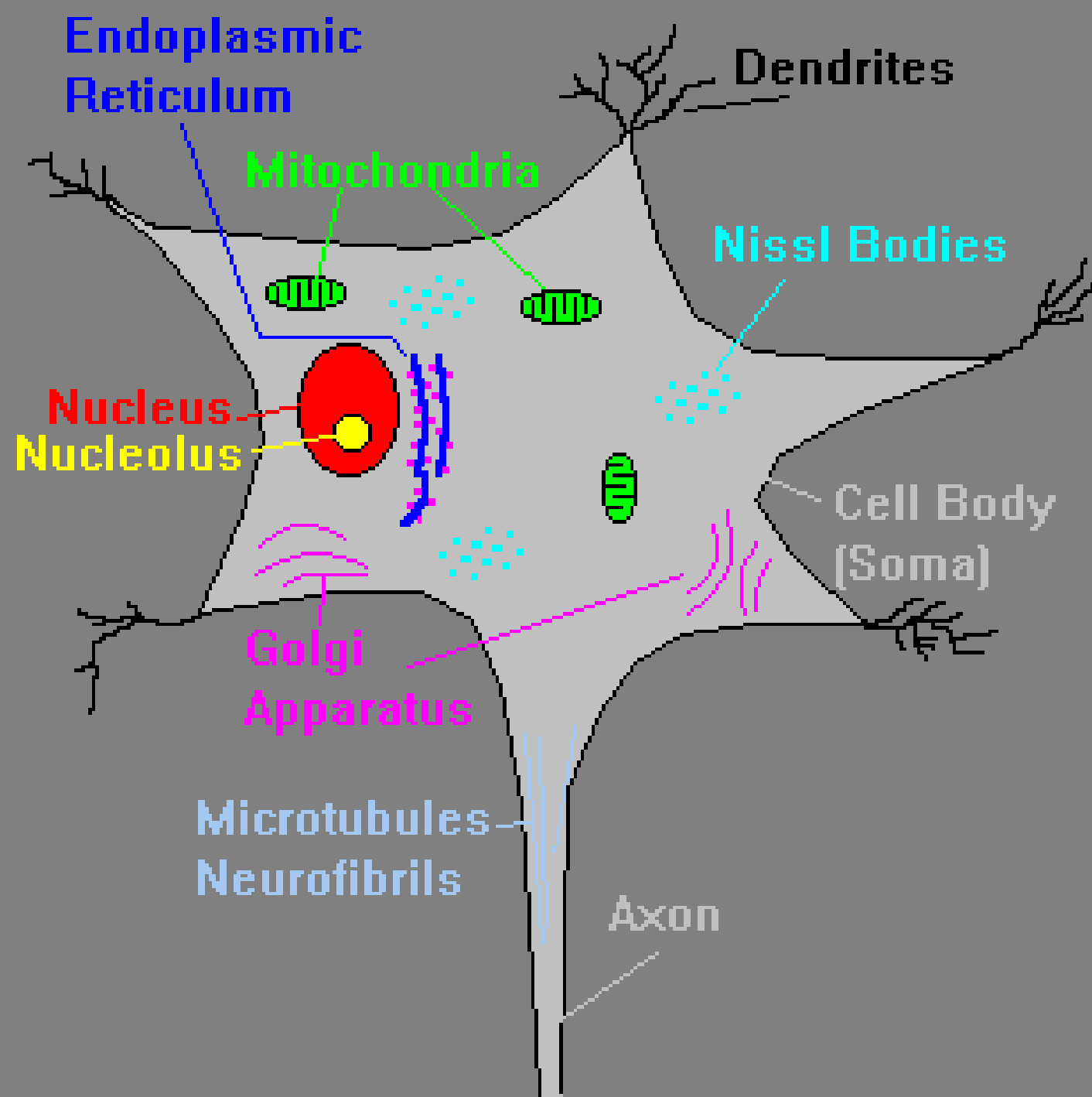
Nöroglia Hücreleri:

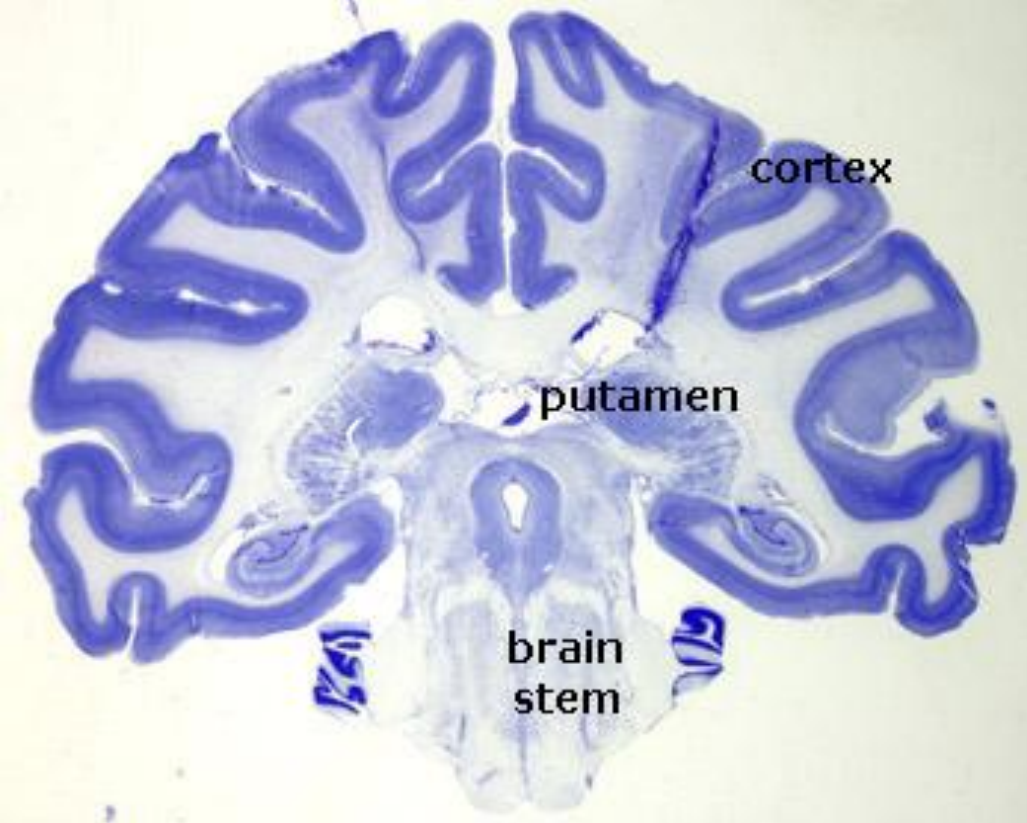
- Ependim hücreleri
- Astrositler (Fibröz ve protoplazmik)
- Oligodentrositler
- Mikroglialar

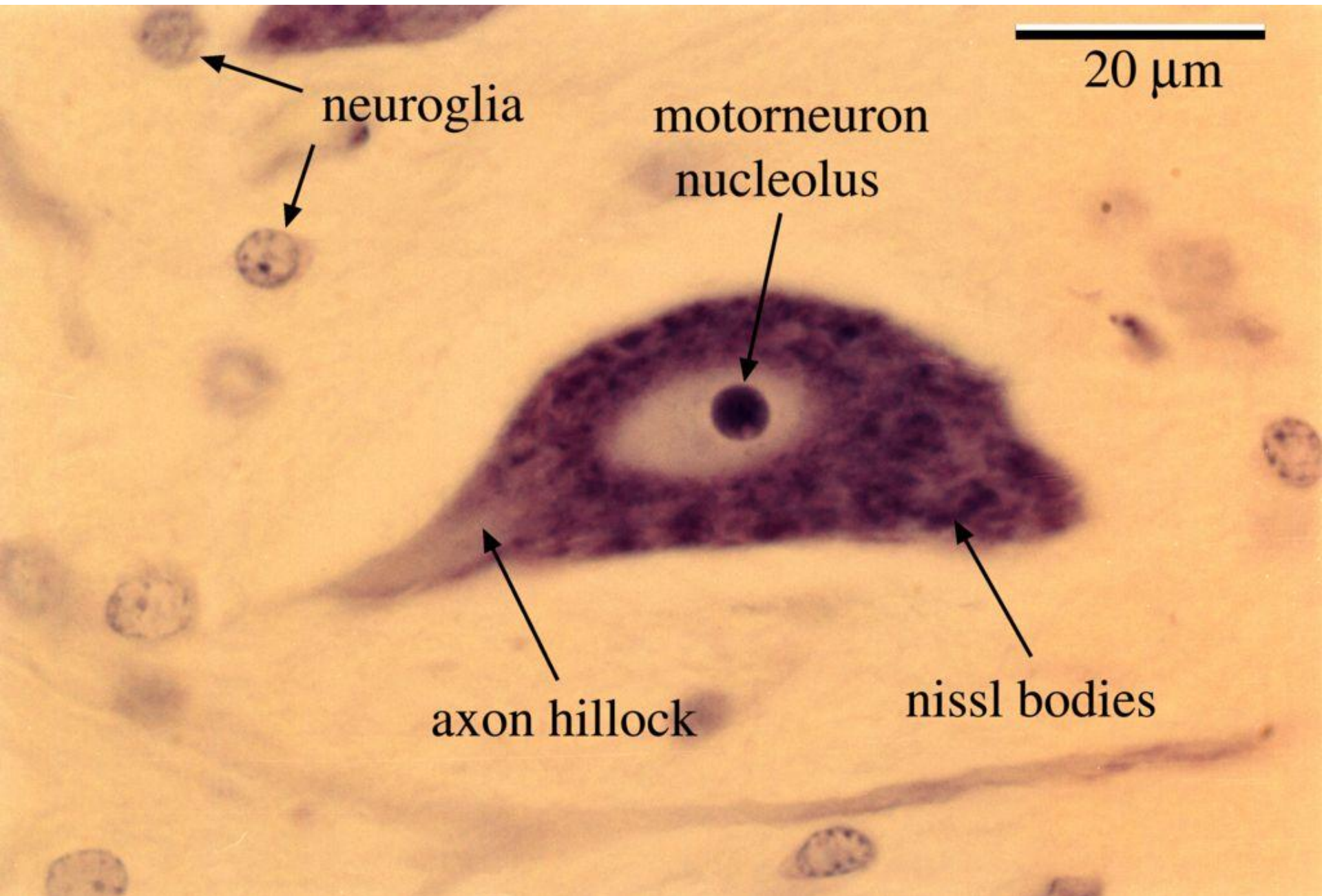
#### B-Bağdokusu (PSS’de)

Bağdokudan oluşmuş ara dokuda;

- Schwann hücreleri
- Satellit hücreleri







20  $\mu\text{m}$

neuroglia

motorneuron  
nucleolus

axon hillock

nissl bodies

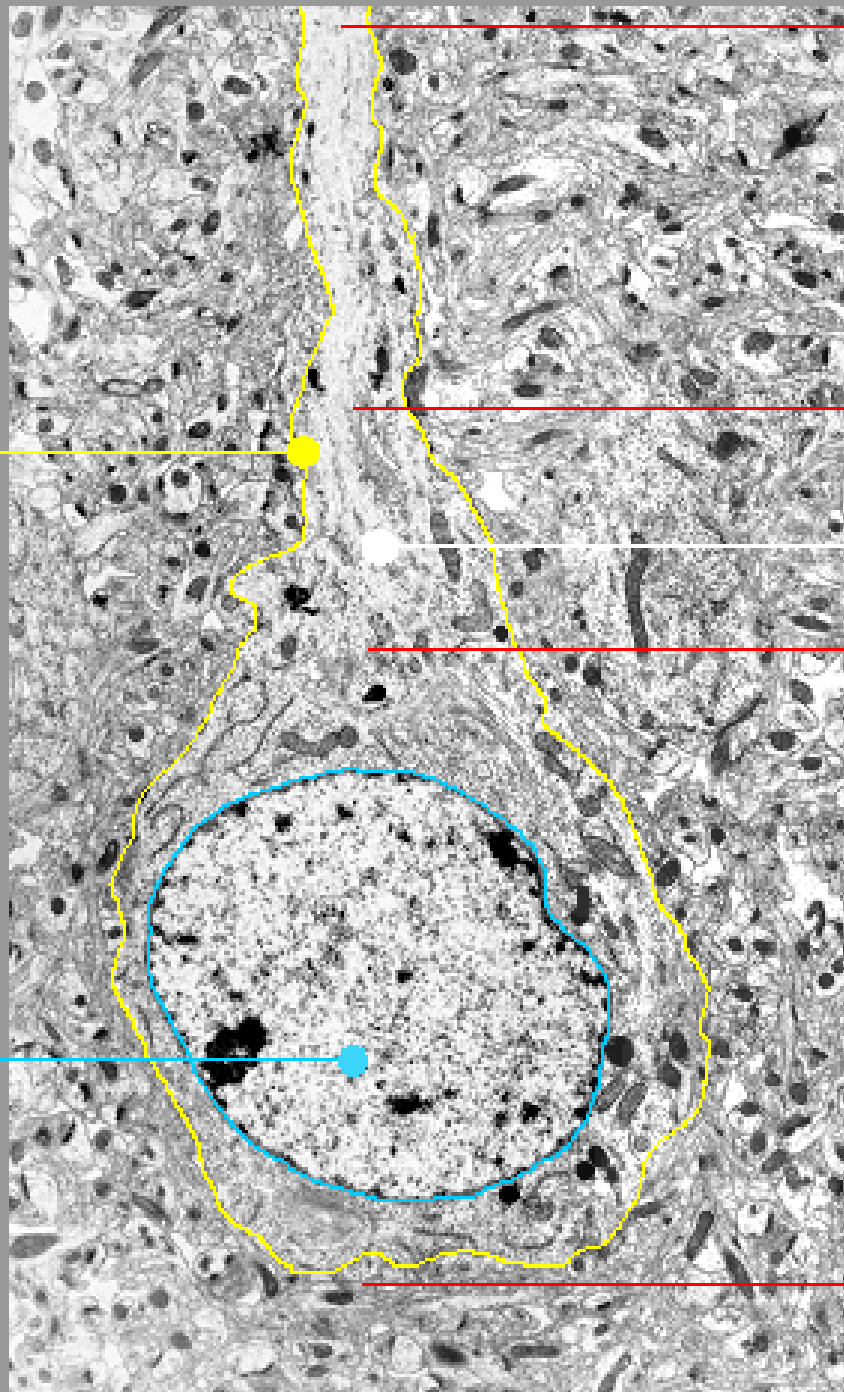
plasma  
membrane

dendrite

cytoplasm  
organelles

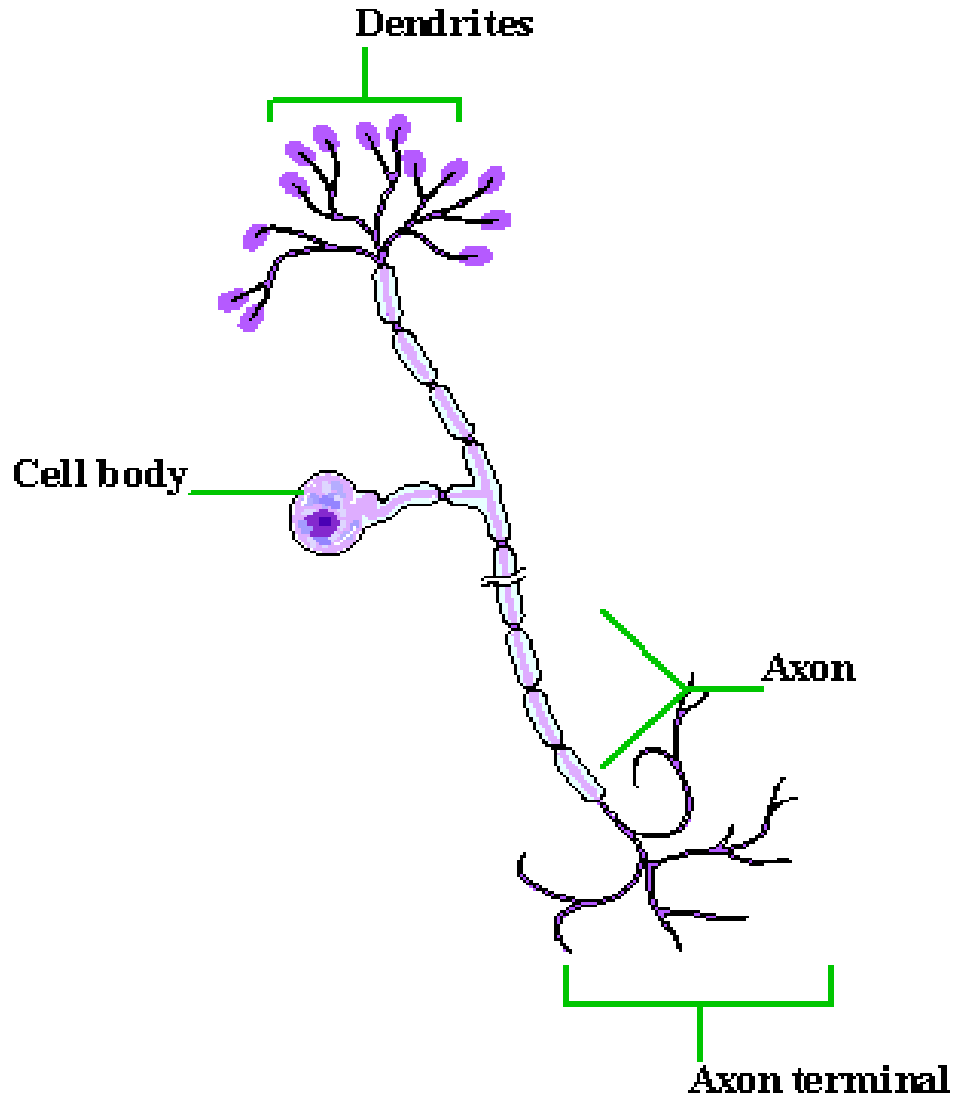
nucleus

perikaryon

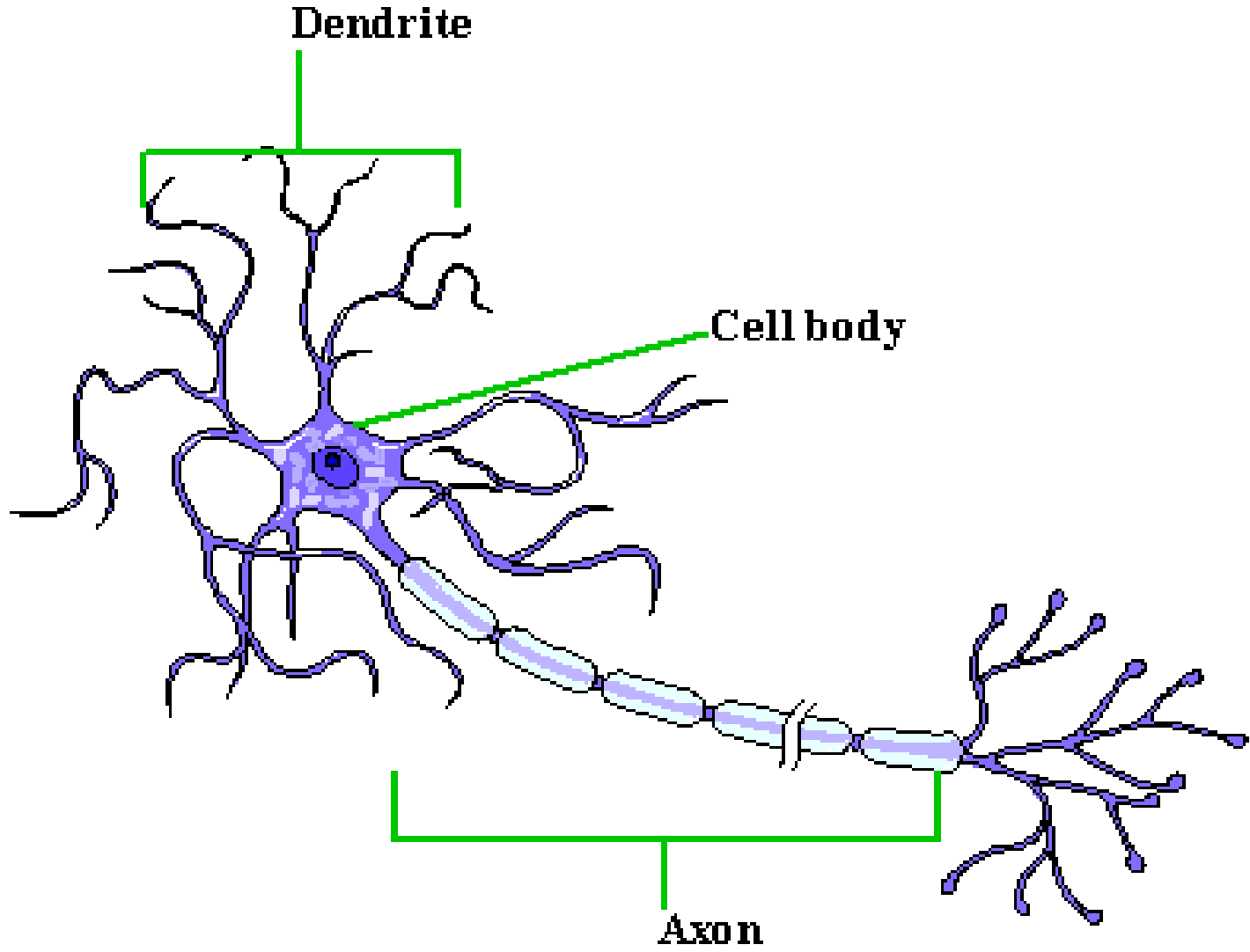


# Fonksiyonlarına Göre Nöronlar:

## 1-Sensorik veya Aferent Neuron



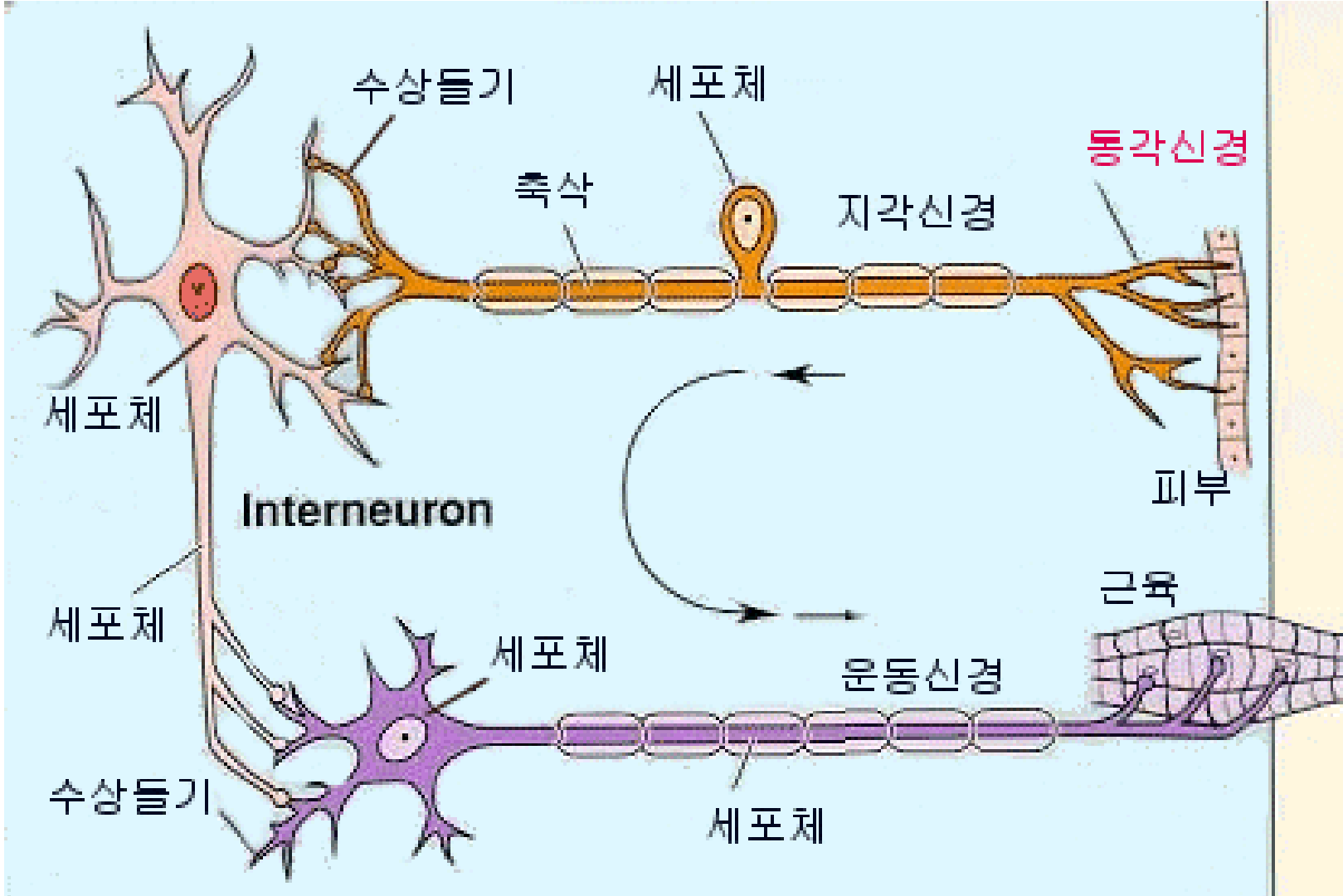
## 2-Motor veyā Efferent Neuron

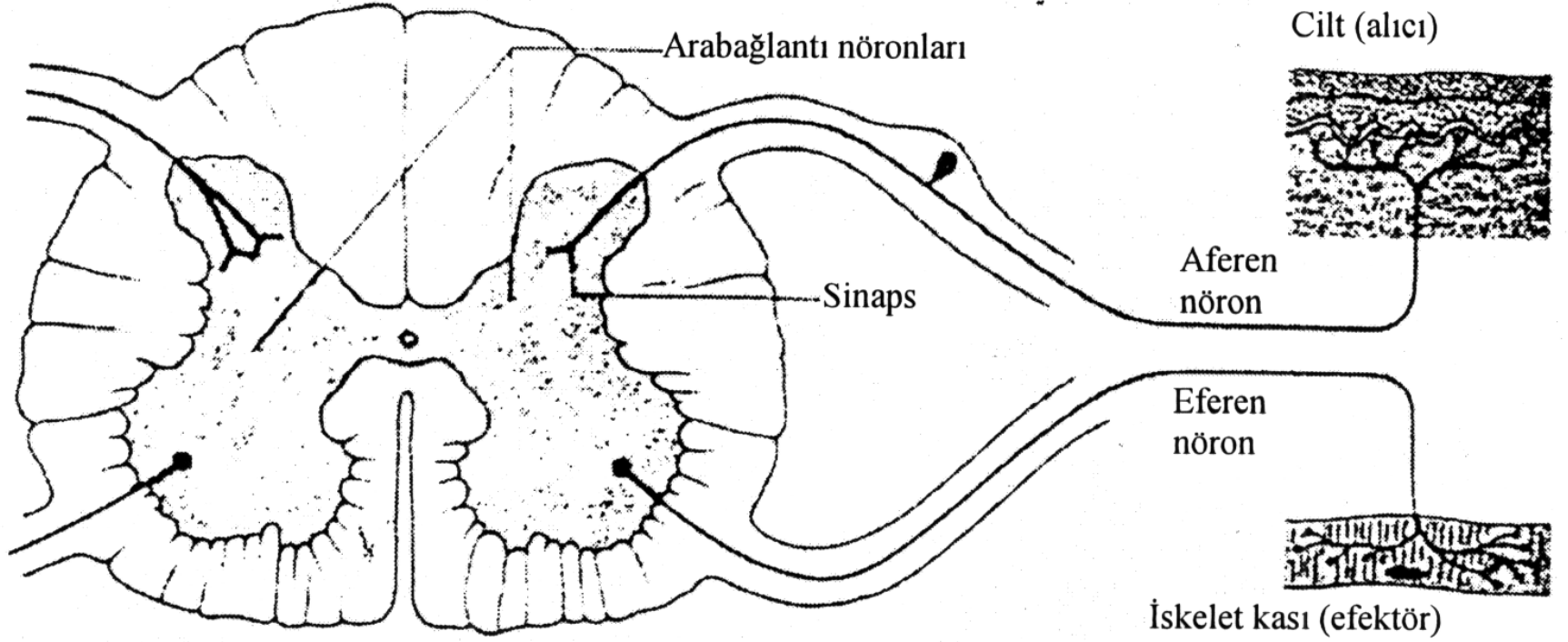




### 3- Ara veya Bağlayıcı Nöron

Sinir impulslarını bir nöronun dendritinden diğer nöronun aksonuna iletir ve bunların hepsi sadece beyin ve medulla spinalisin gri maddesi içinde bulunur.





Şekil 12.5 Refleks yayının elemanları

Sinir Hücreleri gövdelerinden yayılan uzantıların sayısına göre 3'e ayrılır:

1-Multipolar nöronlar:1 akson

2 veya daha çok dendrit

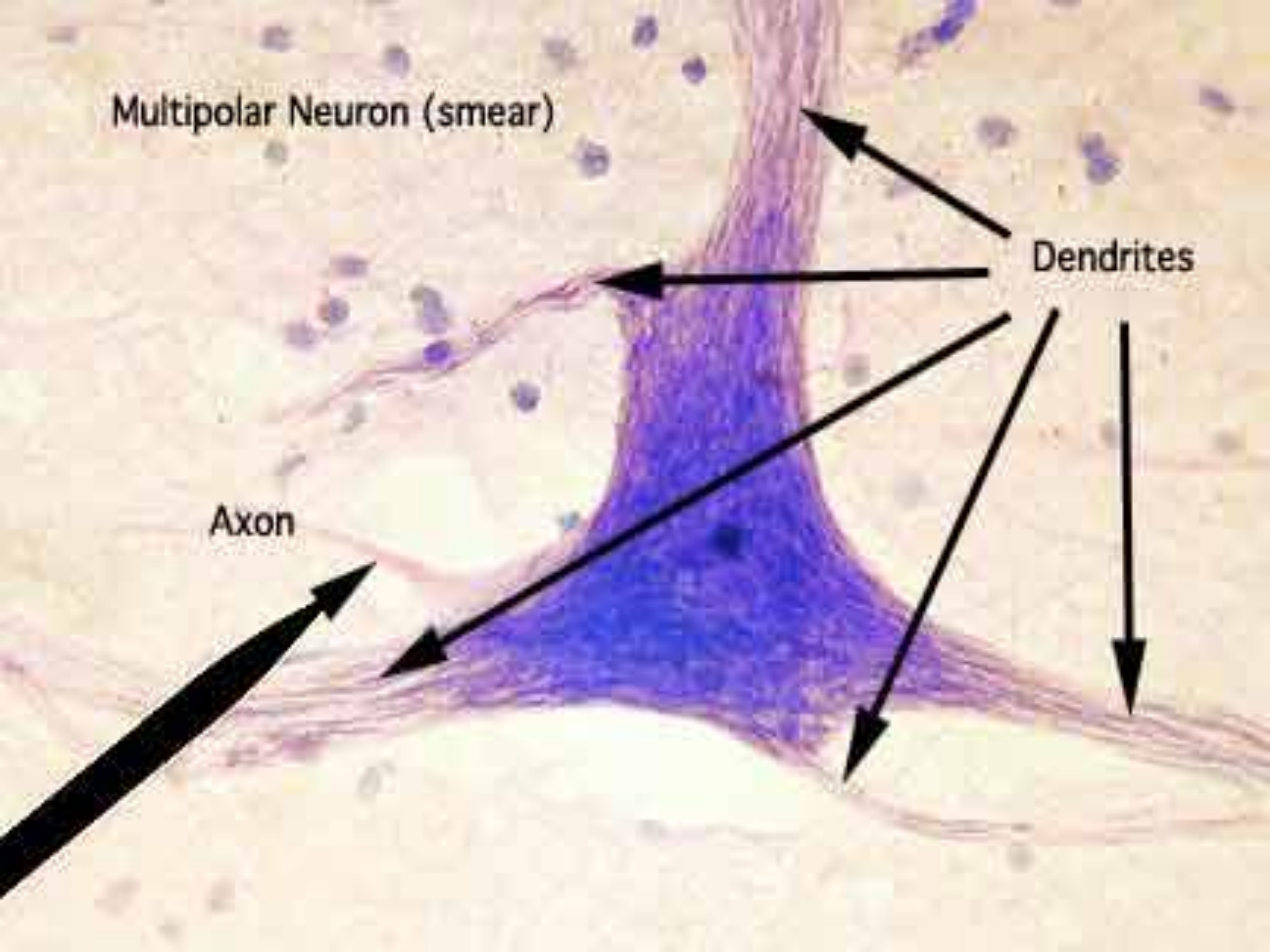
2-Bipolar nöron: 1 akson, 1 dendrit

3-Unipolar (pseudounipolar nöron): 2'ye bölünmüş 1 akson

Multipolar Neuron (smear)

Dendrites

Axon



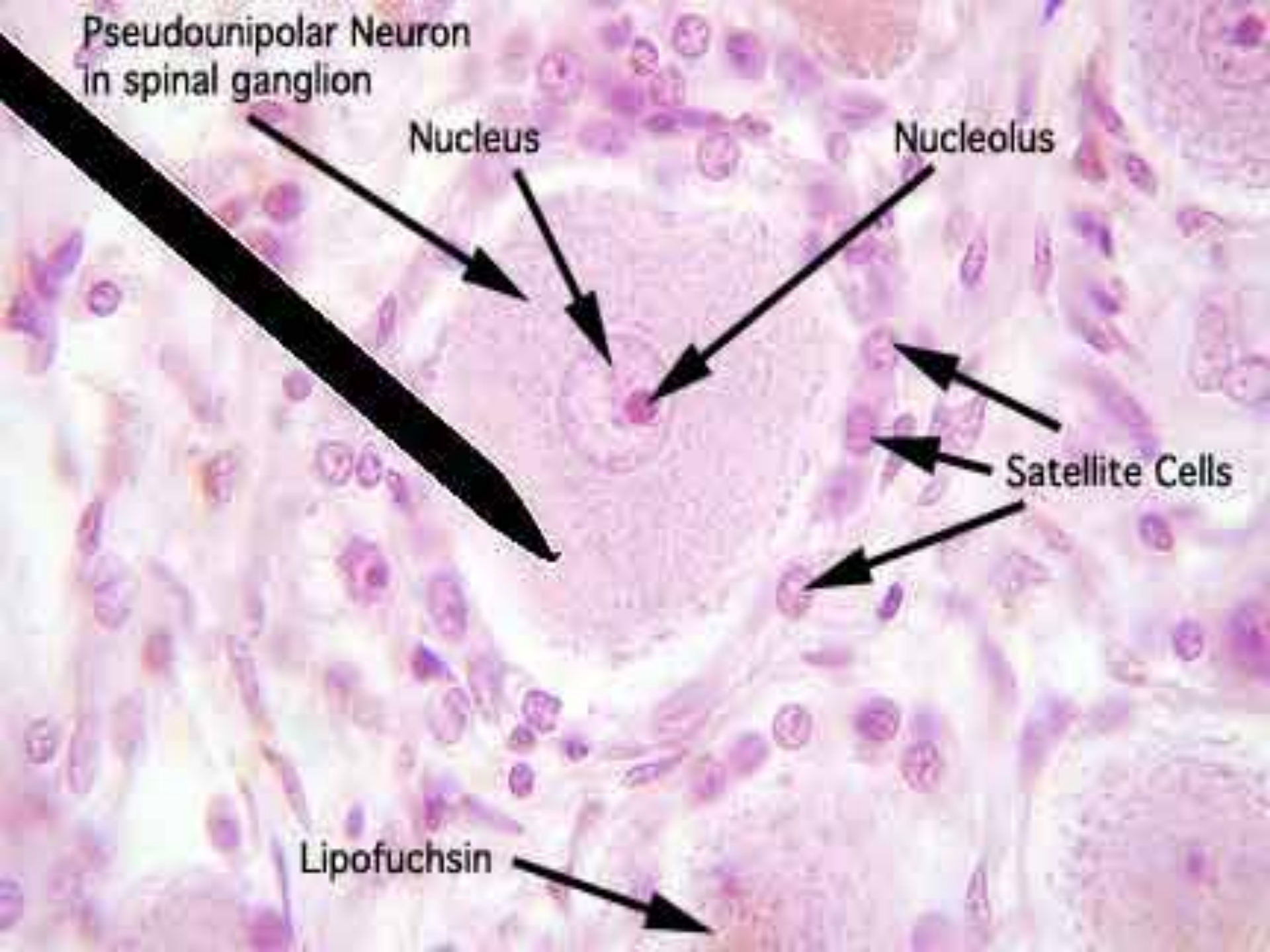
Pseudounipolar Neuron  
in spinal ganglion

Nucleus

Nucleolus

Satellite Cells

Lipofuchsin

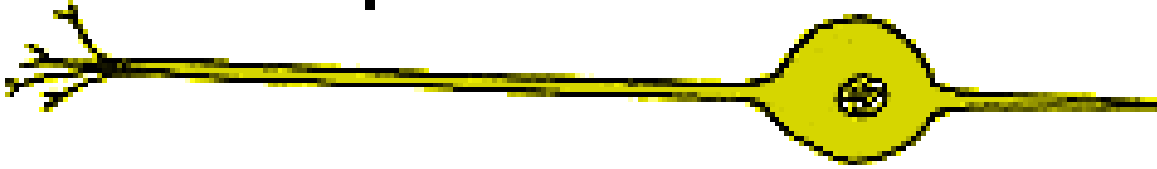


# Types of Neurons

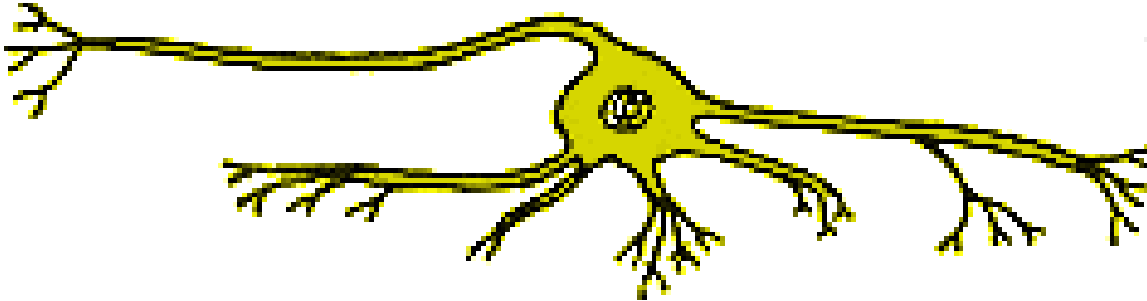
Unipolar



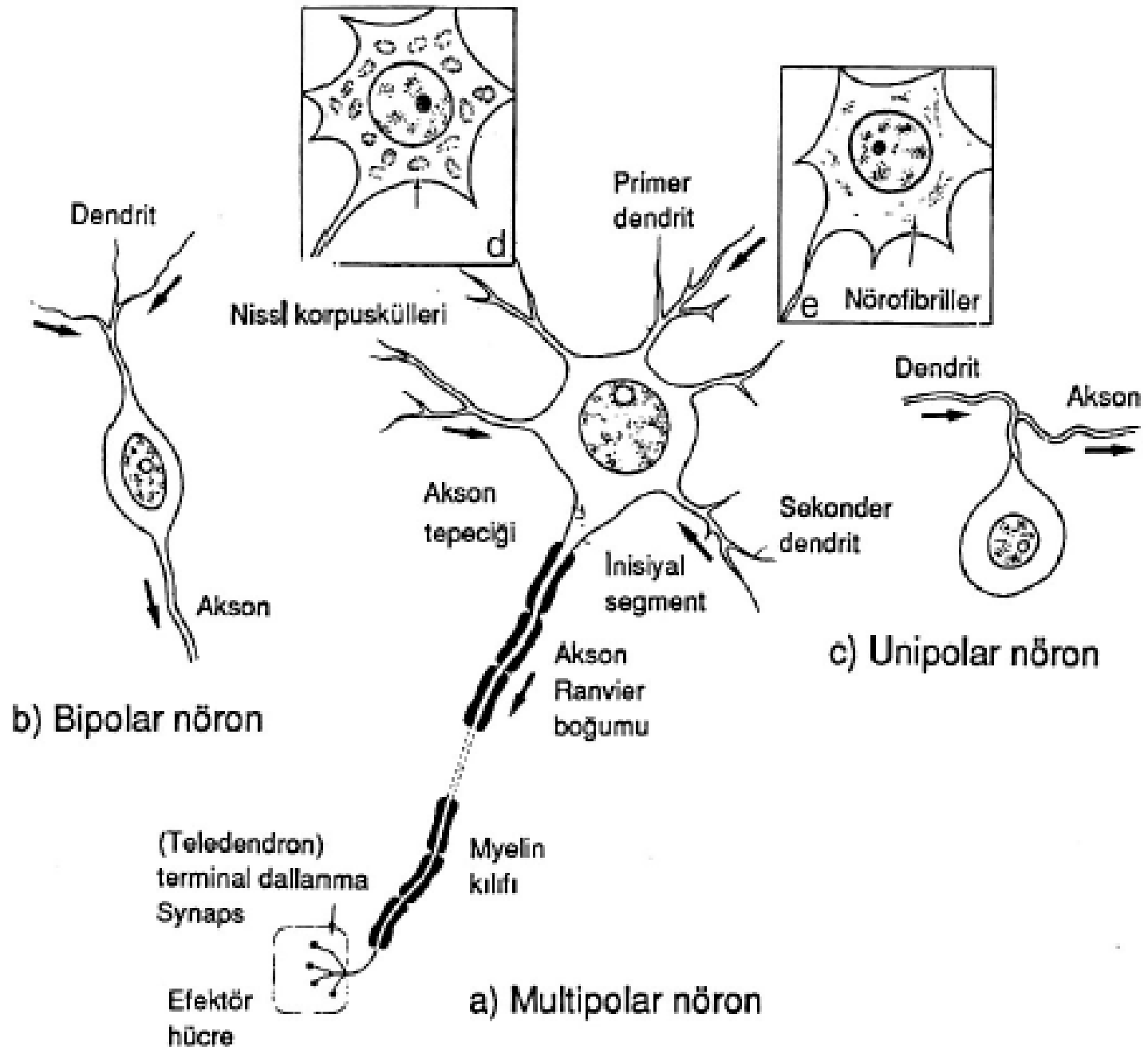
Bipolar



Multipolar

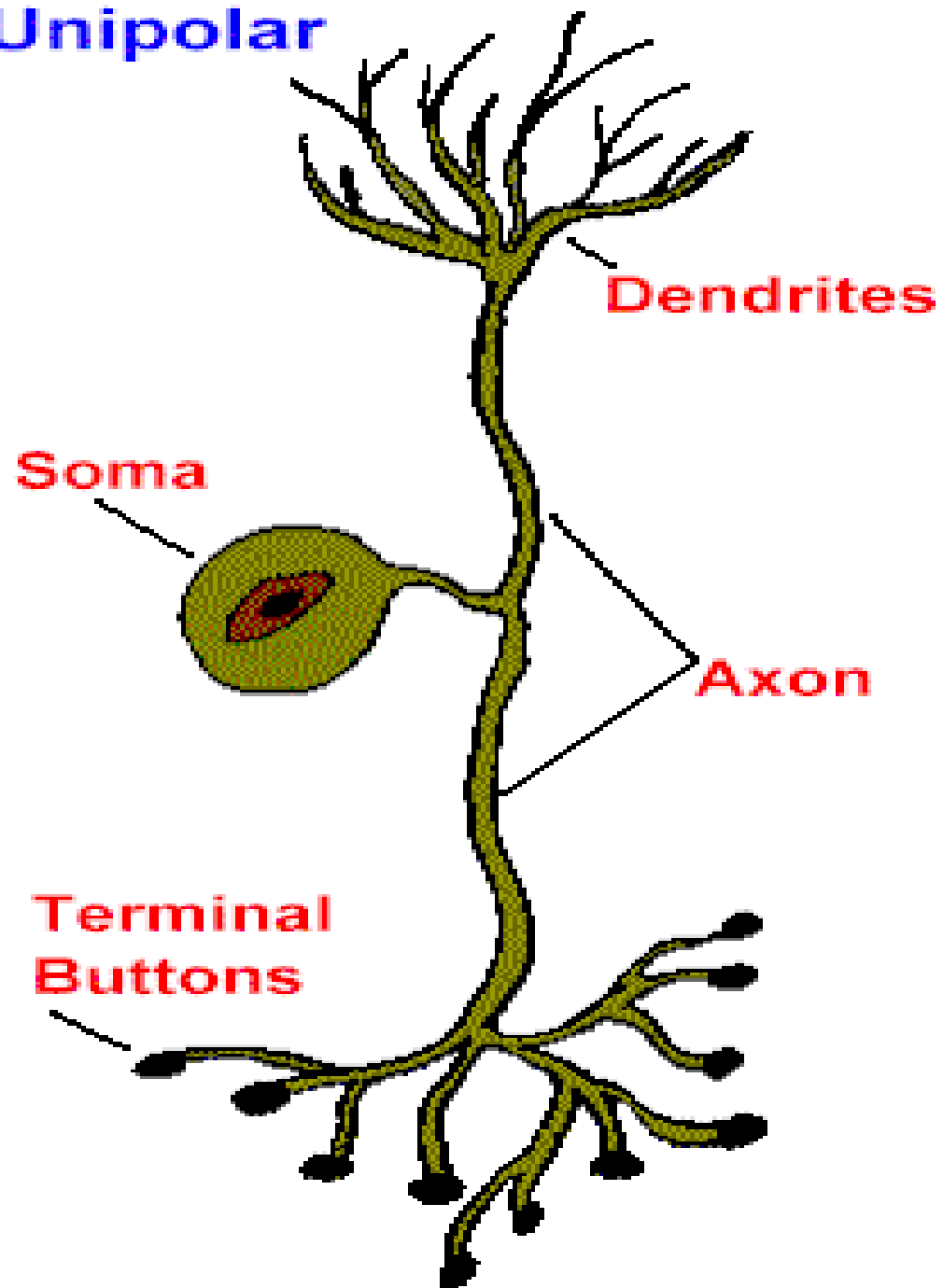


Uzantılarının  
tiplerine ve  
sayısına  
göre:



Şekil 9.1: Nöron tipleri

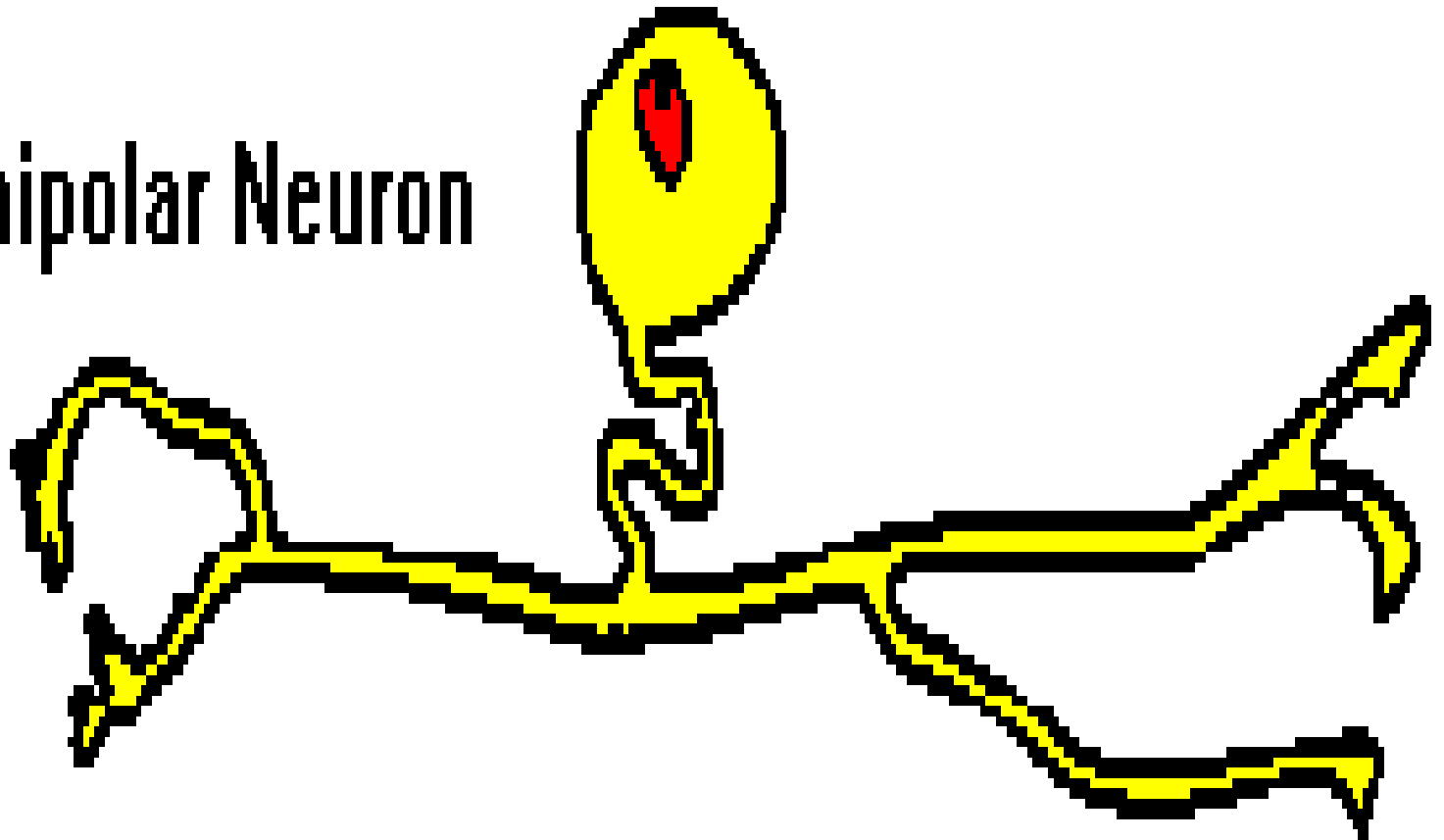
# Unipolar

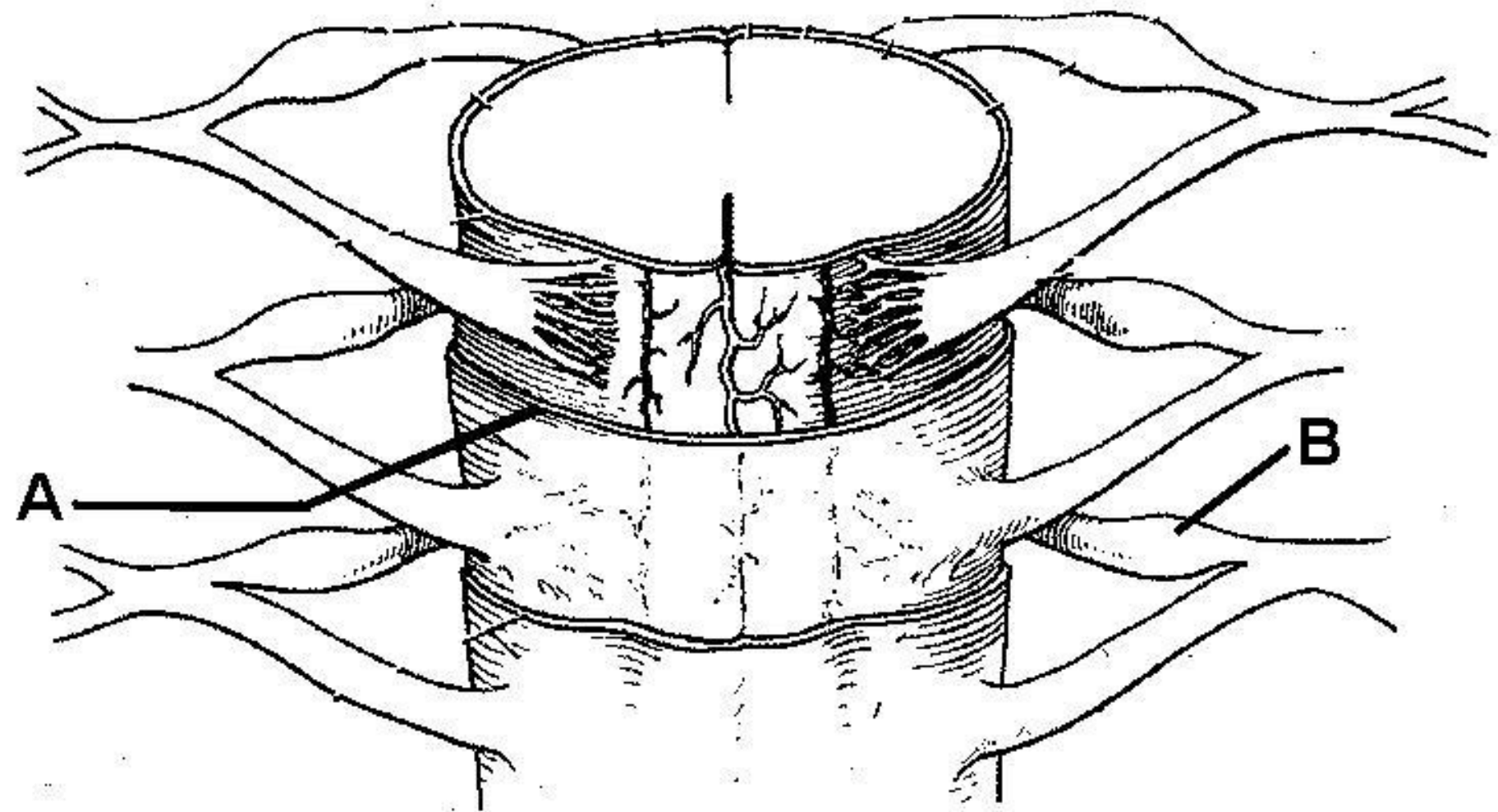


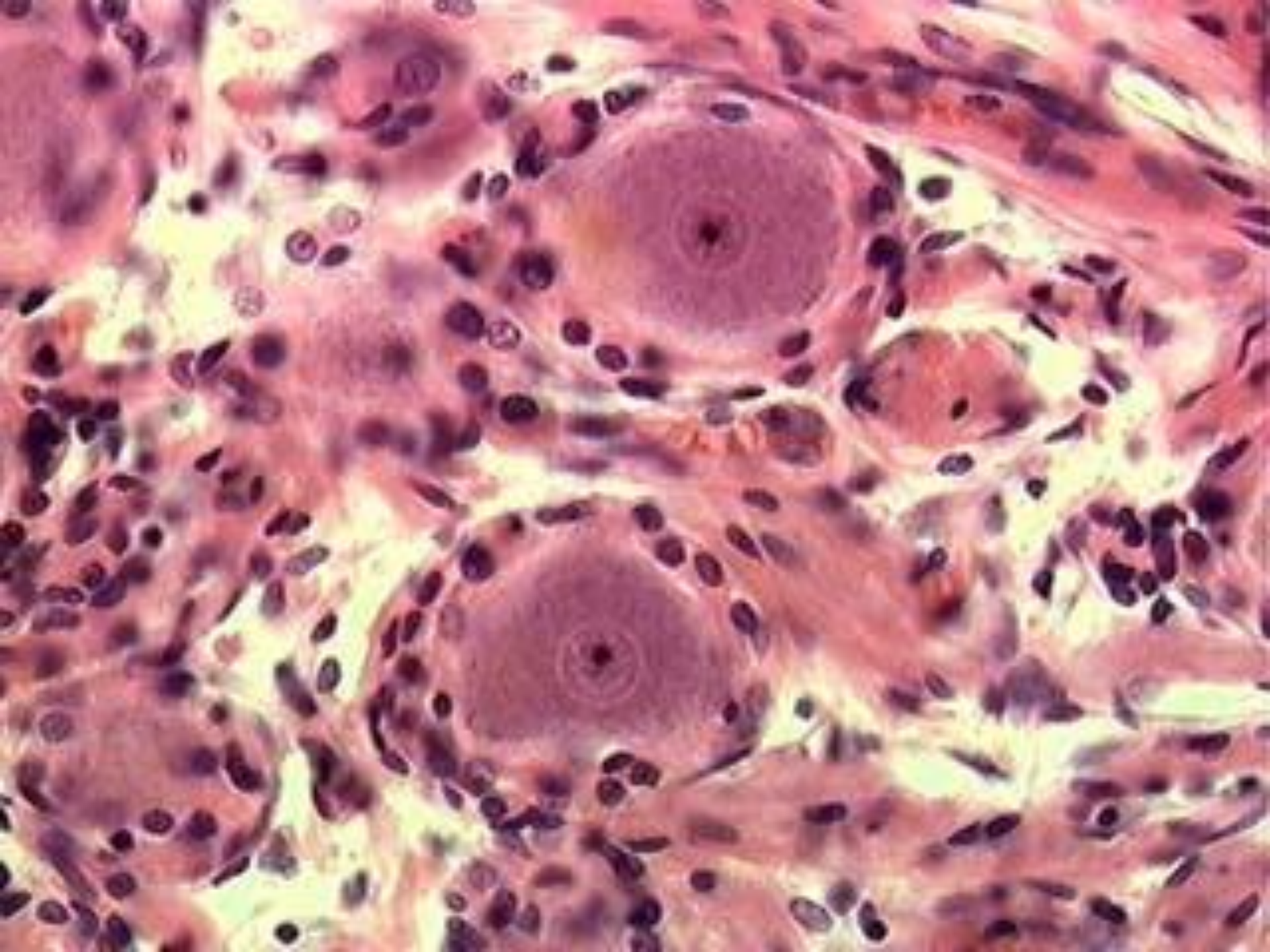


**Pseudounipolar cells (example: dorsal root ganglion cells).  
Actually, these cells have 2 axons rather than an axon and  
dendrite. One axon extends centrally toward the spinal cord, the  
other axon extends toward the skin or muscle.**

**Pseudounipolar Neuron**







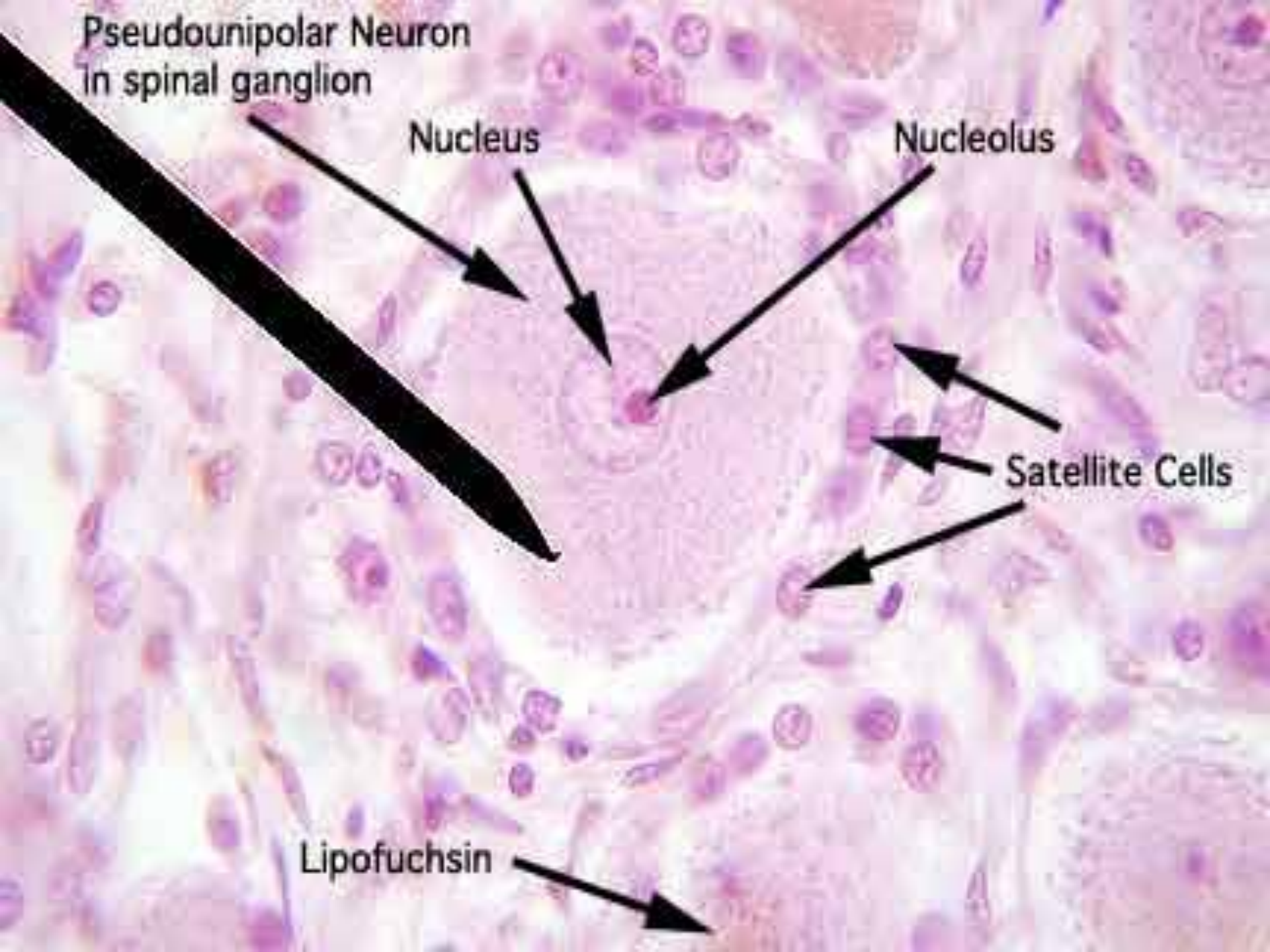
Pseudounipolar Neuron  
in spinal ganglion

Nucleus

Nucleolus

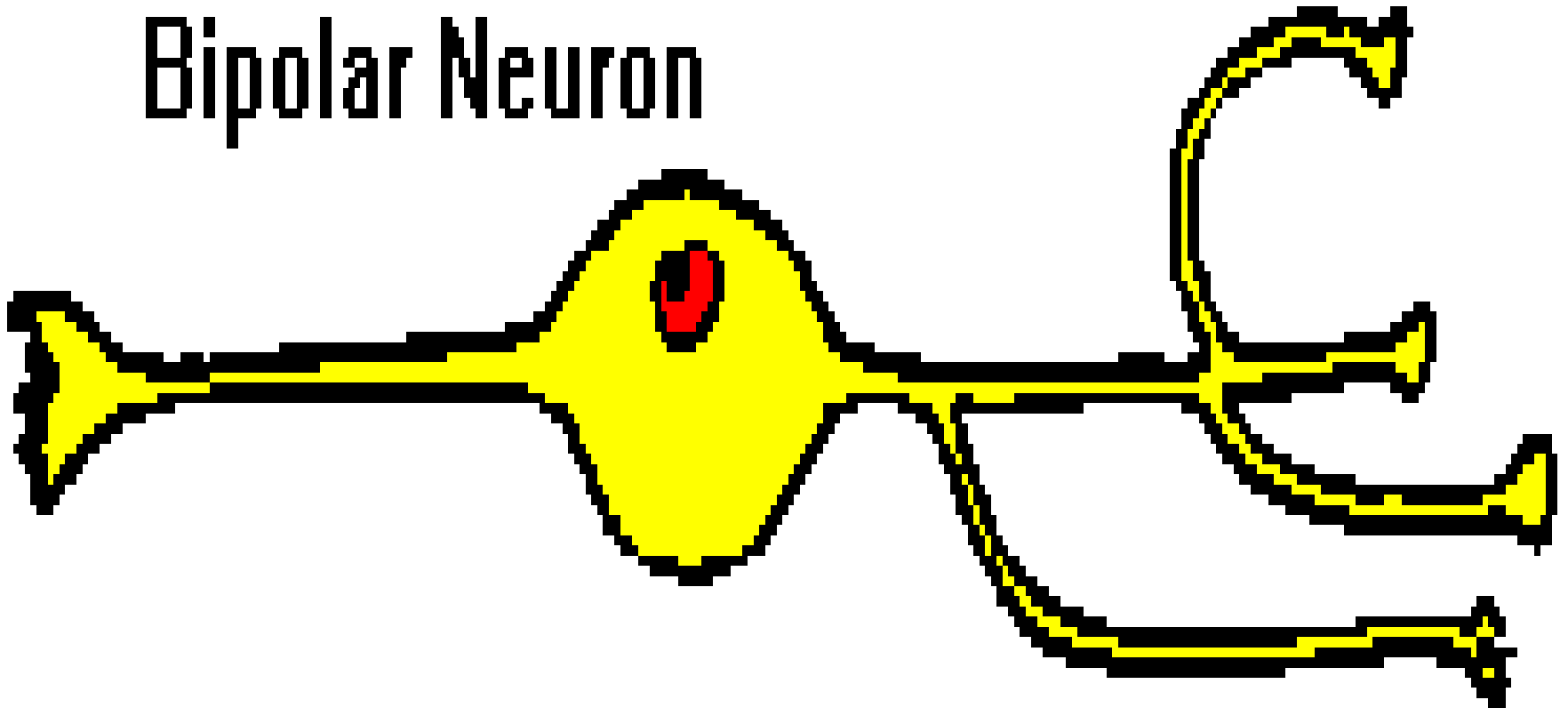
Satellite Cells

Lipofuchsin

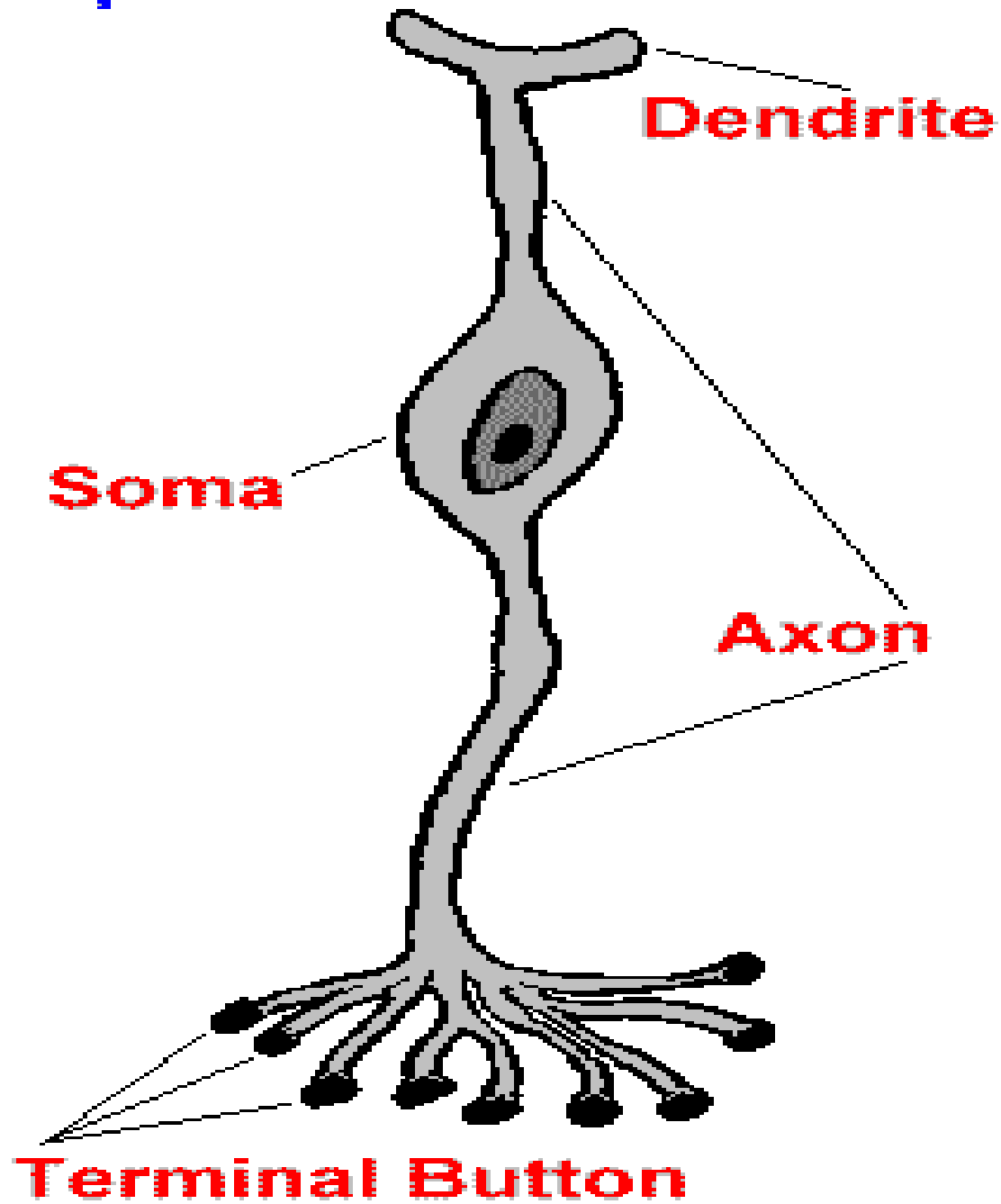


**Bipolar neurons have two processes extending from the cell body (examples: retinal cells, olfactory epithelium cells).**

## Bipolar Neuron



# Bipolar



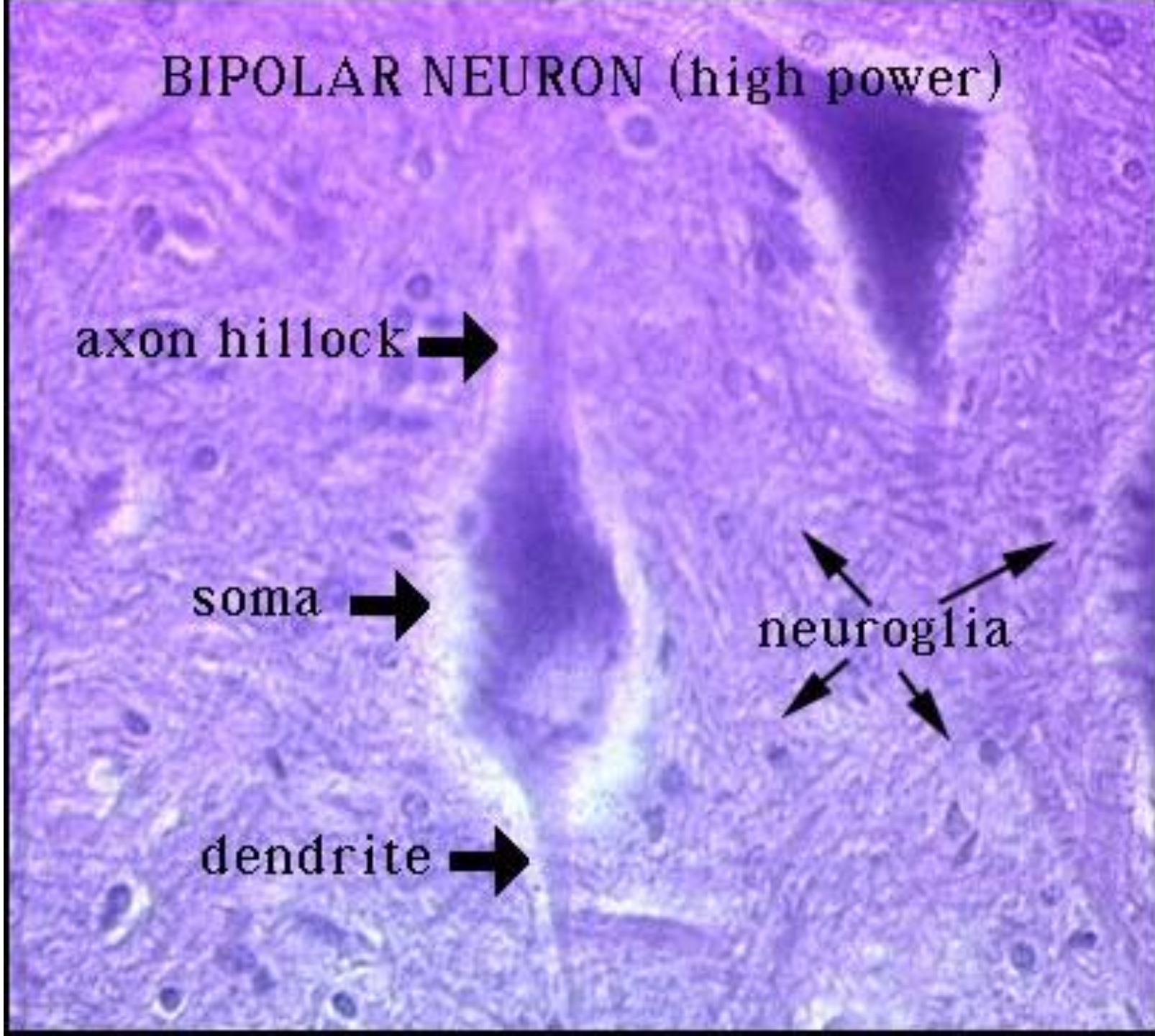
# BIPOLAR NEURON (high power)

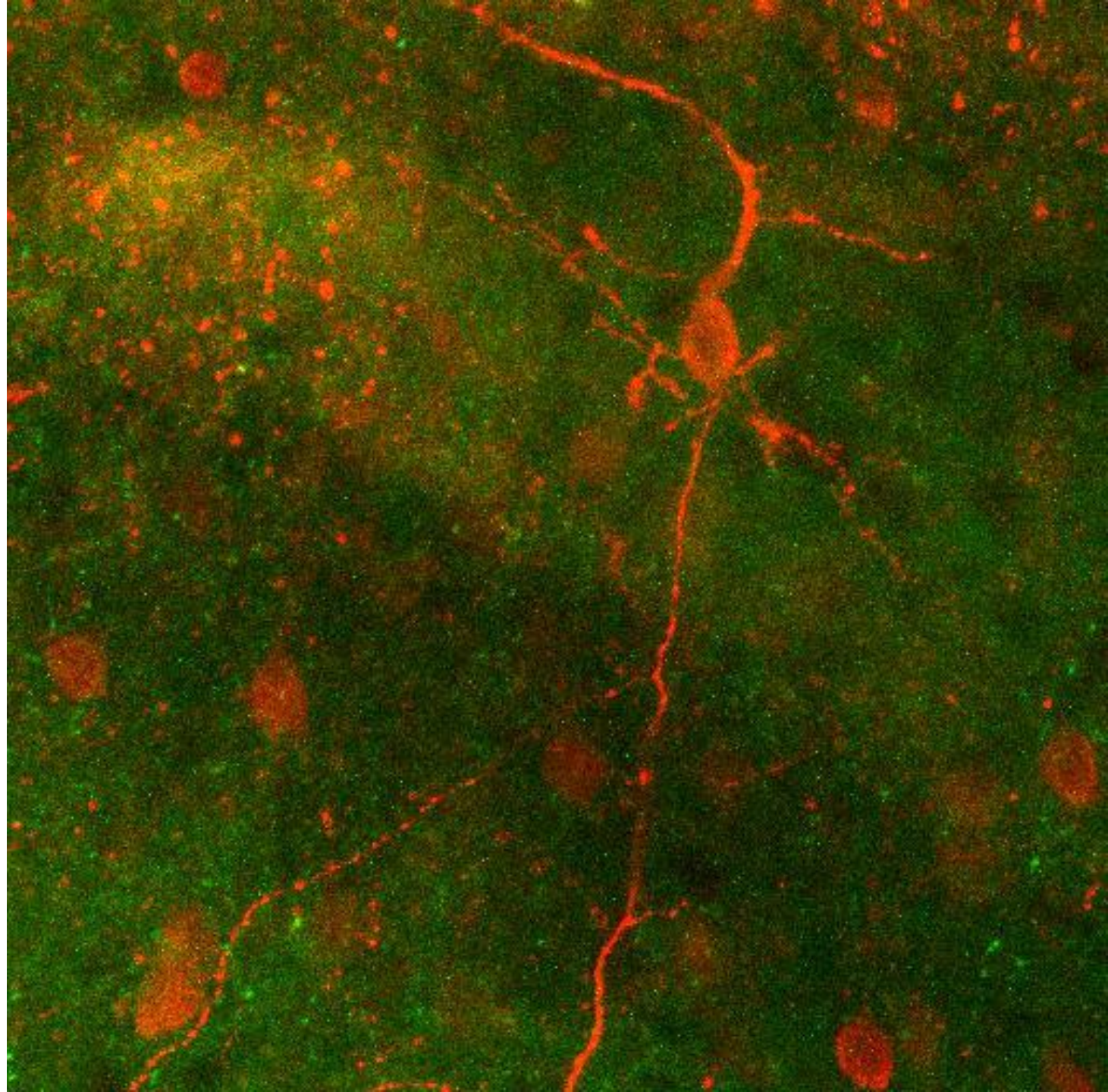
axon hillock →

soma →

dendrite →

neuroglia



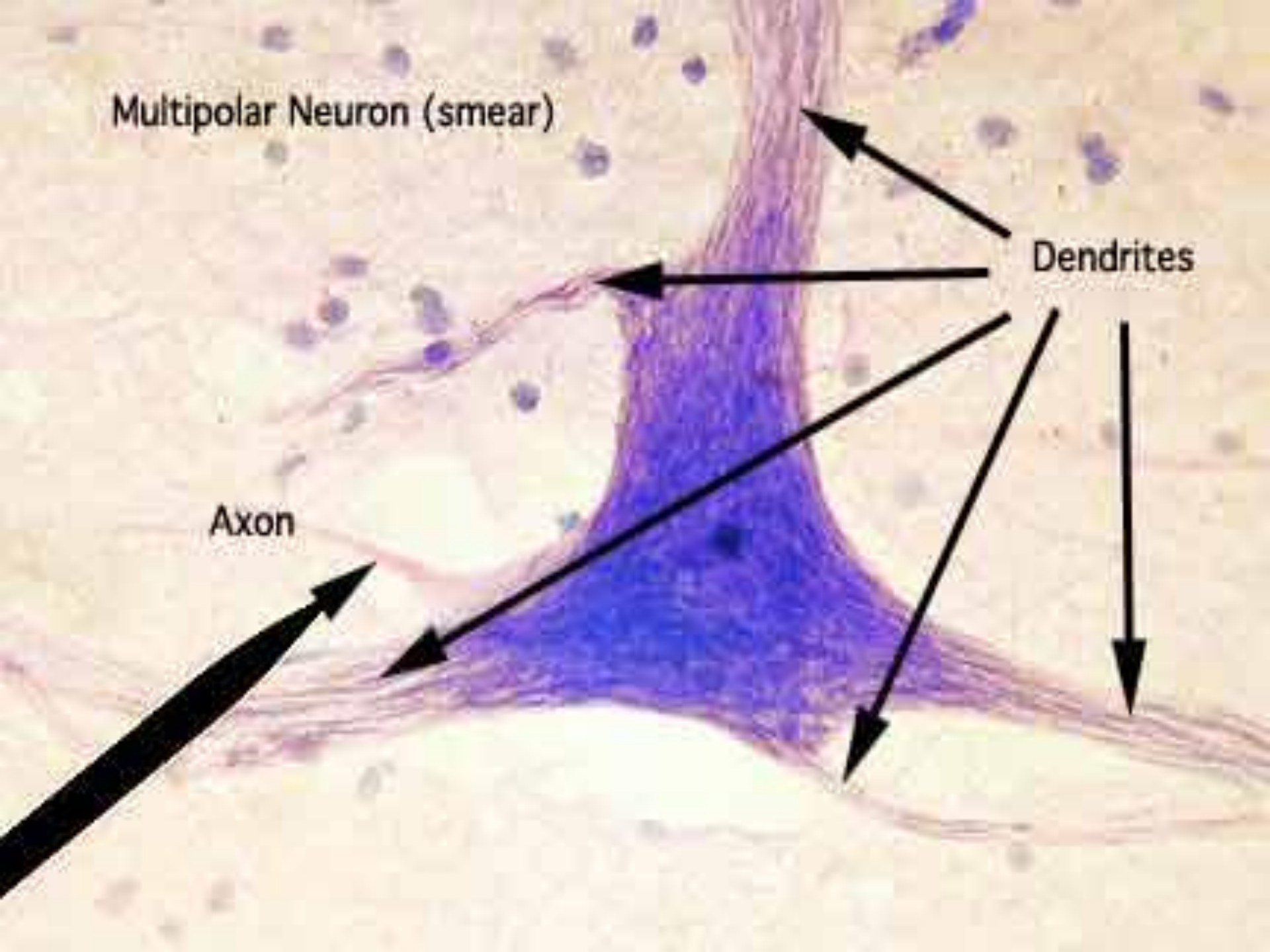




Multipolar Neuron (smear)

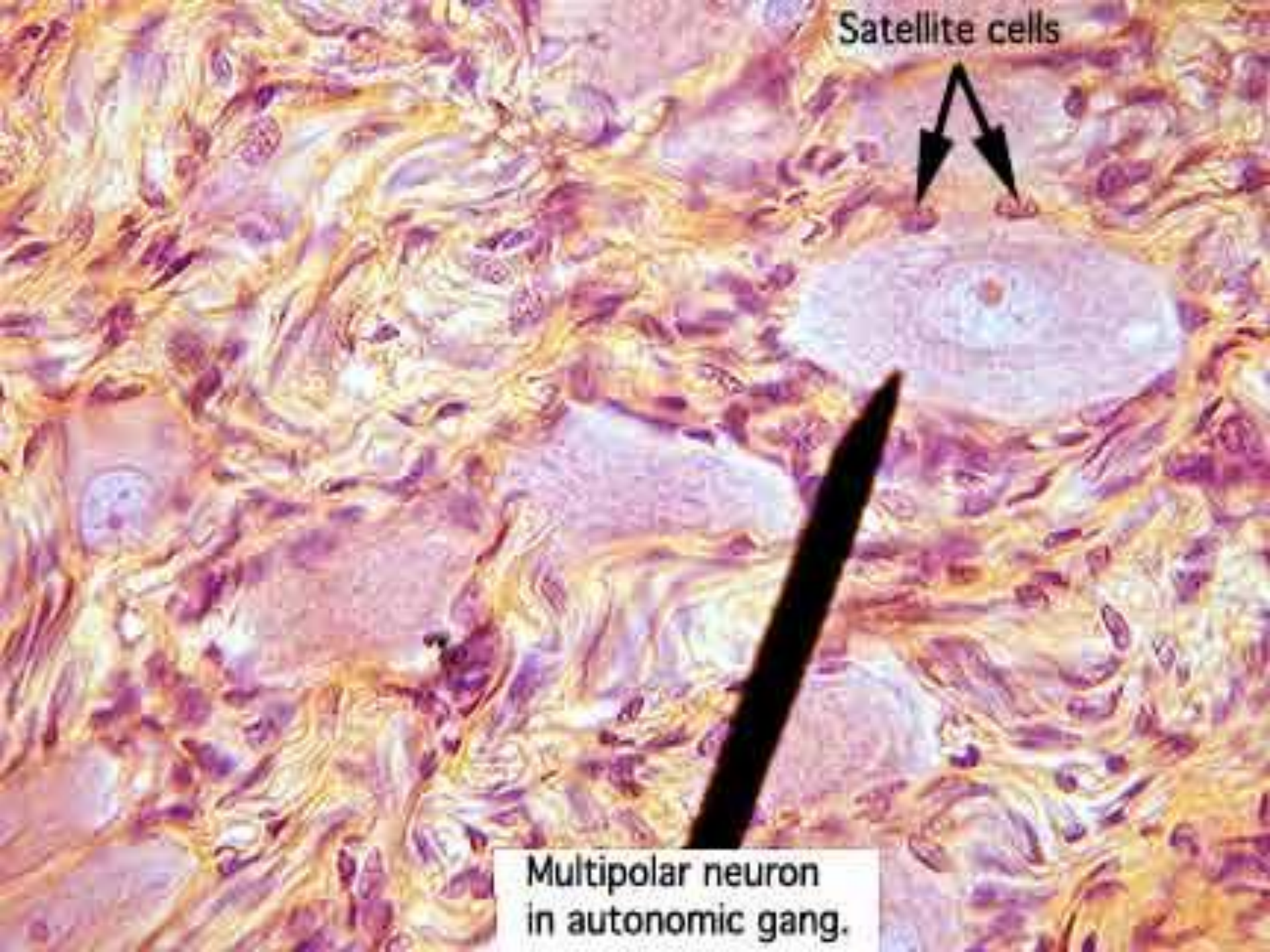
Dendrites

Axon





Satellite cells

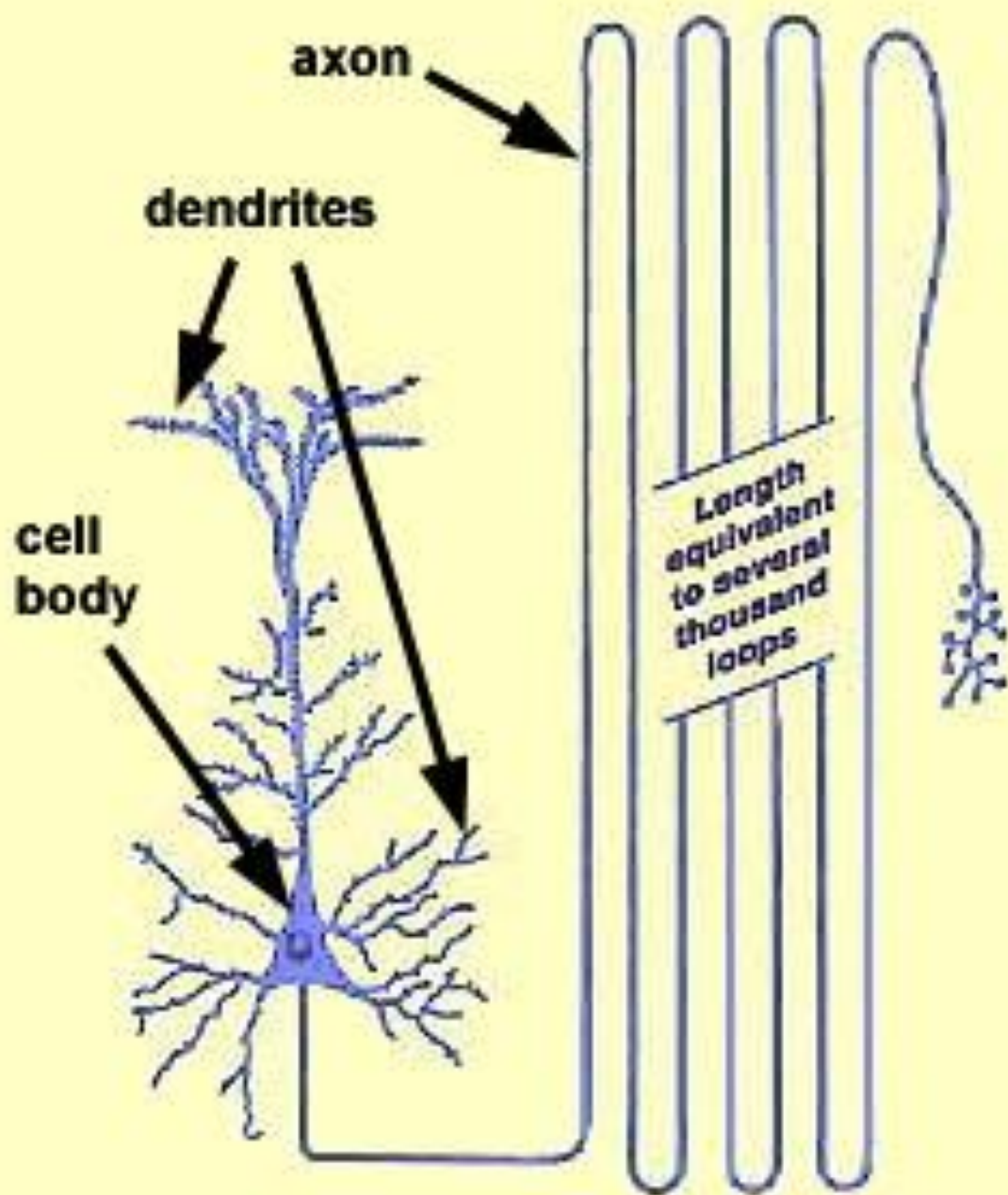


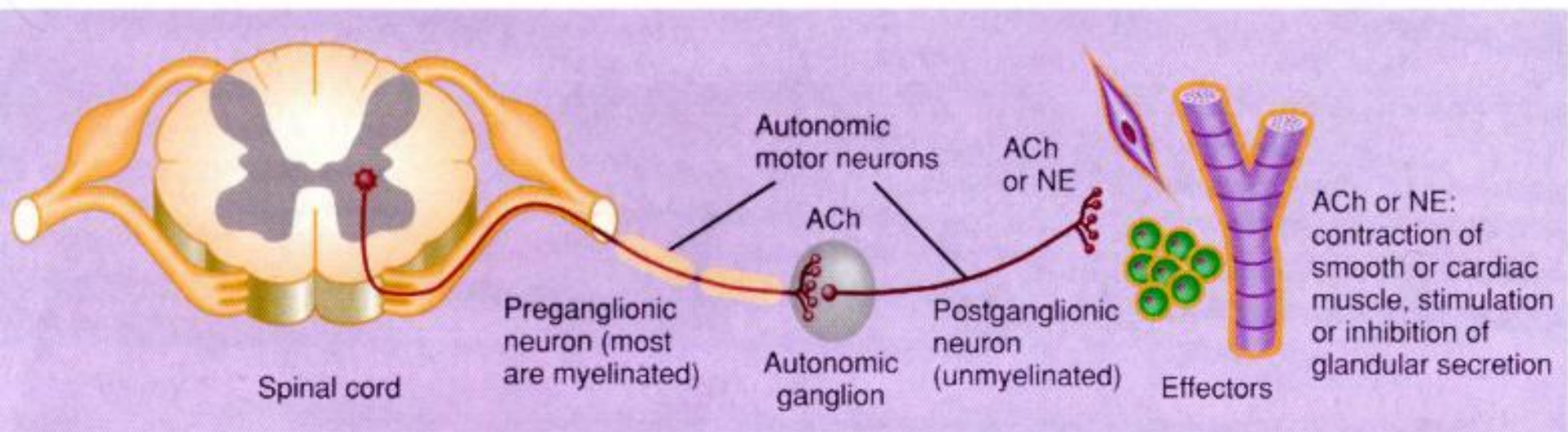
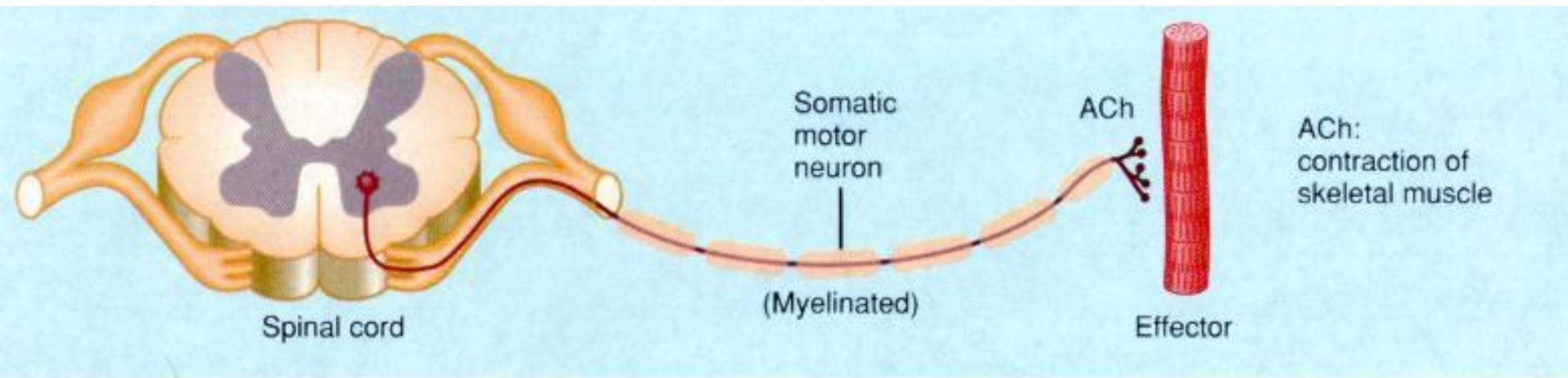
Multipolar neuron  
in autonomic gang.

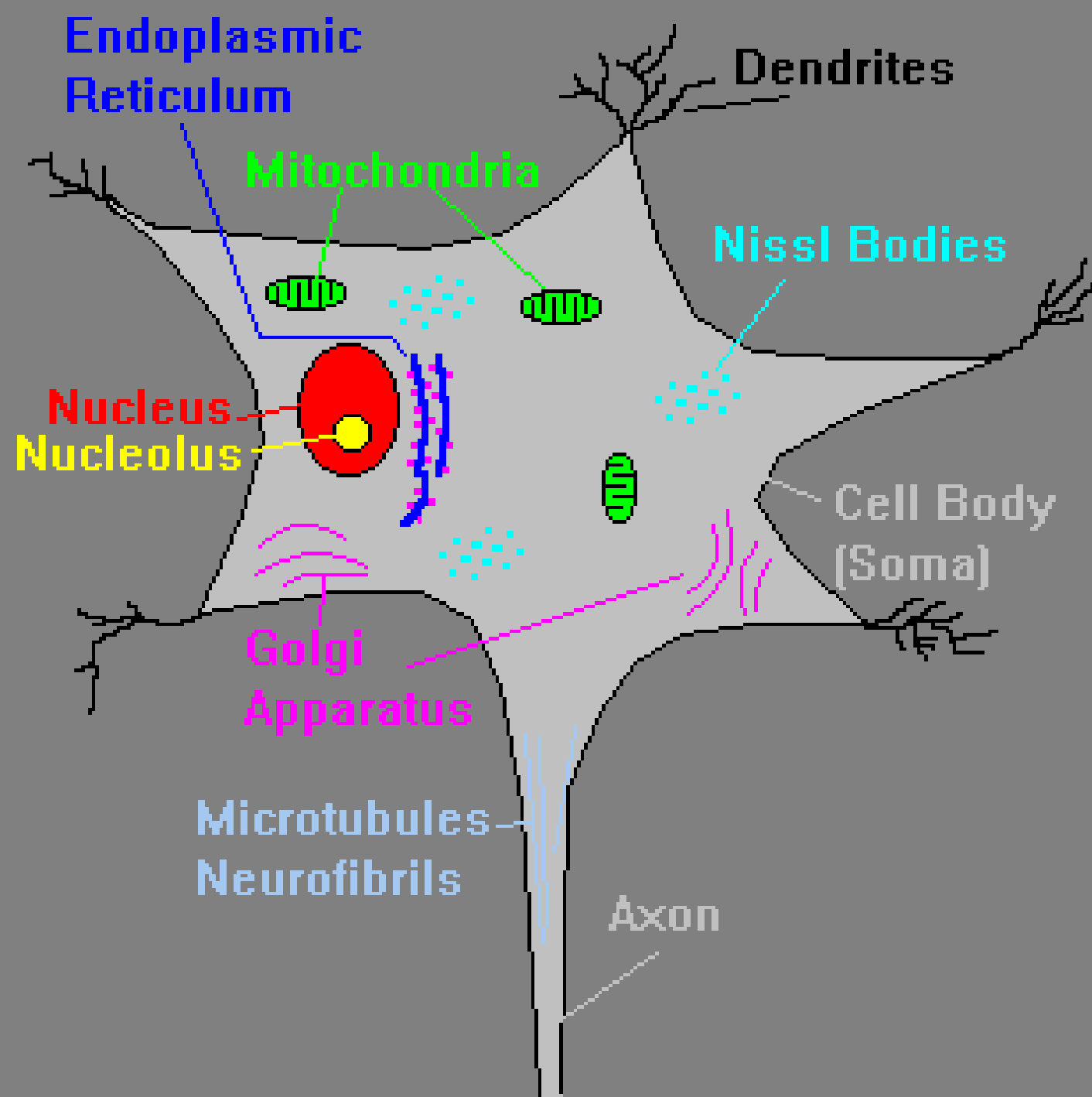


# Aksonlarının uzunluğuna göre: (Merkezi sinir sisteminde)

- 1-Golgi I tipi nöron : MSS'deki motor çekirdeklerin nöronlarında aksonlar 1 metreden daha uzaktaki alıcı hedeflere ulaşır.
- 2-Golgi II tipi nöron : MSS'deki ara nöronlar oldukça kısa aksonlara sahiptir.

