第二讲
神经科学基础
Lecture 2
Neuroscience Basics

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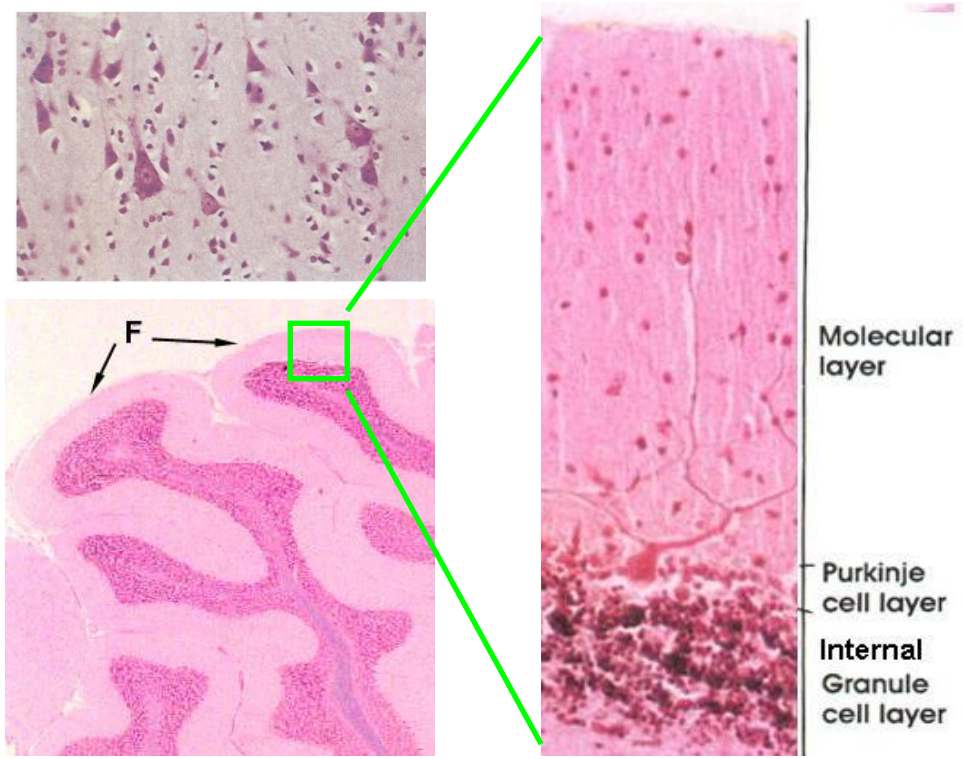
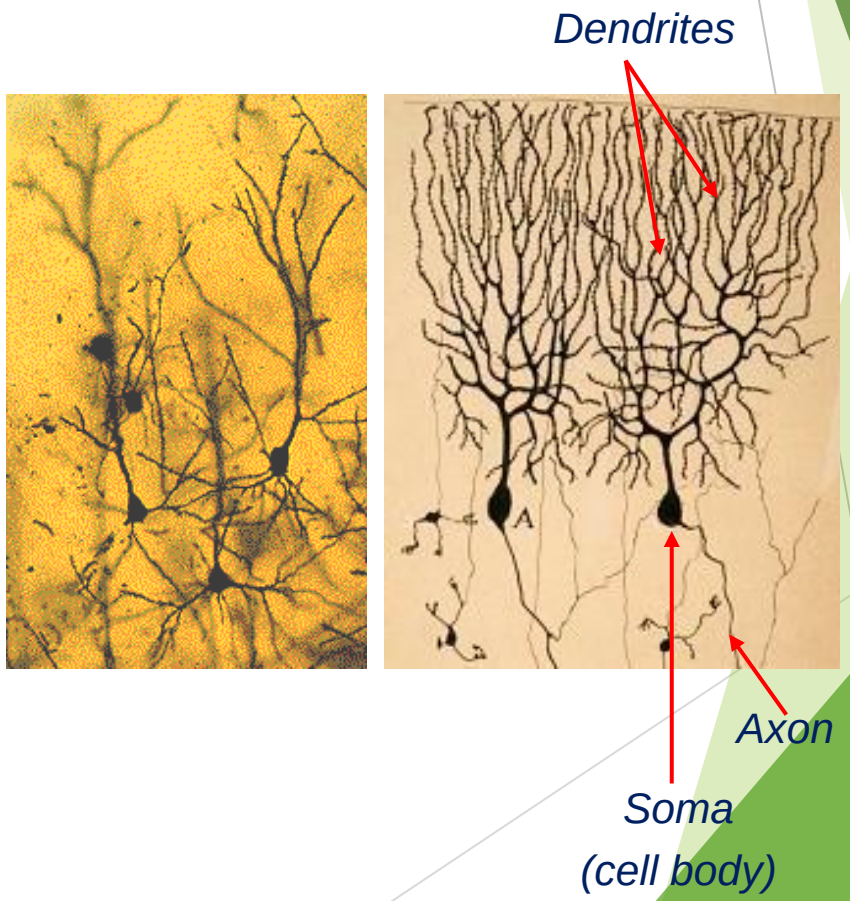
脑的组成及历史沿革
Constitution of brain and historical achievements