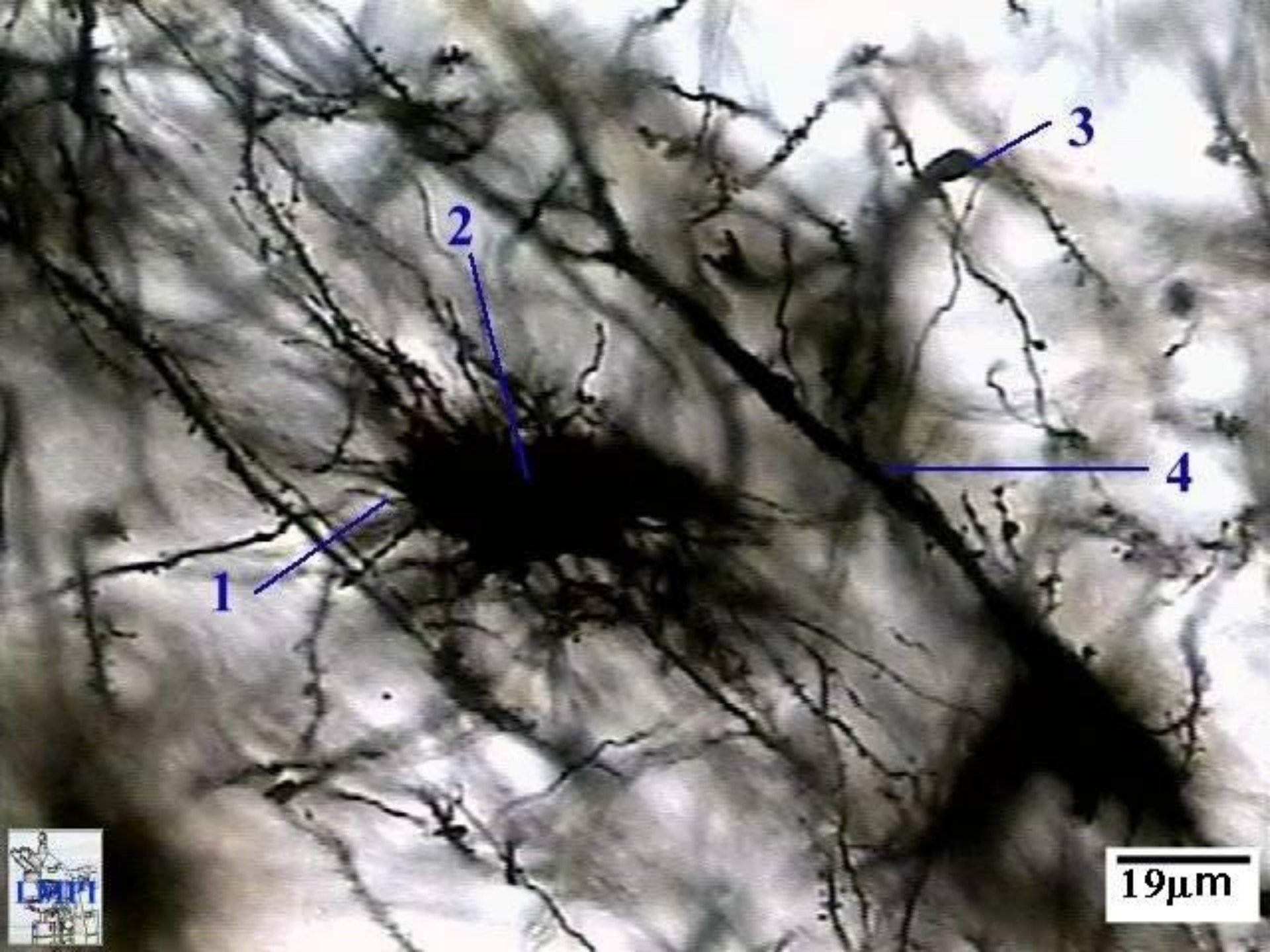












1

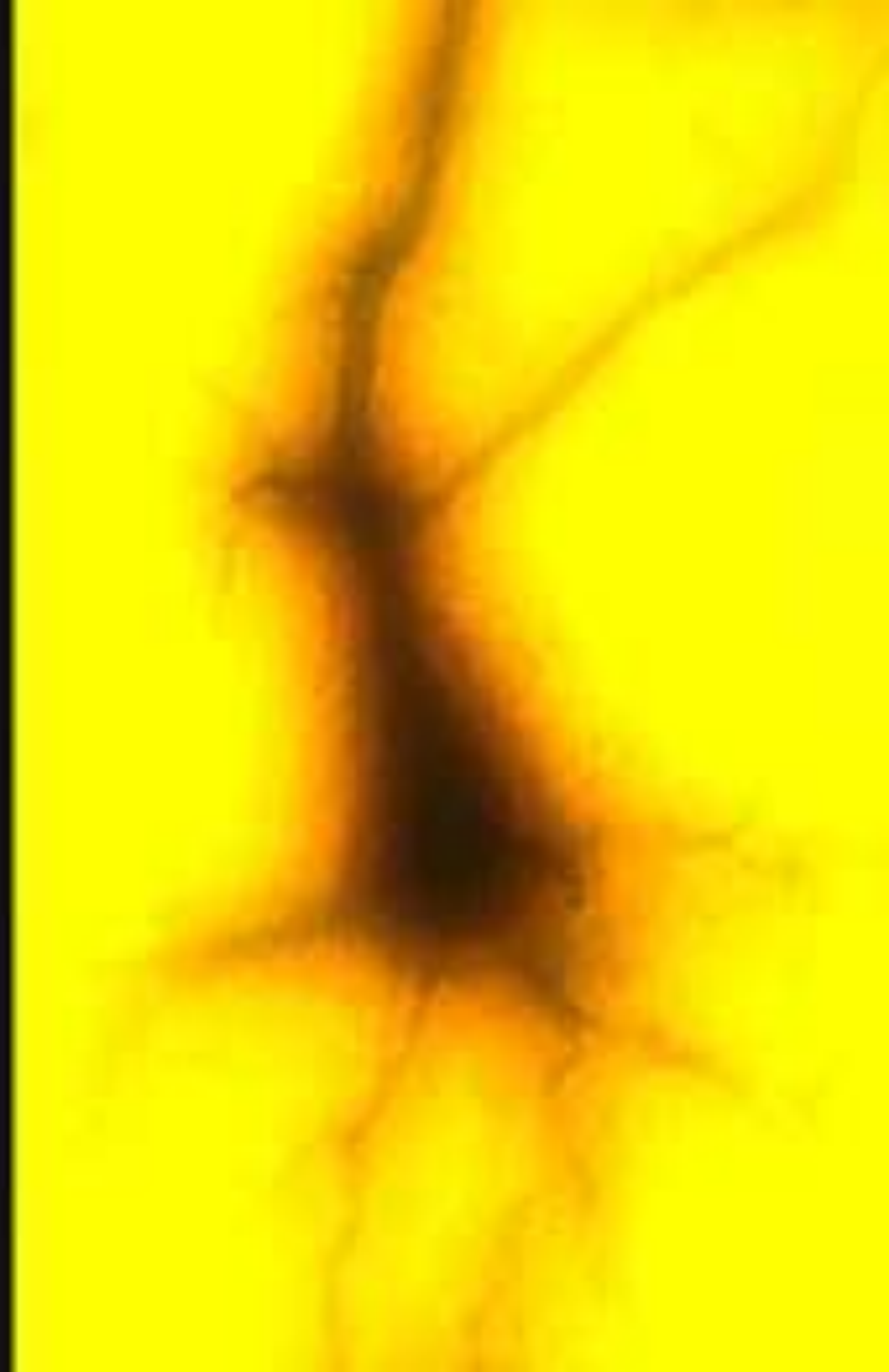
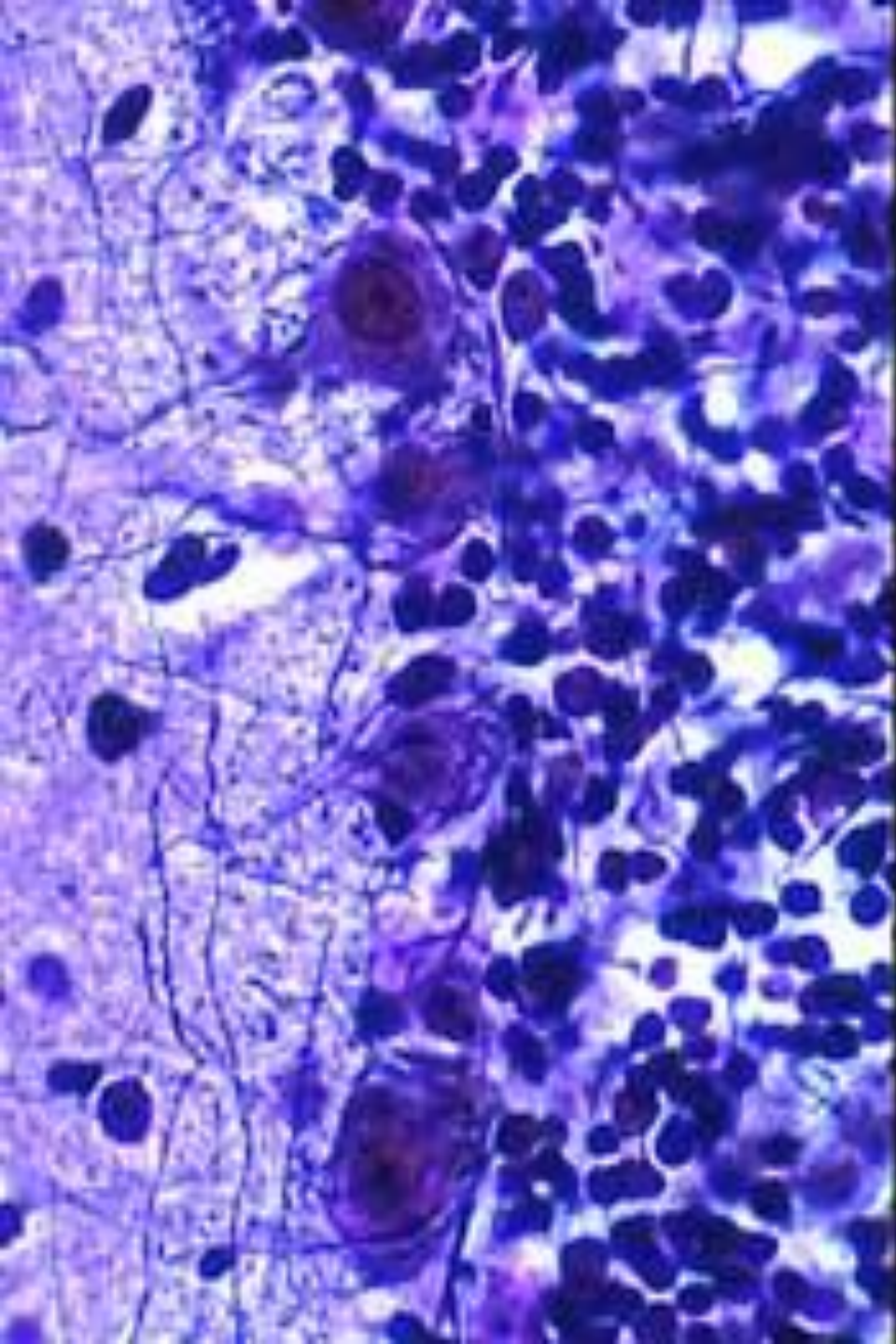
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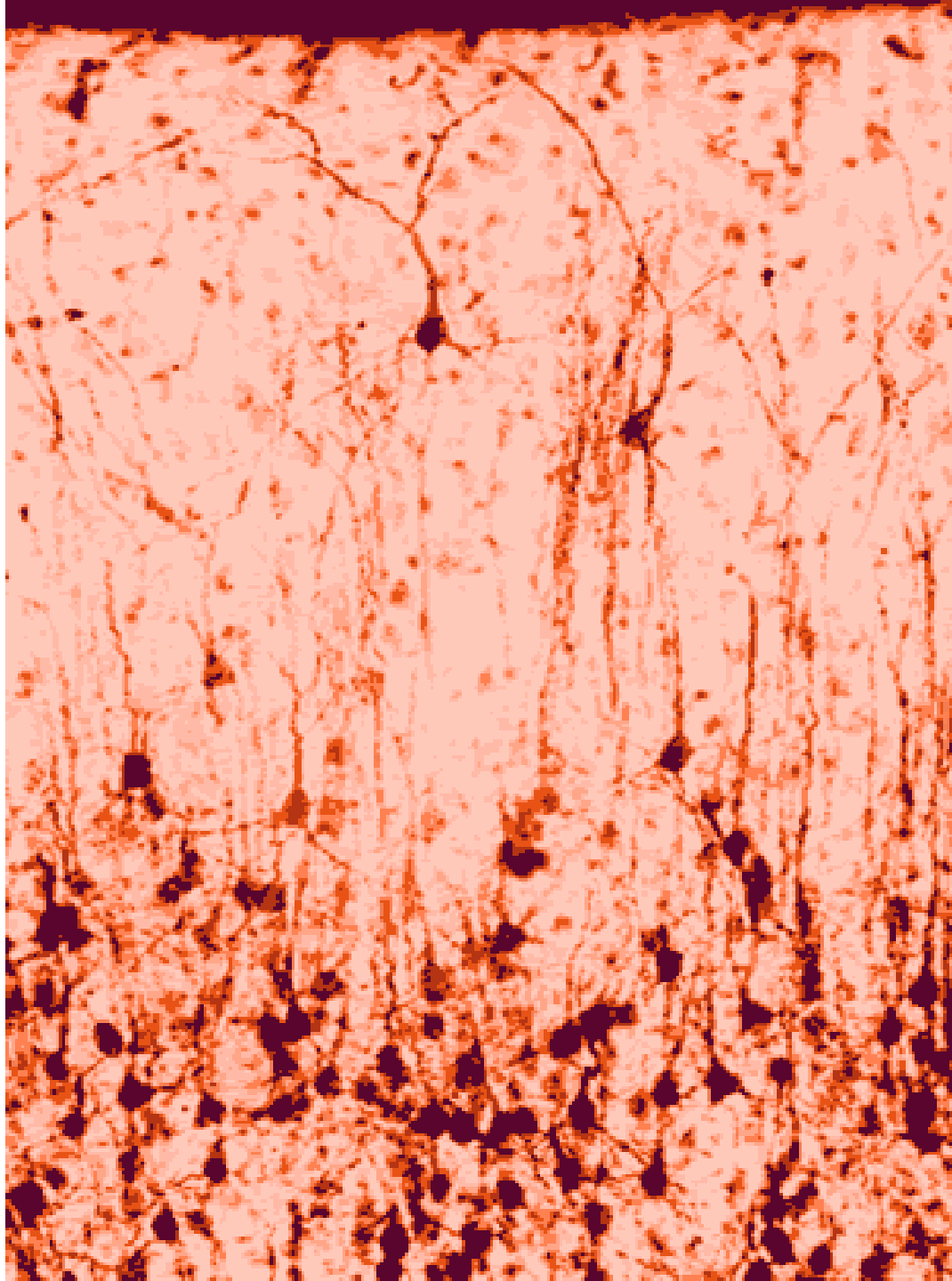
3

4

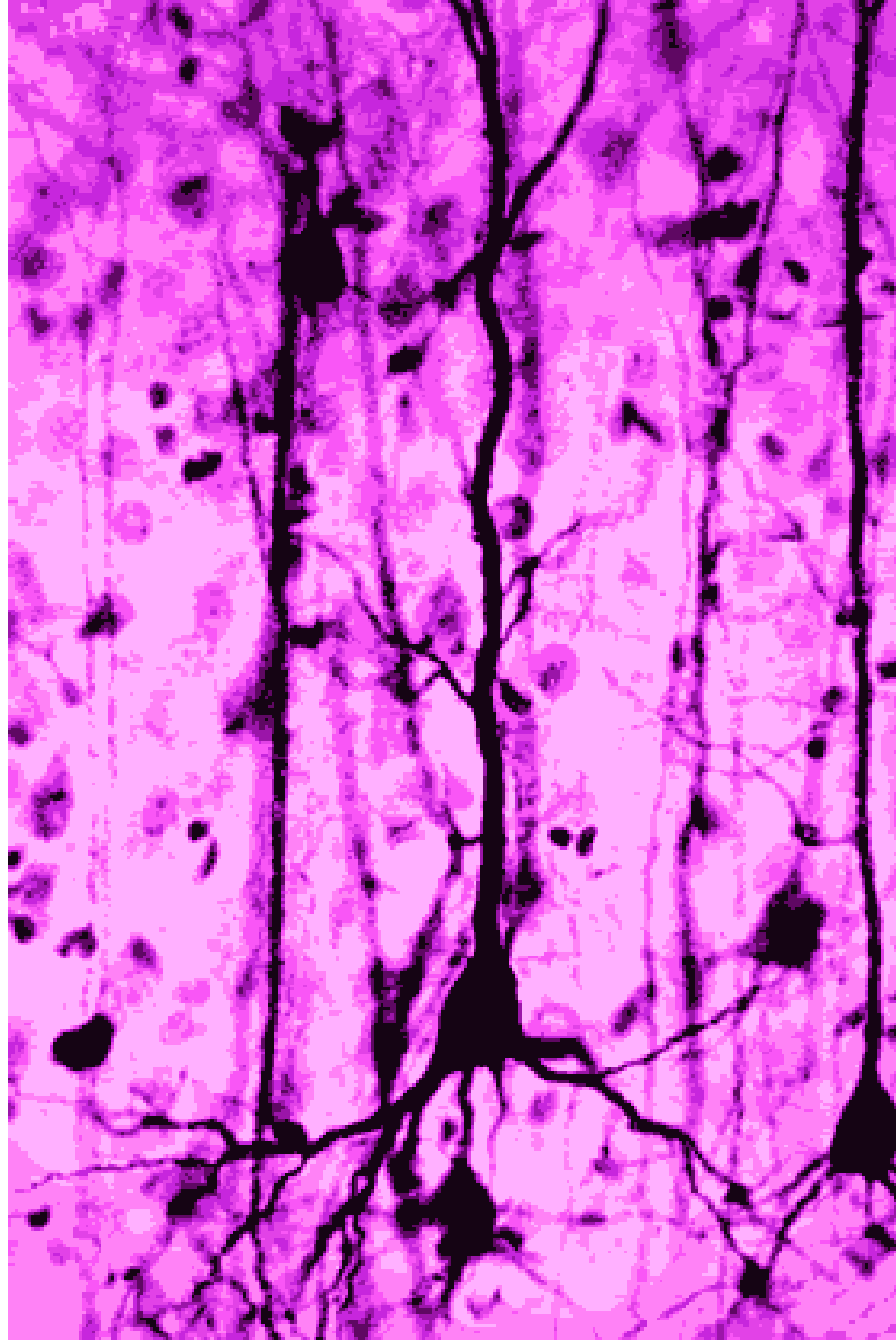
19 $\mu$ m

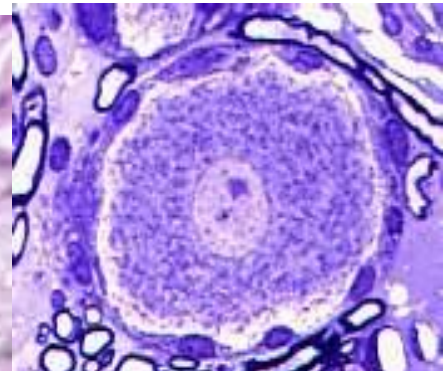
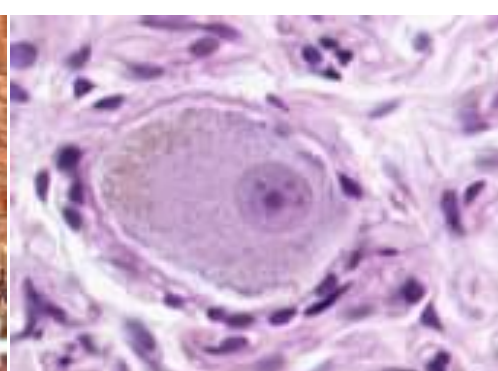
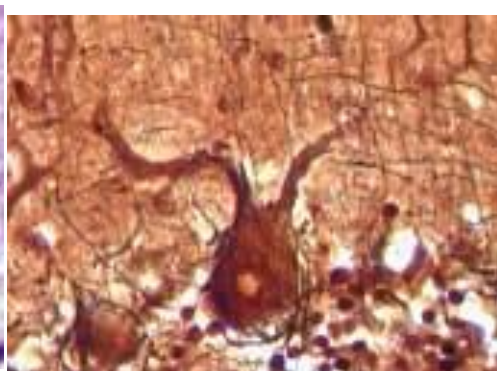
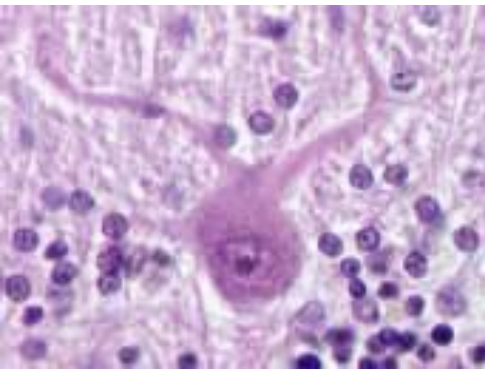
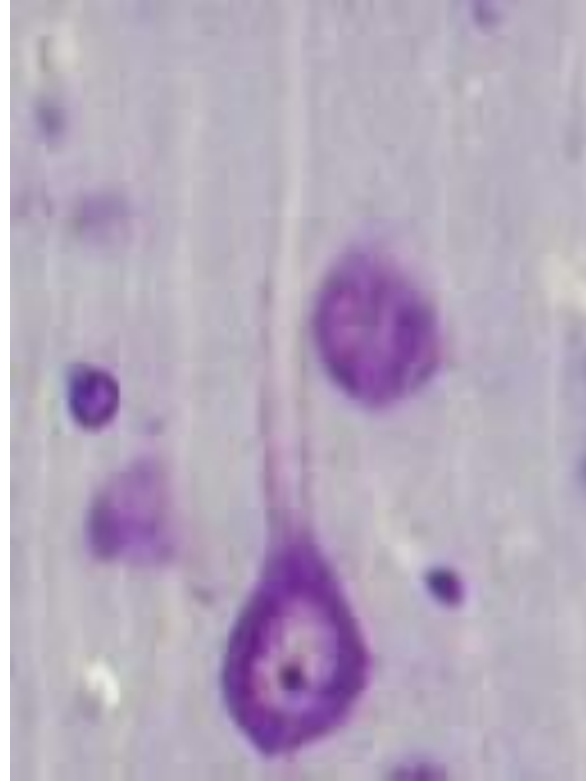


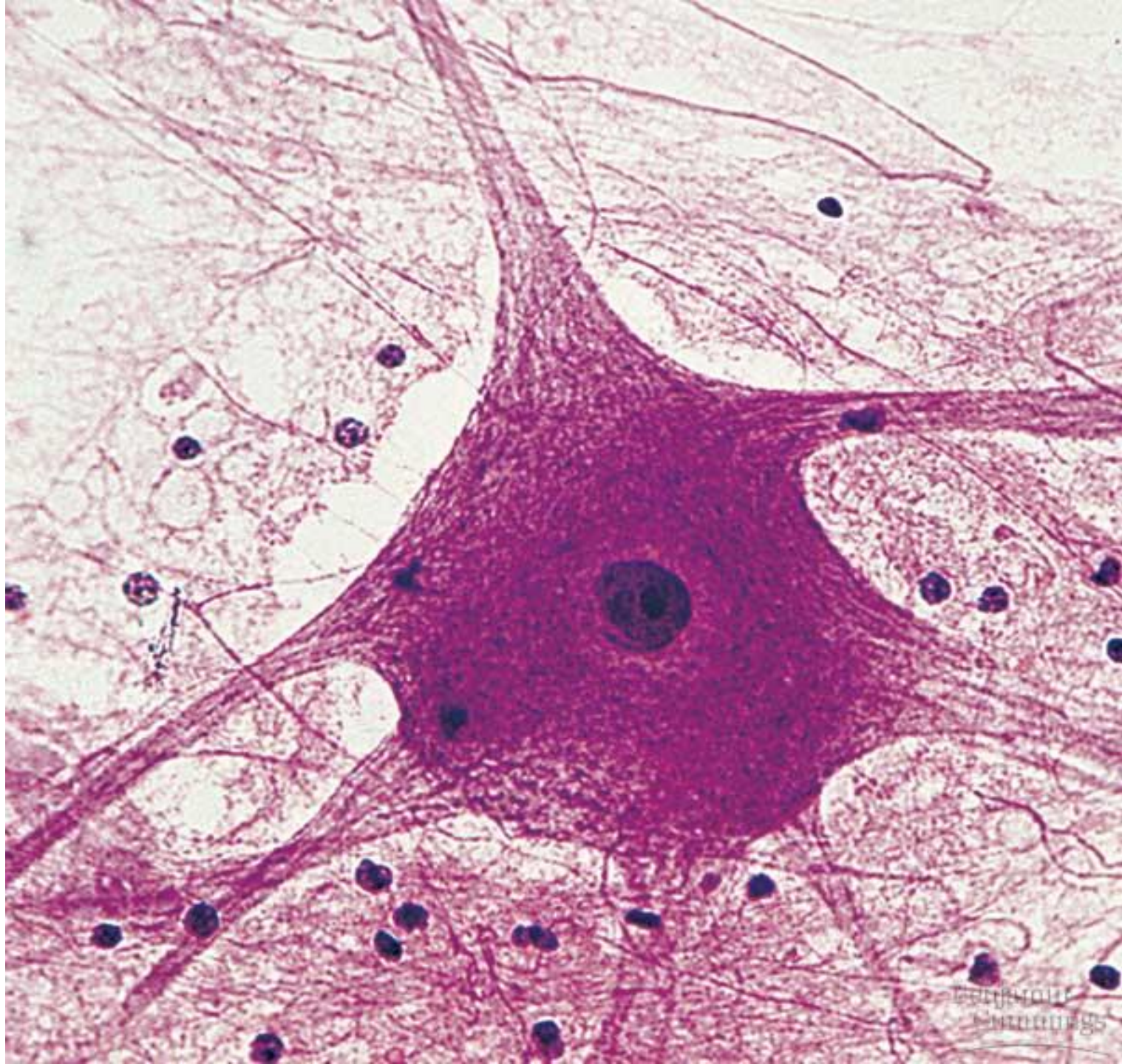




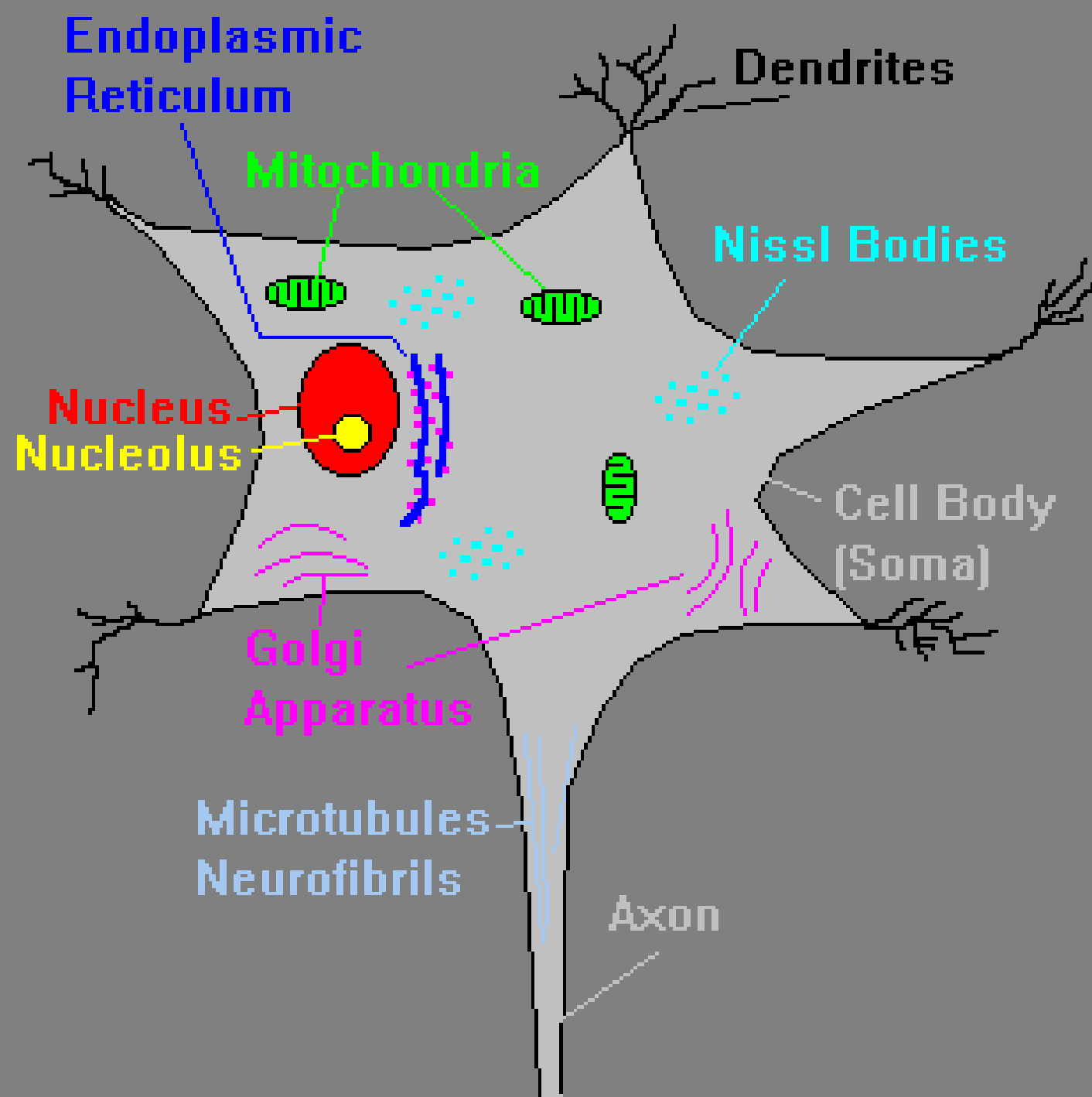












Cell Body  
(Soma)

Presynaptic  
Terminal

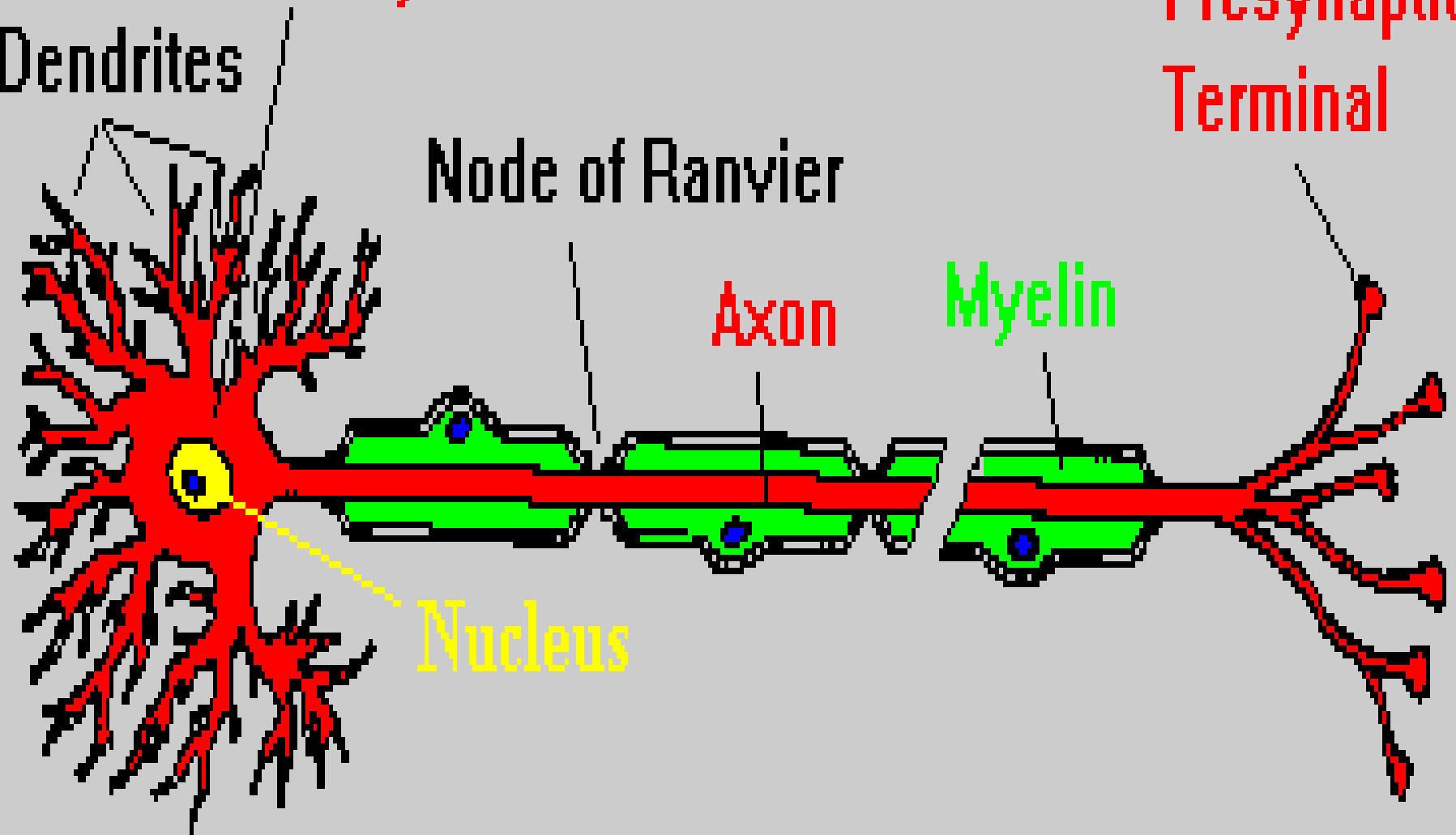
Dendrites

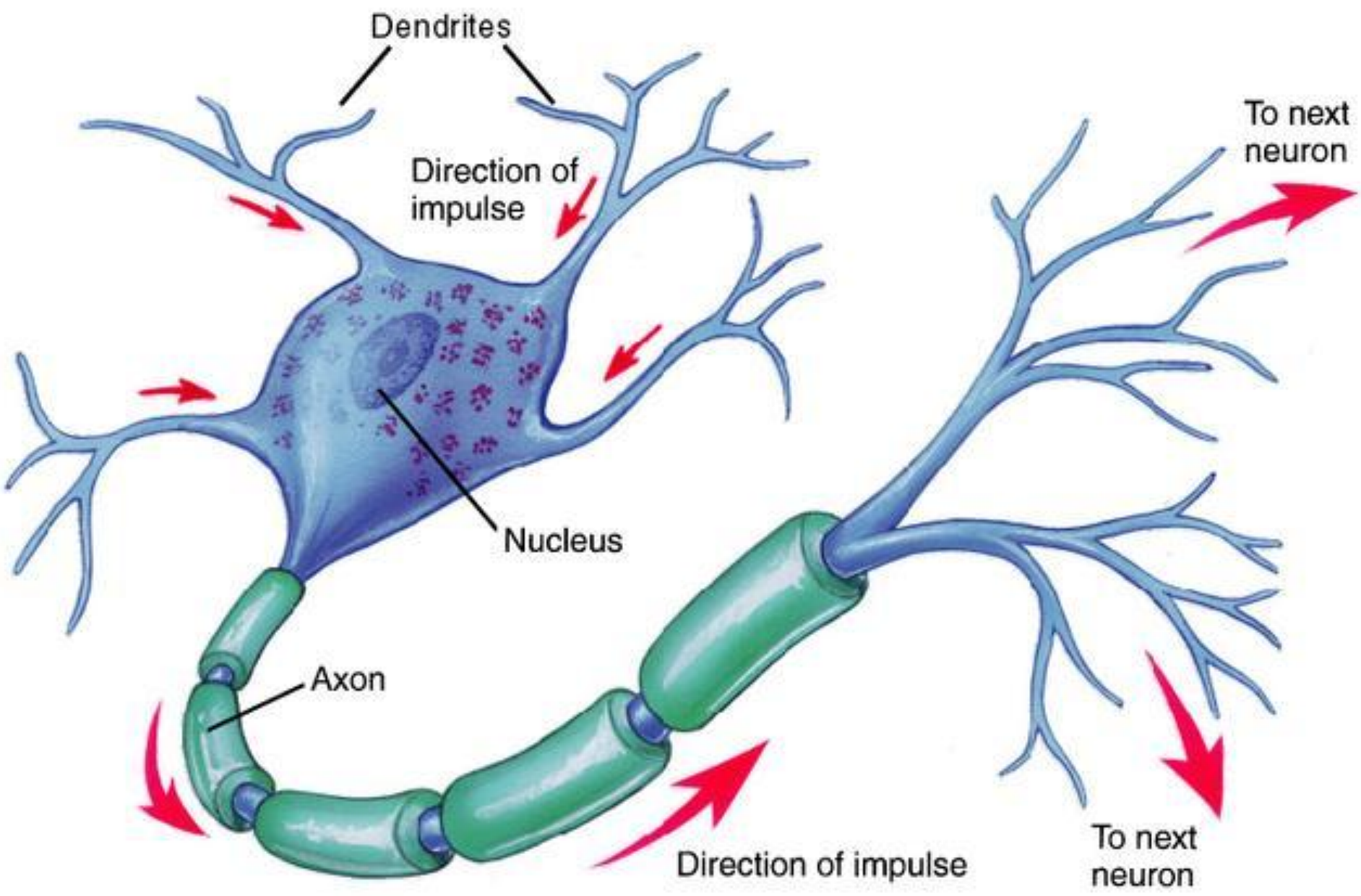
Node of Ranvier

Axon

Myelin

Nucleus

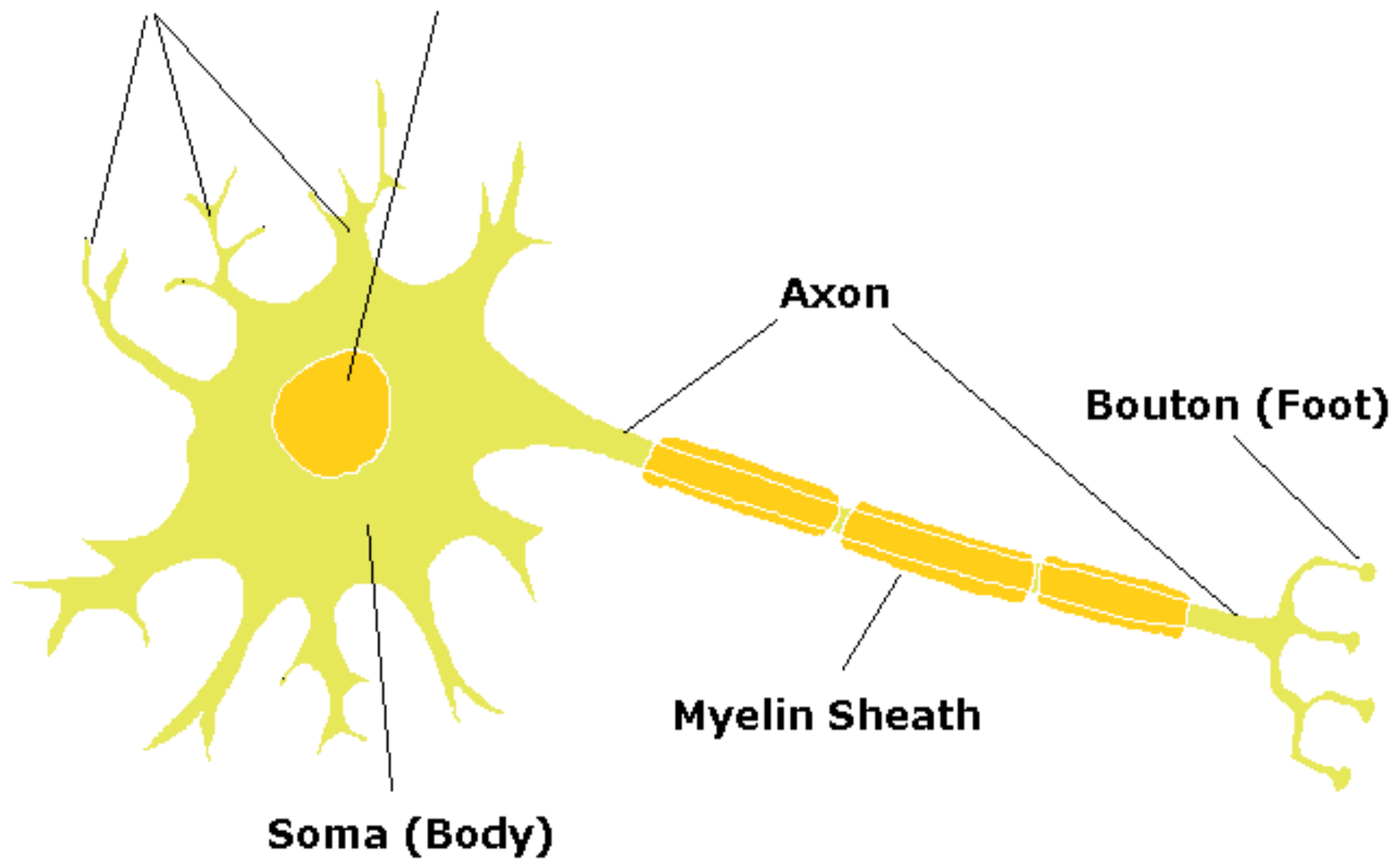




**Dendrites**

**Nucleus**

**A NEURON**



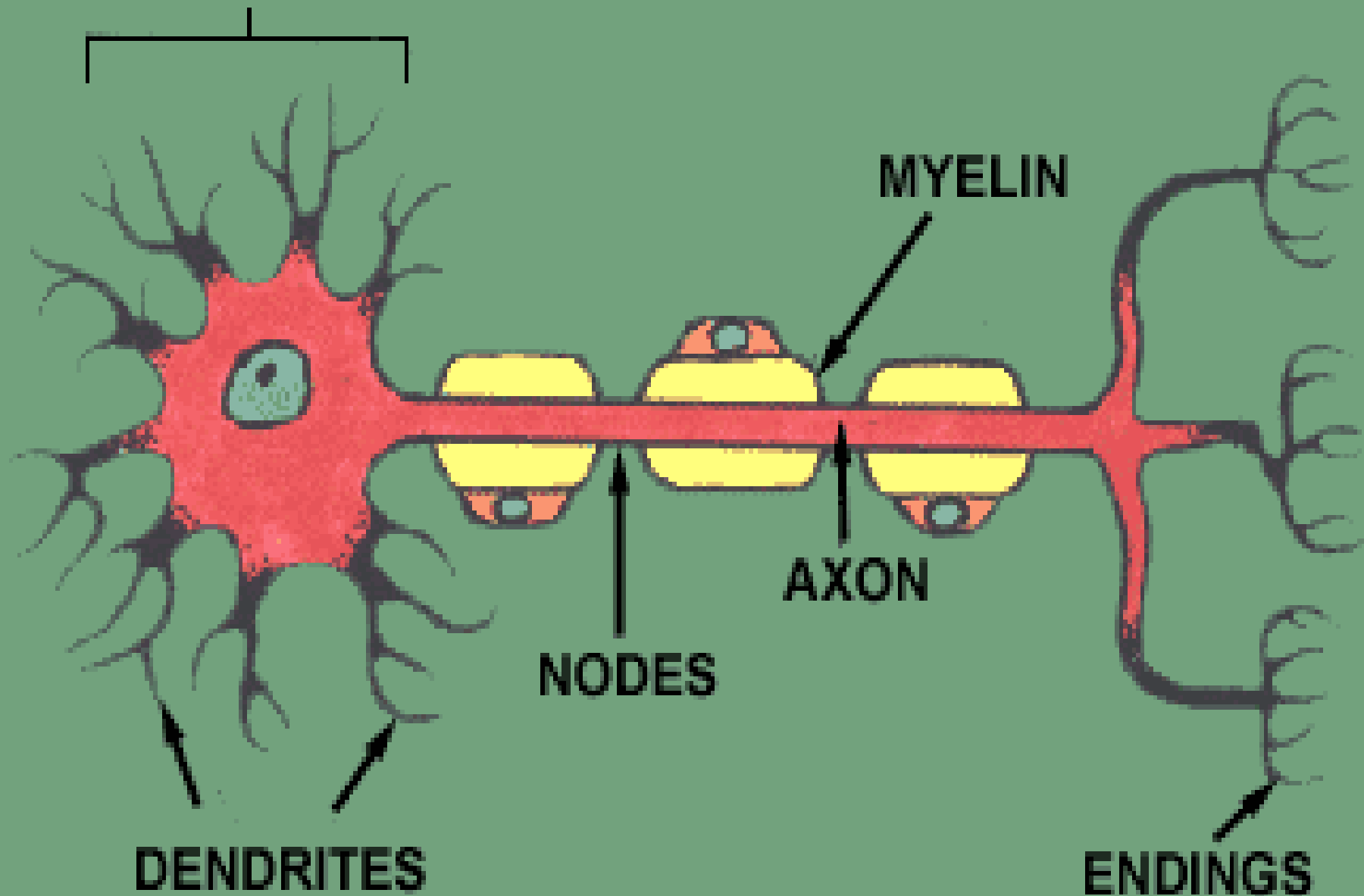
**Axon**

**Bouton (Foot)**

**Myelin Sheath**

**Soma (Body)**

**CELL BODY**



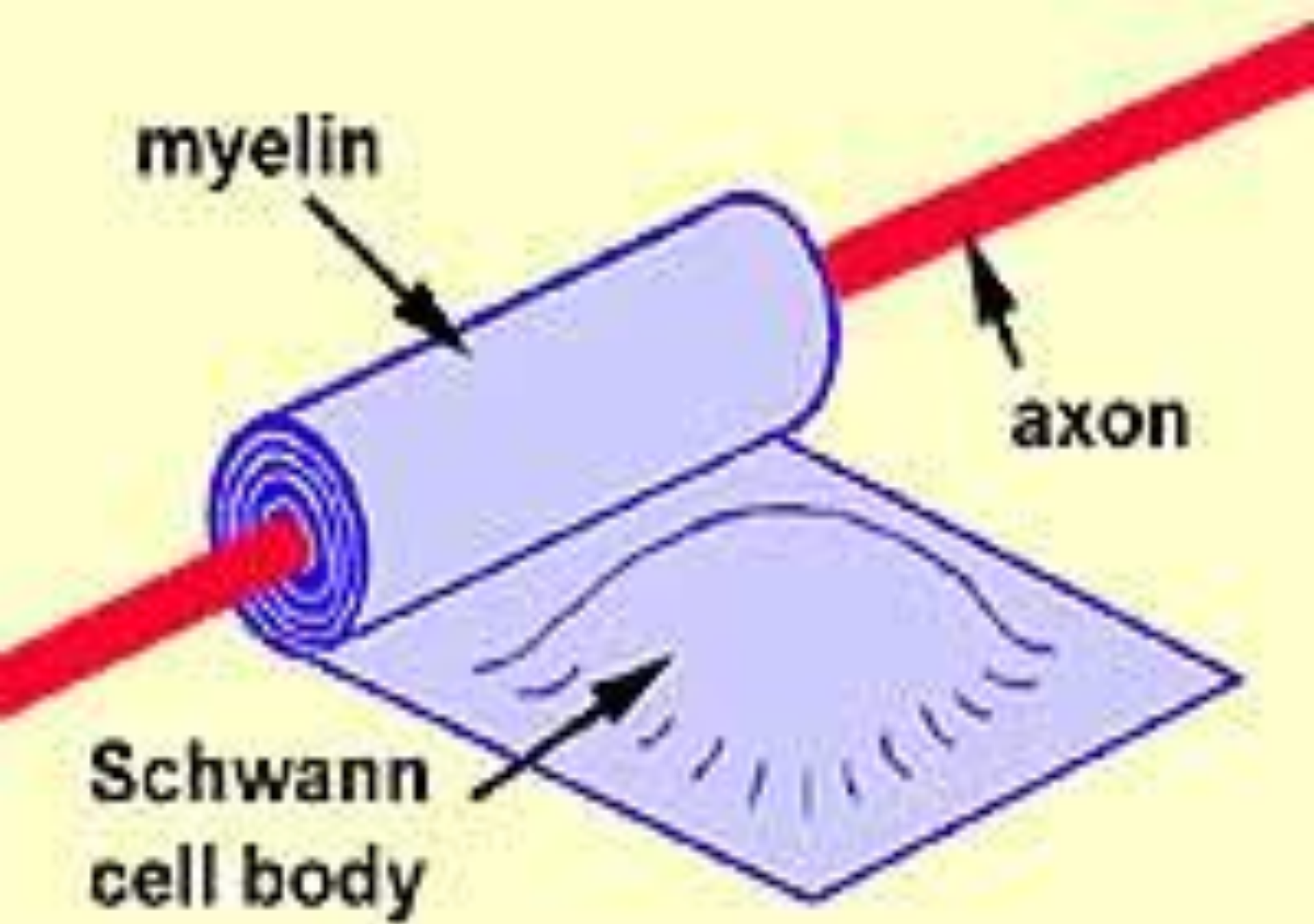
**MYELIN**

**AXON**

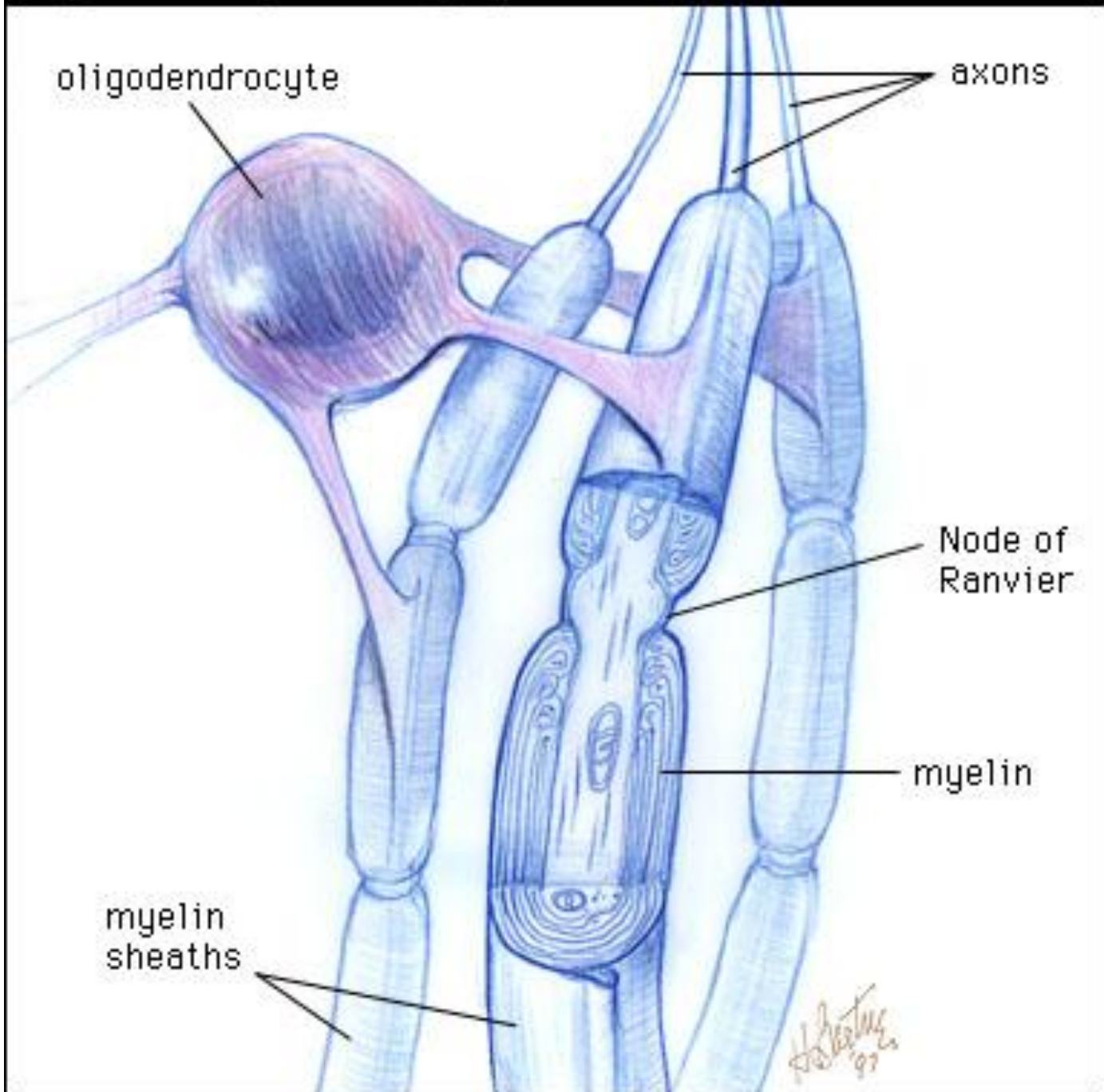
**NODES**

**DENDRITES**

**ENDINGS**



# Oligodendrocyte Making Myelin



oligodendrocyte

axons

Node of Ranvier

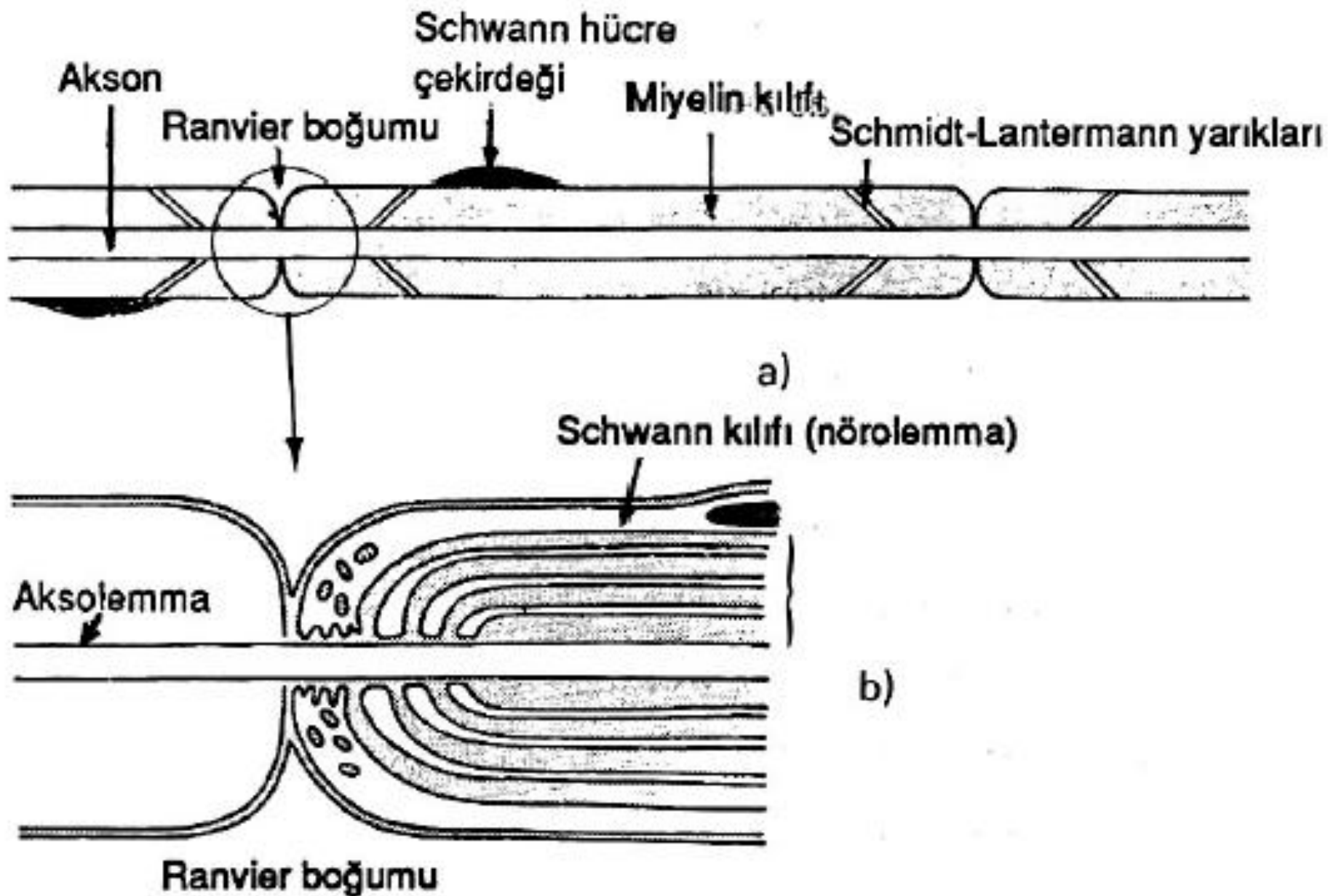
myelin

myelin sheaths

H. H. H. 97

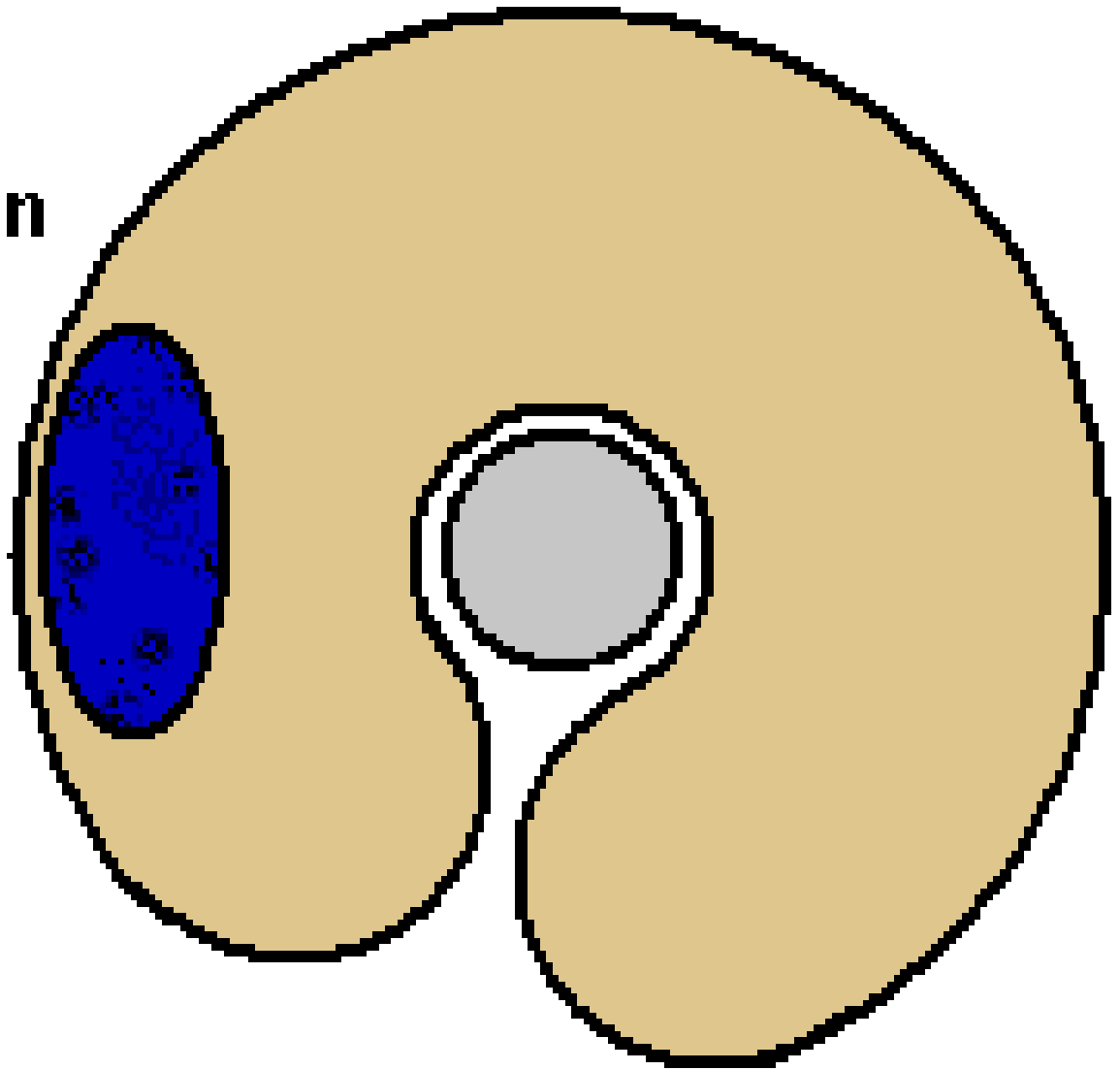


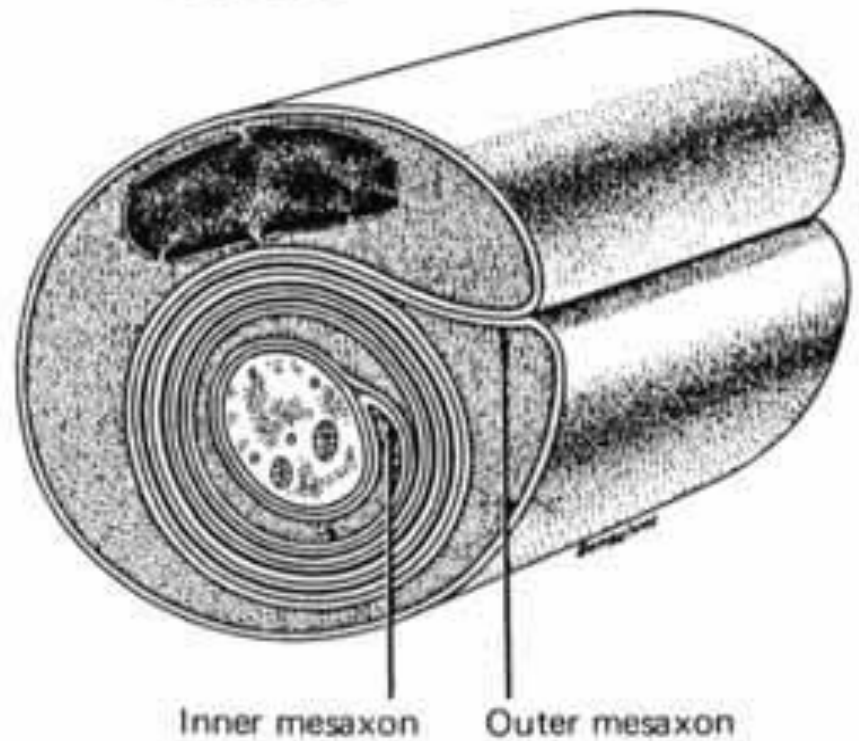
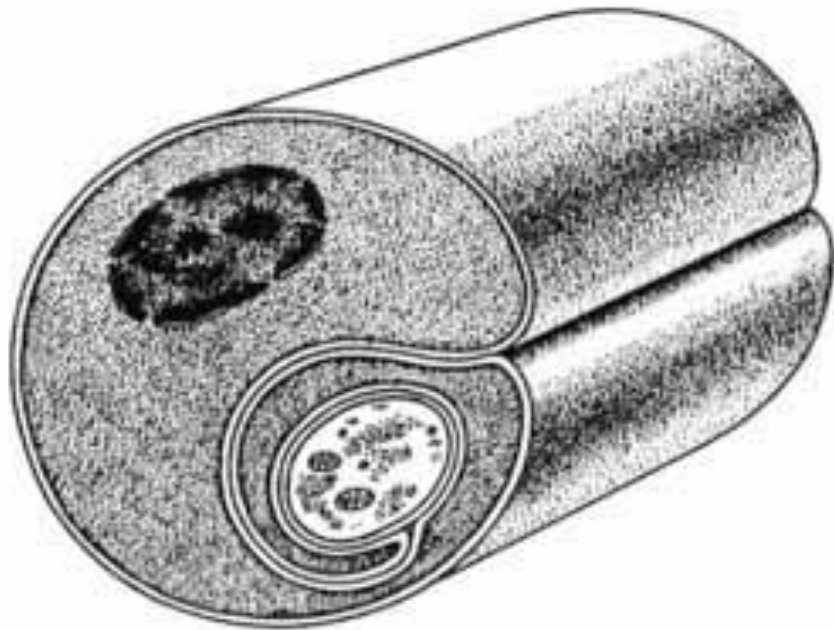
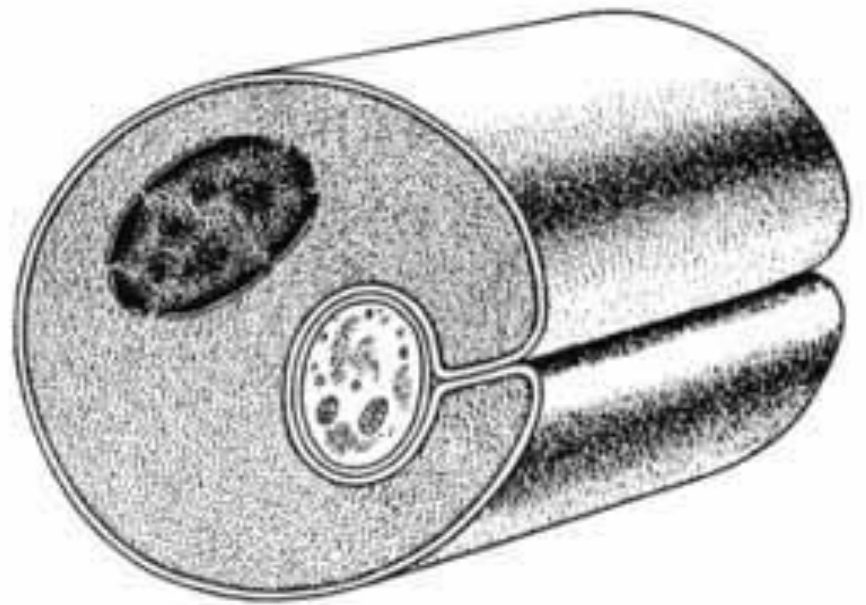
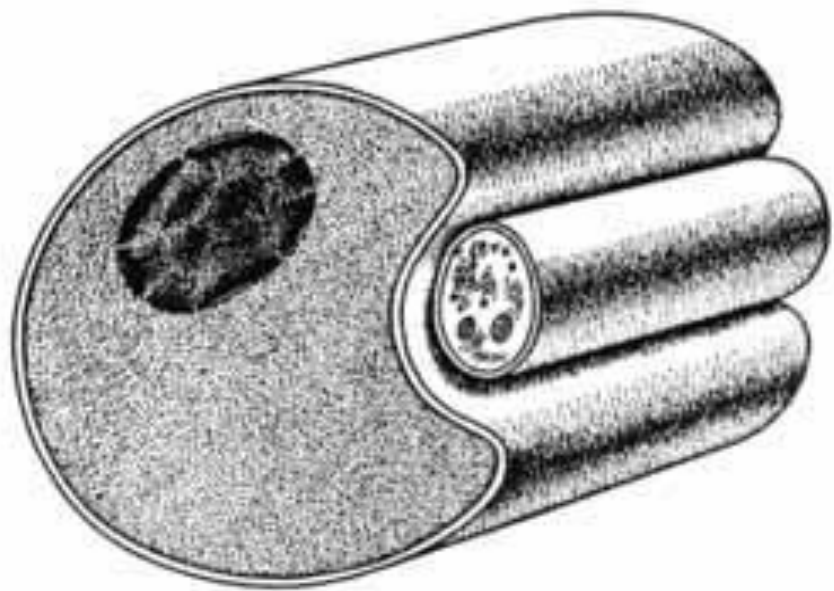




Şekil 9.2: Miyellinli sinir lifi a) Işık mikroskopik şema b) Elektron mikroskopik şema

# Myelination of a peripheral axon

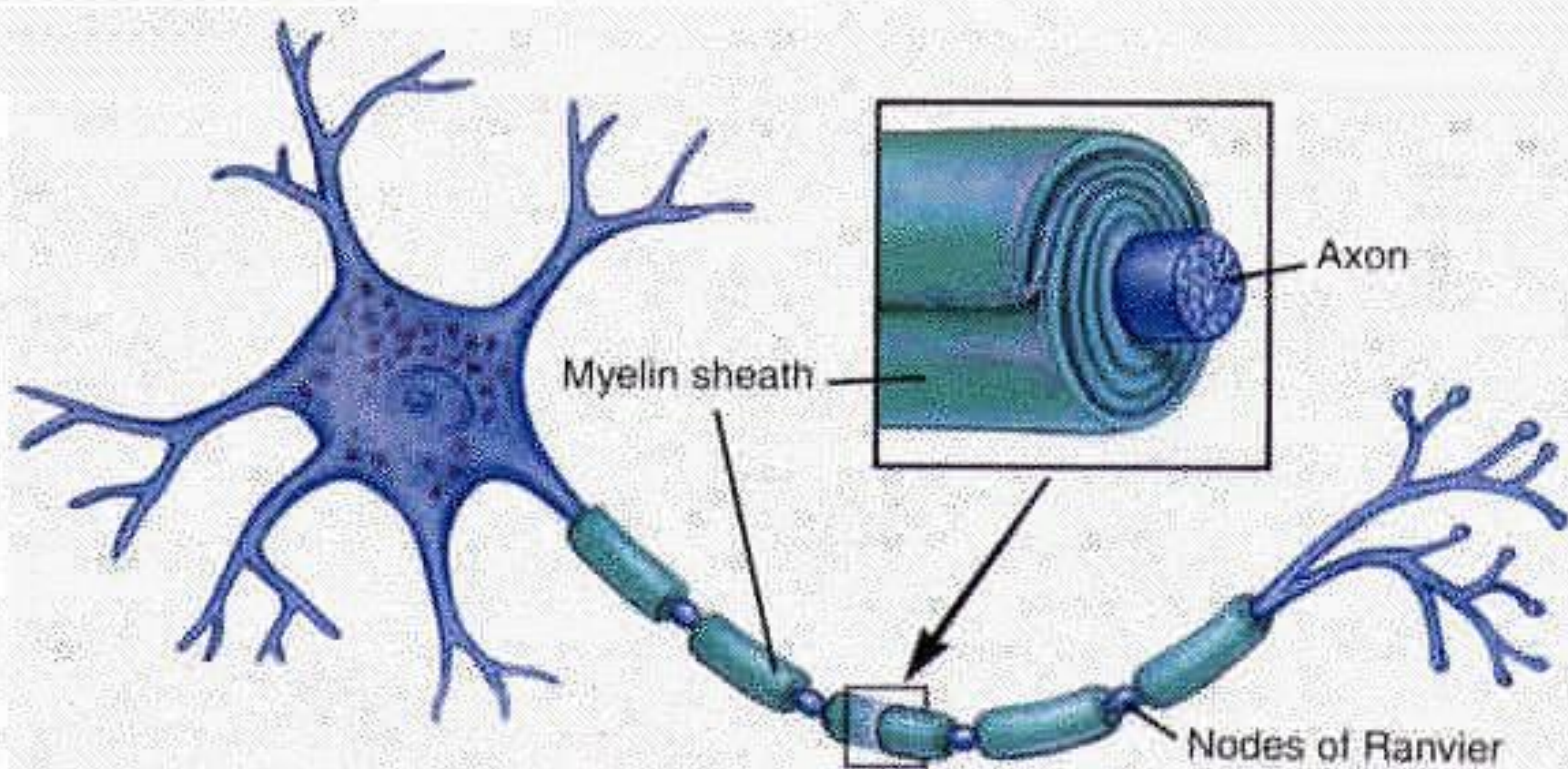




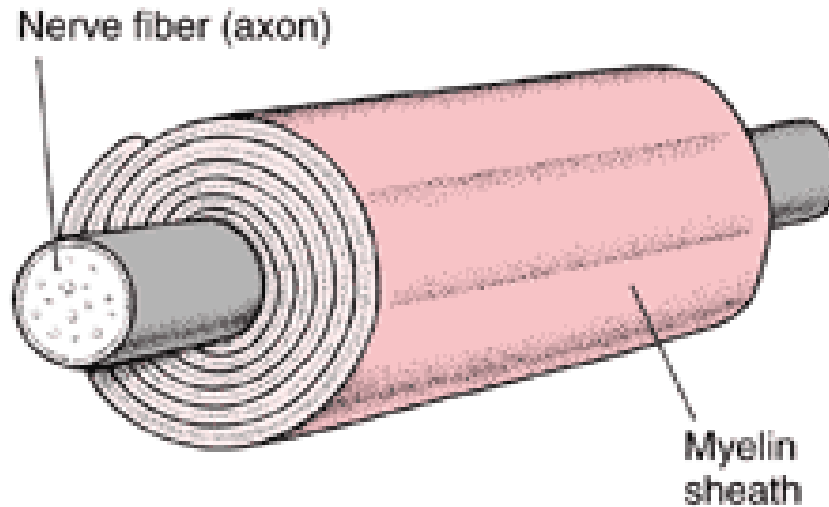
Inner mesaxon

Outer mesaxon

## Myelin Sheath



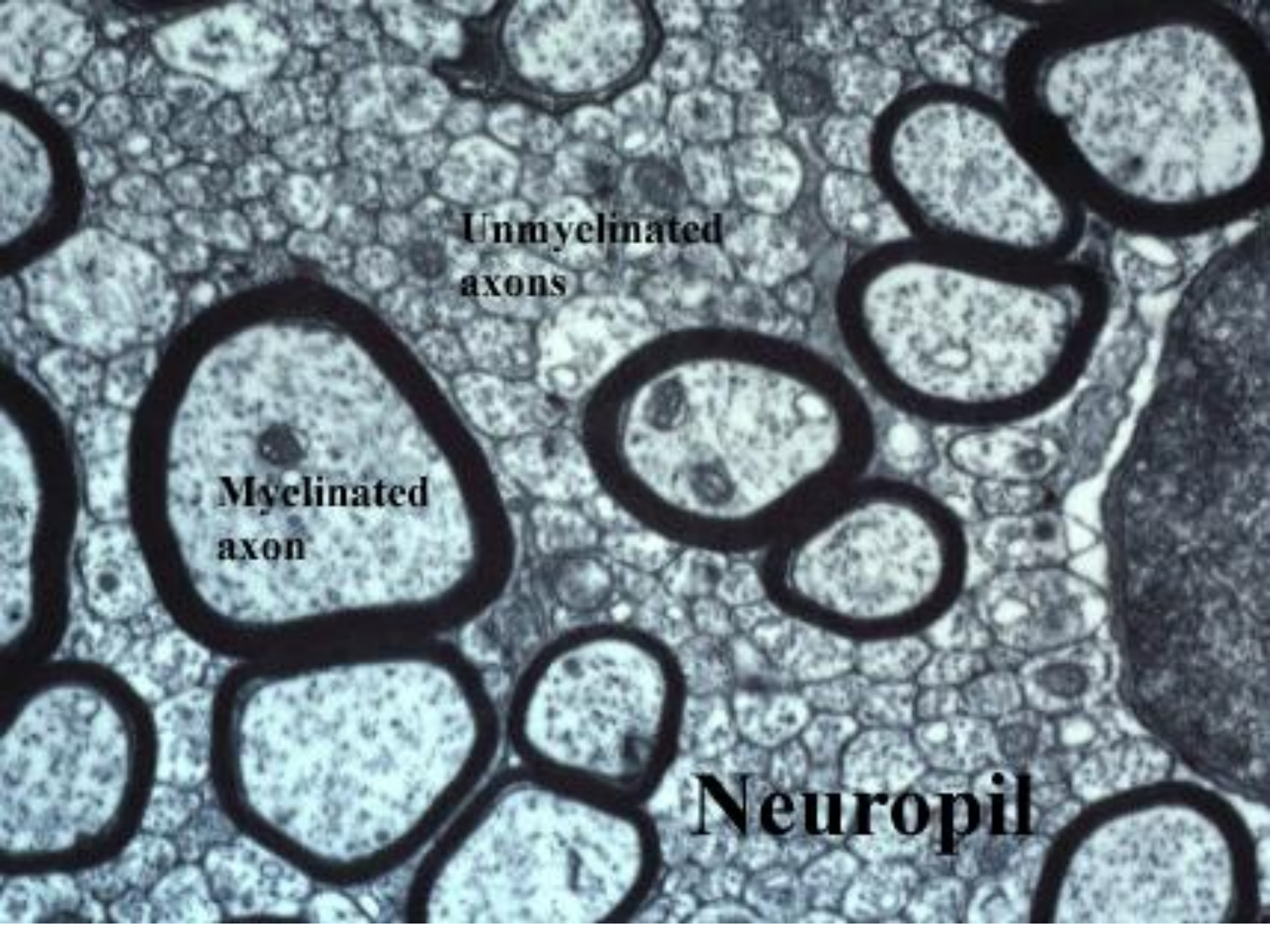
# Insulating a Nerve Fiber



**Normal Myelin Sheath**



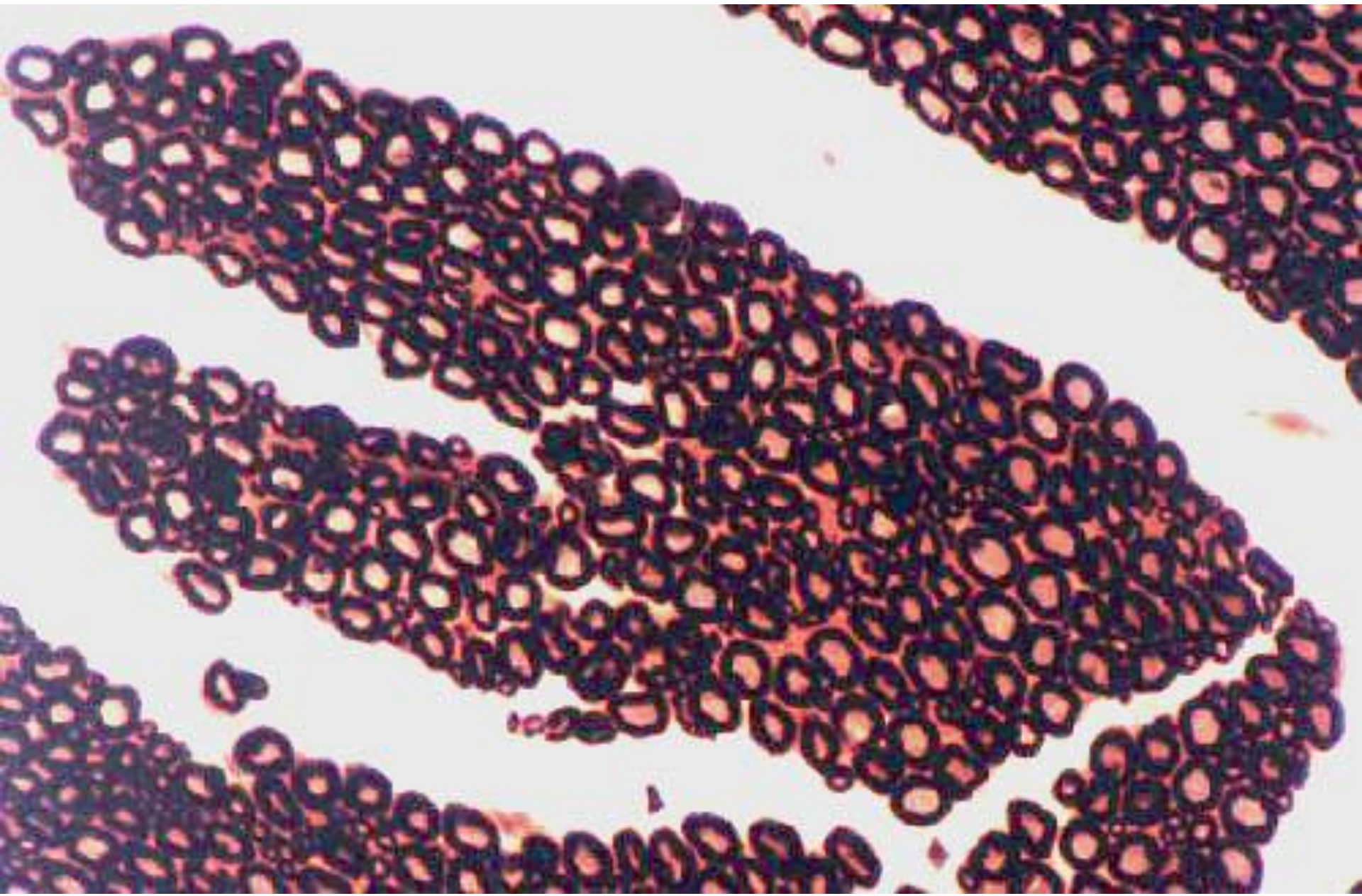
**Damaged Myelin Sheath**

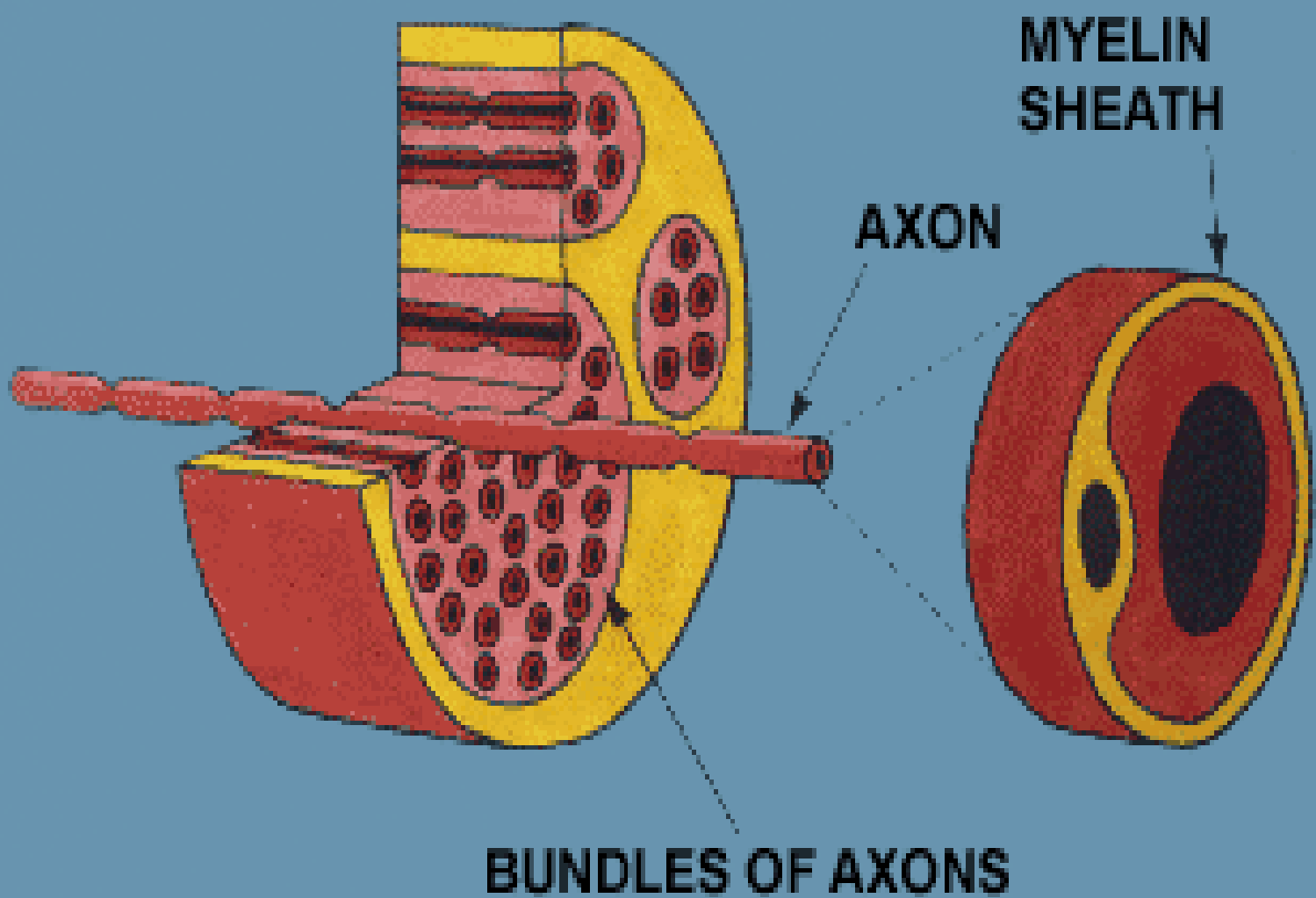


**Unmyelinated  
axons**

**Myelinated  
axon**

**Neuropil**





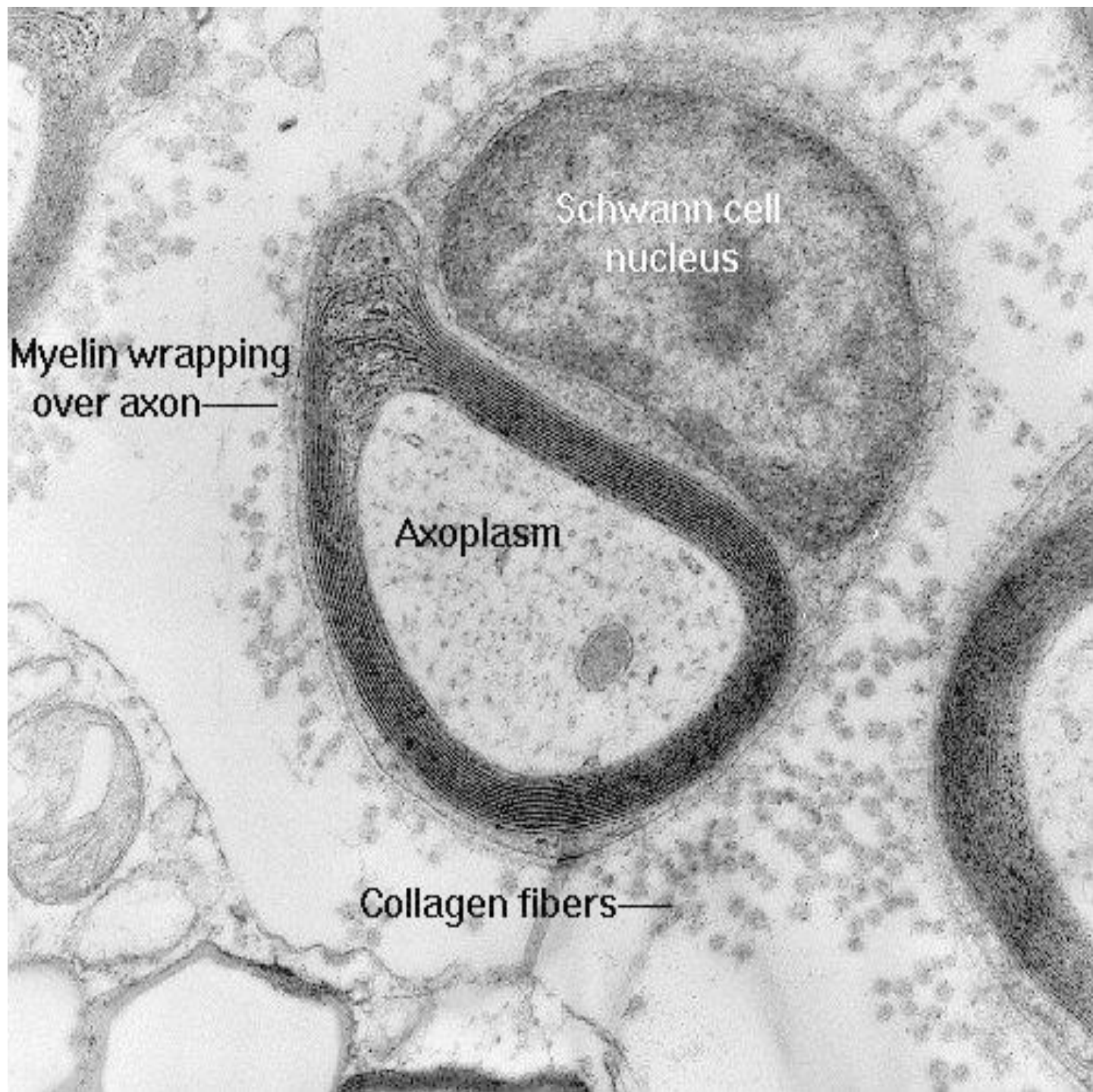
MYELIN SHEATH

AXON

BUNDLES OF AXONS







Schwann cell  
nucleus

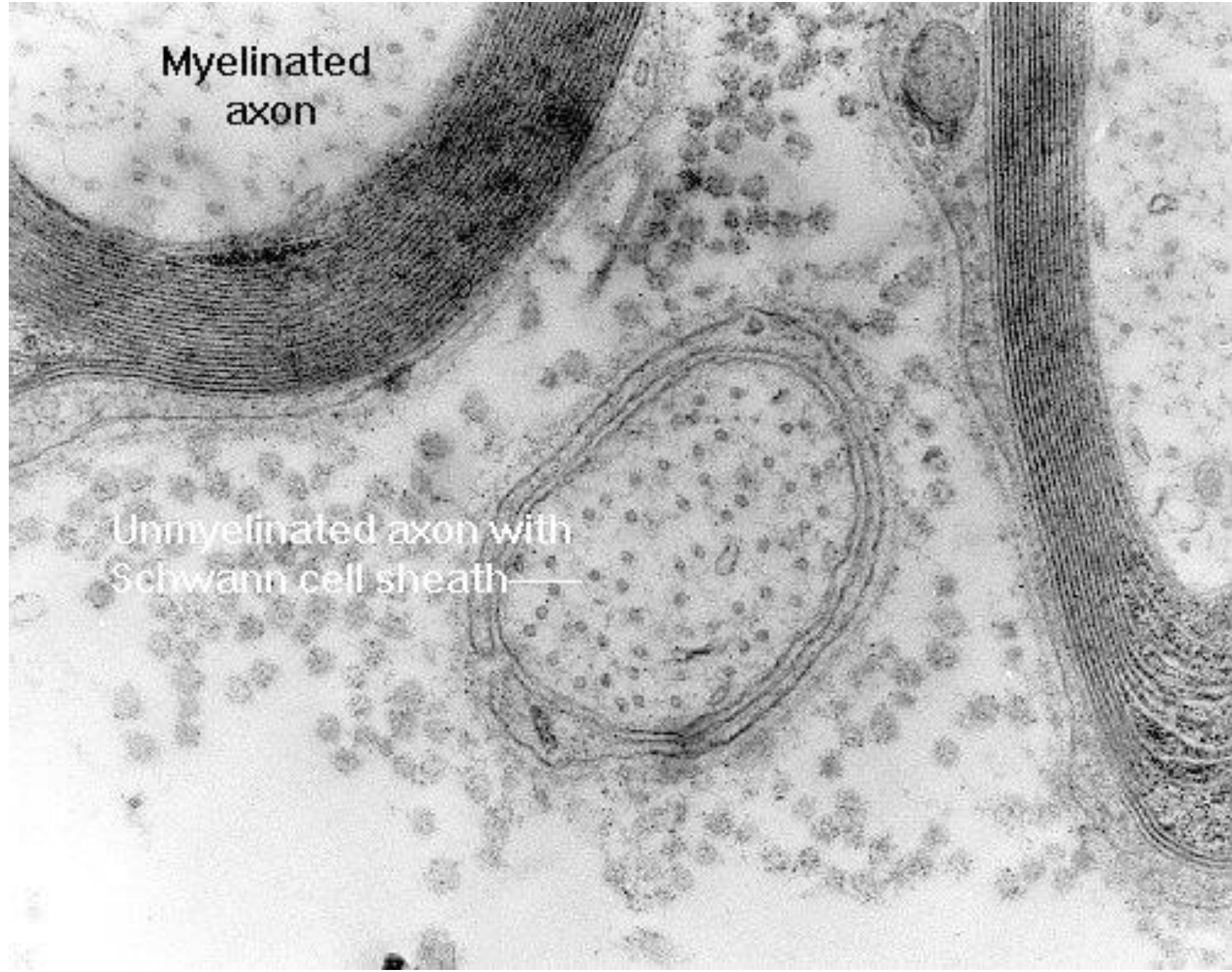
Myelin wrapping  
over axon—

Axoplasm

Collagen fibers—

Myelinated  
axon

Unmyelinated axon with  
Schwann cell sheath



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Photo: Prof. H. Vahlensieper

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100 nm

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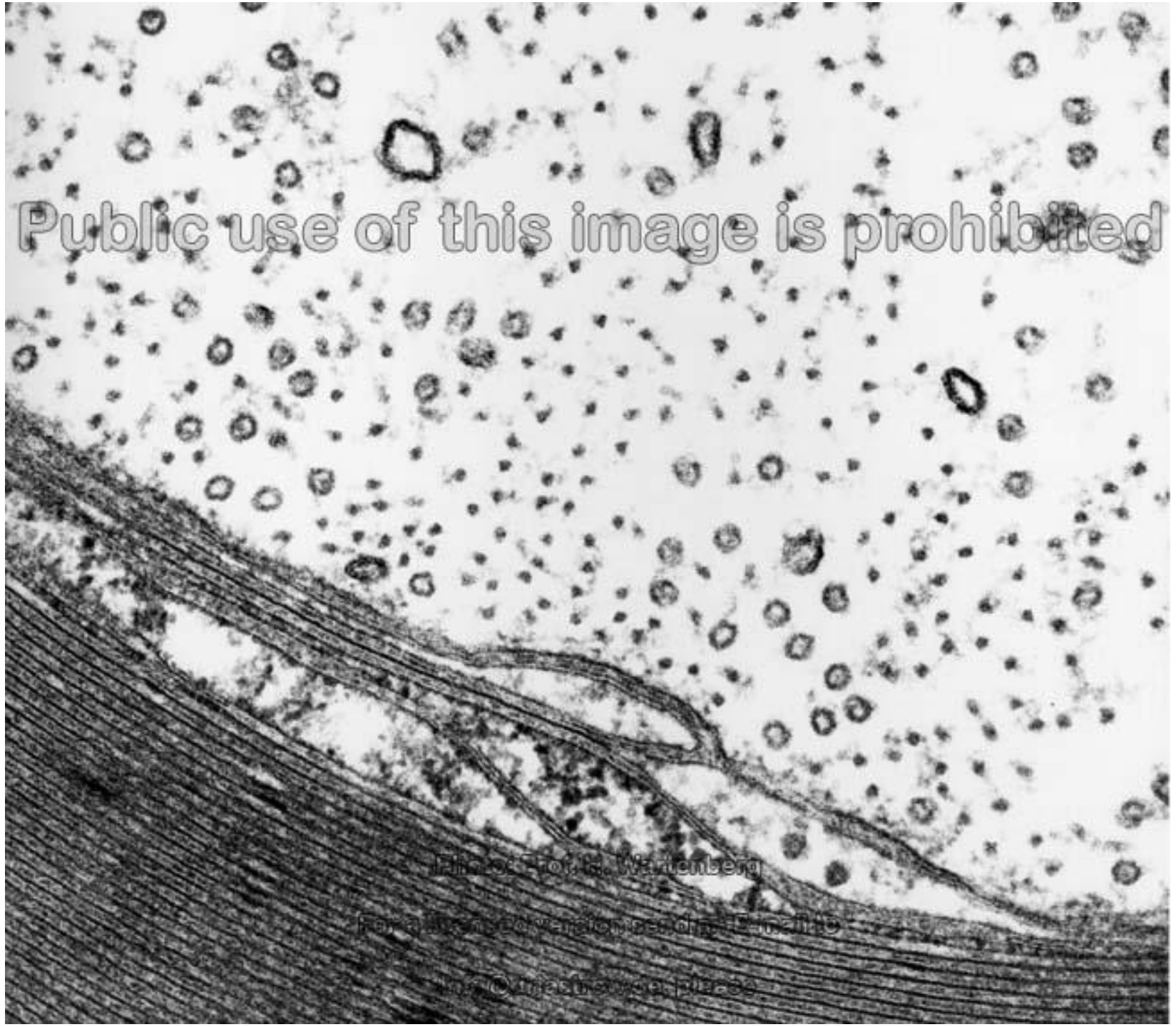
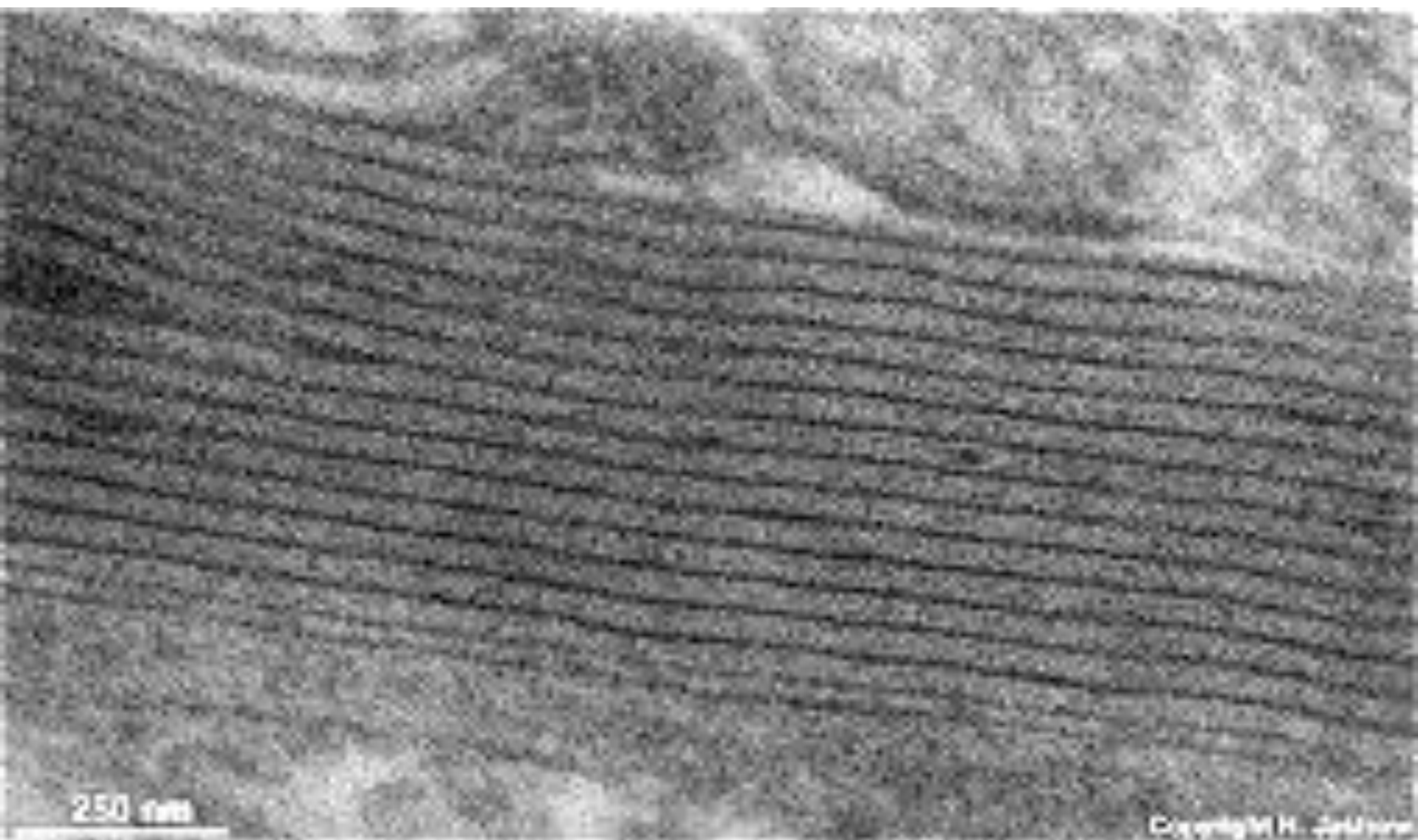
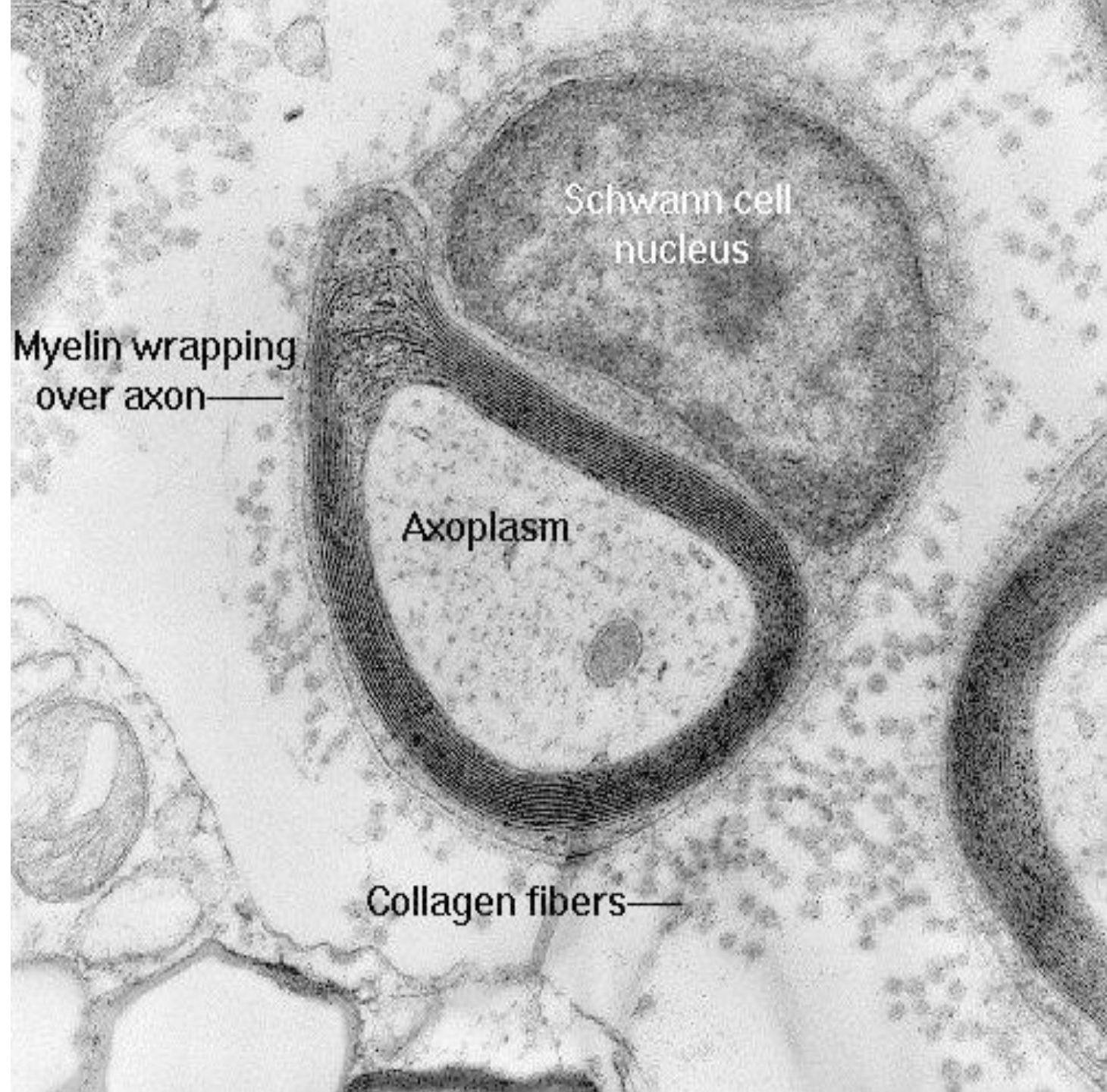