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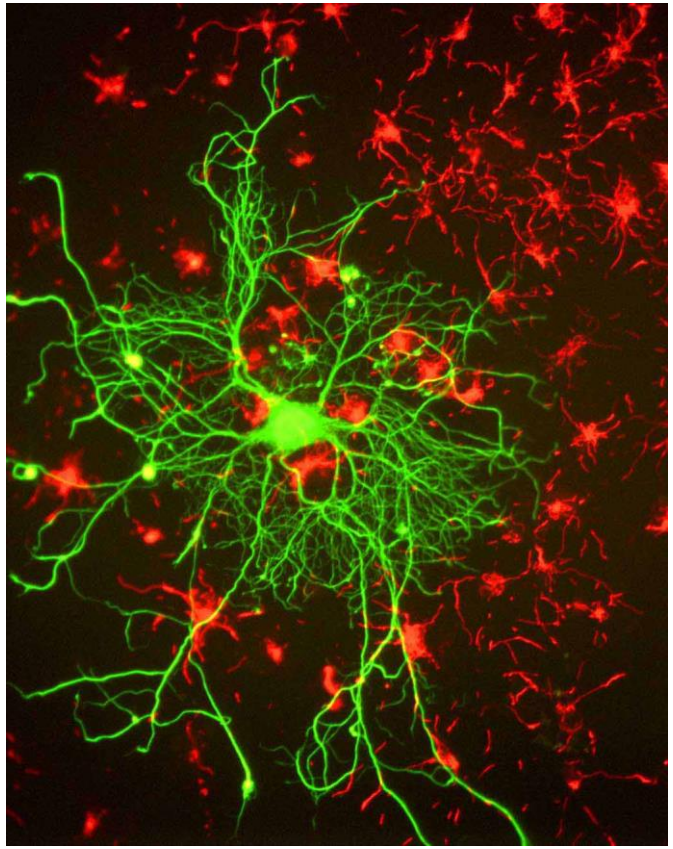
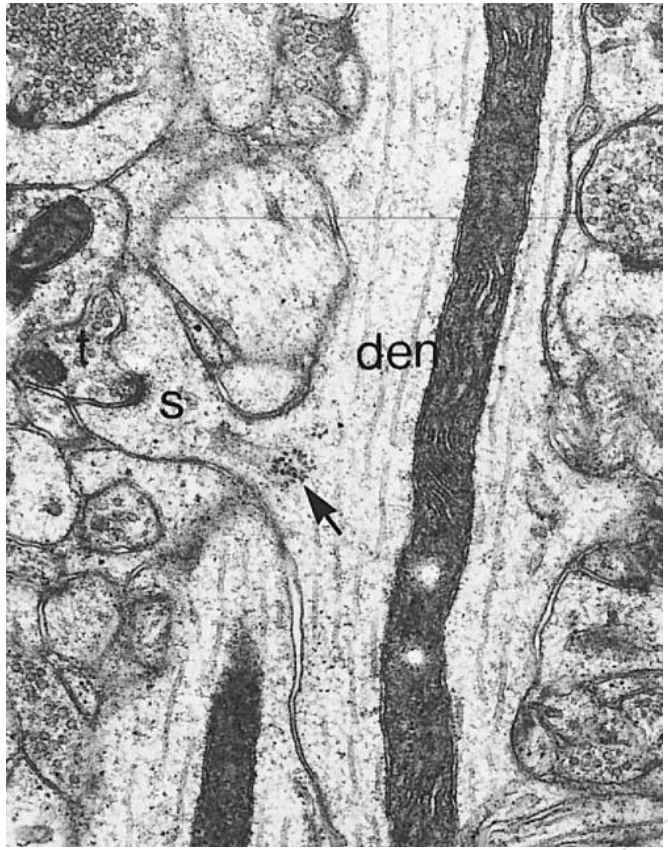




神经元及其结构
Neuron and its structure

- 神经元或神经细胞是神经系统的重要组成部分，其包含于脑，脊髓及周边神经中

  Neurons or neuronal cells are the core components of the nervous system, which includes the brain, spinal cord, and peripheral ganglia.

- 神经元具有电生理活动，其可以处理和传导电信号与化学信号

  Neurons are electrically excitable and can process and transmit information by electrical and chemical signaling.

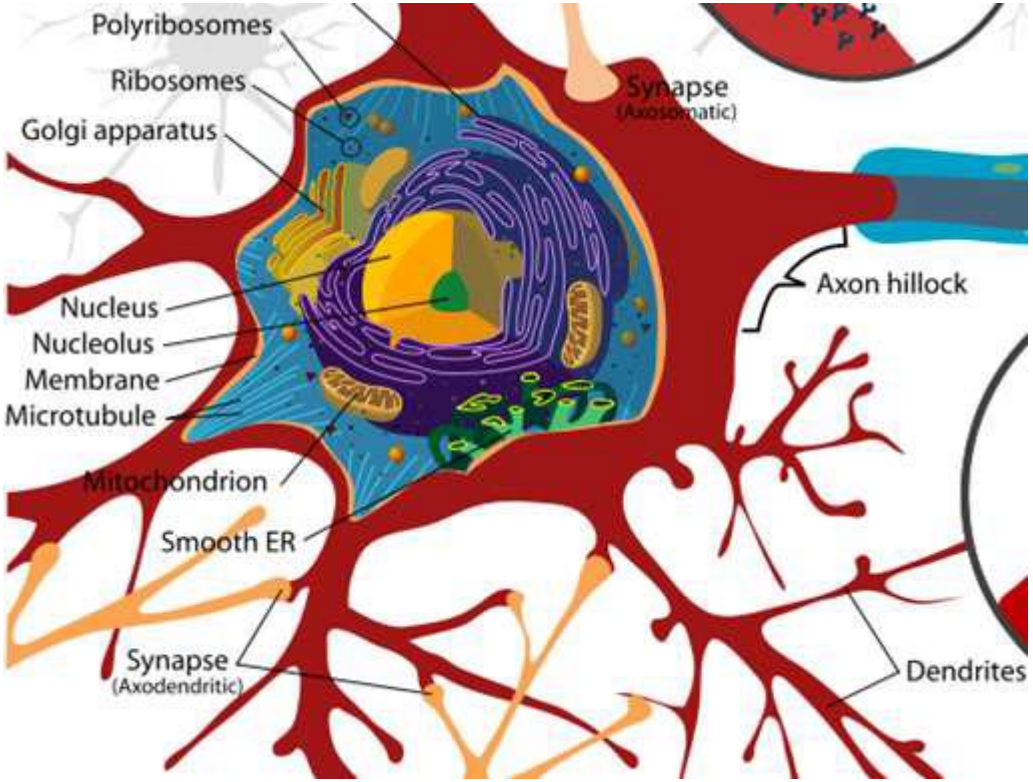
- 人脑大约包含100亿个神经元，每个神经元约与1万个其它神经元相连

  Human brain comprises tens of billions of neurons, each linked to thousands of other neurons via the chemical channels called synapse.