Photo of Prof. H. Wartenberg

Paradise of various bending 15.11.10

The Ornstein-Zernike



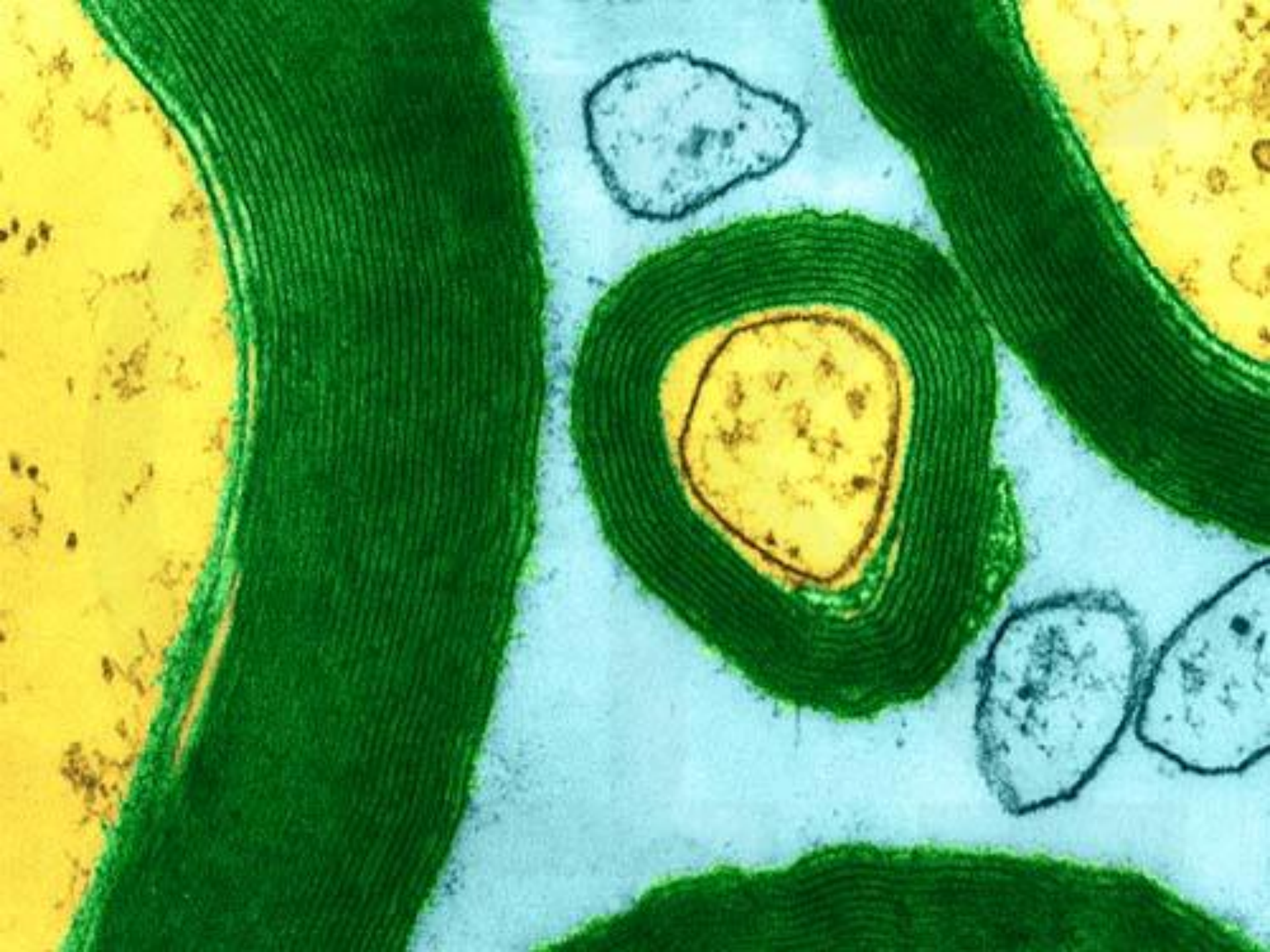


Schwann cell  
nucleus

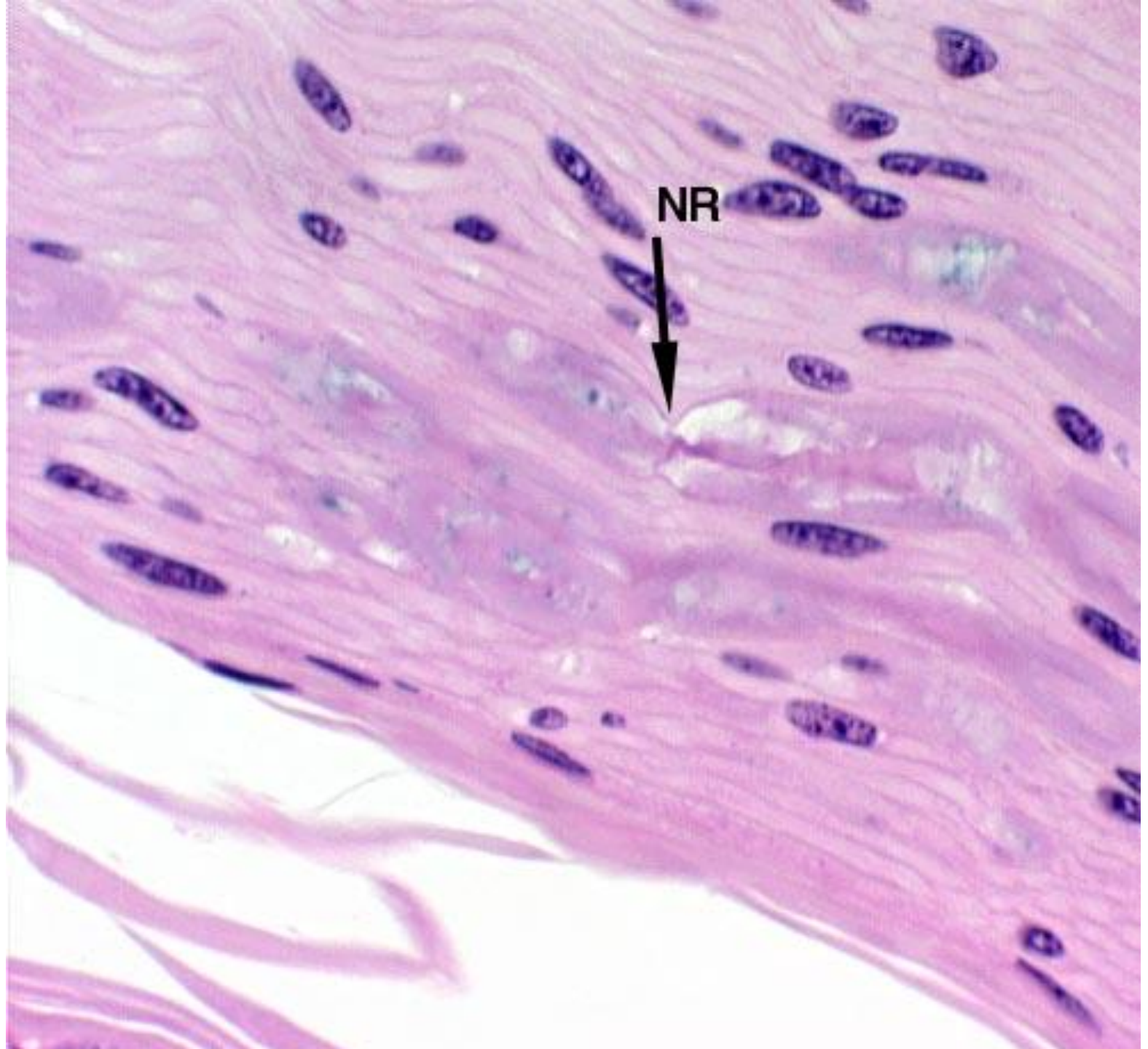
Myelin wrapping  
over axon—

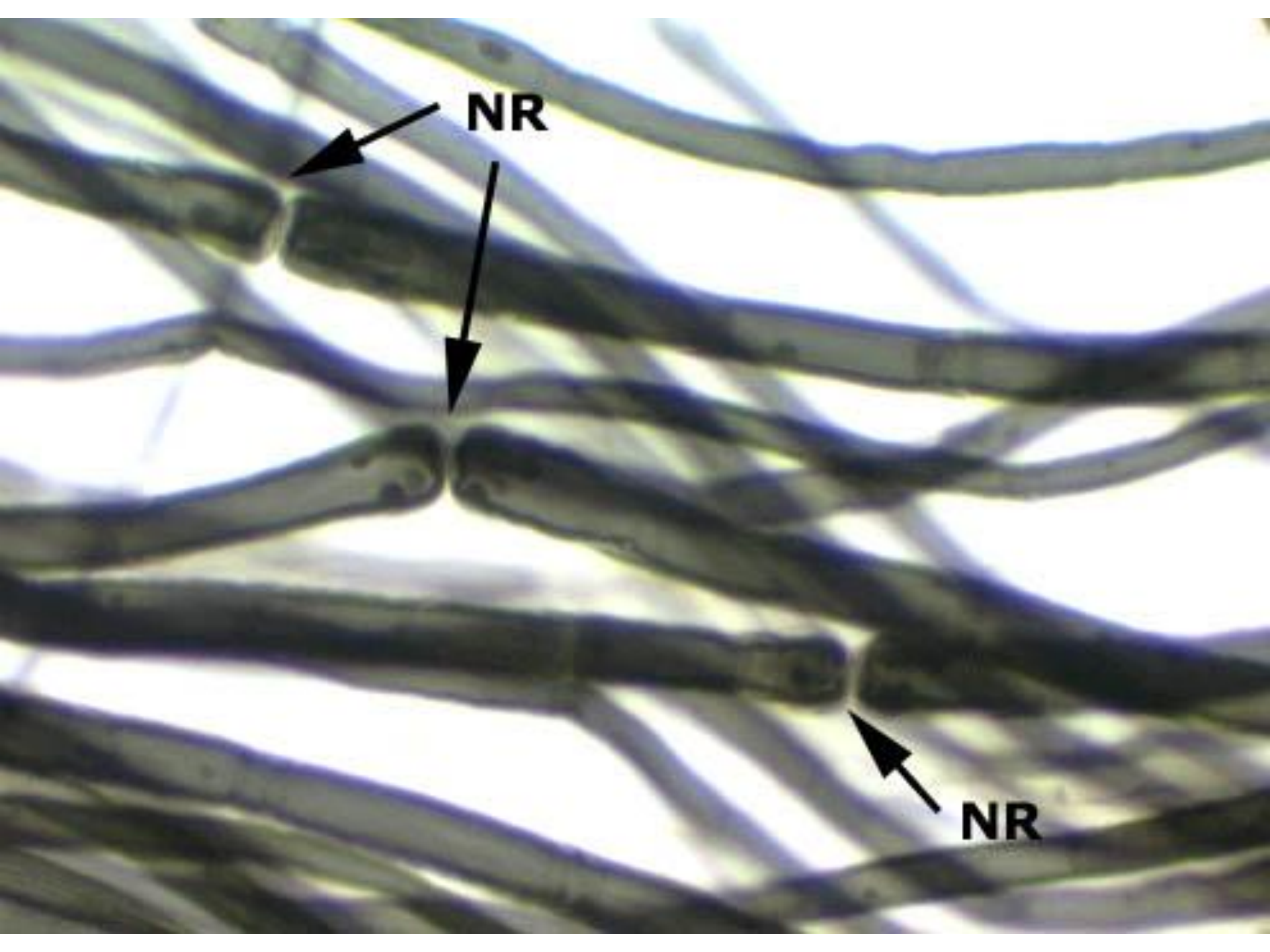
Axoplasm

Collagen fibers—









**NR**

**NR**

Node of Ranvier  
Osmium stained



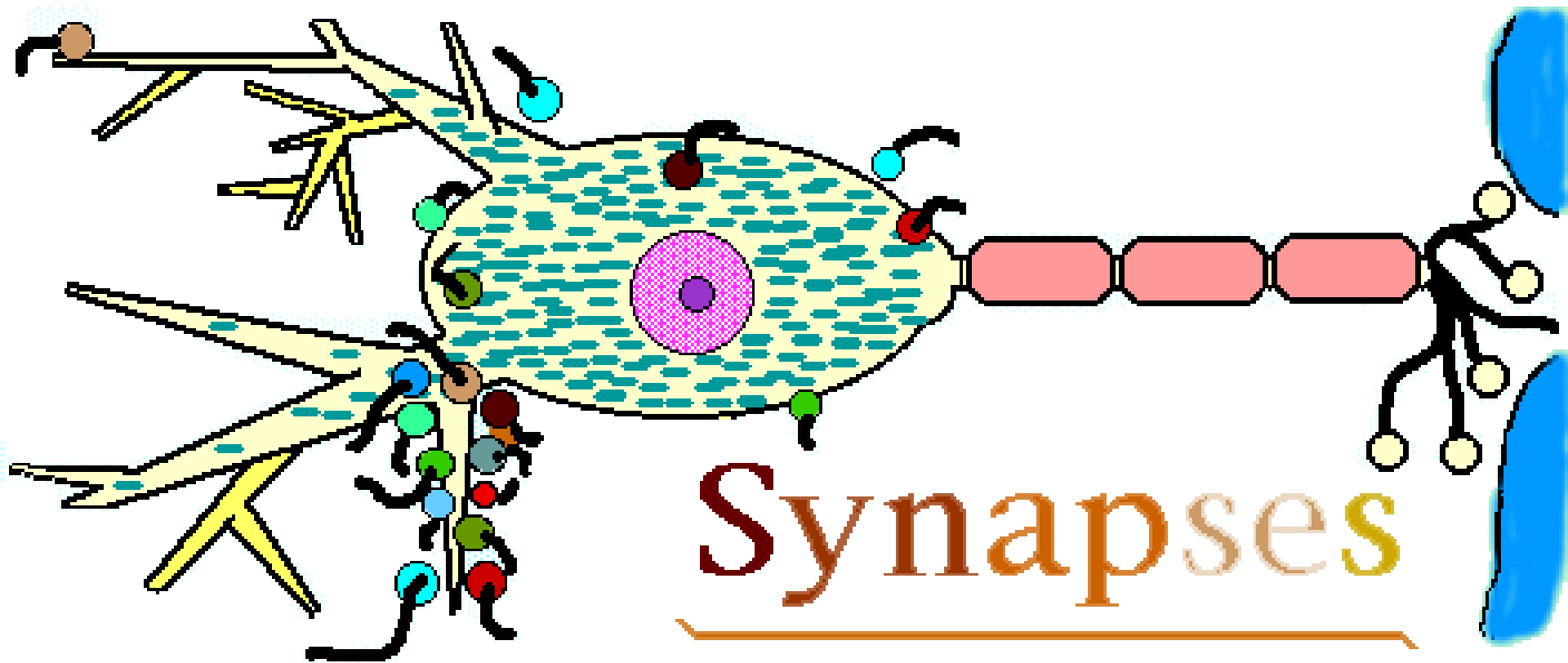


■ **Sinir Lifleri** : Yukarıda anlatıldığı gibi miyelin kılıfı ve schwann hücre kılıfı (nörolemma) ile sarılmış her bir aksona sinir lifi denir (Şekil 9.1 ve Resim 9.8). Buna göre miyelin kılıfı olanlar **miyelinli sinir lifleri** miyelin kılıfı olmayanlar ise **miyelinsiz sinir lifleri** olarak isimlendirilir. Miyelinli sinir lifleri (Şekil 9.2), merkezi sinir sisteminde nörolemma içermezler ve bu sistem organların beyaz cevherini şekillendirirler. Periferik sinir sisteminde ise periferik sinirleri yaparlar. Bu lifle-

Embriyoda bütün sinir lifleri önce miyelinsizdir. Erişkinlerde ise bütün miyelinli sinir lifleri başlangıç ve sonlanma bölgelerinde miyelinsizdirler (Şekil 9.3). İskelet kasları sinir fibrilleri kalın (yaklaşık 20 mikron) ve miyelinlidirler. Düz kasların sinir fibrilleri ise ince (1 mikron), çok az miyelinli ya da miyelinsizdirler. Miyelinli sinir fibrilleri (A lifleri) çok hızlı iletim (saniyede 15-100 metre) yaparlar. Özellikle otonom sinir sistemi sempatik bölümünde çok gözlenen ince ve miyelinsiz sinir fibrilleri ise (C lifleri) sinir impulslarının iletiminde oldukça yavaşlardır (saniyede 0.5-2 metre). Bir miktar miyelin içeren küçük çaplı sinir fibrillerinin (B lifleri) iletim hızı da saniyede 3-14 metredir.

■ **Akson sonlanması (Sinapslar)** : Sinir dokusunun organizmada üst düzeyde ve diğer dokuların canlılığı devam ettirecek düzeyde çalışmalarını sağlayabilmesi için kendi hücreleri arasında da entegre bir düzen gerekmektedir. İnsan merkezi sinir sisteminde yaklaşık 10 milyar nöron ve 50 milyara yakın da bunlara yardımcı nöroglia hücresi bulunur. Uzantıları aracılığıyla bunların birlikte yaptığı ağırsı kompleks yapı (nöropil) ile olağanüstü bir koordinasyon sağlanır. Örneğın beyin korteksi tek bir piramidal nöronunda bile 10.000'den fazla başka nöronla bağlantı bulunur. Medulla spinalis ön boynuz motor nöronlarında ise 1800 kadar başka nöronun sonlanması vardır. Bir telefon santrali karmaşası ve kompleks yapısındaki bu bağlantılar, genellikle sinir hücresinin uzantılarından aksonun bir diğeri nöronun perikaryonu (akso - somatik) ya da dendriti (akso - dendrik) üzerinde **sinaps** (Şekil 9.4) adı verilen yapı ve fonksiyondaki bağlantı noktaları şeklinde sonlanması ile gerçekleşir. Sinapslar daha ender olarak dendro - aksonik, dendro - dendrik, somoto - dendrik, somoto - somotik ya da akso - aksonal da olabilmektedir. Ayrıca son yıllarda aksonunun, kas, bez hücresi gibi efektör yapılarındaki sonlanmaları da sinaps olarak değerlendirilmektedir.

Sinapslarda hem uyarıyı götüren nörona (örneğin aksonunun son kısmı), hem de uyarıyı alan nörona ait (örneğin dendritinin yüzeyi) kısımlar bulunur. Bu kısımlar membran yapılarıdır (aksolemma, dendrolemma gibi) ve şişkinlikler halinde sonlanan aksonun membranına **pre-sinaptik membran**, uyarıyı alacak olan hücrelerin membranına **postsinaptik membran**, ikisinin arasındaki 200 - 300 Angstron'lık aralığa **sinaps aralığı** denir. Bu aralıktan dolayı aksonla gelen uyarılar doğrudan diğer hücreye geçemezler. Şişkinlikle sonlanan aksonun sitoplazmasında bol mitokondri ve **sinaptik vesikül** bulunur (Şekil 9.4). Sinaptik vesiküllerde bulunan nörotransmitter madde veya kimyasal mediyatör adı verilen uyarıcı maddeler, uyarı sonucu sinaps aralığına dökülür. Bu maddelerin postsinaptik membrana ulaşması ile membranın iyonlara karşı geçirgenliği değişir ve elektriksel membran polarizasyonu değişerek uyarı diğer hücreye iletilmiş olur. Sinapta bulunan bol mitokondriler ileti sırasında gereken enerjinin oksidatif fosforilasyonla karşılanmasında ve K, Na, H iyon konsantrasyonunun sağlanmasında iş görürler. Asetil kolin, katekolaminler (adrenalin, noradrenalin ve dopamin) ile GABA (Gamma aminobutirik asit), glutamik asit, serotonin, glisin, bazı nörotransmitterlerdir. Ayrıca son yıllarda endorfinler, VIP (vazoaktif intestinal peptit), bombasin, histamin ve nörotransmitter etkili bulunmaktadır. Bu nörotransmitterler postsinaptik membrandaki reseptörün cinsine göre inhibitör ya da eksitatör etki gösterirler.





Akson son bölümü

Nörofibriller

Mitokondri

Sinaptik vesikül

Intersinaptik fibrilcikler

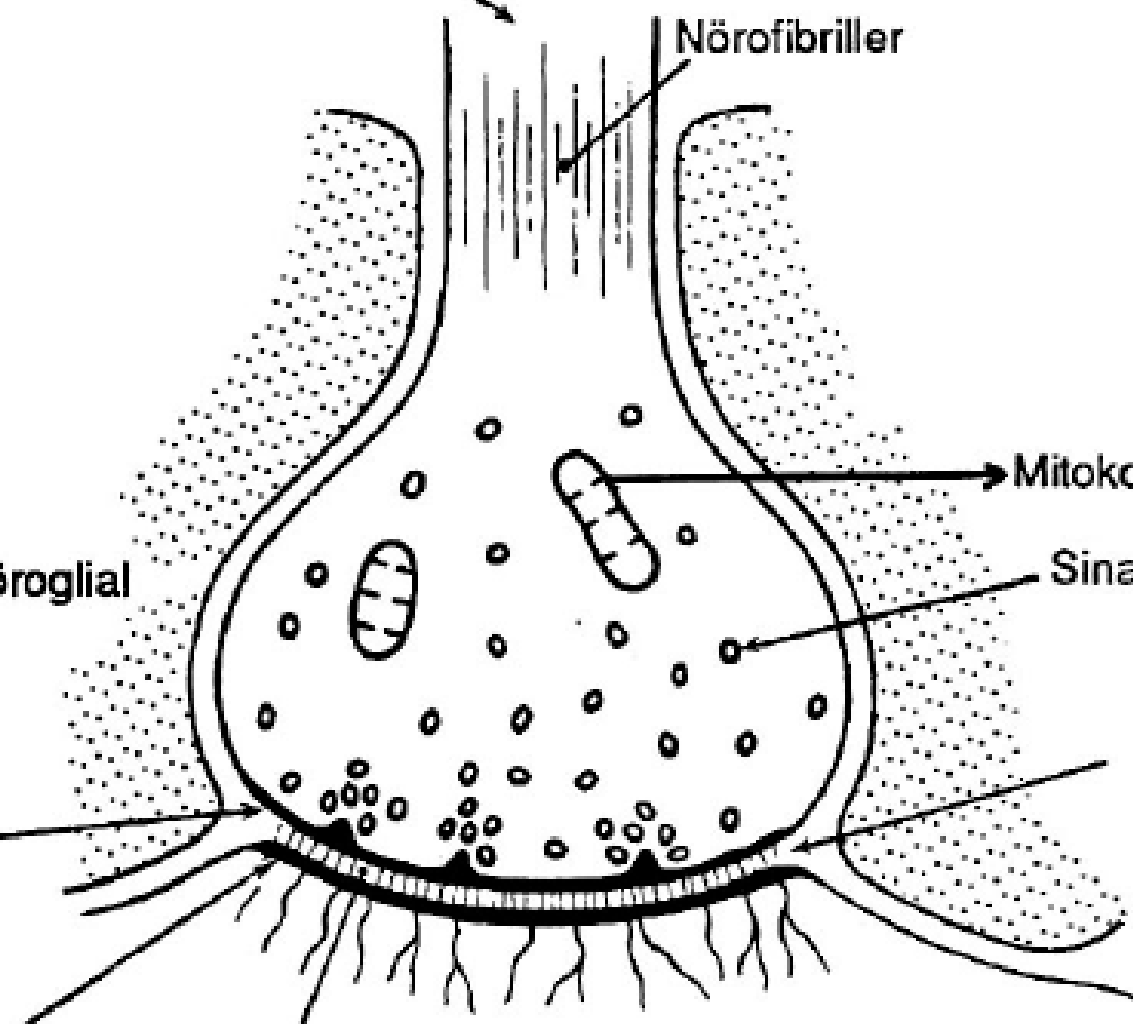
Periferik nöroglial yapılar

Presinaptik membran

Postsinaptik membran

Sinaps aralığı

Postsinaptik



Aksonların miyelinini kaybedip özelleşmiş Schwann hücre kılıfı içinde (telogial) dallanarak çizgili kas hücrelerinde kas - sinir bağlantı hattı ile sonlanmaları olan **motor plaklar** da sinapsların bir şeklidir. Sinir liflerinin çizgili kaslarla olan nöromüsküler bağlantı noktalarıyla ilgili bölümü,

# SİNAPS

Nöronlar, aralarında iletiyi aktarmak amacıyla, değişik elemanlarıyla çok özel kontaklar oluştururlar. Bunlar sinaps olarak adlandırılır.

\*Sinapslar, iletide kullandıkları aracıya bağlı olarak, iki tipe ayrılırlar;

- 1- Kimyasal sinapslar
- 2- Elektriksel sinapslar (nexus)

# 1- Kimyasal sinapslar

Kimyasal sinapslar klasik sinapslardır.

\*Presinaptik birim

\*Sinaptik aralık

\* Post sinaptik birim den oluşur.

\*İki birim arasında 200-300Å luk sinaptik aralık bir yer alır.

\*Pre sinaptik birim bol miktarda sinaptik vesikul bulunur.

\*Presinaptik vesiküller farklı şekillerde olabilirler.

Buna göre;

1-Yuvarlak açık merkezli vesiküller (agranüler) (Kolinergic, eksitator)

2-Yoğun merkezli vesiküller (granüler) (Adrenergik)

3-Yassı vesiküller (İnhibitör)

4-Büyük yoğun merkezli vesiküller (Adrenergik)

\*Post sinaptik membran presinaptik membrandan daha elektron yoğun bir yapıya sahiptir.

## **2- Elektriksel sinapslar (nexus)**

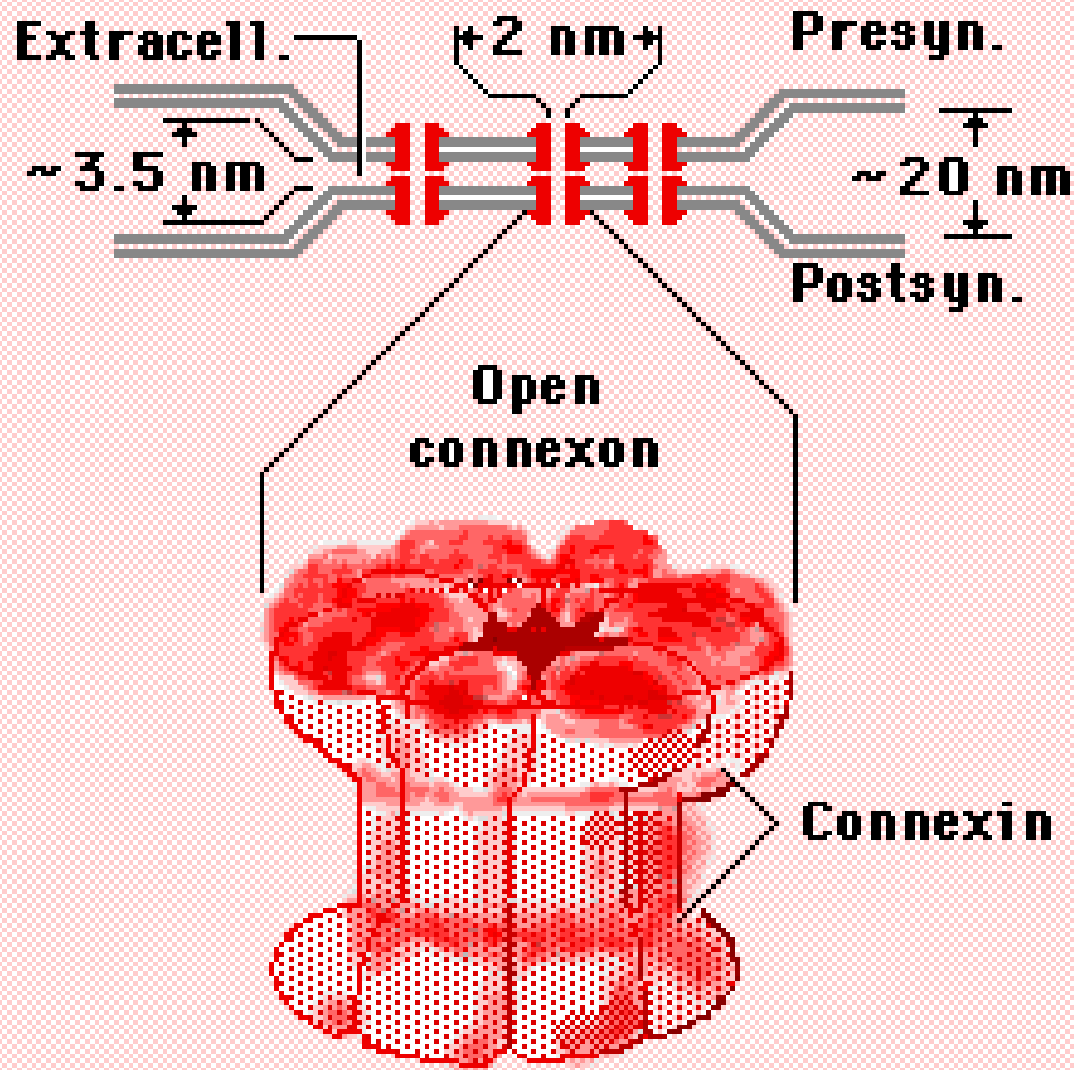
\*Elektriksel sinapslarda da pre ve post sinaptik birimler ve sinaptik aralık bulunur.

\*Burada sinaptik aralık 20Å kadardır.

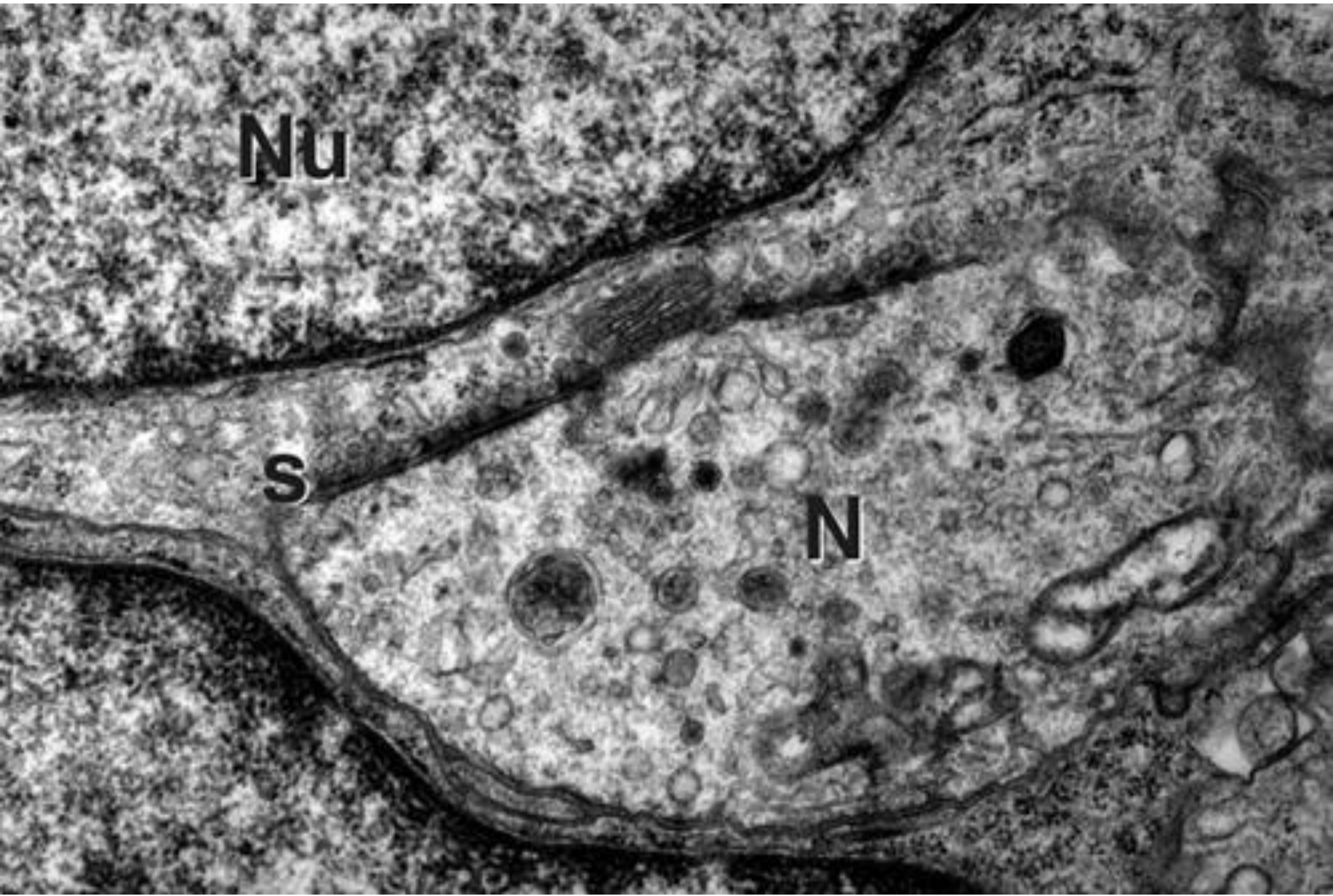
\*Bu sinaps yapısında iki birim arasında geçişi sağlayan direk kanallar mevcuttur.

- Sinapslar kontak sađlayan componentlere gre de  tipe ayrılmaktadır.
- **1- İternronal sinapslar**  
**2- Nromuskular plak**  
**3- Nroglandular plak**
- **İternronal sinapslar**  
Nronlar arasında kurulan sinapslardır. Bu sinapslar pre ve post sinaptik componentlere gre
  - 1-Aksosomatik sinapslar
  - 2-Aksodendritik sinapslar
  - 3-Aksoaksonik sinapslar
  - 4-Dendrodendritik sinapslar
  - 5-Somatosomatik sinapslar
  - 6-Somatoaksonik sinapslar
  - 7-Somatodendritik sinapslar olarak sınıflandırılmaktadır.
- **Nromuskular plak**
  - \*Kas ile akson arasında kurulan zel kontak oluřumudur
  - \*Akson myelinini kaybeder
  - \*Akson terminali, kas lifi iine dođru (sinaptik oluk) gmlr.
  - \*Post sinaptik birim ok sayıda girinti ierir
- **Nroglandular plak**
  - \*Bezlerle aksonların yaptığı kontaklardır.
  - \*Akson dalları tek tek bez hcreleri zerinde kk topakcıklar Őeklinde sonlanır

# Electrical Synapse (Gap Junctions)



# Neuro-neuronal synapse





# Neuromuscular synapse

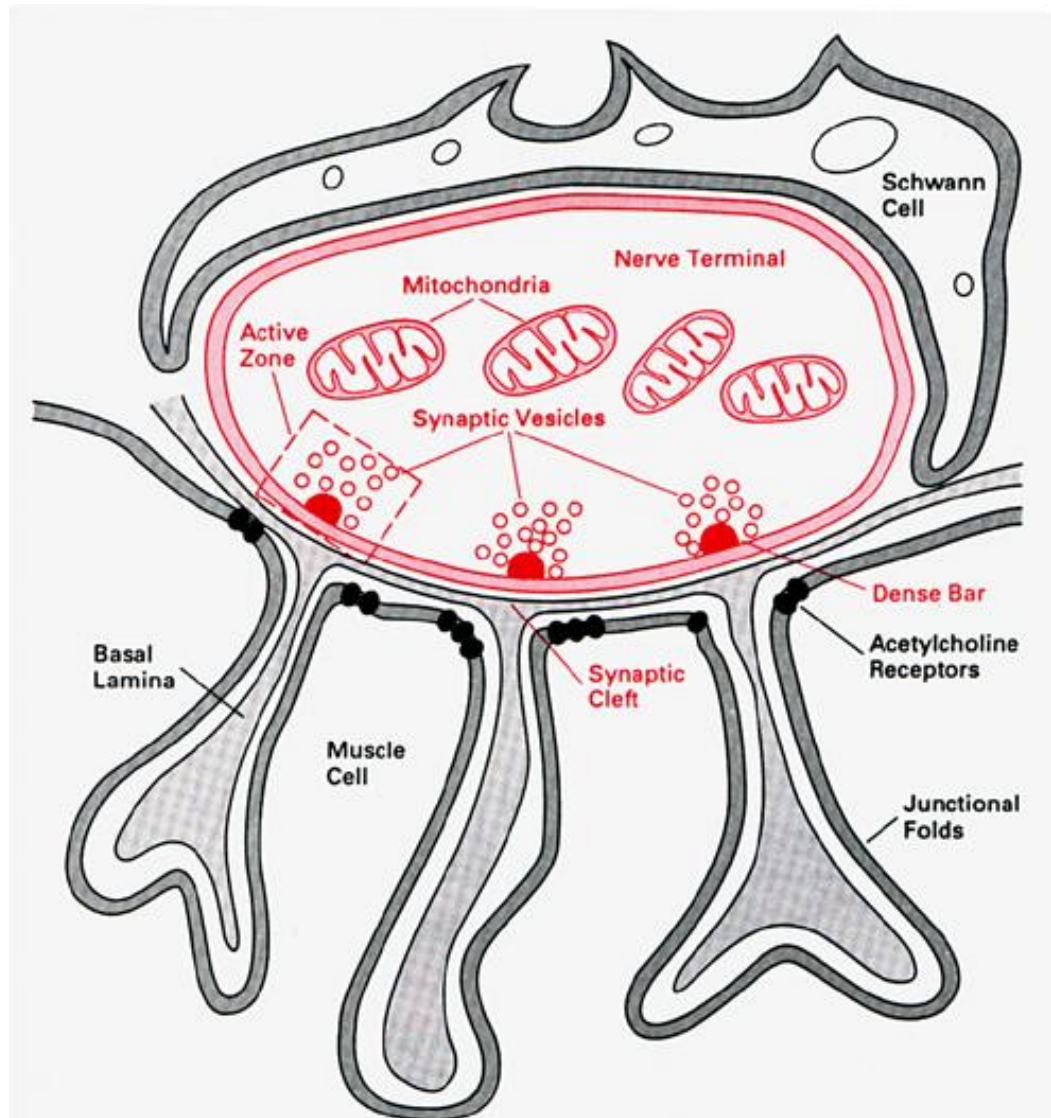
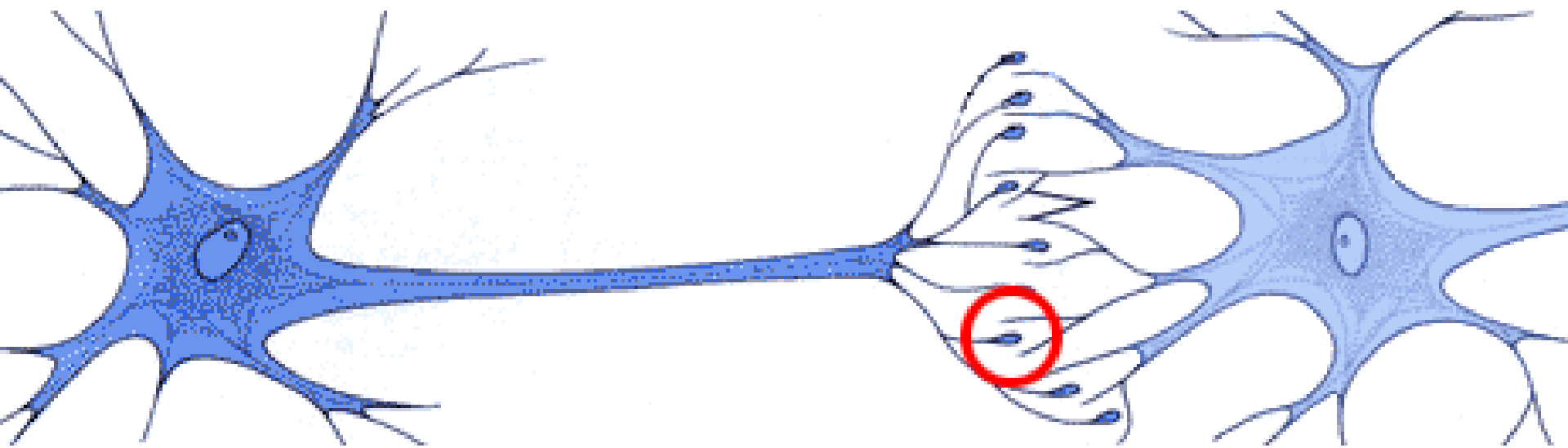
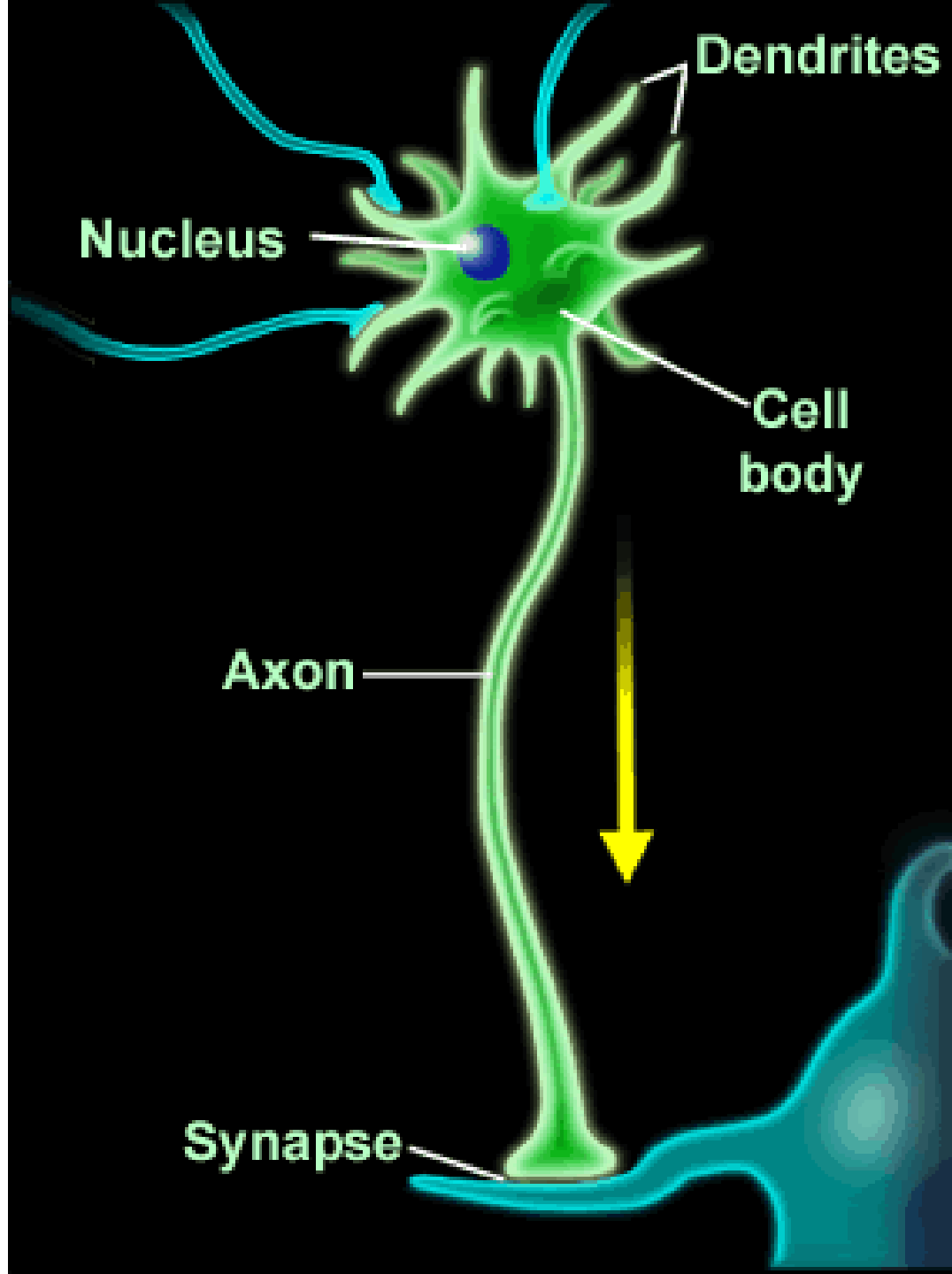
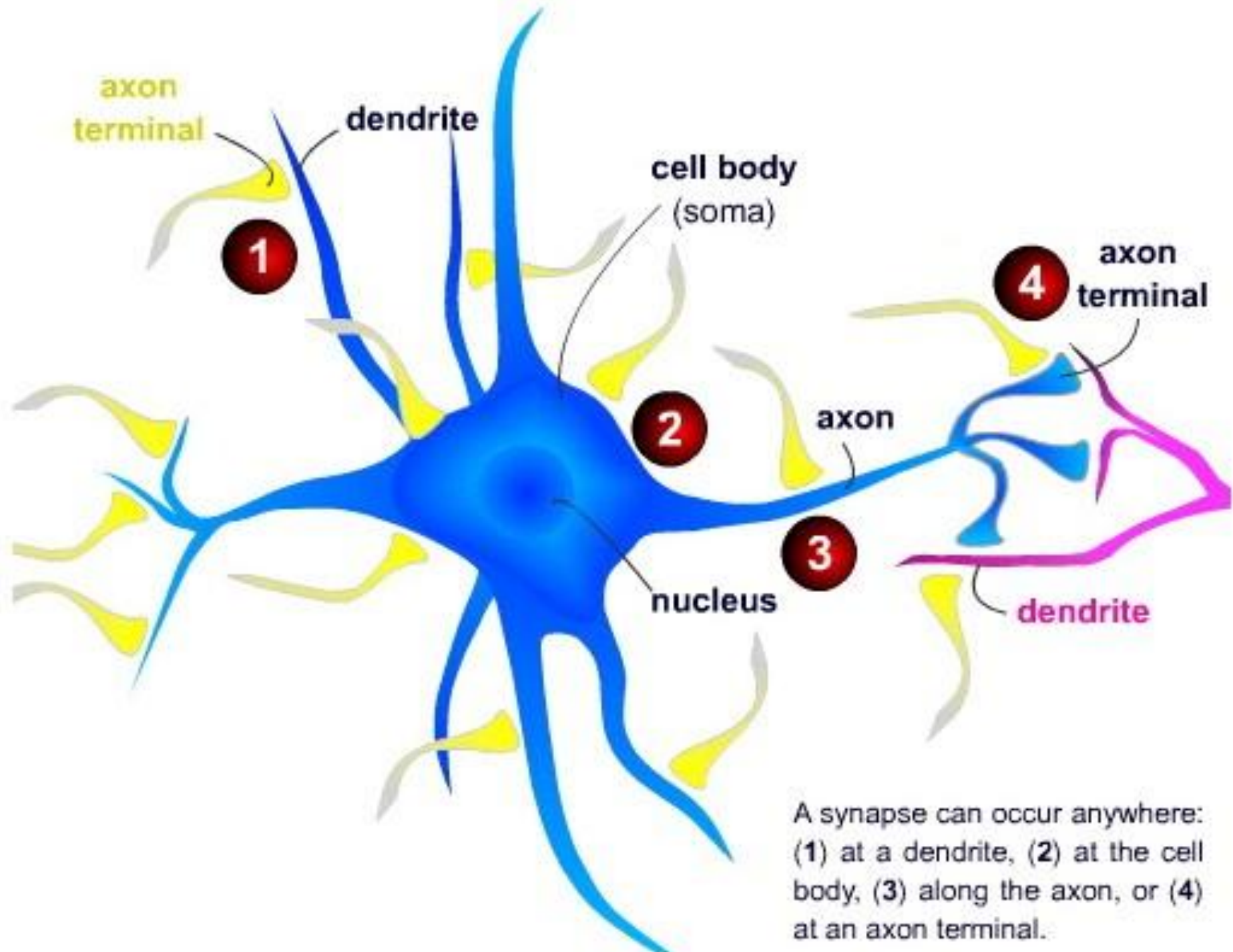


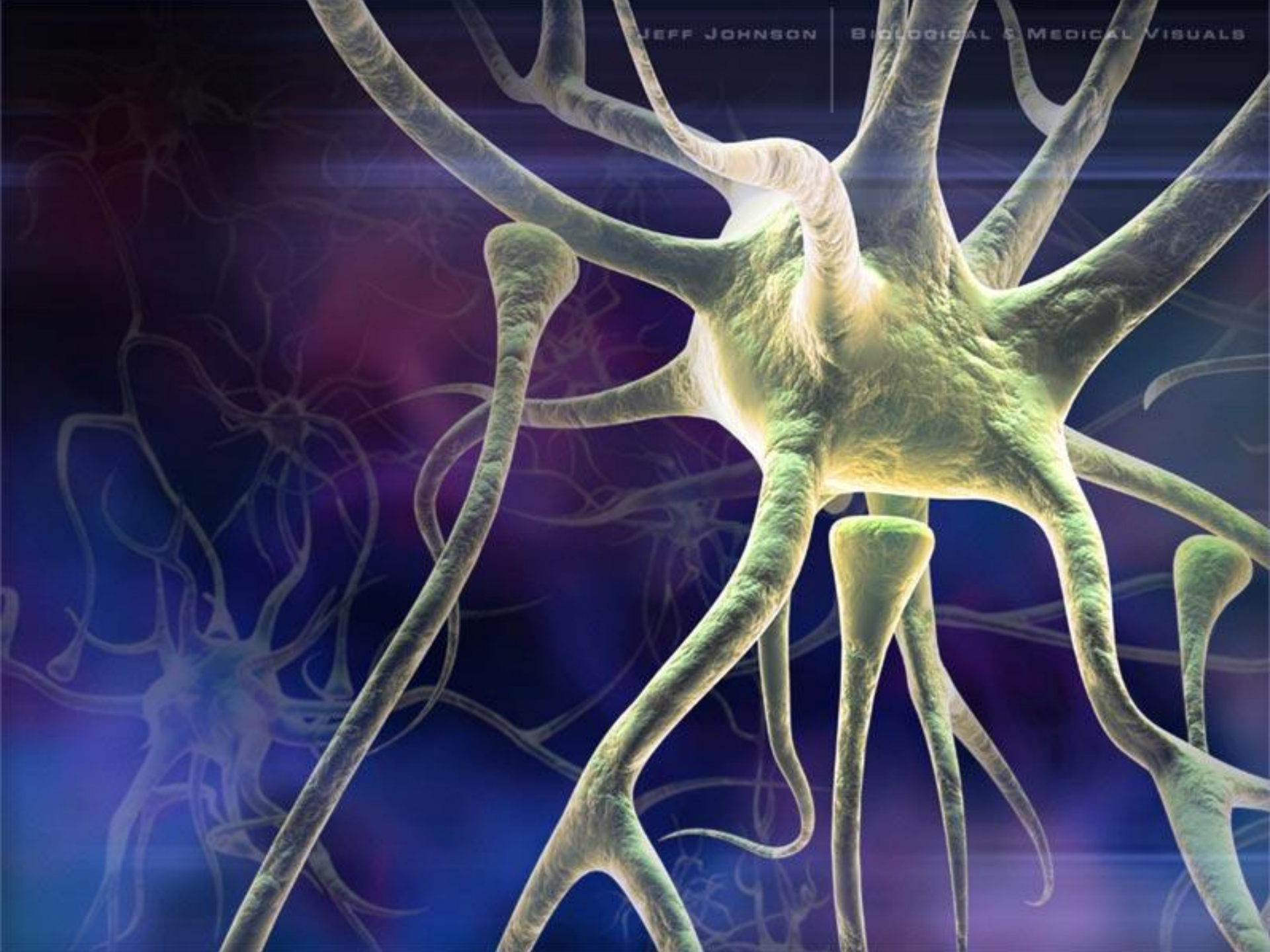
Figure 8-1. Diagram of a vertebrate neuromuscular junction.