神经元及其结构
Neuron and its structure

- 神经元主要有三部分组成：细胞体，树突，轴突

  A neuron consists of three main parts the cell body or perikaryon or soma, dendrites and axons.



神经元及其结构
Neuron and its structure

- 细胞体是神经元的最重要的部分，其包含细胞质，一些重要的生化过程在细胞体内发生

  The cell body is the central region which is the most important part of the neuron containing the nucleus of the cell. The soma is, the site of major metabolic activity in the neuron.

- 哺乳动物的神经细胞的细胞体的大小可由0.005 mm to 0.1 mm；人体大脑的灰质层即由成团的细胞体所致

  The size of neuronal somas range widely from 0.005 mm to 0.1 mm in mammals. Collections of cell bodies (somas) give the greyish appearance to the gray matter of the brain.

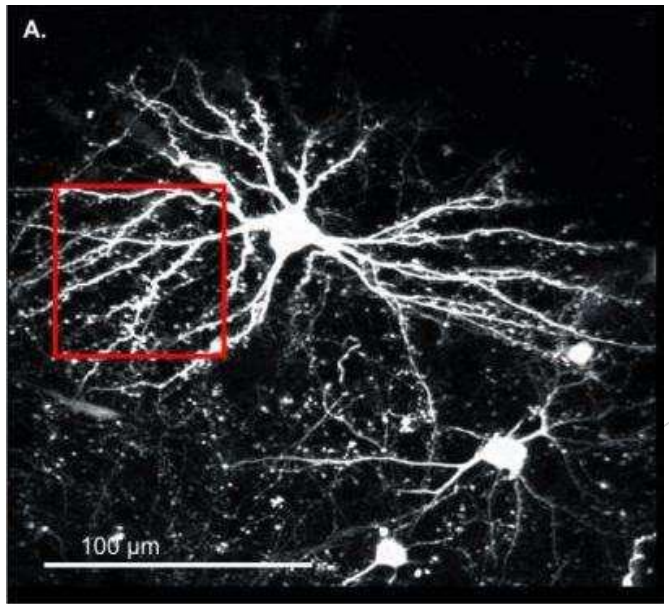
神经元及其结构
Neuron and its structure

- 树突是接收由其它神经元所传入的信号的延伸结构，又称为传入纤维

  Dendrites are extensions that carry impulses toward the cell body and are referred to as being afferent fibers.

- 其间接地增大了细胞体的表面积，从而使与其它神经元的通讯更加有效

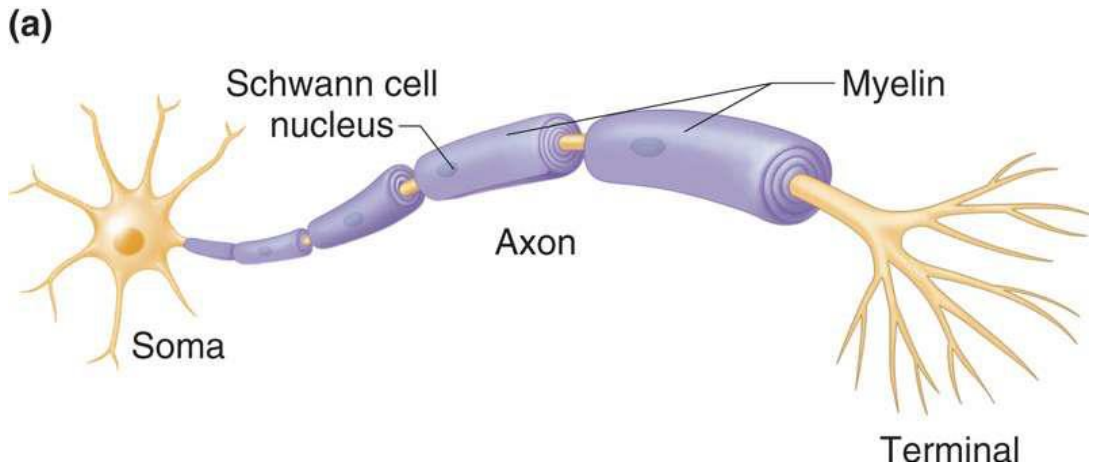
  They effectively increase the surface area of a neuron to increase its ability to communicate with other neurons.



神经元及其结构
Neuron and its structure

- 轴突是从细胞体延出的狭长型的凸起，其将信号传出神经元

  An axon is a long, slender protoplasmic protrusion that extrude from the cell body of a neuron. It conducts electrical impulses away from the neuron's cell body or soma.



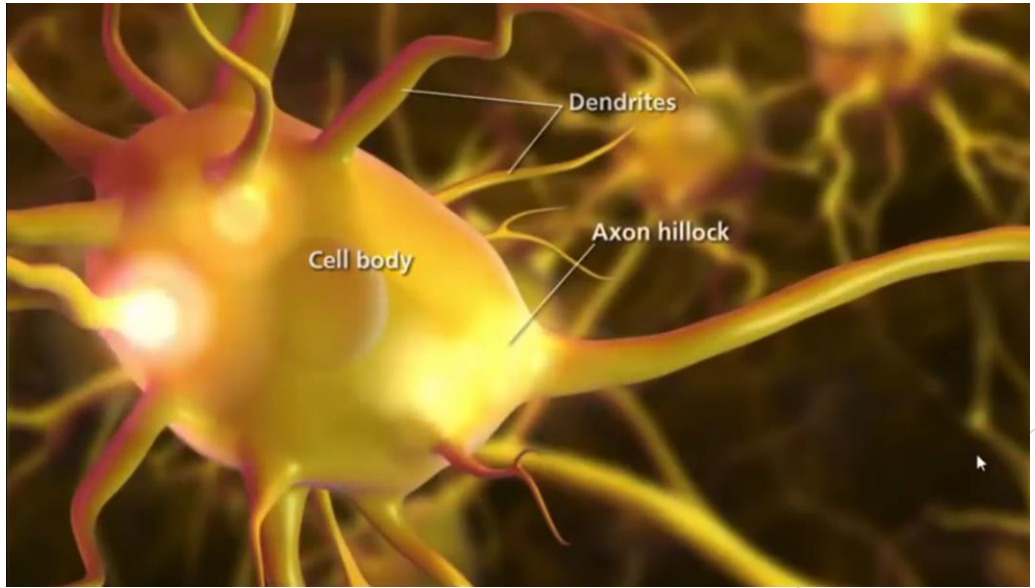
神经元及其结构
Neuron and its structure

- 轴突从多个方面均与树突不同，如形态，结构，功能等

  Axons are distinguished from dendrites by several features, including shape, structure and function.