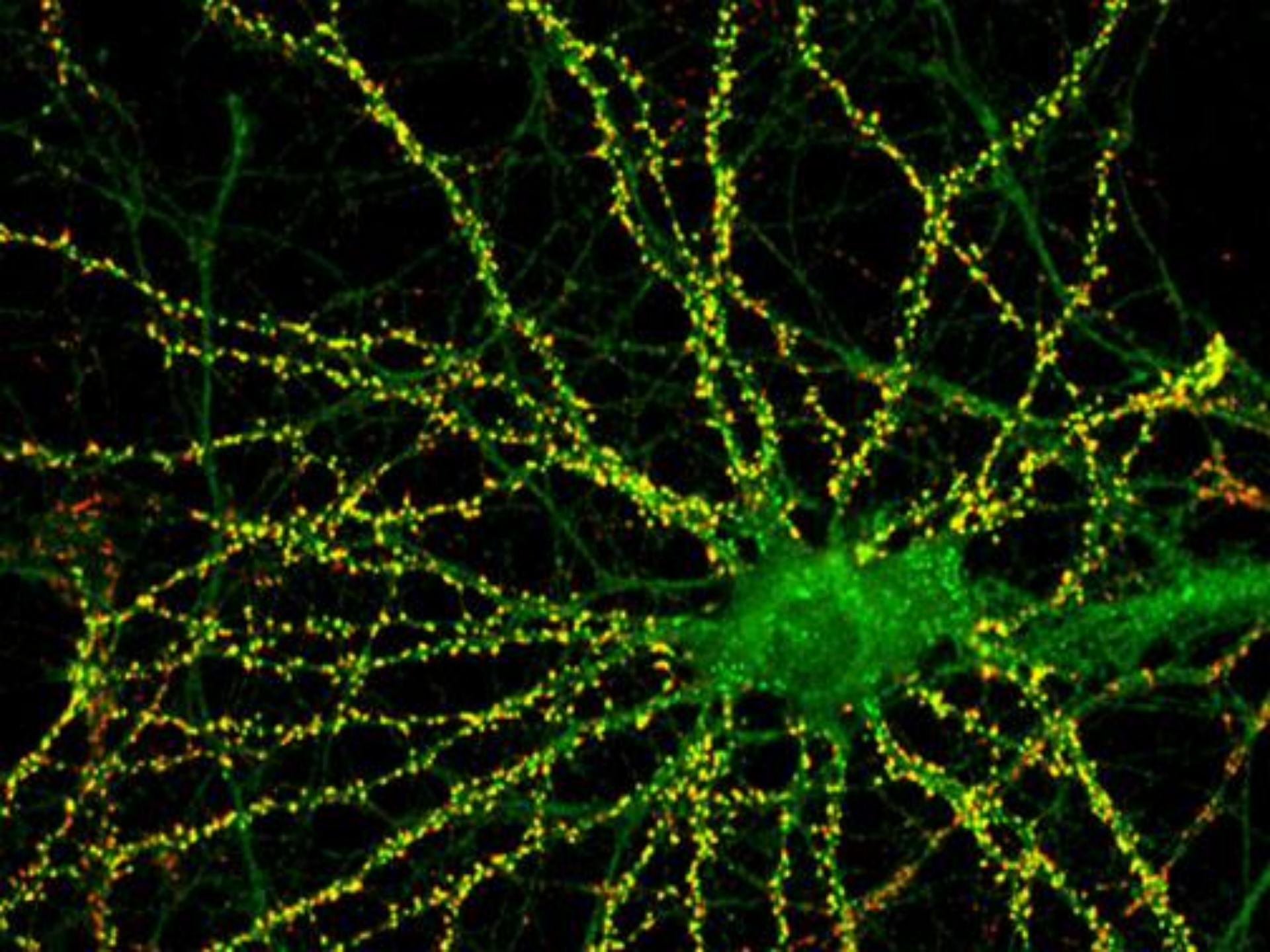


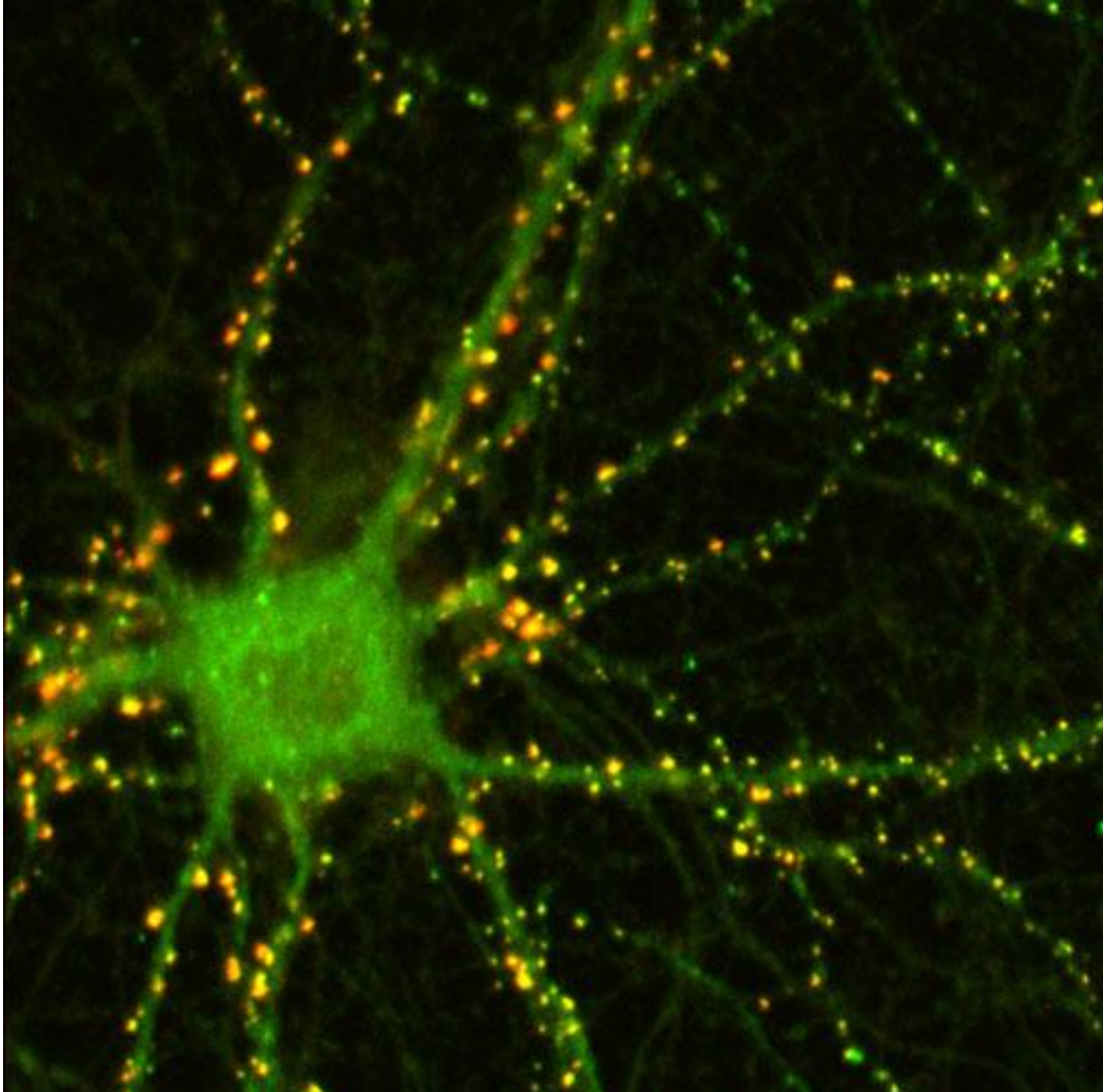




A synapse can occur anywhere: (1) at a dendrite, (2) at the cell body, (3) along the axon, or (4) at an axon terminal.



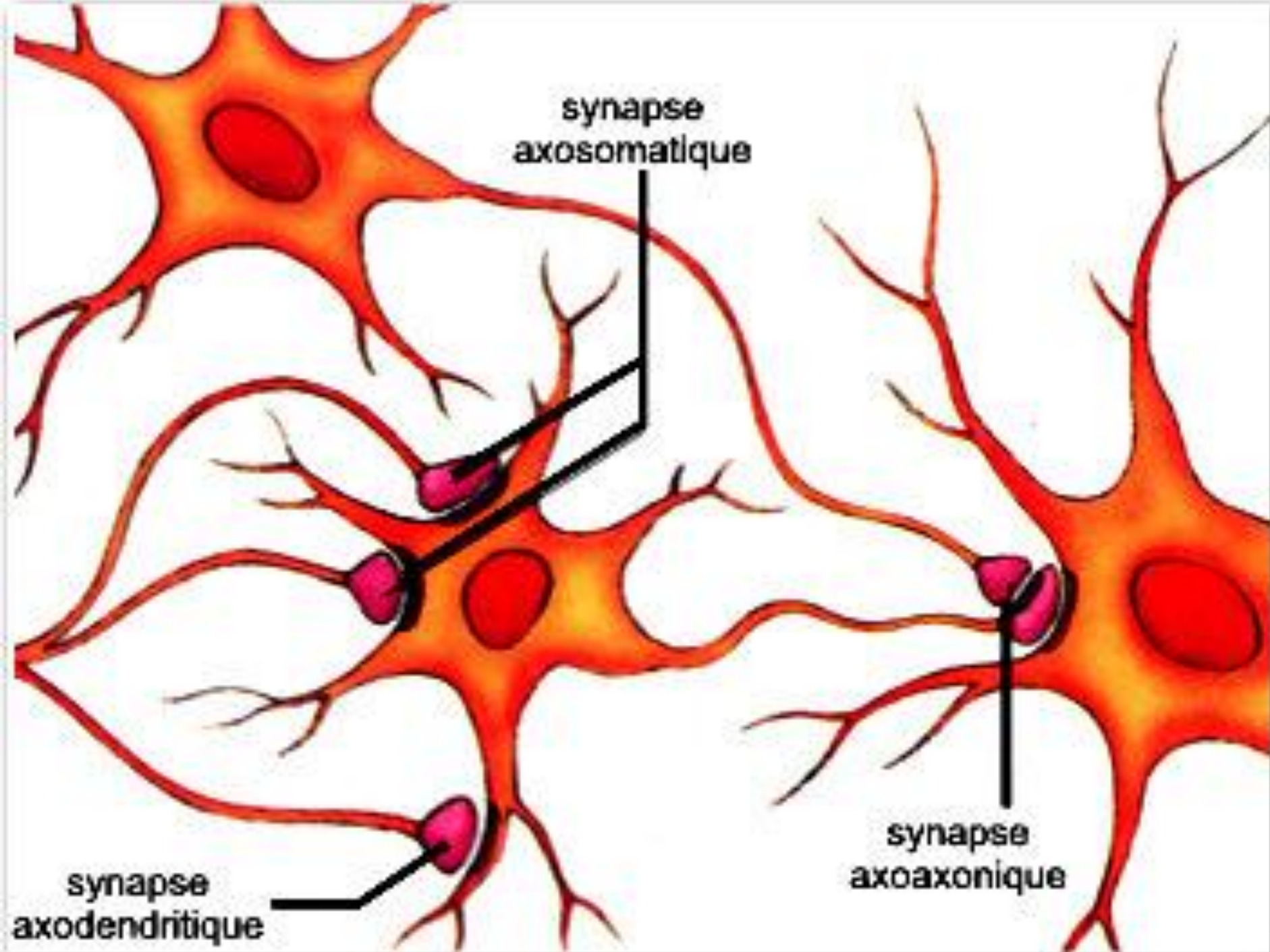






**Neuromuscular Junction**  
**Gold chloride; (Med)**



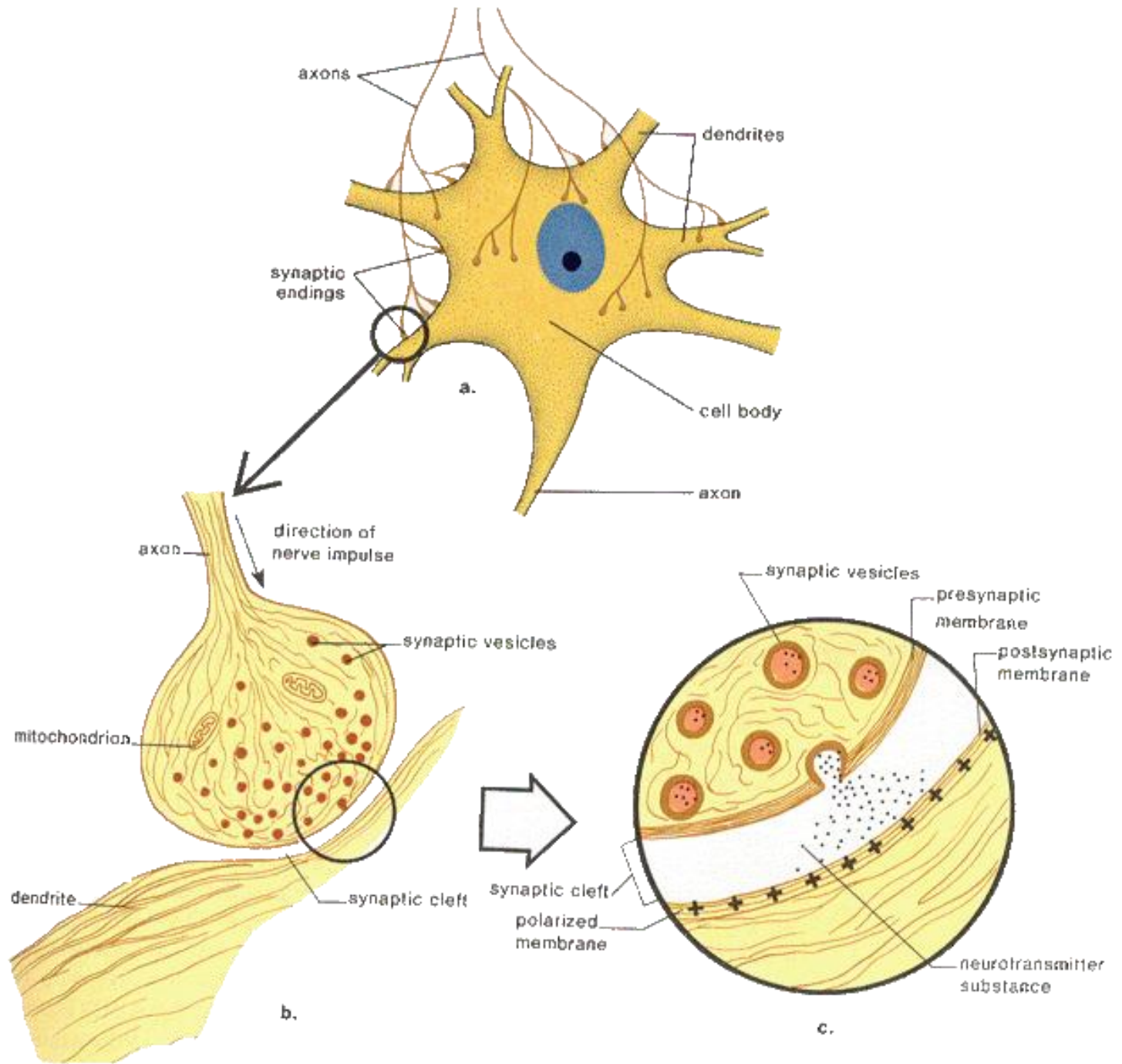


synapse  
axosomatique

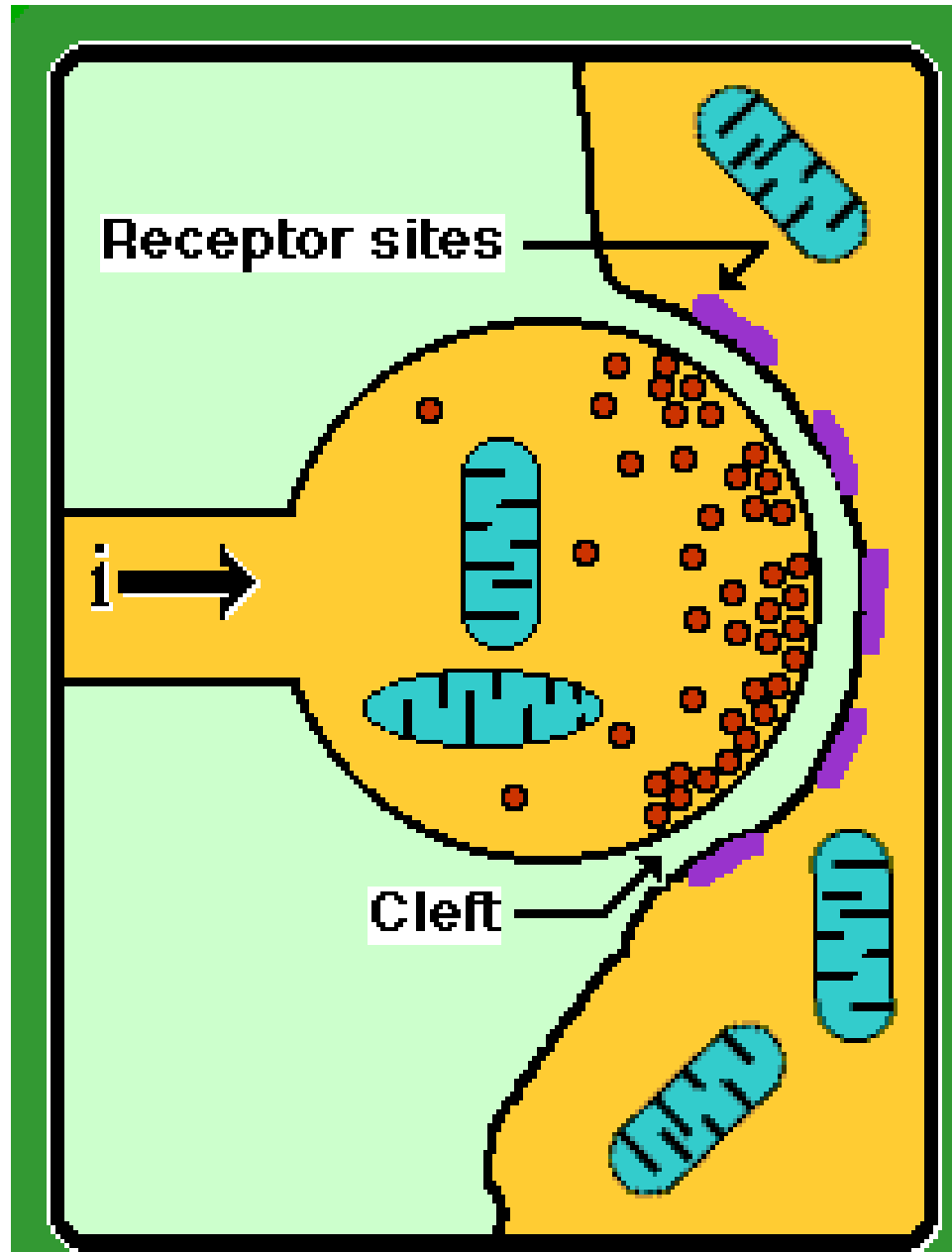
synapse  
axoaxonique

synapse  
axodendritique

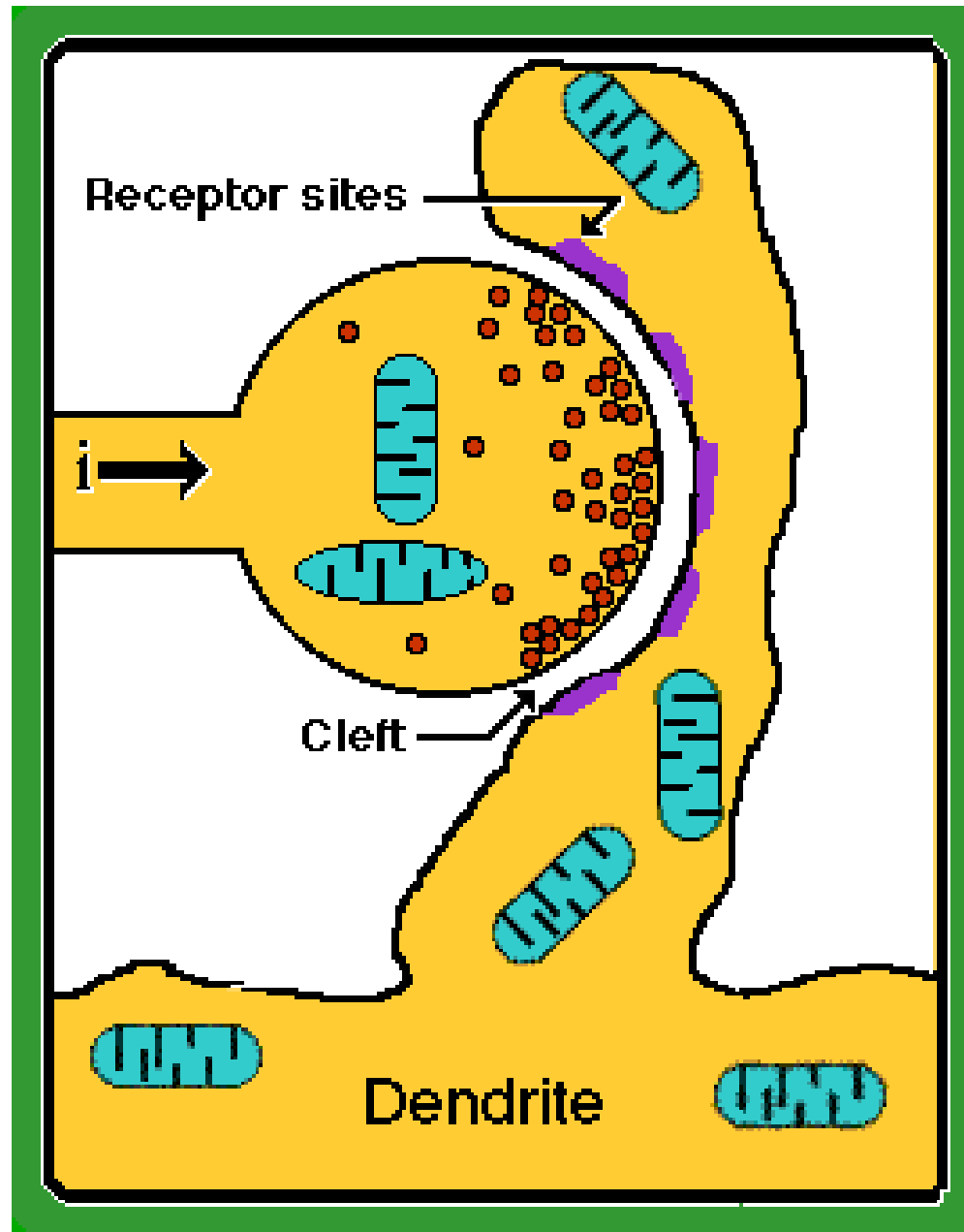


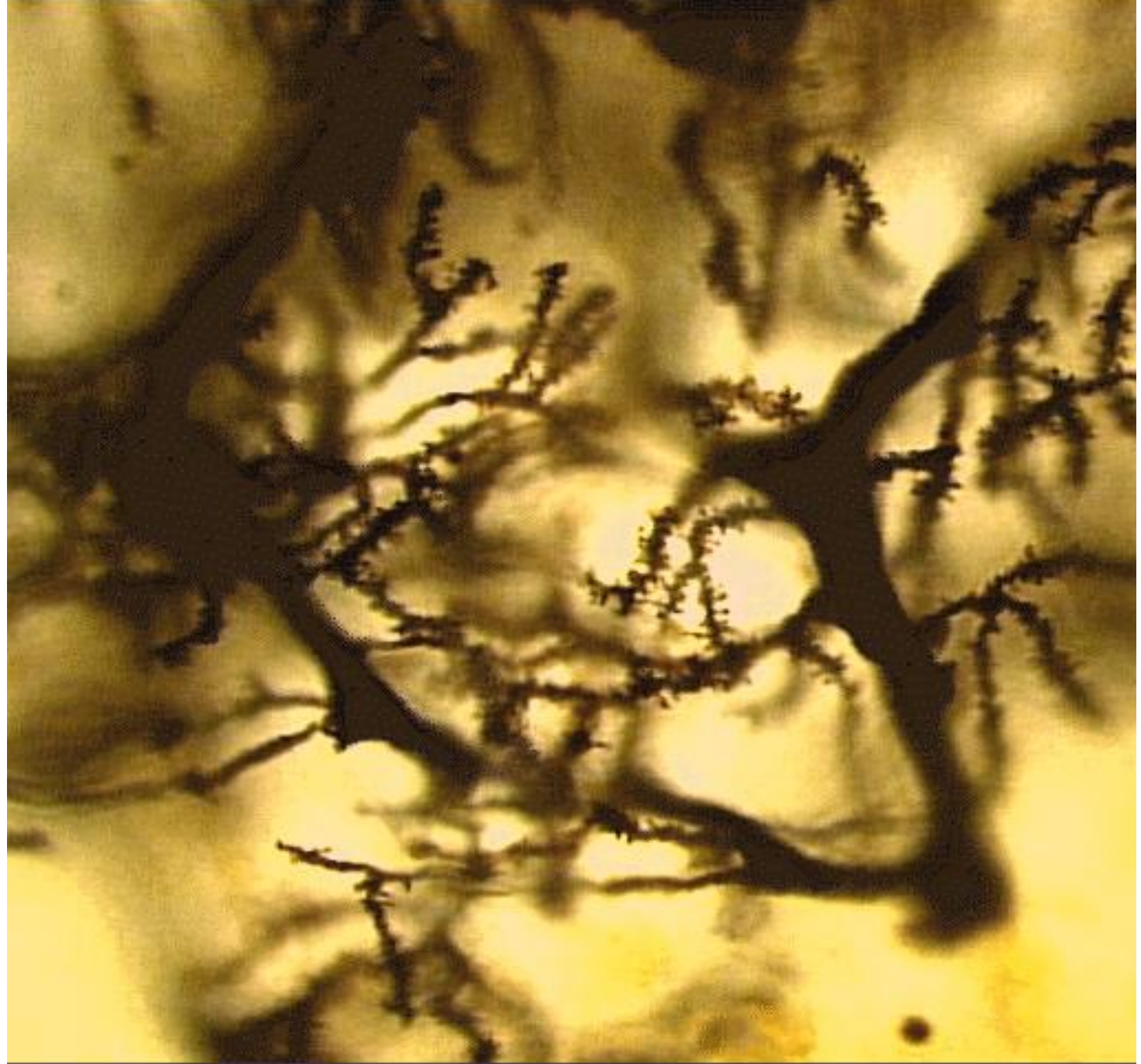


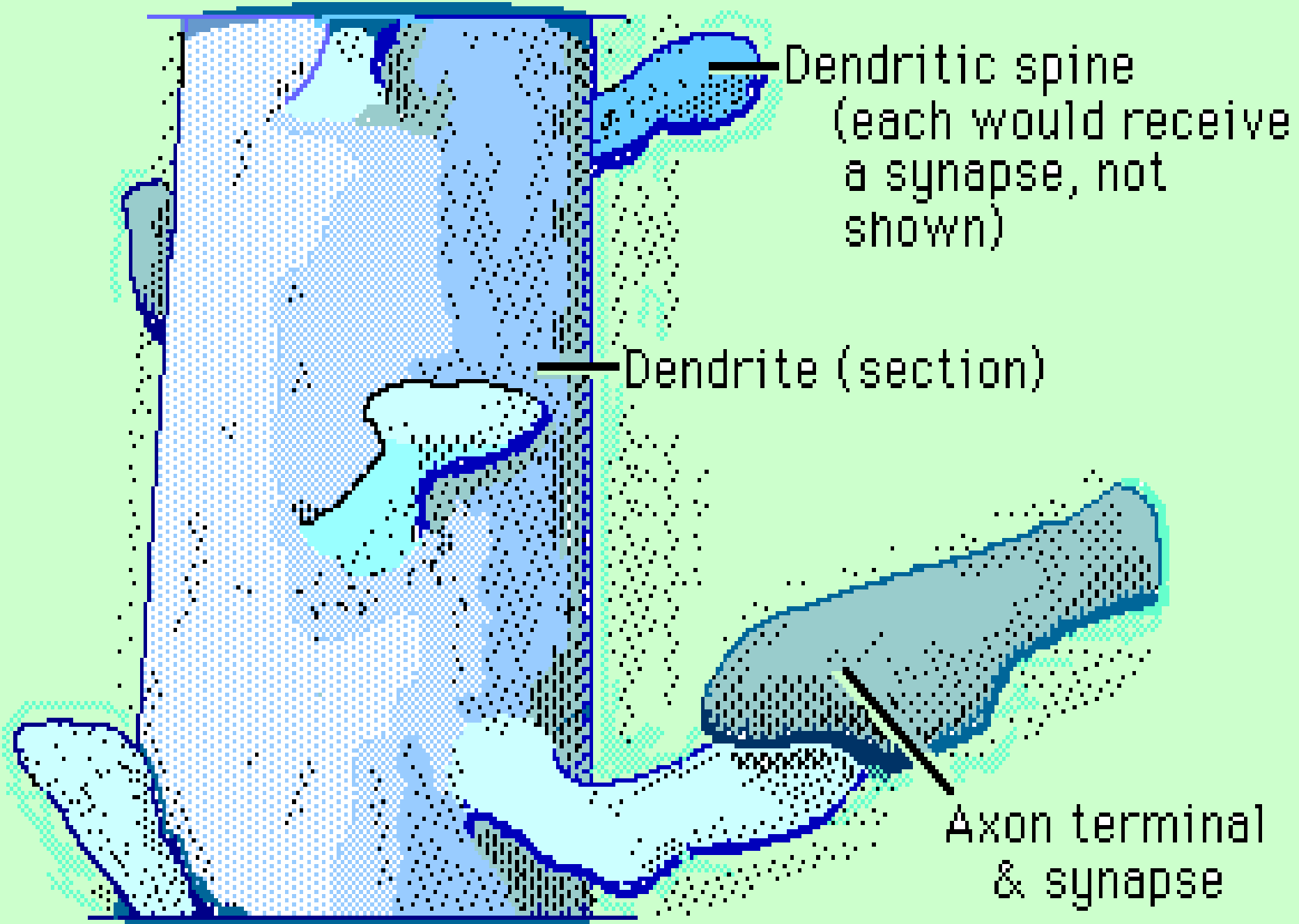
# The Synaptic Terminal



# Axo-dendritic Synapses





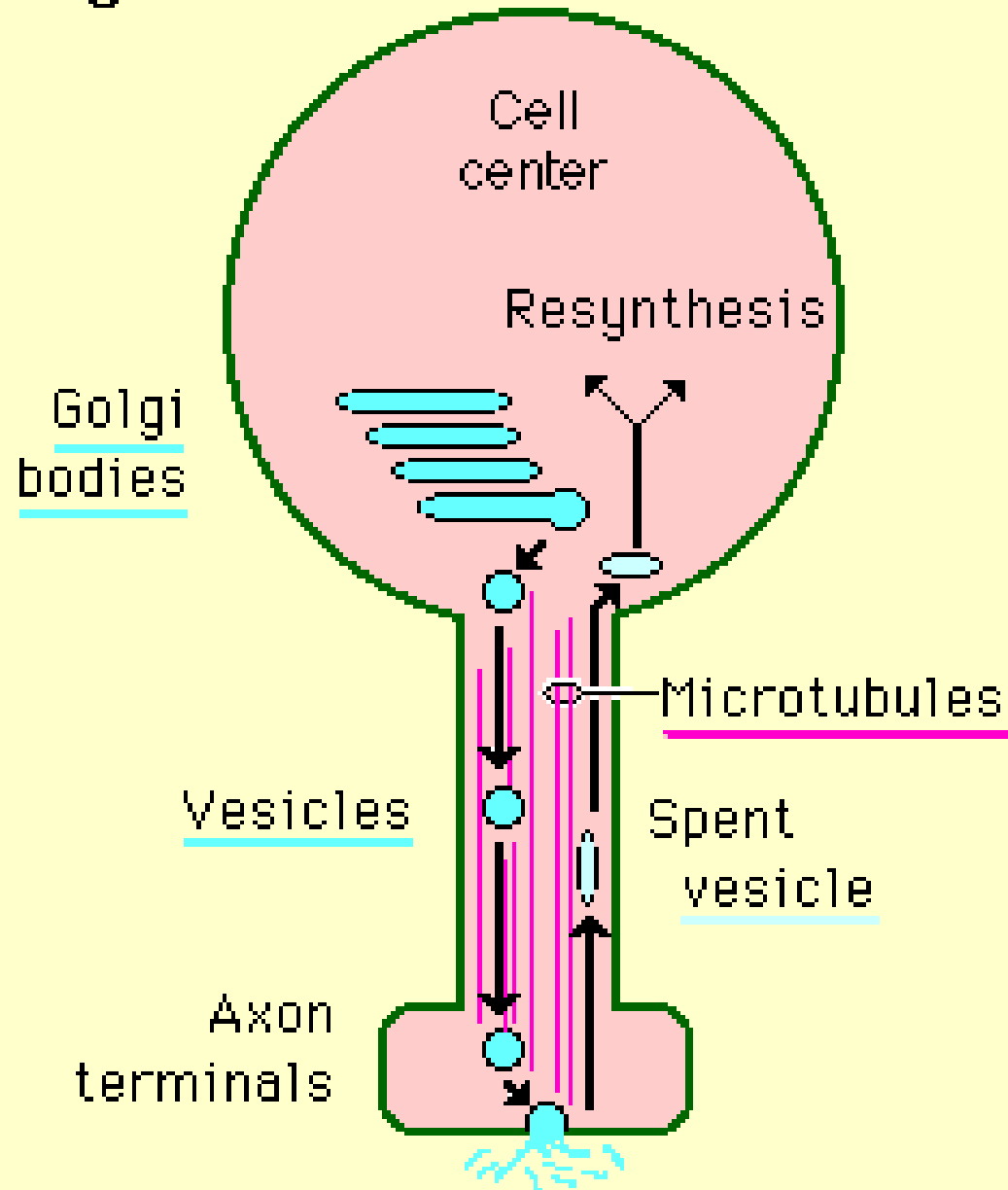


Dendritic spine  
(each would receive  
a synapse, not  
shown)

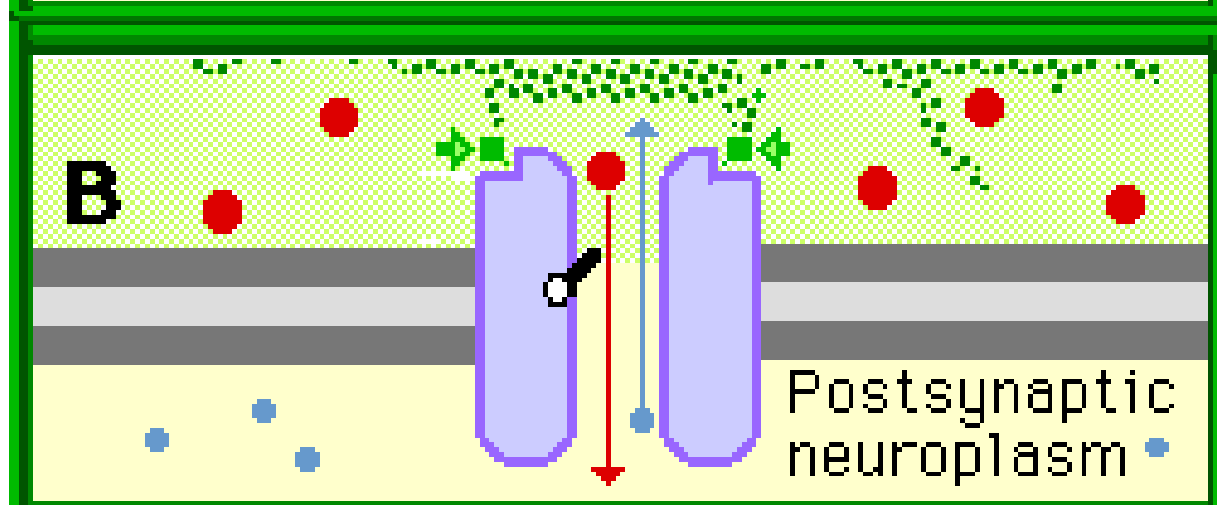
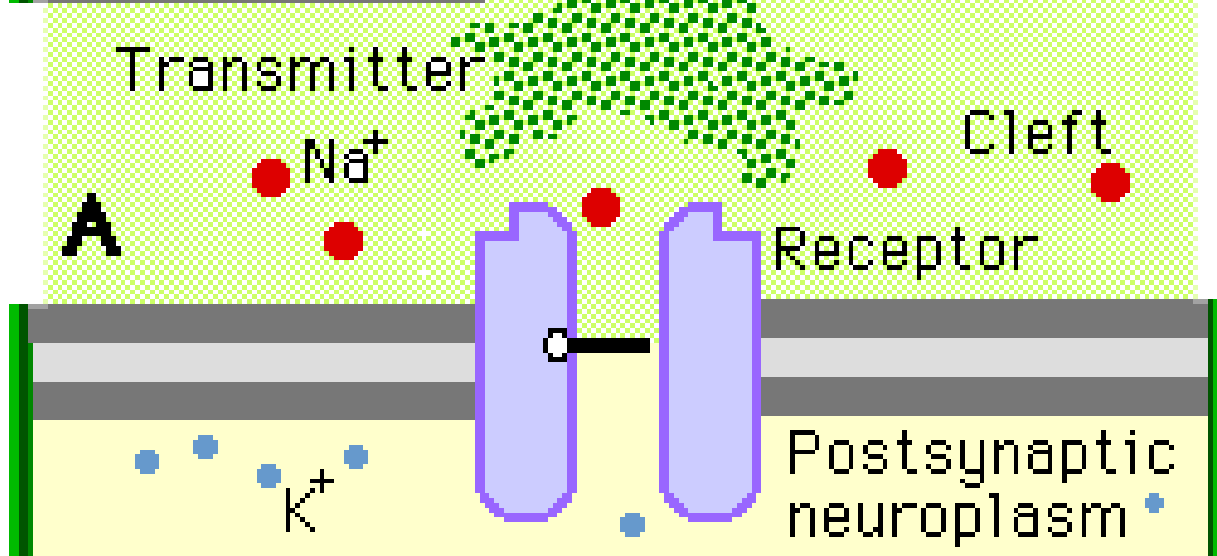
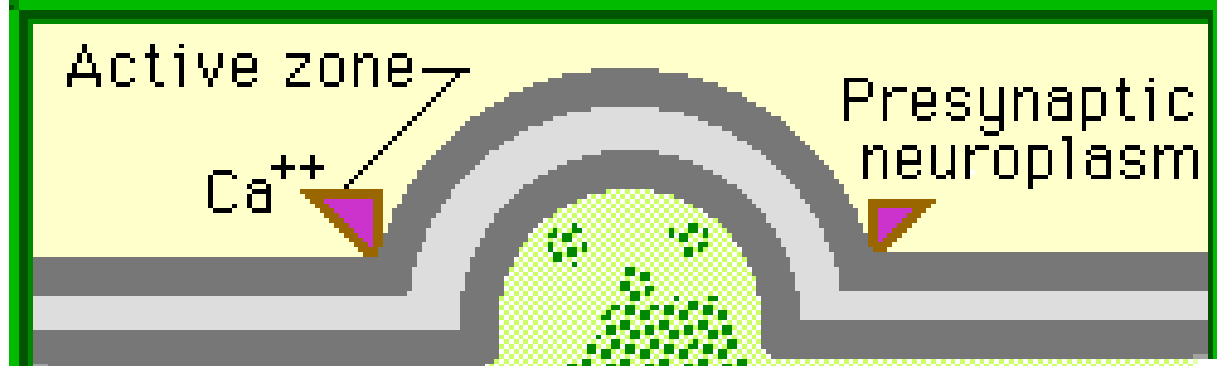
Dendrite (section)