- 轴突与细胞体相连的地方称为轴丘

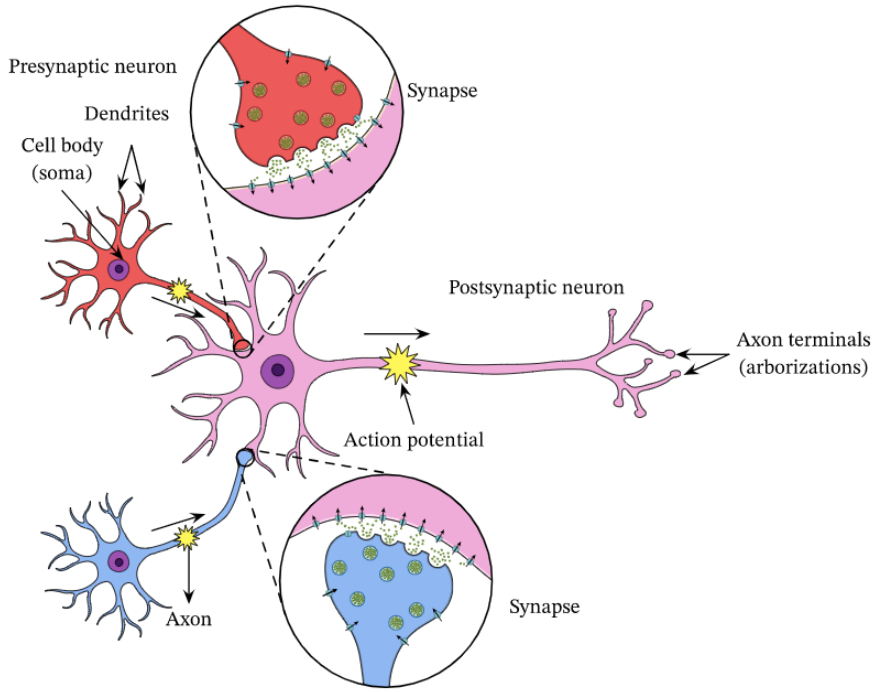
  The point where the axon arises from a cell body is termed as axon hillock.



神经元及其结构
Neuron and its structure

- 通常，树突与轴突相接驳的地方称为突触，为从一个神经元传递信息到另外一个神经元的地方

  The junction between a dendrite and an axon is called a synapse. two neurons, it is where the transmission of information from one neuron to another takes place.

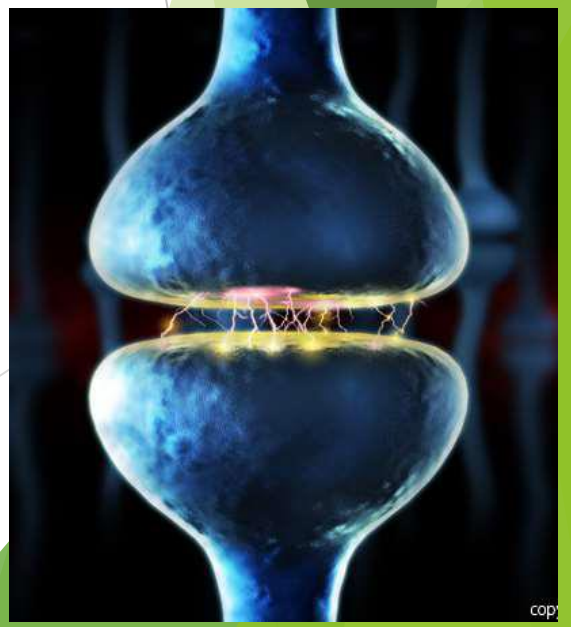


神经元及其结构
Neuron and its structure

- 突触是在生理学上连续的结构，而非在解剖学上连续的结构

  Synapse is not the anatomical continuation. But, it is only a physiological continuity between two nerve cells.

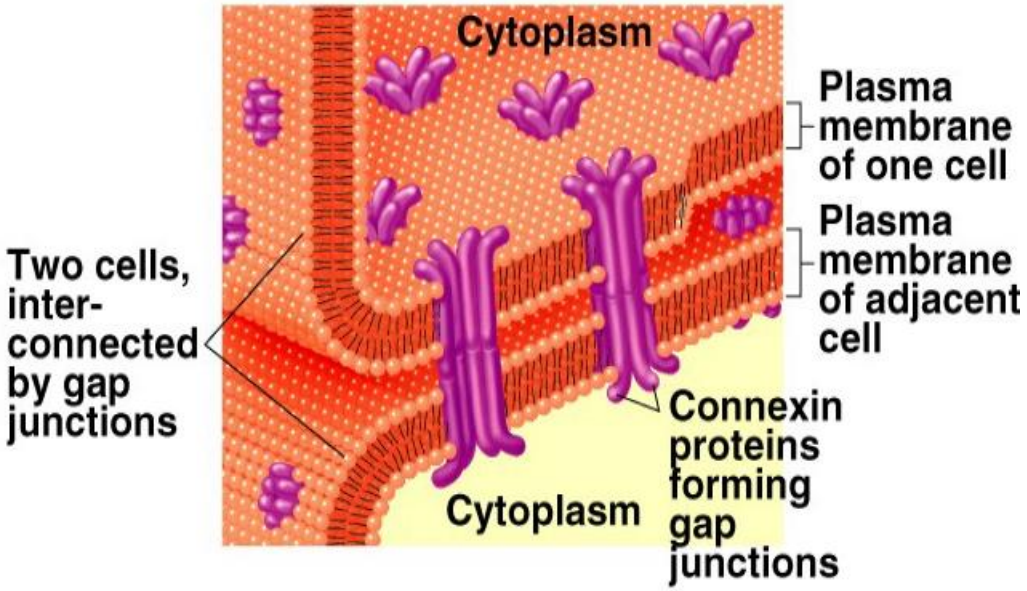
- 突触分为突触前，突触后，突触壁
  - A presynaptic ending that contains neurotransmitters, mitochondria and other cell organelles.
  - A postsynaptic ending that contains receptor sites for neurotransmitters.
  - A synaptic cleft or space between the presynaptic and postsynaptic endings. It is about 20nm wide.