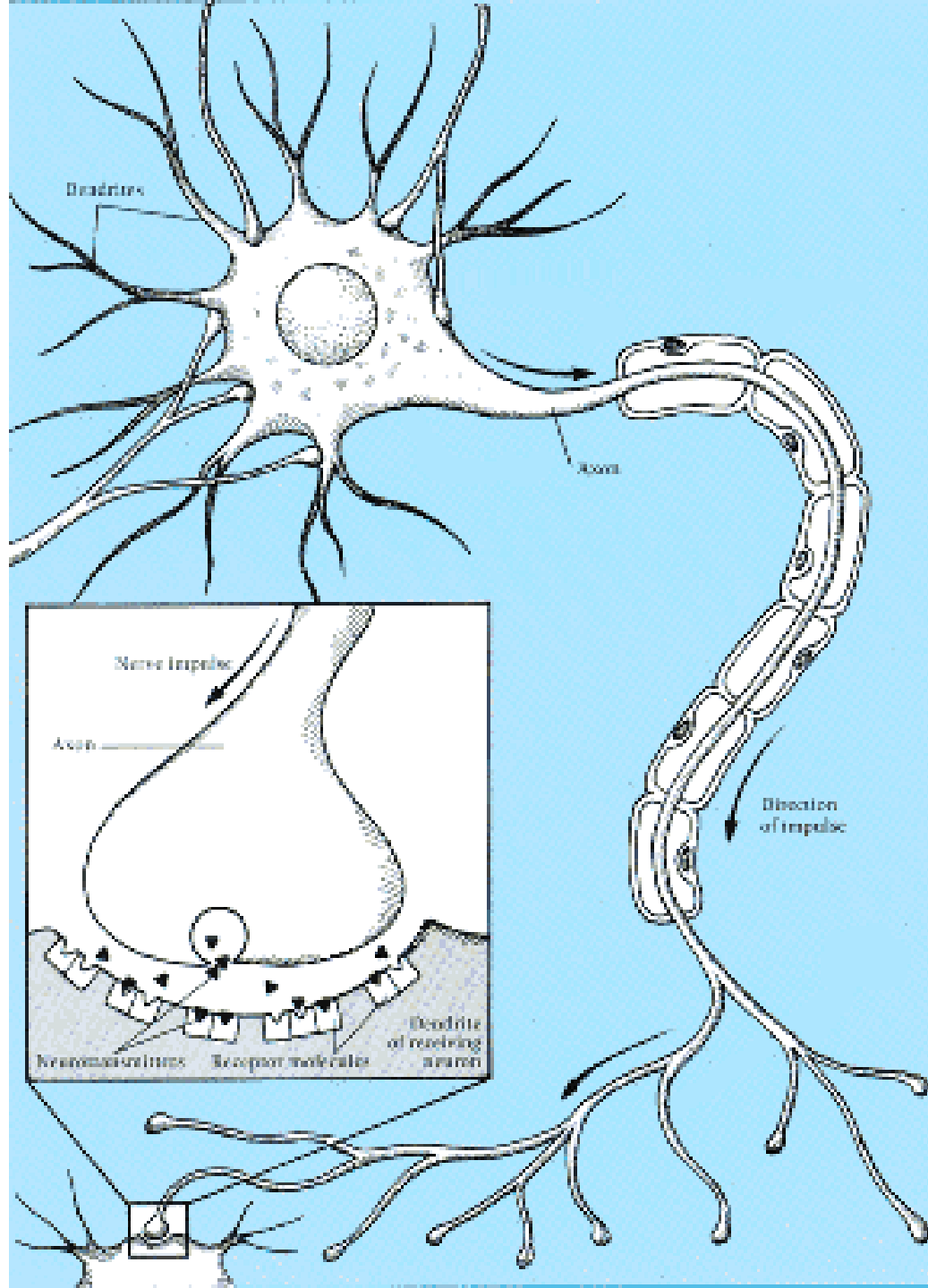
Axon terminal  
& synapse

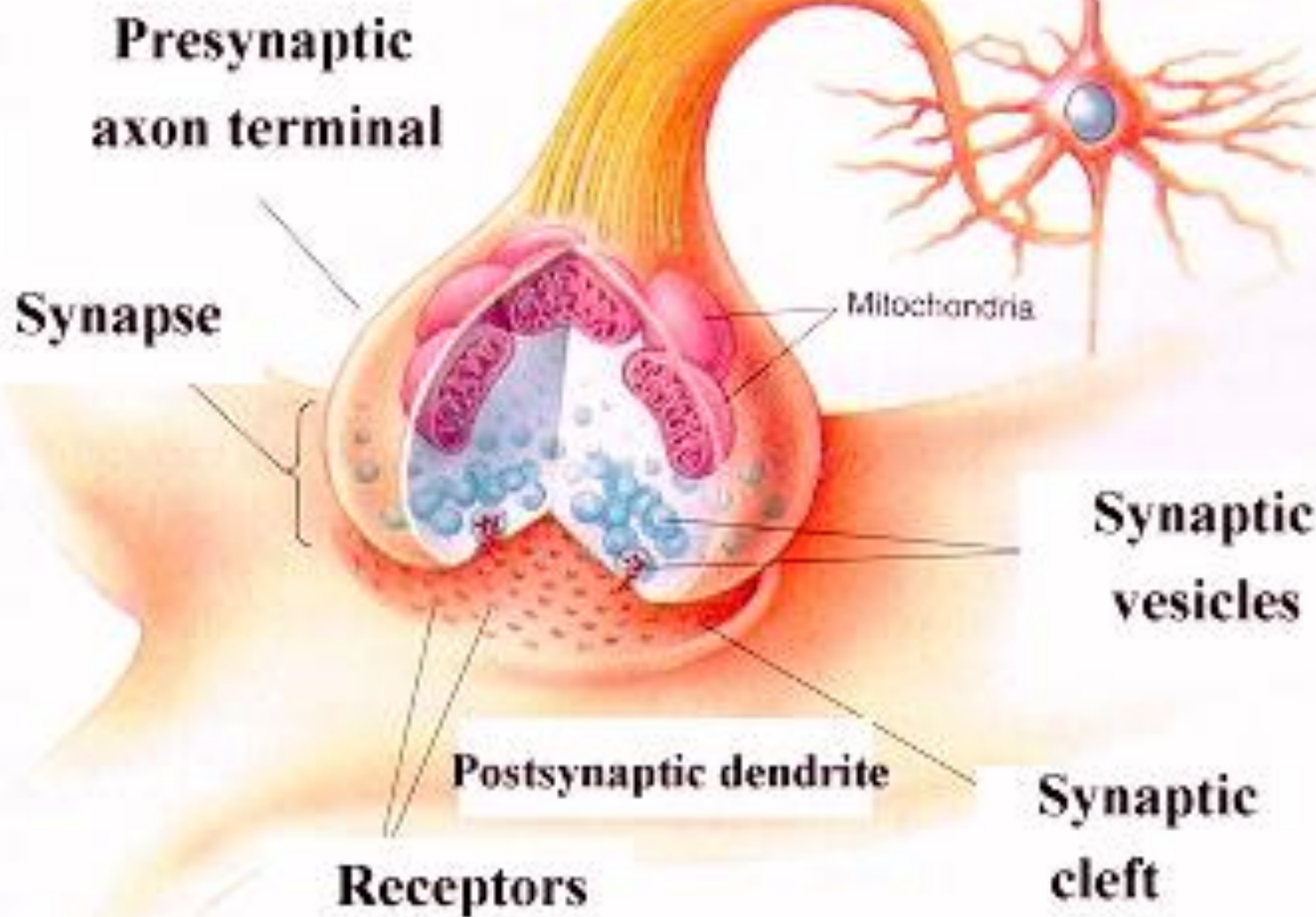
**Fig. 1**

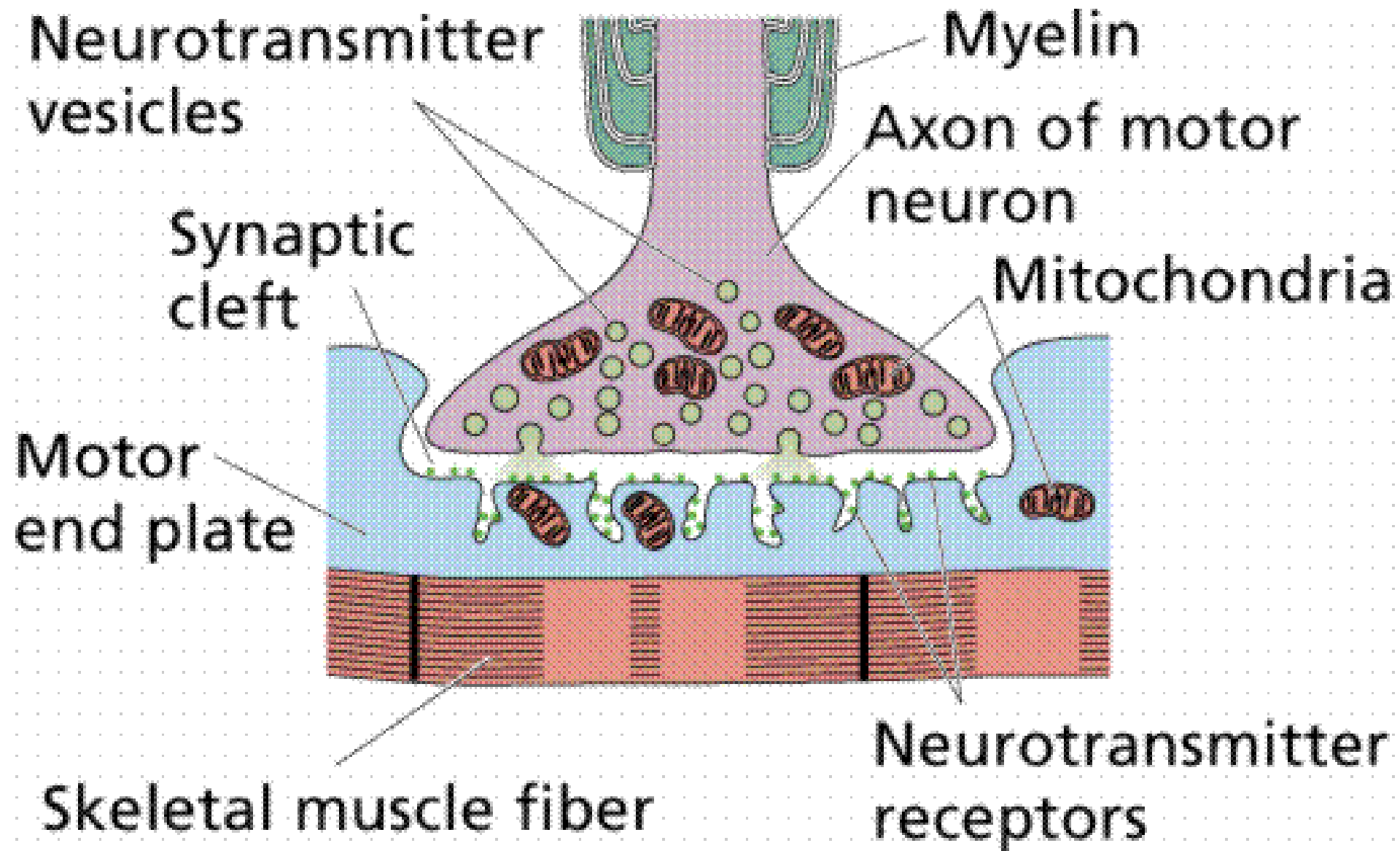


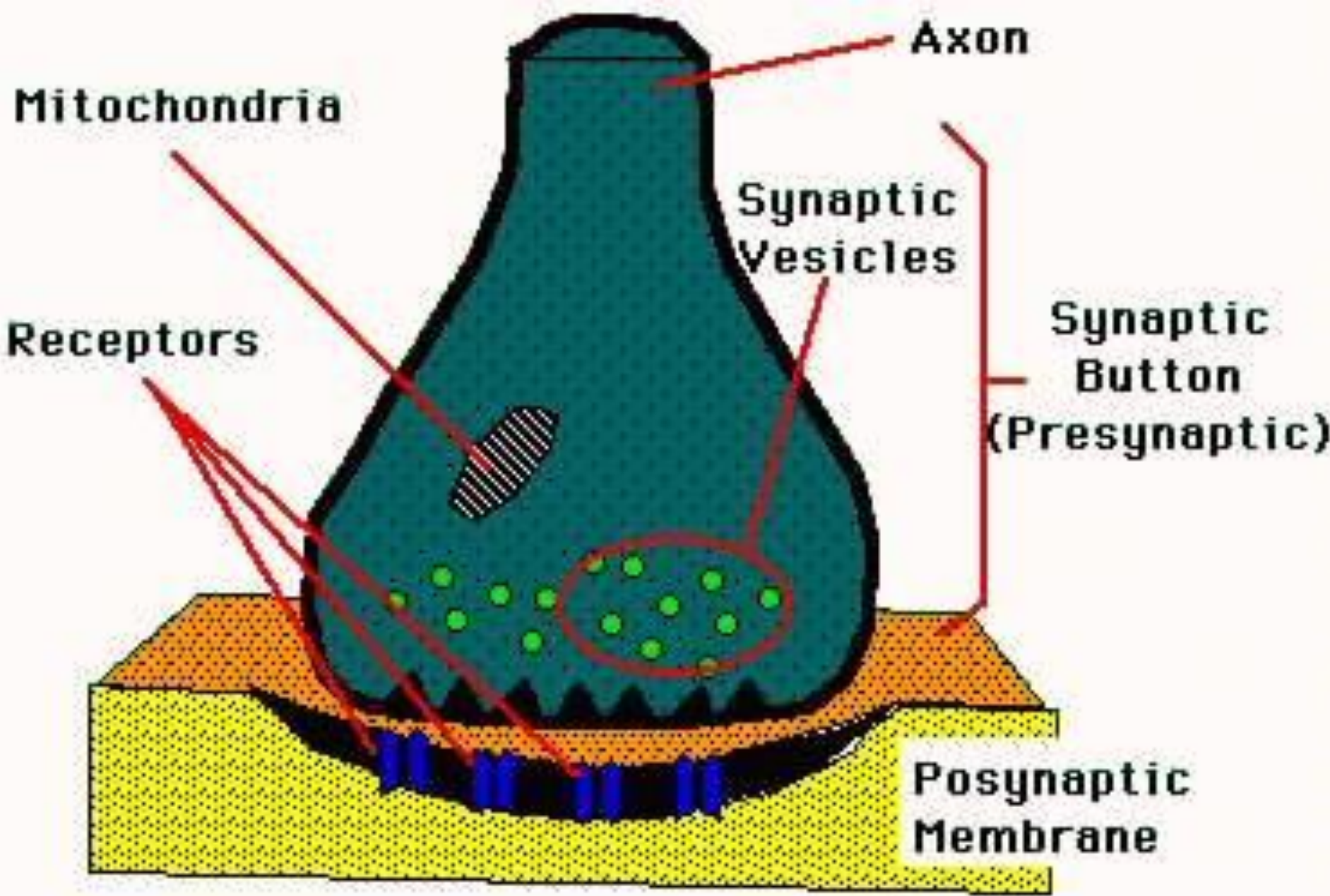


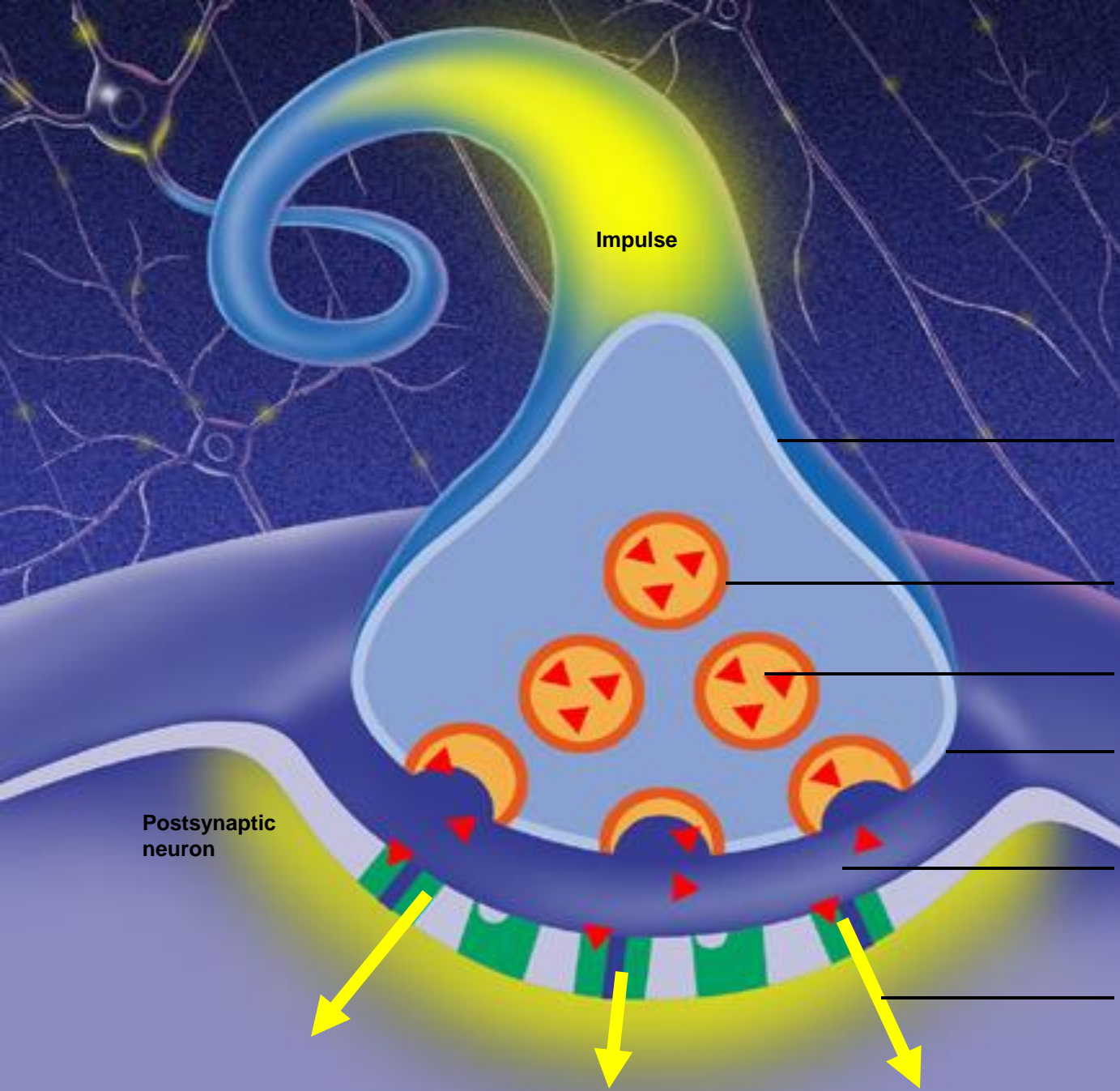












Impulse

Presynaptic neuron

Vesicle

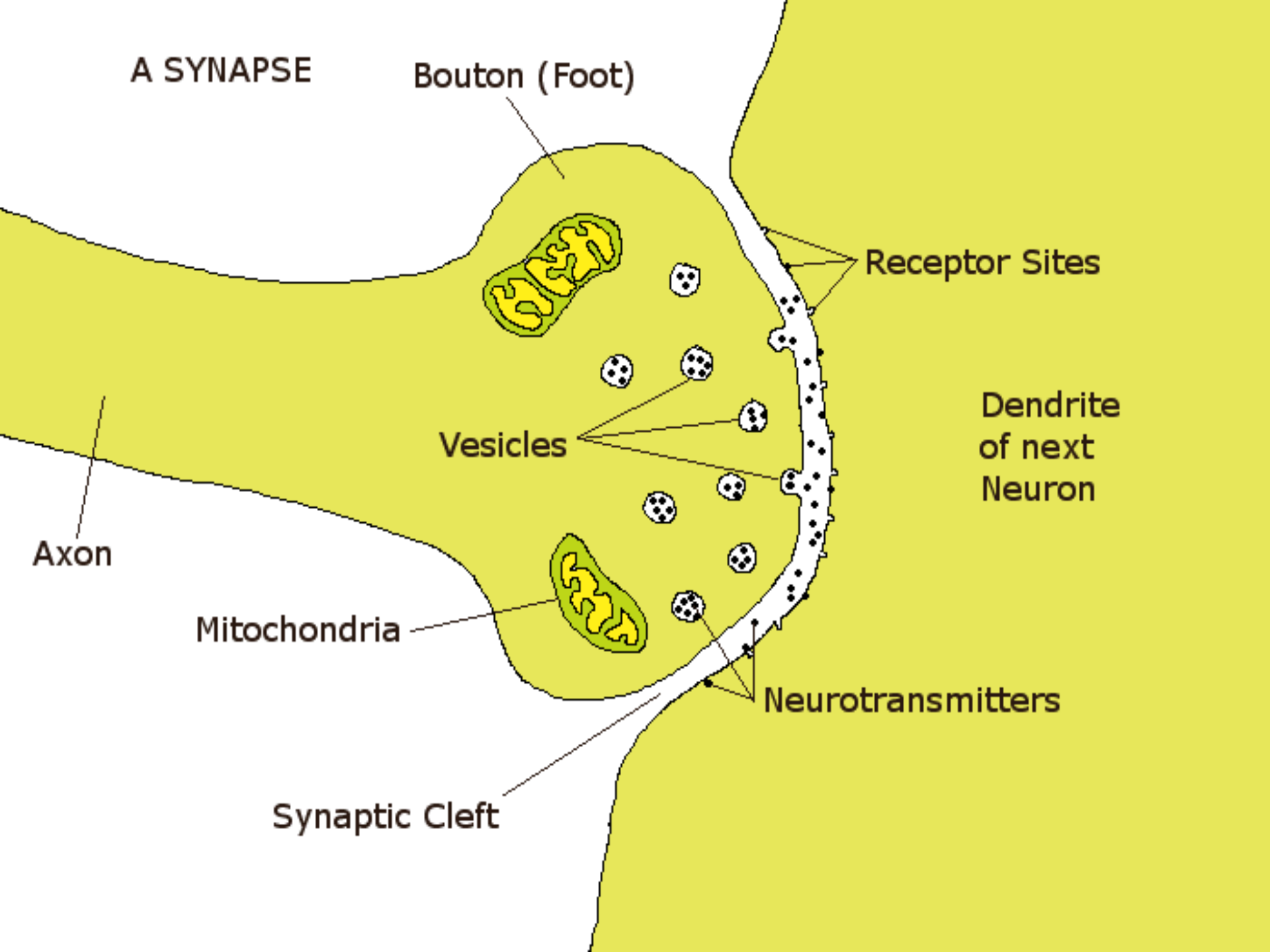
Transmitters

Synaptic cleft

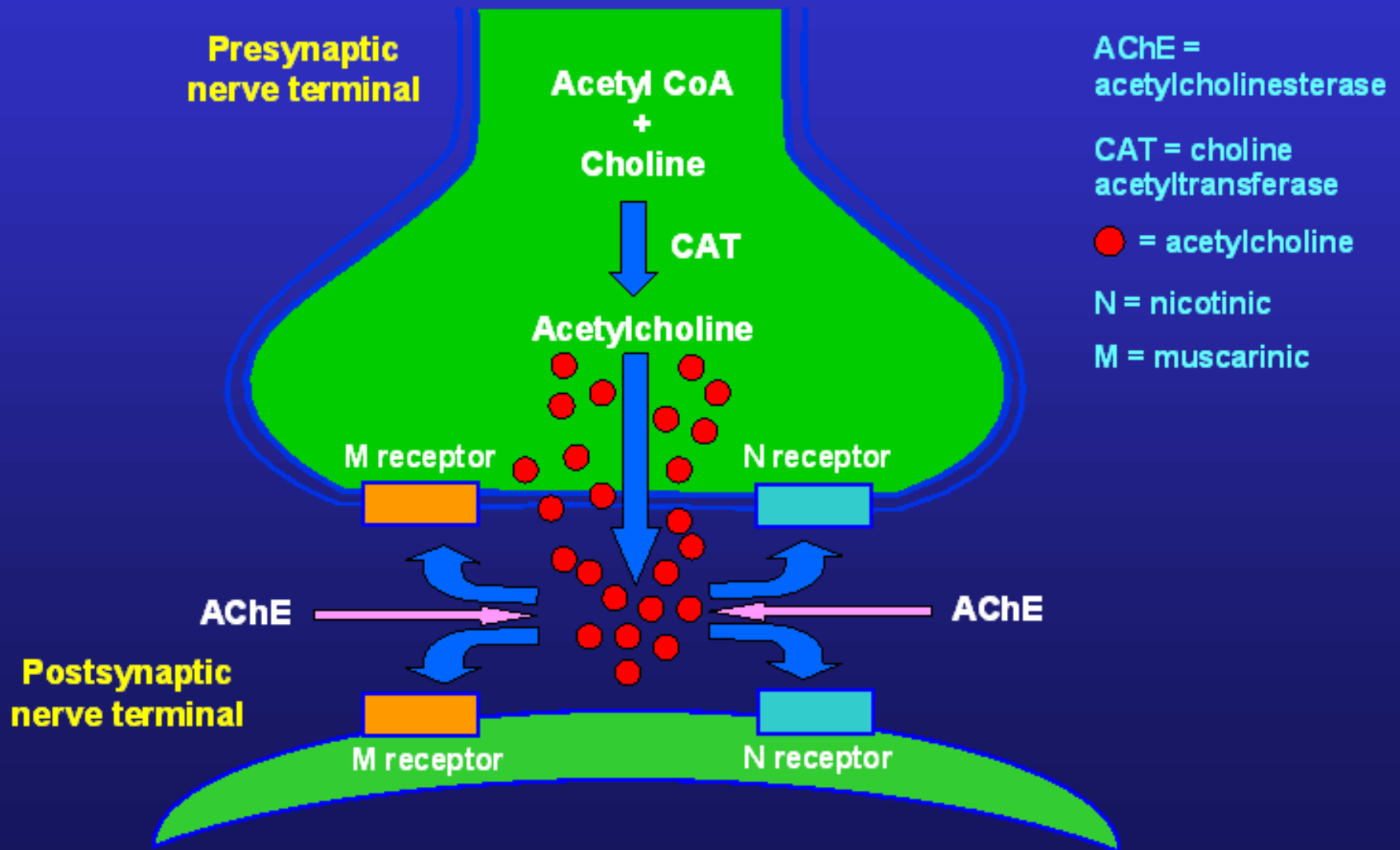
Receptors

Postsynaptic activity

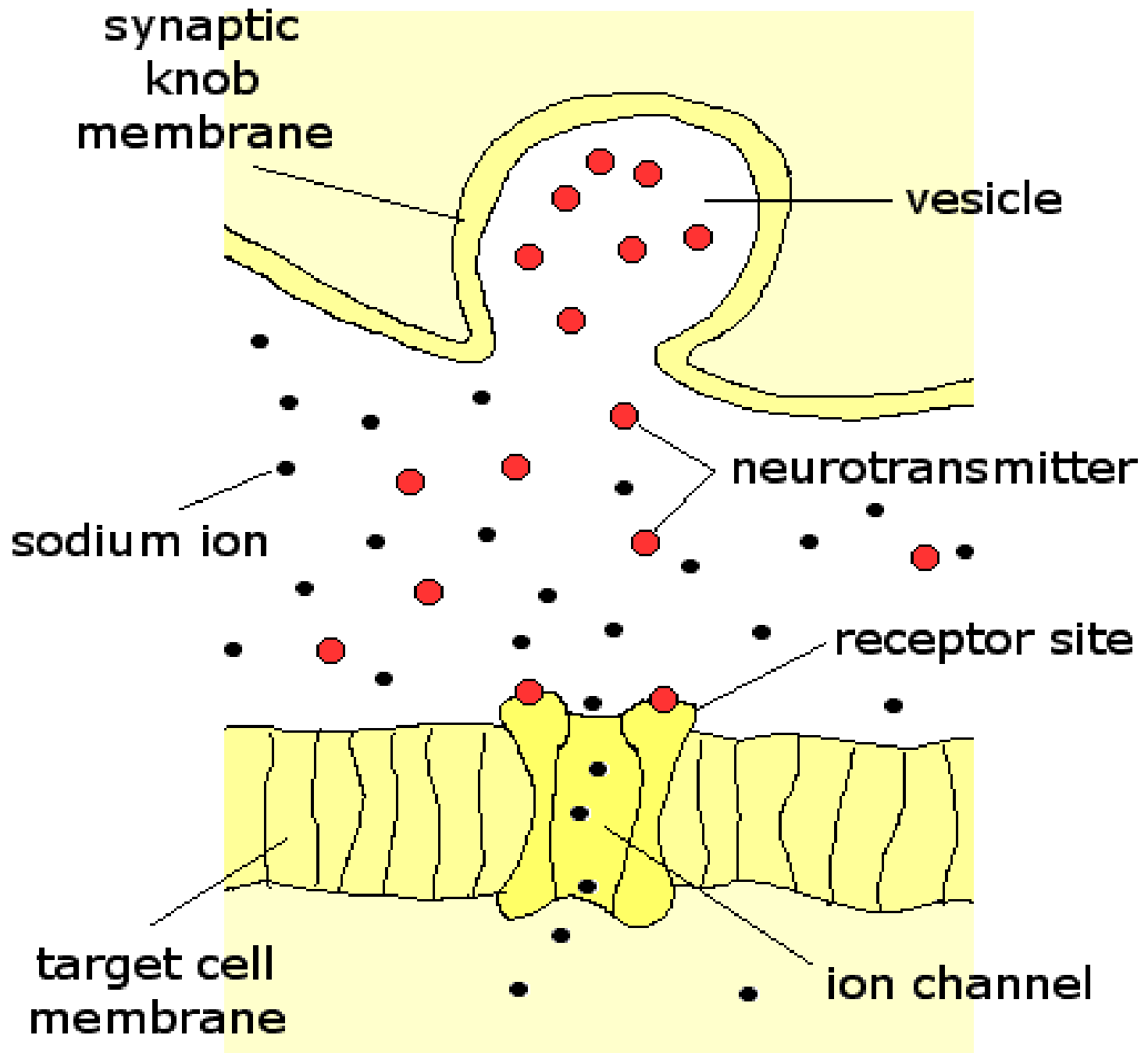
Postsynaptic neuron

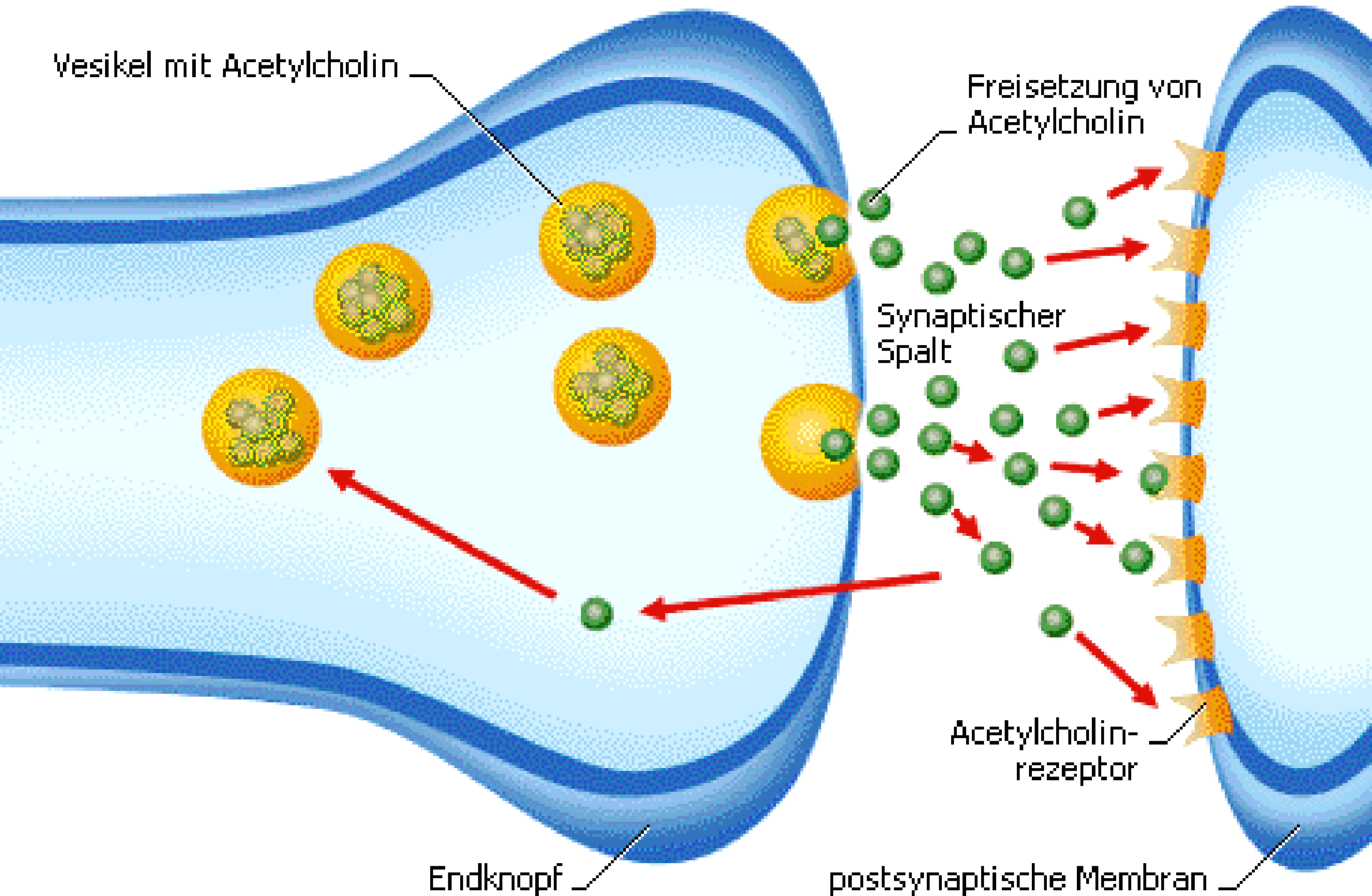


# Action of ACh at pre- and postsynaptic nerve terminals and its removal by AChE









Vesikel mit Acetylcholin

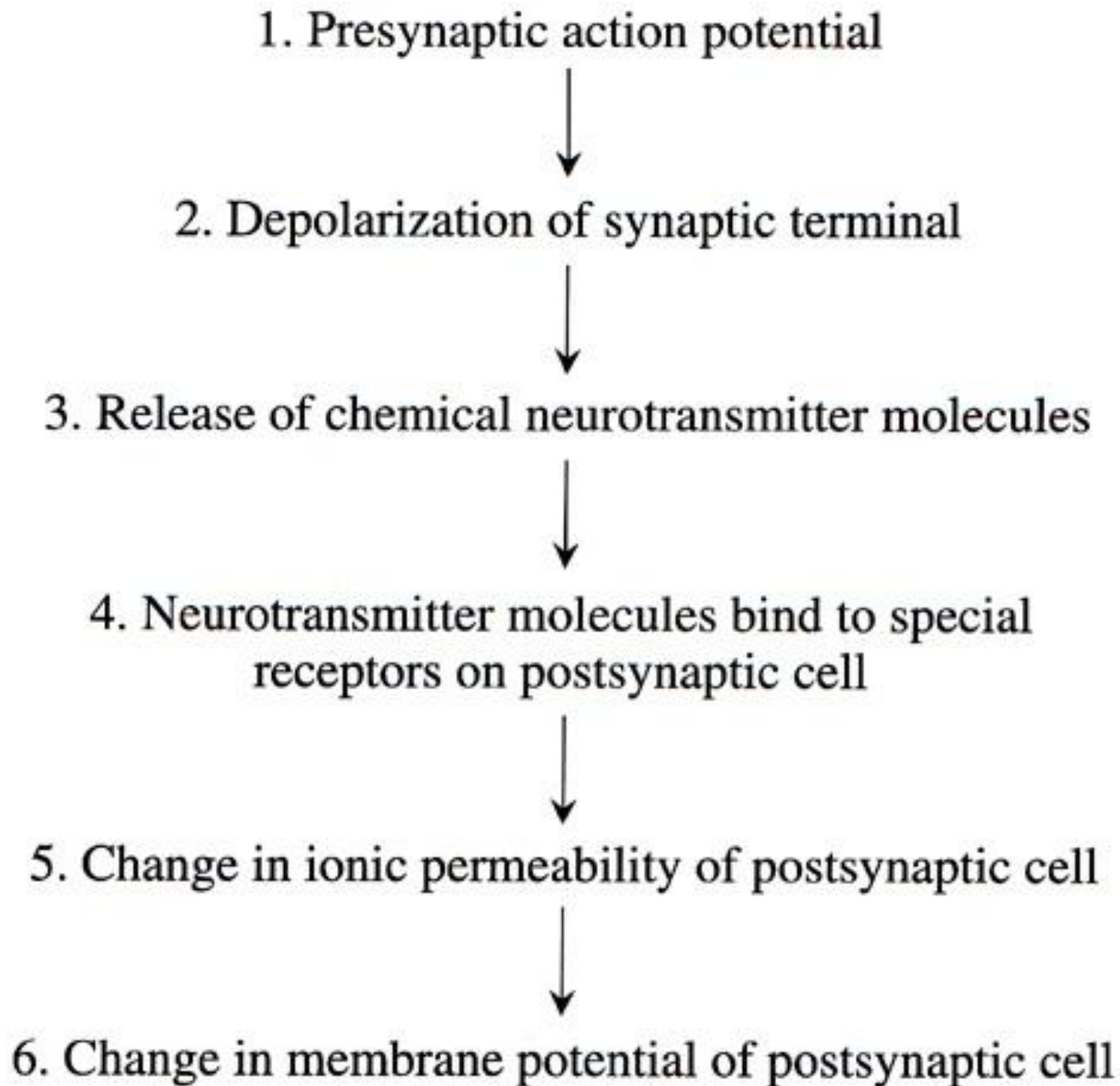
Freisetzung von Acetylcholin

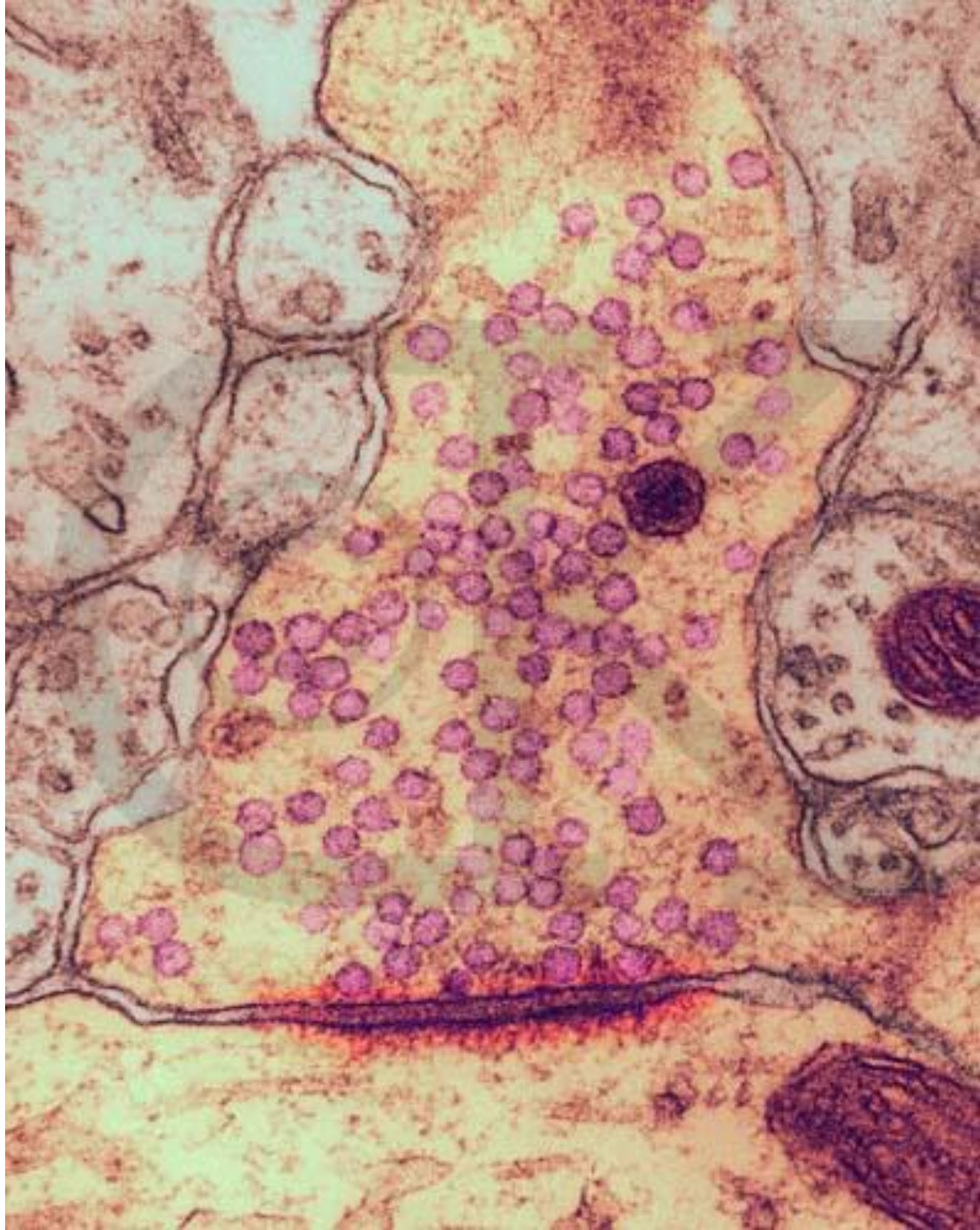
Synaptischer Spalt

Acetylcholin-rezeptor

Endknopf

postsynaptische Membran





## 2.2. Nöroglia Hücreleri

Sinir dokusunda, asıl fonksiyon gören nöronların perikaryon ve uzantılarının aralarını dolduran ve gerek mekanik bağlayıcılık gerekse metabolik destekleyicilik yapan özel bir doku bulunmaktadır. Bu dokuya **nöroglia dokusu** ya da **gliöz doku** adı verilir. Hücrelerinin uyarılma özelliği bulunmayıp **nöroglia** veya **glia hücreleri** olarak adlandırılırlar. Nöronlar gibi uzantılı, ancak gerek hücre gövdesi gerekse uzantıları açısından küçük olan hücrelerdir. Buldukları sinir dokusunun merkezi ya da periferik sinir sisteminde oluşuna göre 6 tip glia gücresi bulunur.

### I- Merkezi sinir sistemi nöroglia hücreleri :

1- Ependim hücreleri

2- Astrositler (Protoplazmik ve Fibröz)

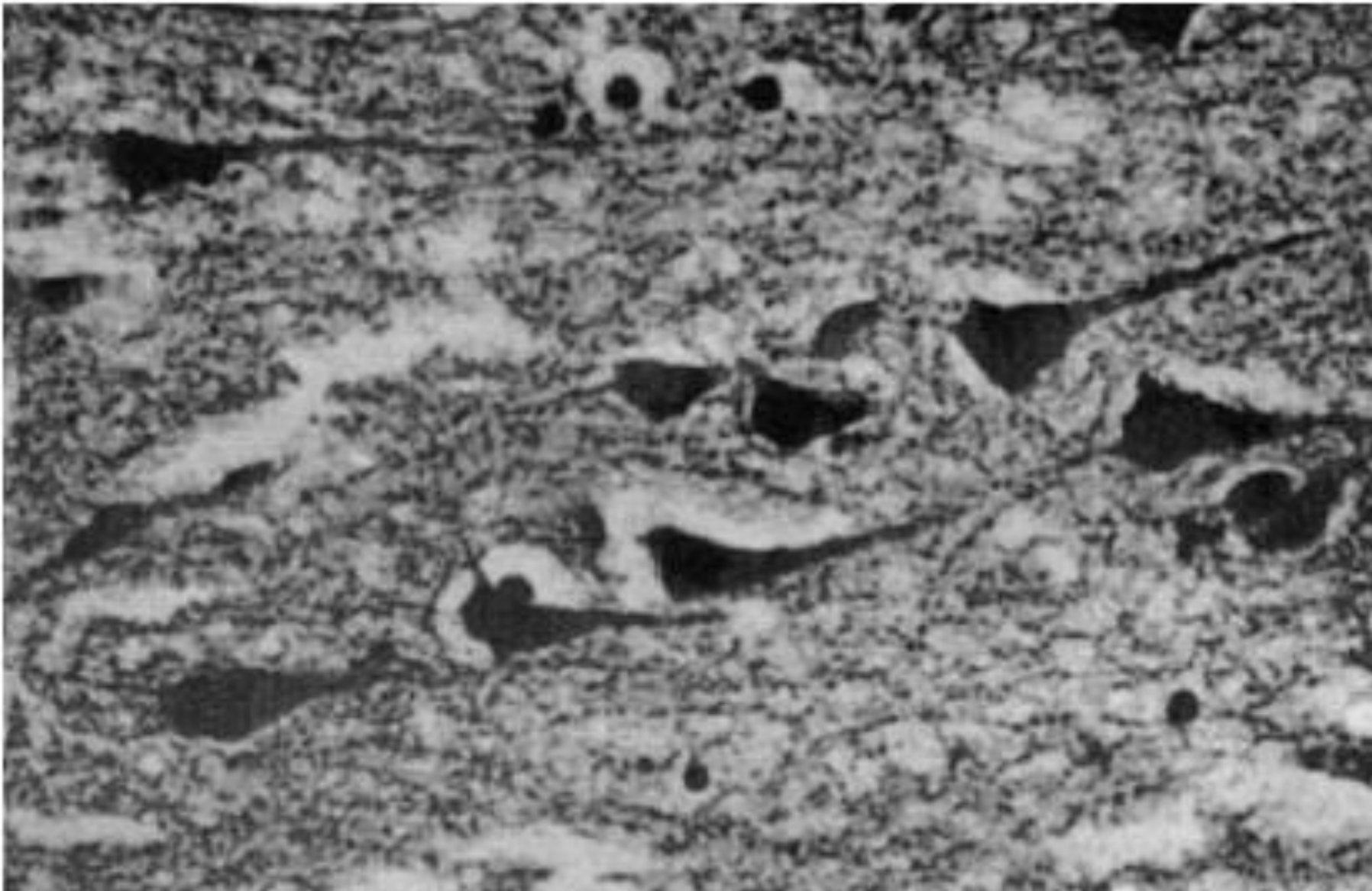
3- Oligodendroglialar

4- Mikroglialar

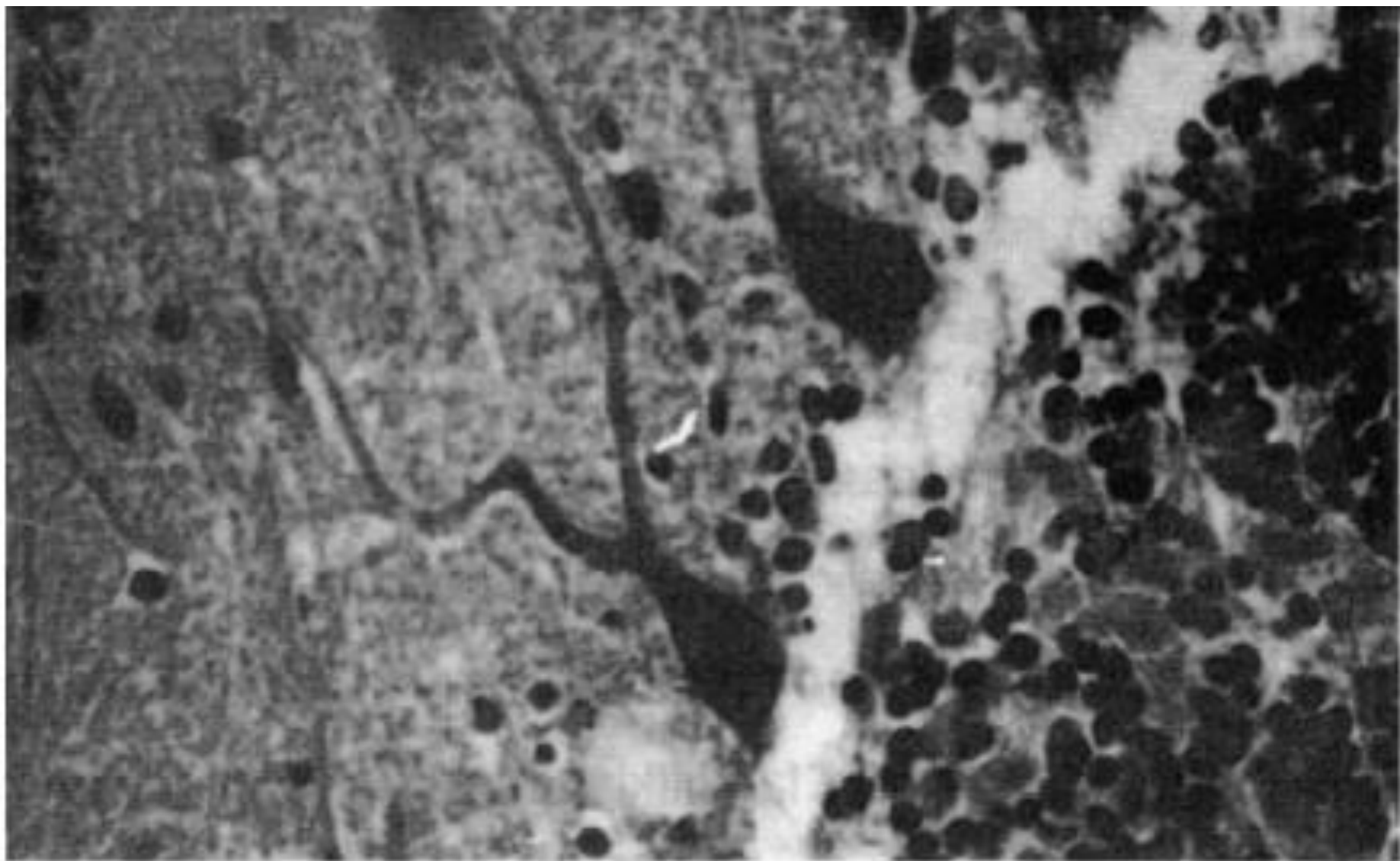
### II- Periferik nöroglialar :

1- Schwann hücreleri (teloglial hücre, terminal lemmal hücreler, destek hücreleri)

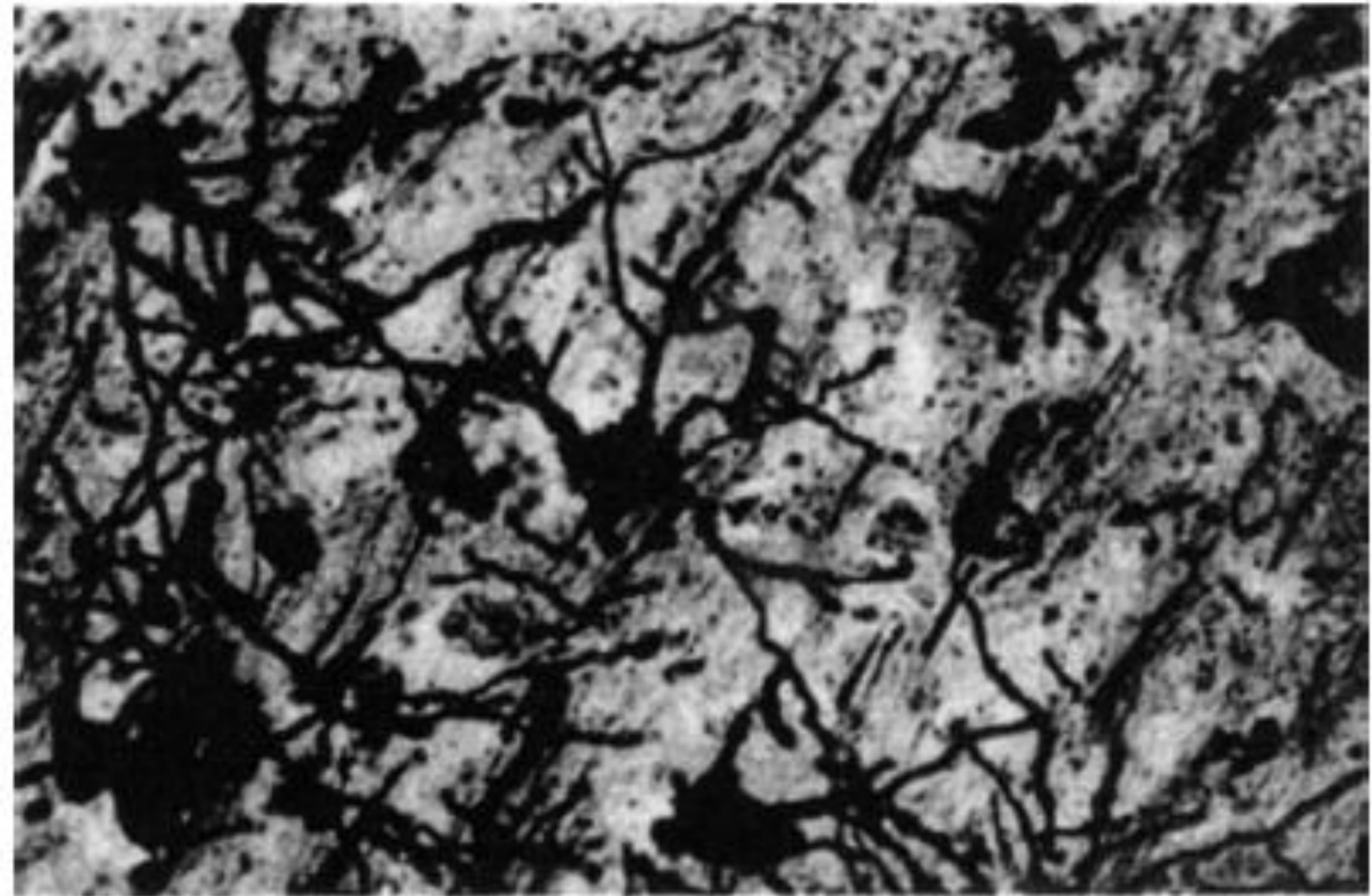
2- Satellit hücreleri



**Resim 9.3: Beyin. H.E. Piramidal hücre**



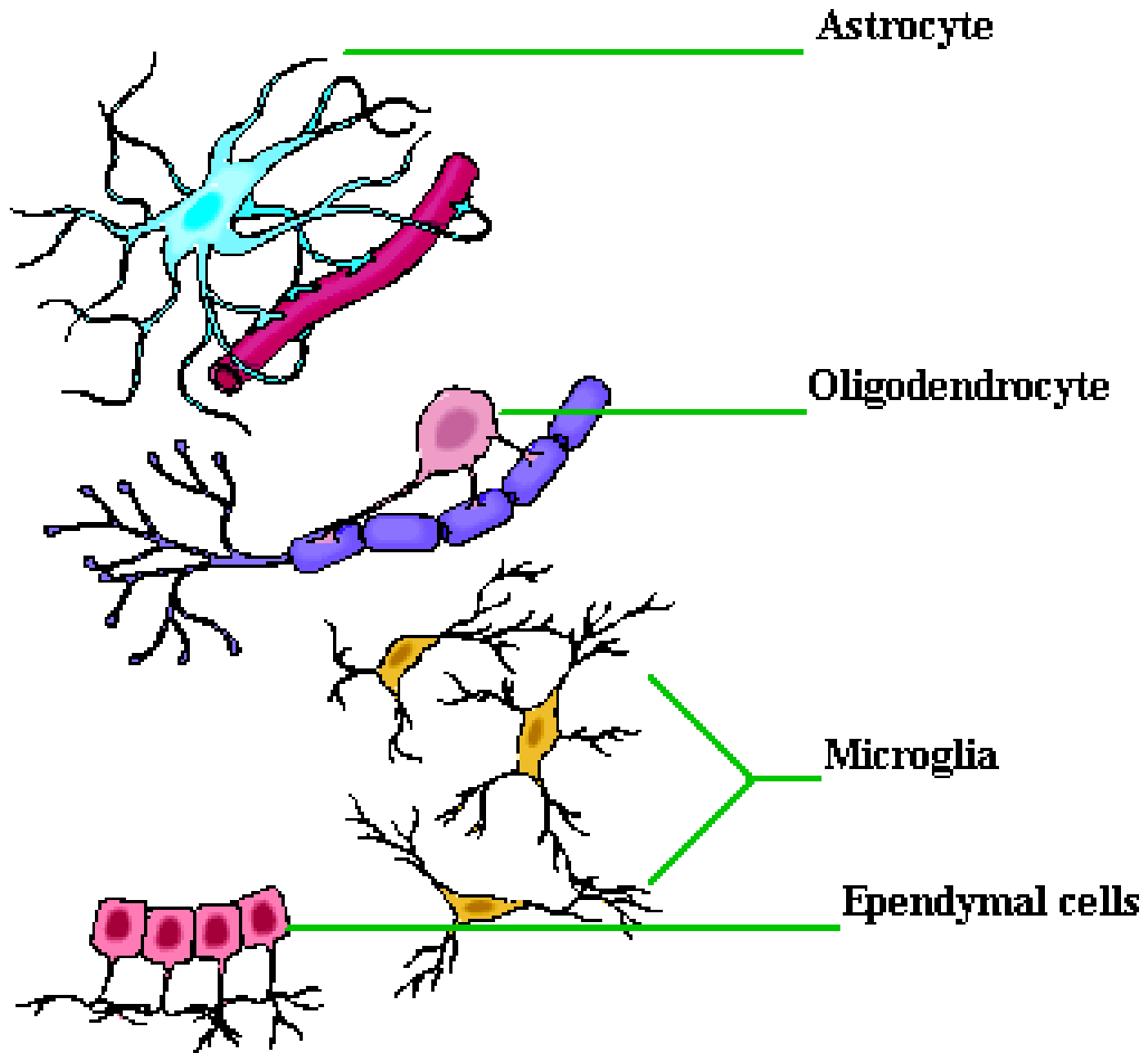
**Resim 9.4: Beyincik H.E. Purkinje hücresi**