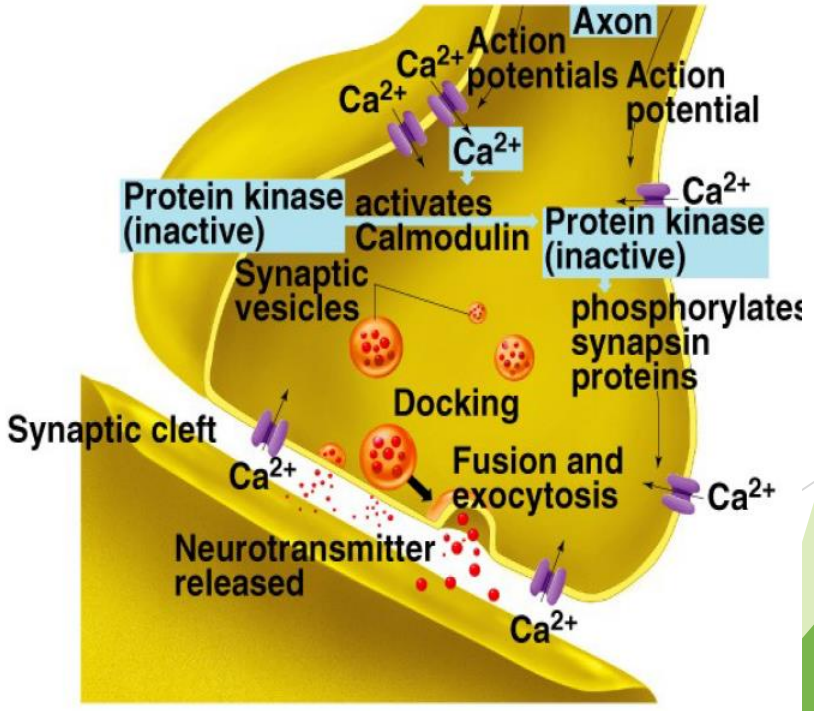


神经元及其结构
Neuron and its structure

- 信息在突触之间的传递可以通过电方式，也可以通过化学方式

  Information exchange at synapses can be achieved by electrical coupling or neurotransmitter releasing

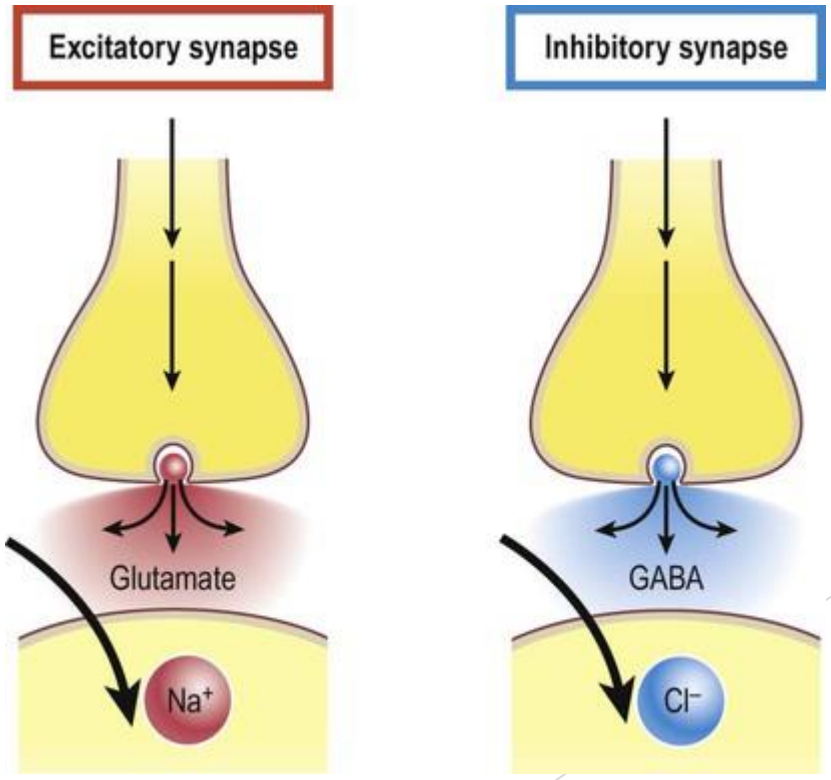




神经元及其结构
Neuron and its structure

- 上游神经元可以通过前突触增强后突触所在神经元的活性，或者抑制后突触所在神经元的活性

  The upstream neurons can excite or inhibit the downstream neurons via the interaction between pre-synapse and post-synapse.



电生理
Electrophysiology

- 电生理是研究生物细胞或组织电活动特性的生理学分支；其覆盖从微观上操纵离子通道的通道蛋白，到宏观上测量器官的生理对象的电压电流变化，等等。

  Electrophysiology is the branch of physiology that studies the electrical properties of biological cells and tissues. It involves measurements of voltage changes or electric current or manipulations on a wide variety of scales from single ion channel proteins to whole organs like the heart, brain.

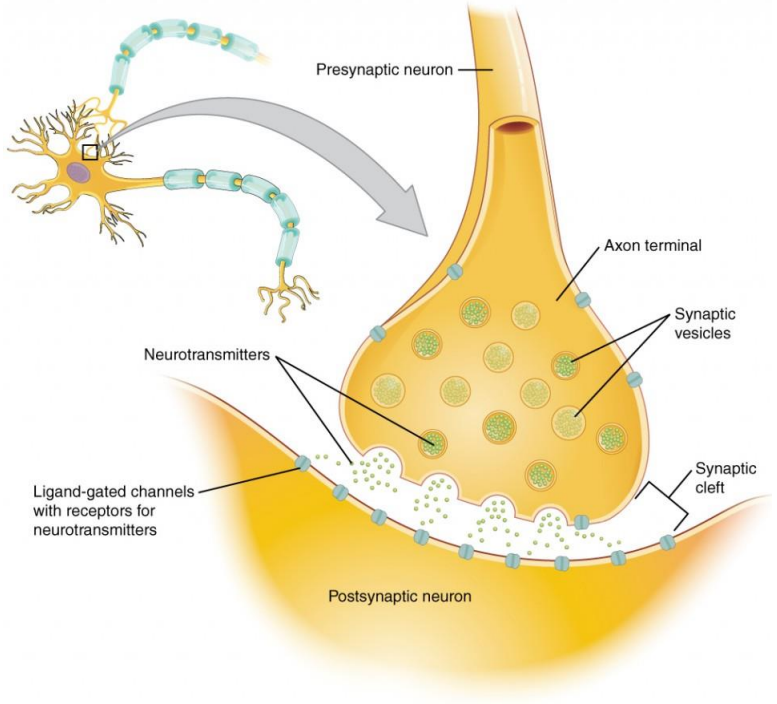
- 这里以视觉系统为例，主要从神经元层次讲电压、电流的产生及传导

  Here focus the generation and propagation of potential and current from the neuronal perspective, exemplified by the visual system.

电生理
Electrophysiology

- 与神经元相关的电位分为两类，局部分级电位与动作电位，局部分级电位只在短距离有效；动作电位可在长距离范围内传导

  Neurons use only two types of electrical signals: local graded potentials, which spread over short distances, and action potentials, which are conducted rapidly over long distances.



电生理
Electrophysiology

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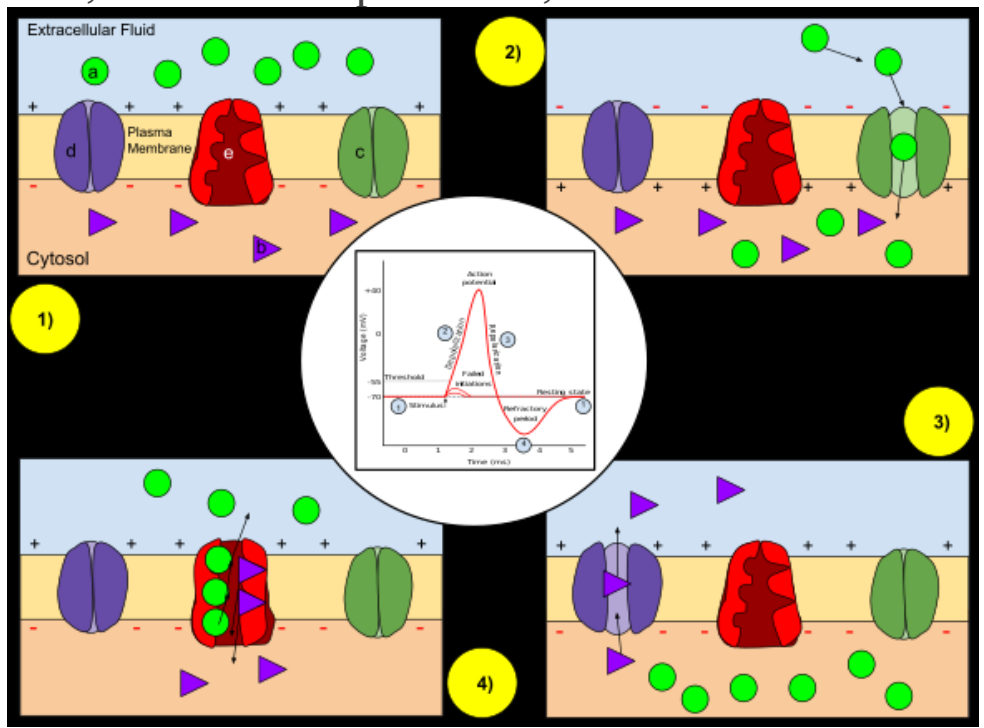
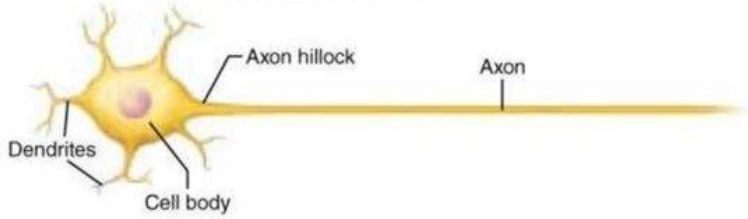


电生理
Electrophysiology

GRADED POTENTIALS VS. ACTION POTENTIALS (1/2)

	GRADED POTENTIAL (GP)	ACTION POTENTIAL (AP)
Location of event	Cell body and dendrites, typically	Axon hillock and axon
Distance traveled	Short distance—typically within cell body to axon hillock (0.1–1.0 mm)	Long distance—from trigger zone at axon hillock through entire length of axon (a few mm to over a meter)
Amplitude (size)	Various sizes (graded); decays with distance	Always the same size (all-or-none); does not decay with distance
Stimulus for opening ion channels	Chemical (neurotransmitter) or sensory stimulus (e.g., light, pressure, temperature)	Voltage (depolarization, triggered by GP reaching threshold)