**Resim 9.5: Beyin. Gümüşleme**

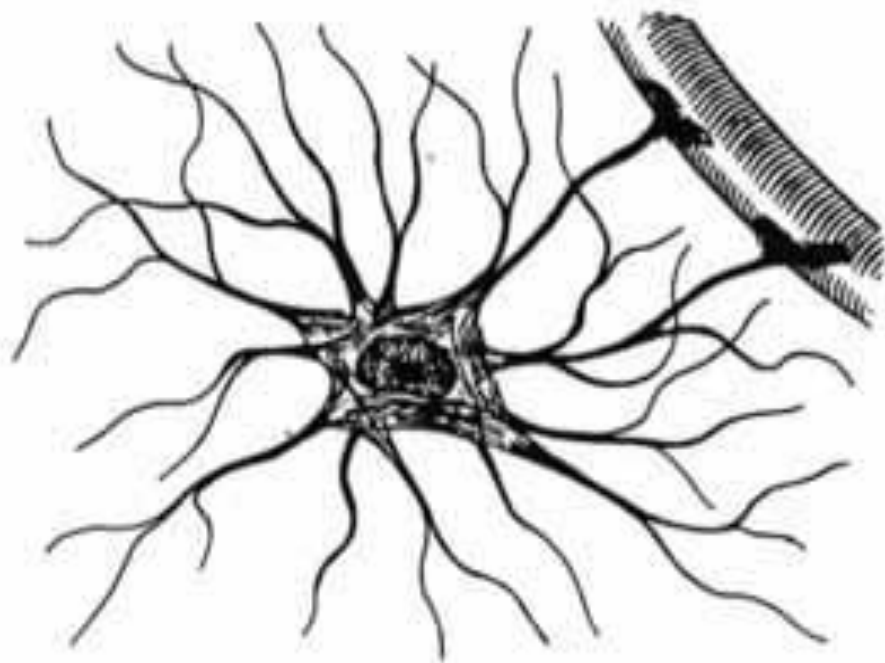


# Neuroglial Cells of the CNS

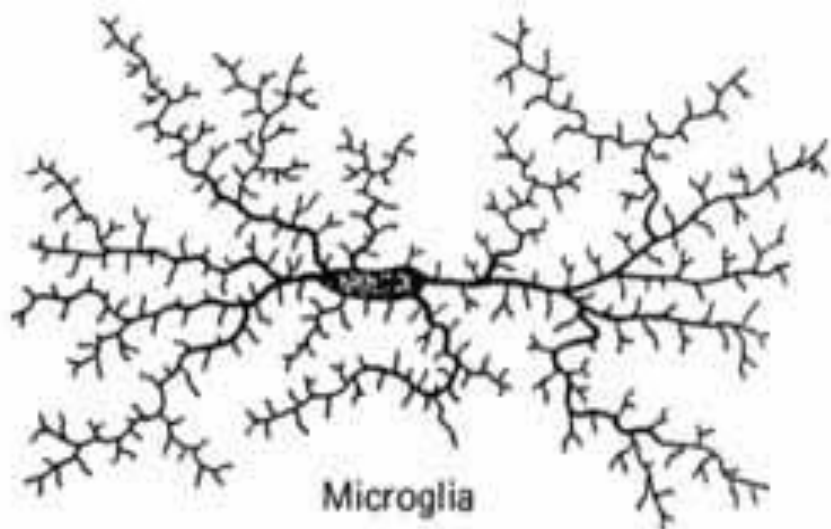




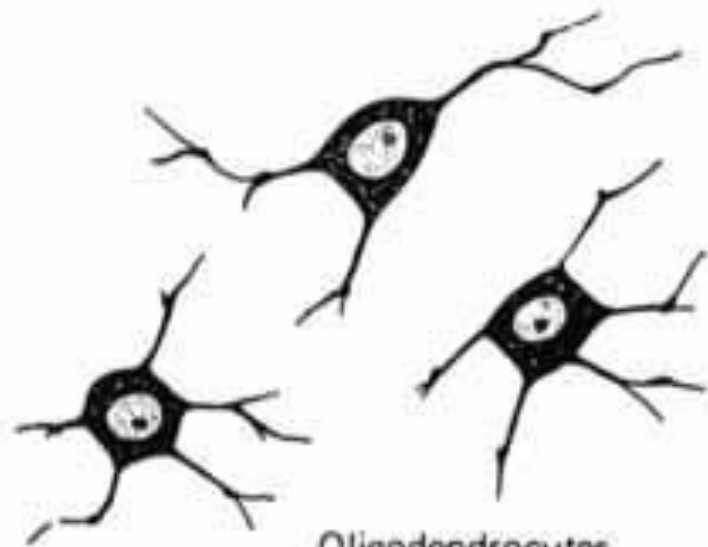
Protoplasmic astrocyte



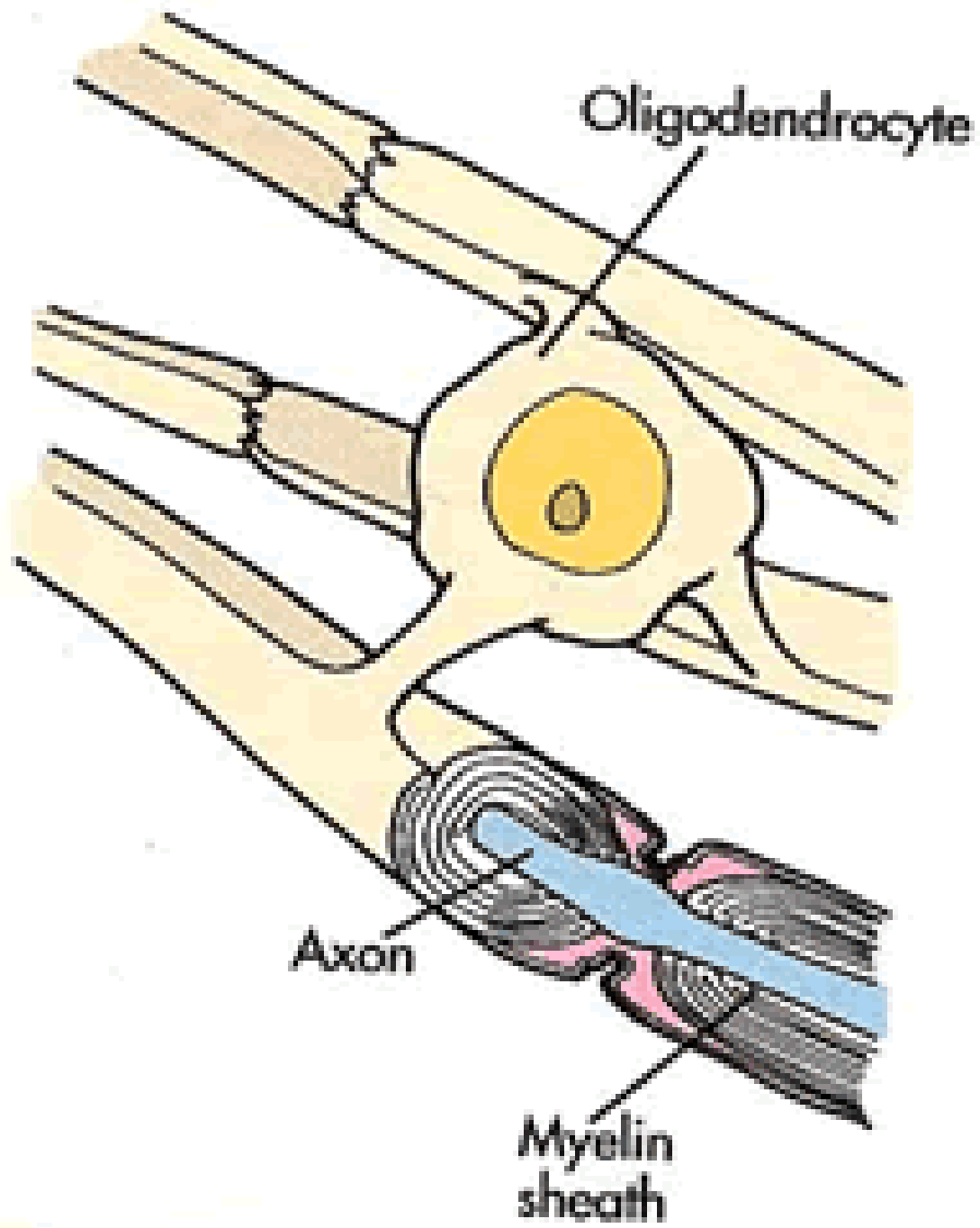
Fibrous astrocyte



Microglia



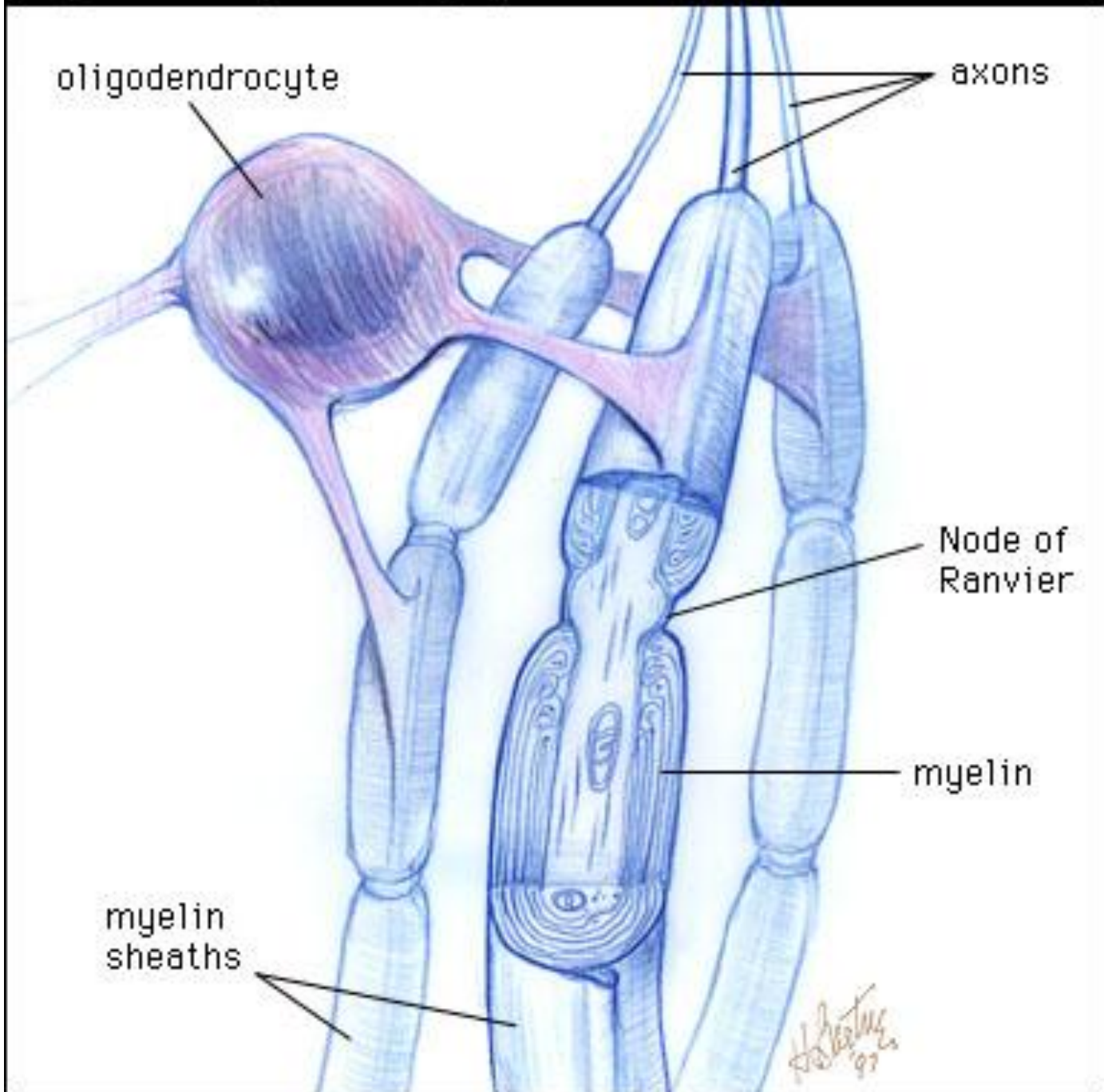
Oligodendrocytes

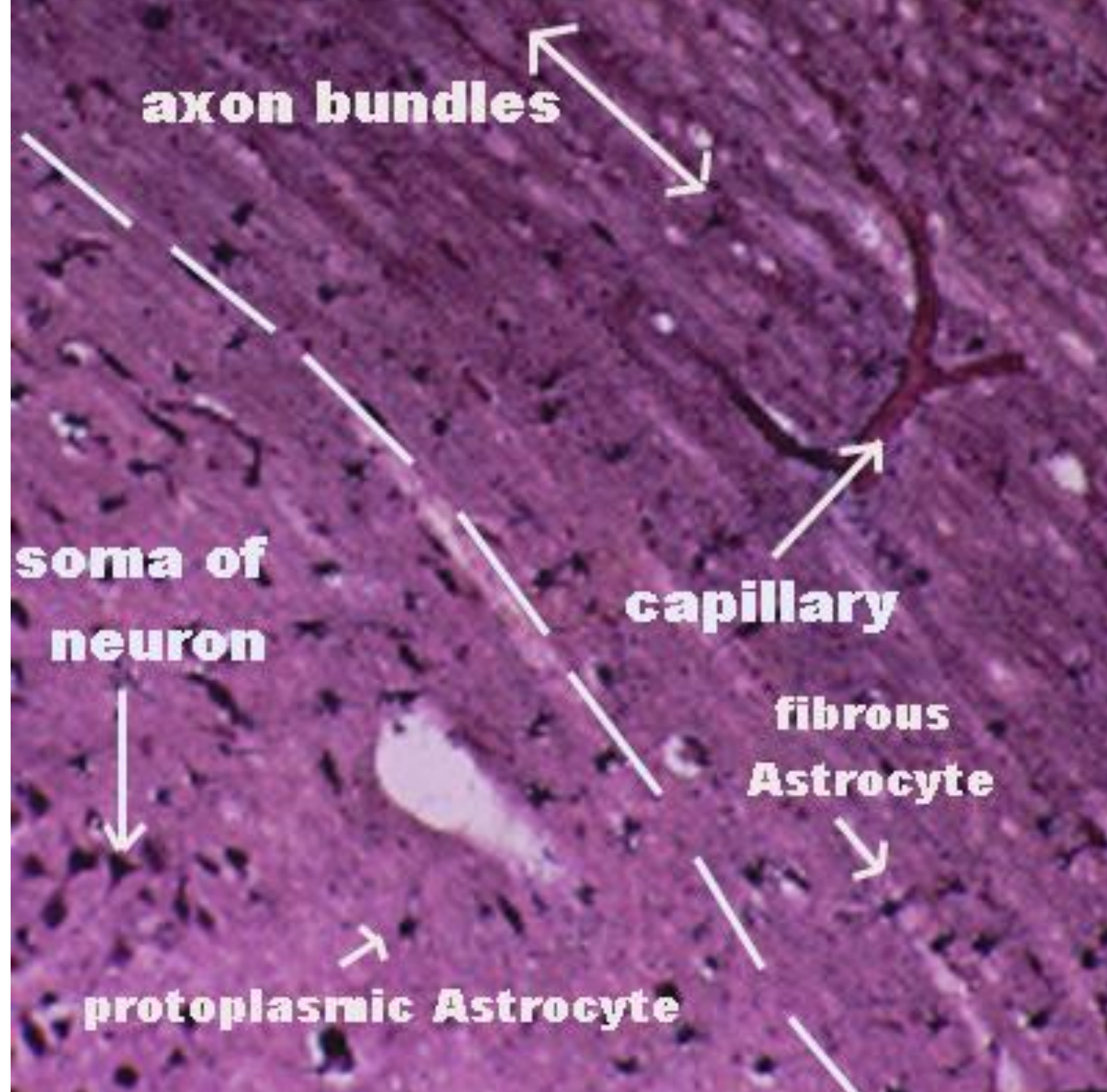


# oligodentrosit



# Oligodendrocyte Making Myelin

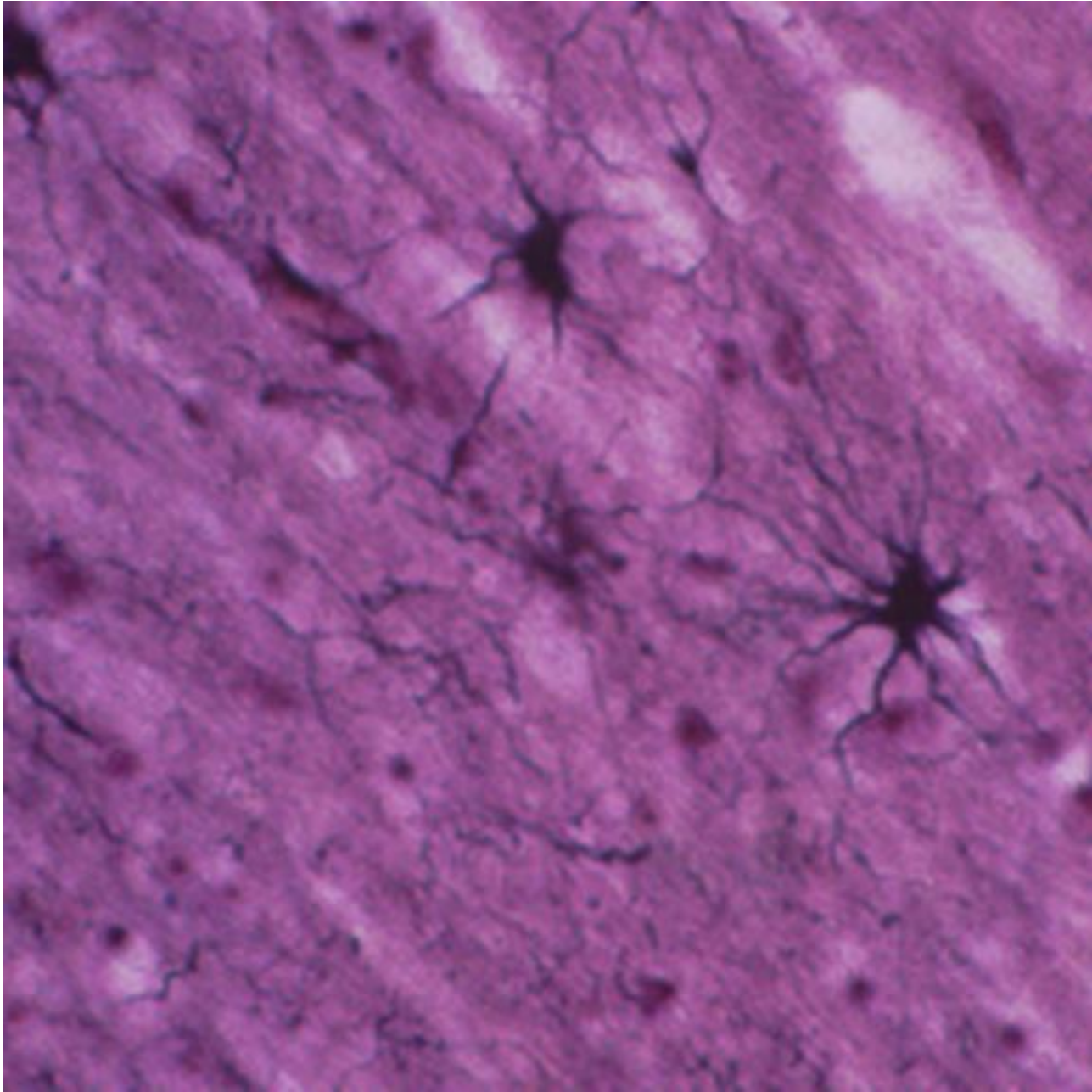




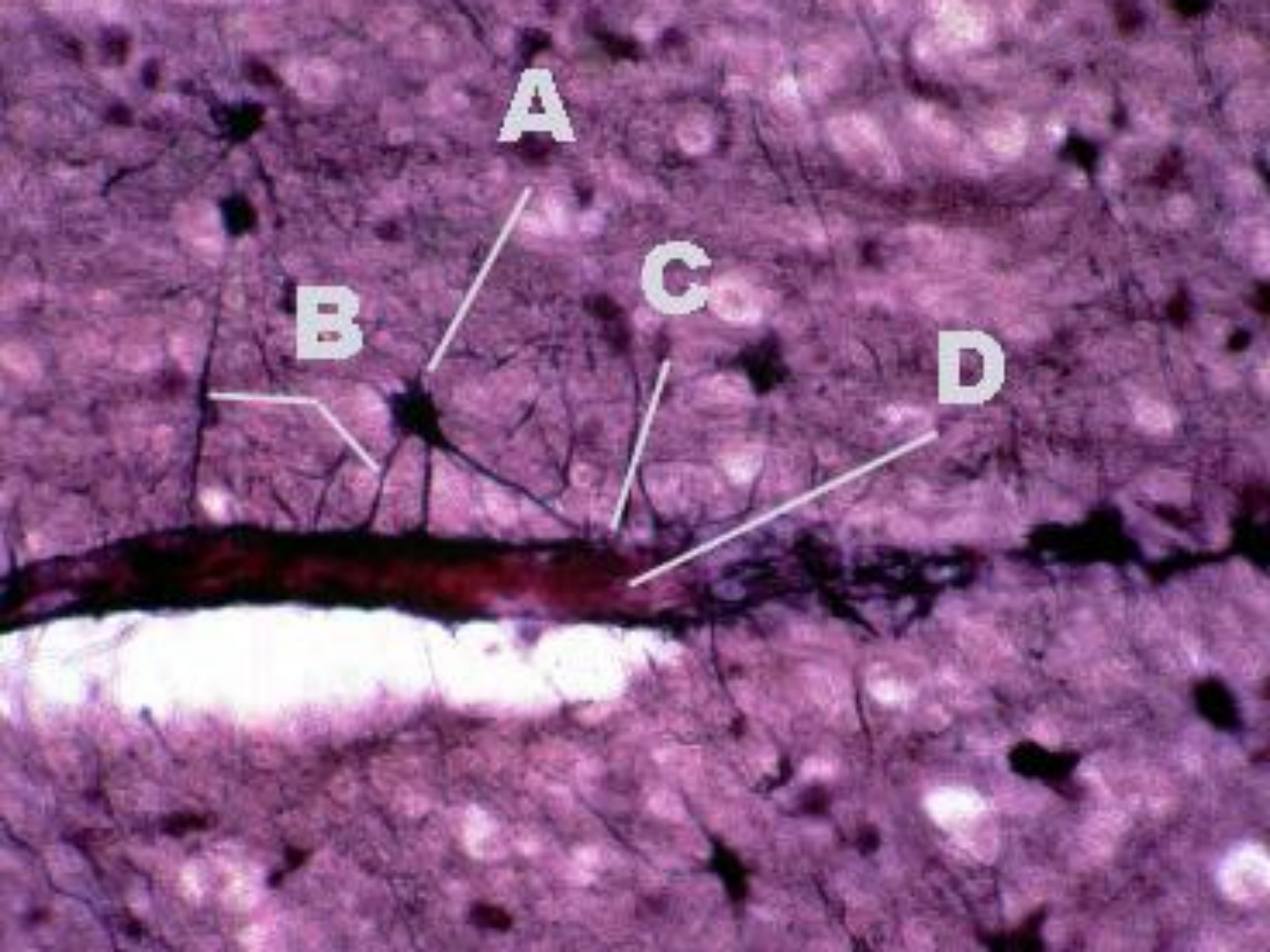
# Astrosit ve kan beyin bariyeri

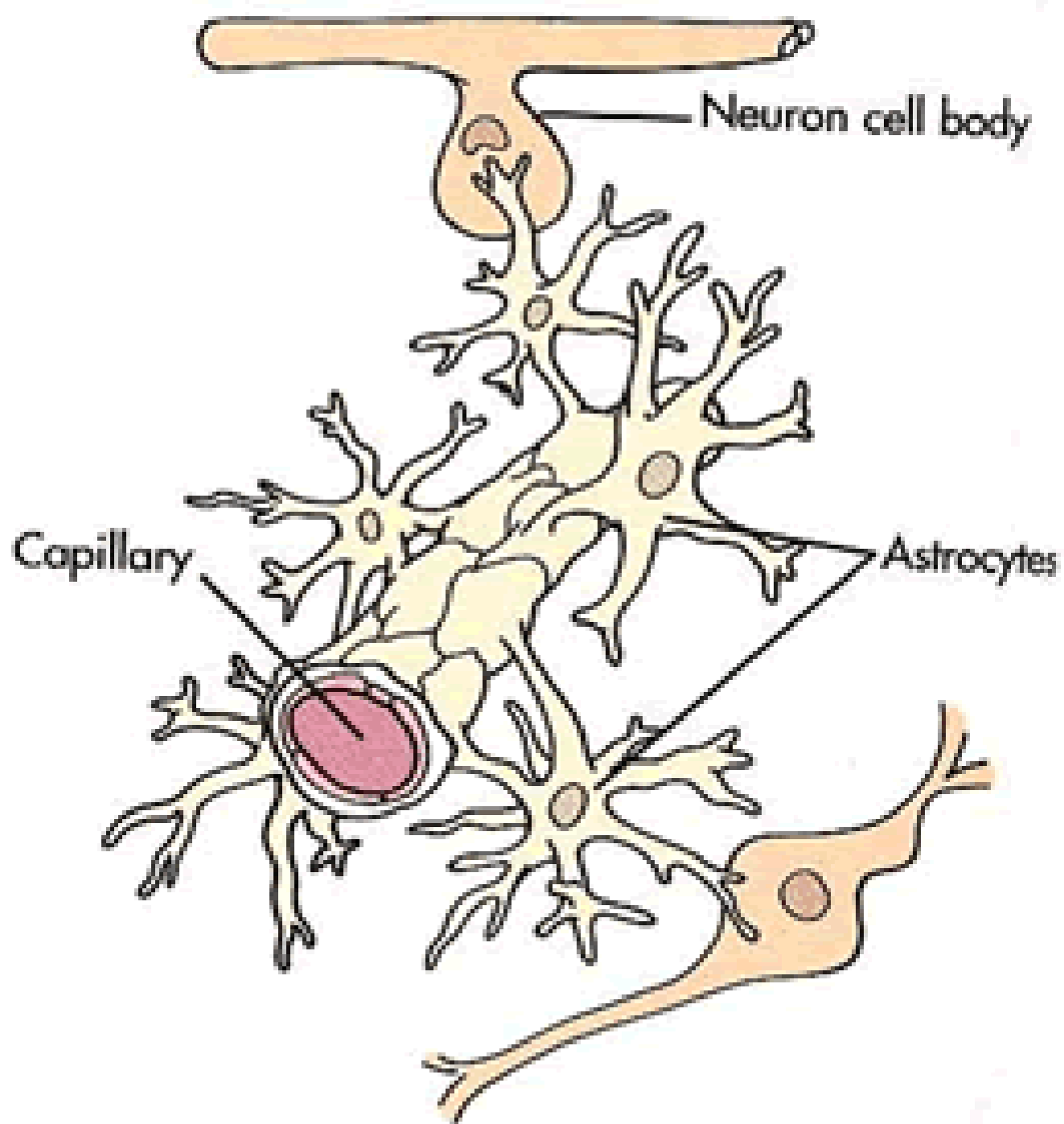


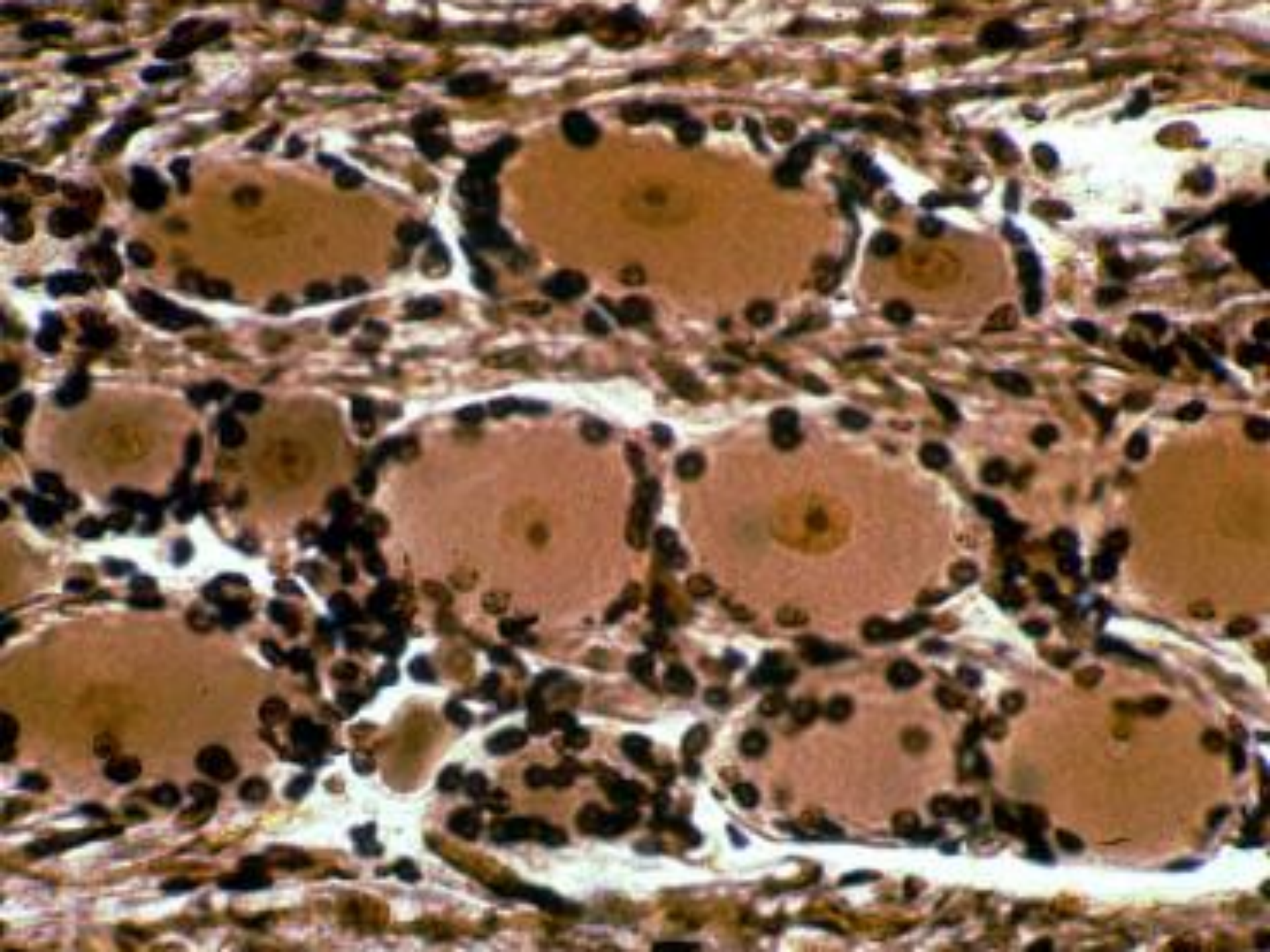
# Fibröz astrosit

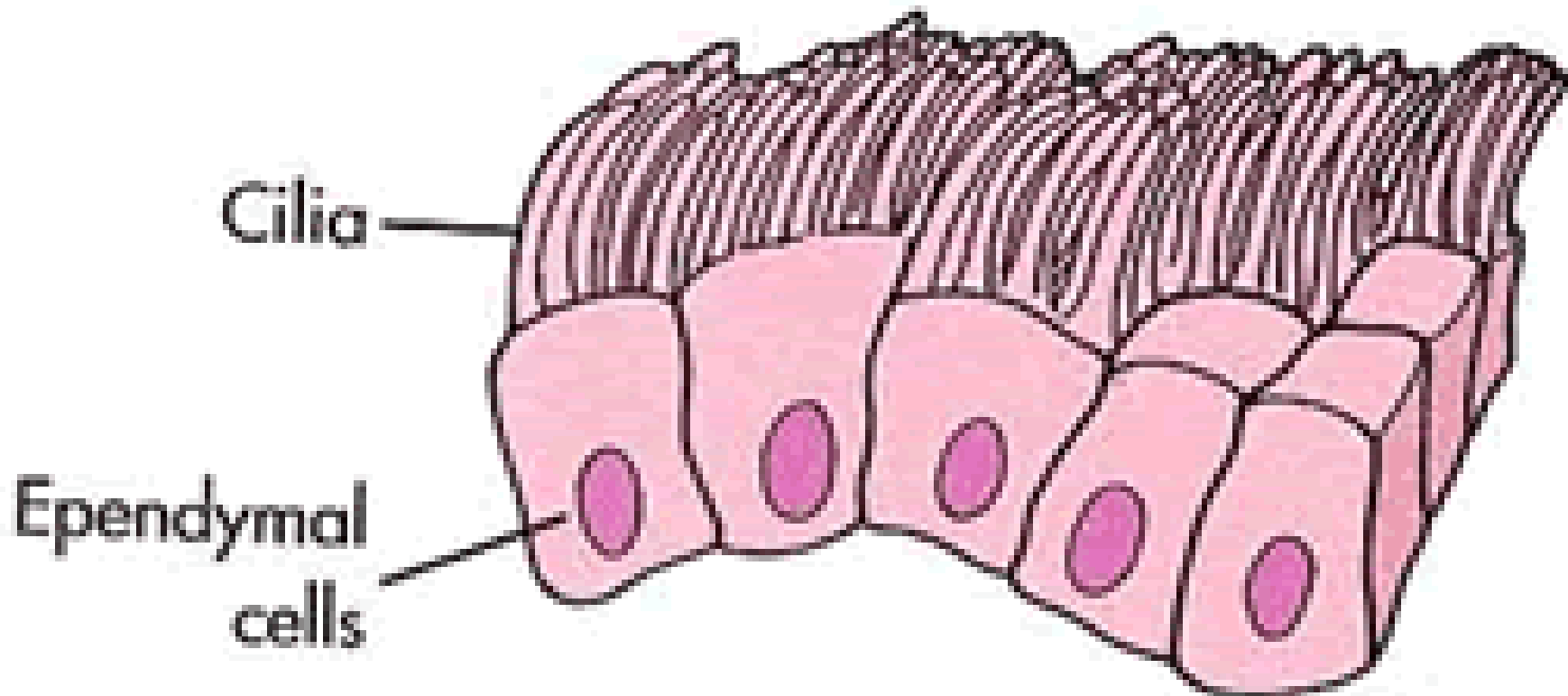










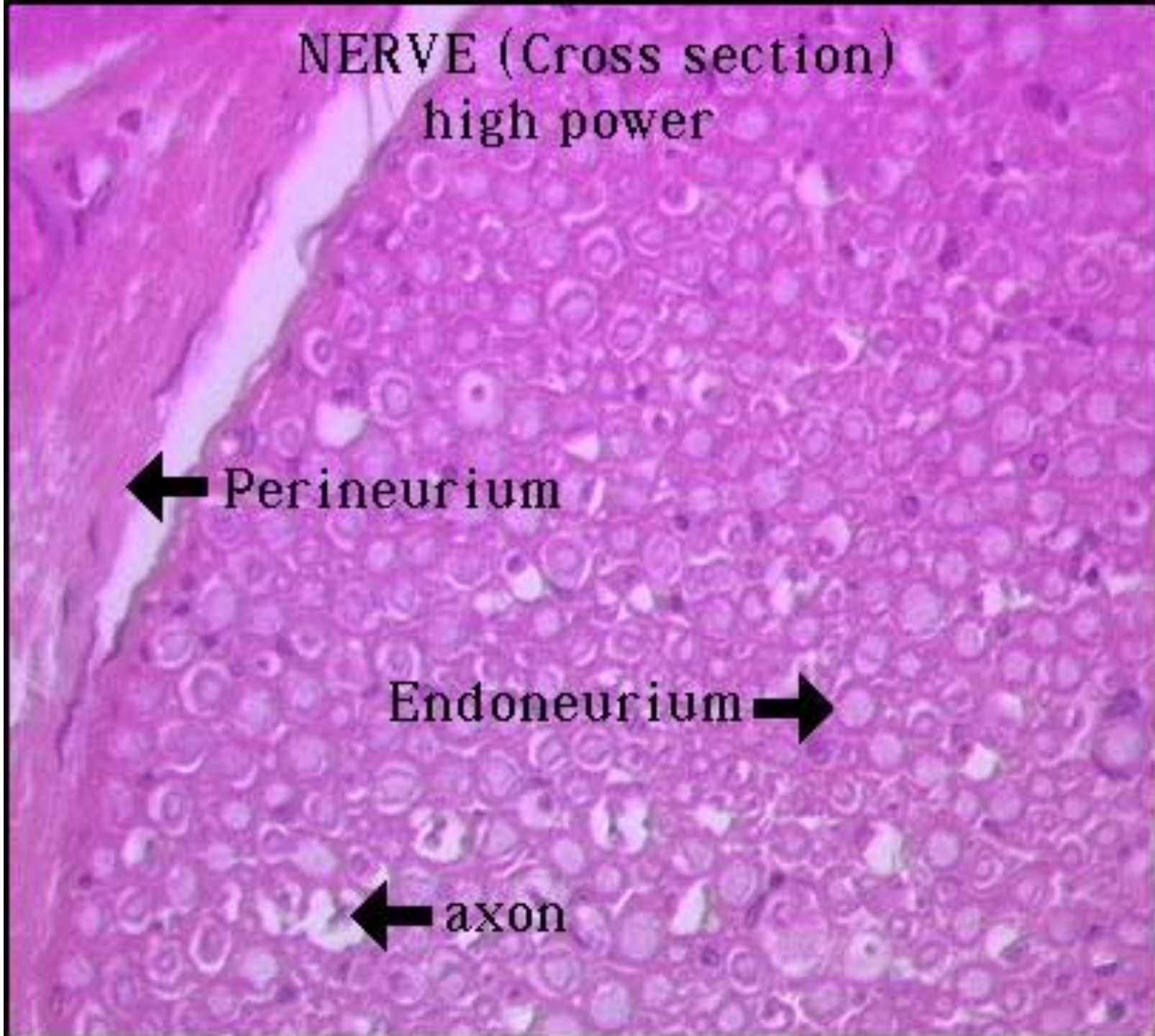


NERVE (Cross section)  
high power

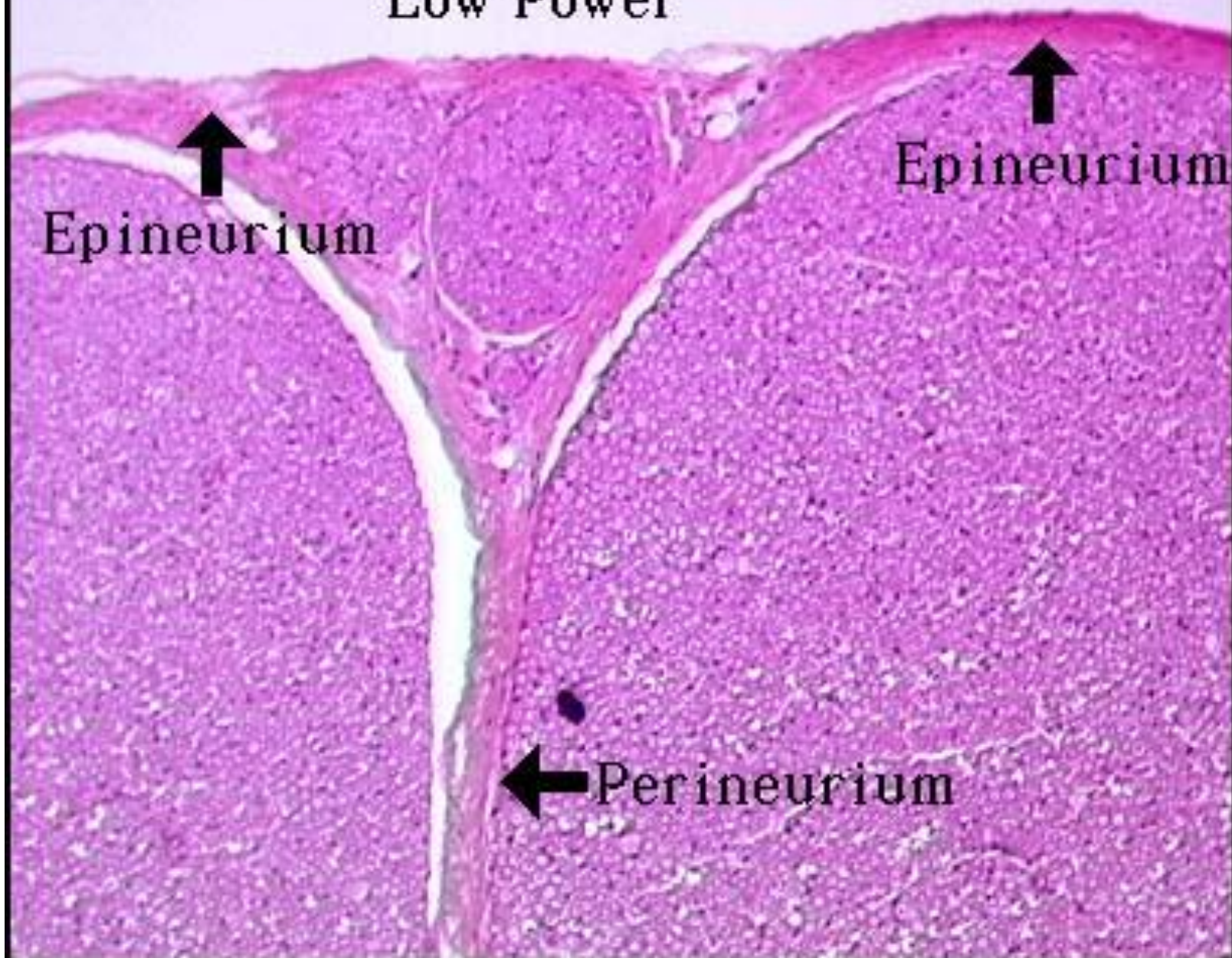
← Perineurium

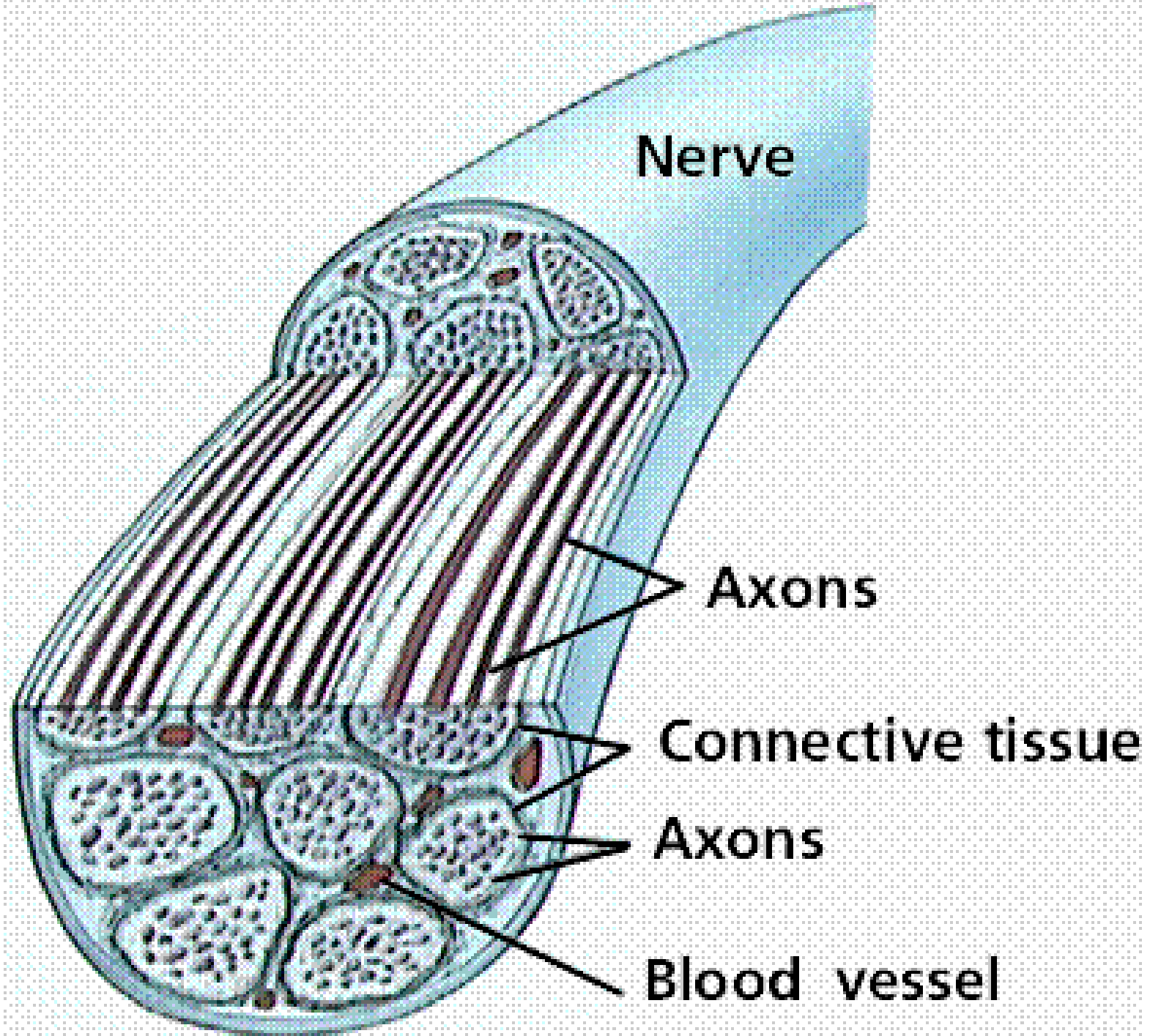
Endoneurium →

← axon



NERVE (Cross section)  
Low Power





# KAYNAK LİSTESİ

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2. Temel Histoloji (Ed. Aytekin Özer, 2011)
3. Genel Histoloji (Mahmut Sağlam, R.Nuri Aştı, Aytekin Özer 2001)
4. Özel Histoloji (Attila Tanyolaç 1999)
5. Histoloji (Ercan Artan 1988)
6. Textbook of Histology (Leeson Leeson Paparo 1981)
7. Basic Histology (L.C. Jungueira, J.Carneiro 1983)
8. Textbook of Veterinary Histology (Dellman Brown 1983)
9. Basic Histology (Douglas F. Paulsen 1989)
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