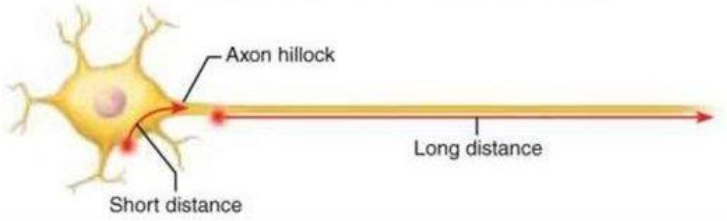
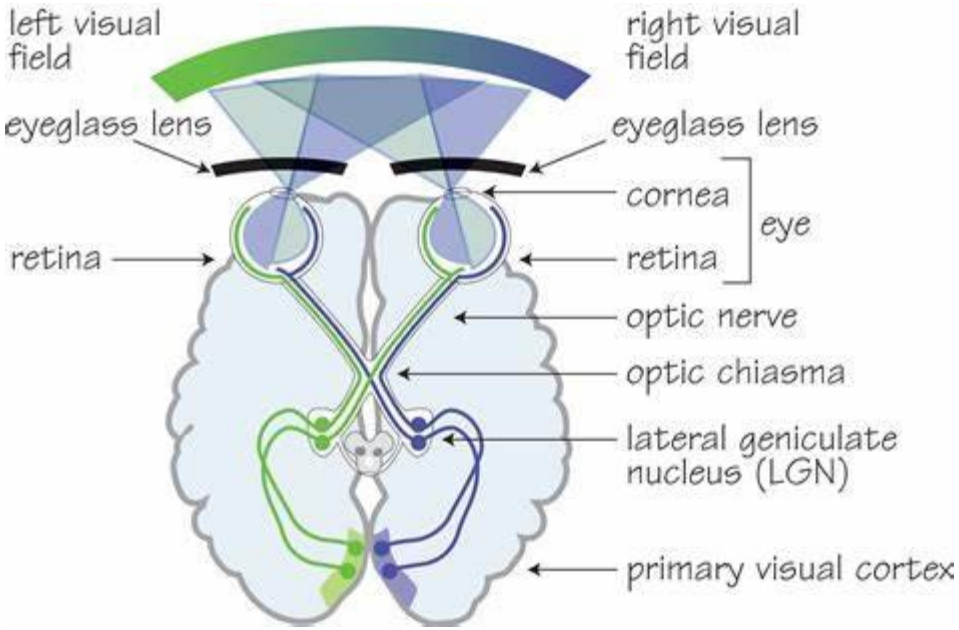


Image source: Adapted from Marieb's Anatomy and Physiology, 9th edition, Pearson.

视觉系统
Visual System

- 视觉信号的传输， 大概可以说从眼部神经元到侧膝体再到视觉皮层

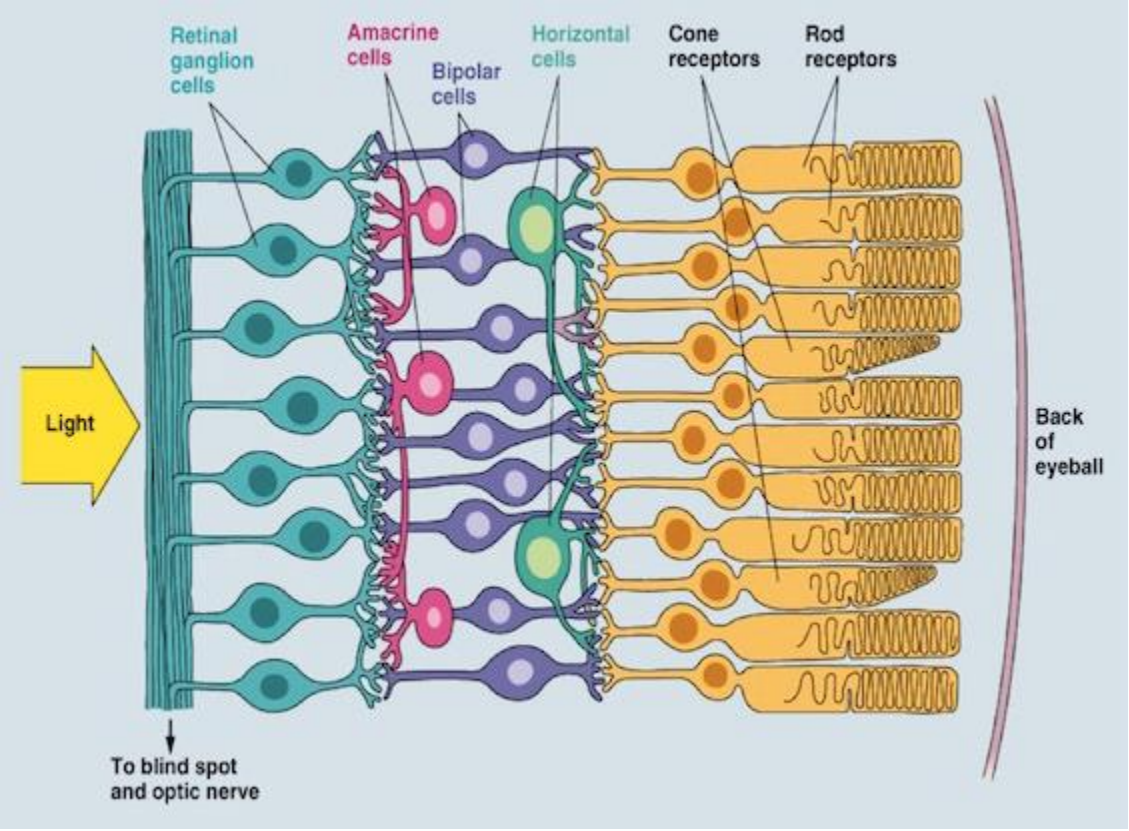
  The propagation of visual system can roughly speaking begin from neurons residing in the eye, to the lateral geniculate network, then to the visual cortex at the occipital area.



视觉系统
Visual System

- 传递视觉信号的通路也是分层和分级的

  The pathway for conducting visual information is arrange



视觉系统
Visual System

- 视觉信号通路

Light → local graded signal in photoreceptor → local graded signaling bipolar cell → local graded potential in ganglion cell → action potential in ganglion cell → conduction to higher centers

（局部）视野域
（Local）Receptive Field

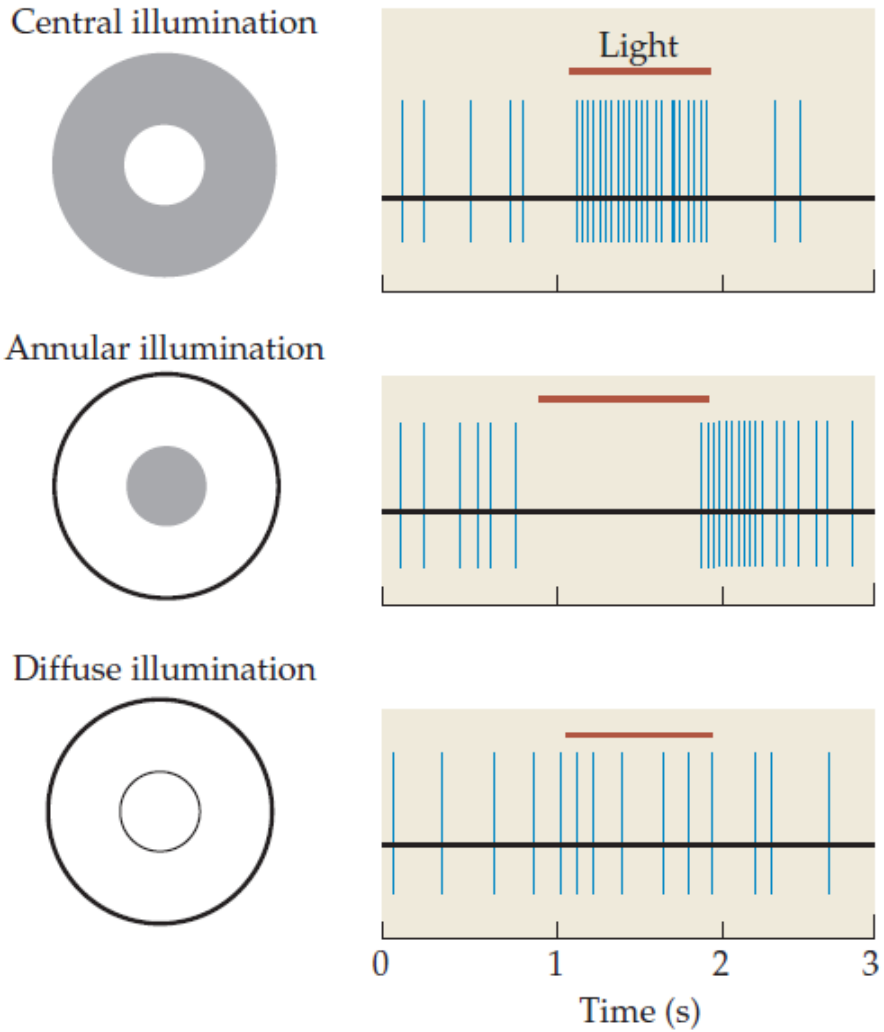
- 视野域定义为针对特定神经元，当视网膜上的某个区域（或对应的视可见范围）感光时，引发的神经元的激发或抑制活动的区域

  A receptive field in the visual system is defined as the area of the retinal surface (or corresponding region of the visual field) that, upon illumination, enhances or inhibits the activity of a neuron.

- 视野域分为简单视野域与复杂视野域，越高层的神经元，视野域越复杂。

  Receptive fields can be divided into simple receptive fields and complex receptive fields. The higher hierarchy the neurons sit, the more complicated their receptive fields.

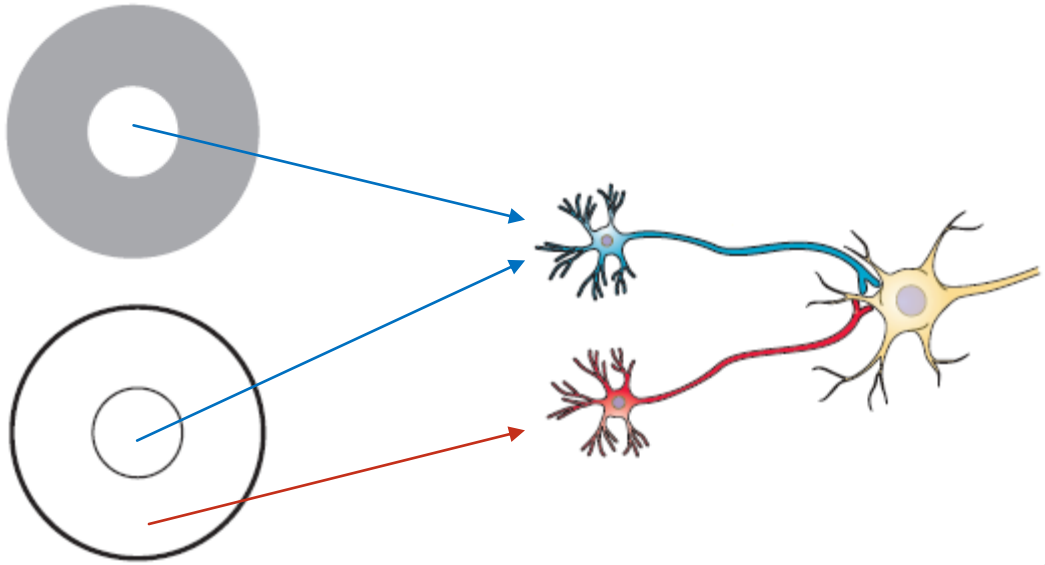
（局部）视野域
（Local）Receptive Field



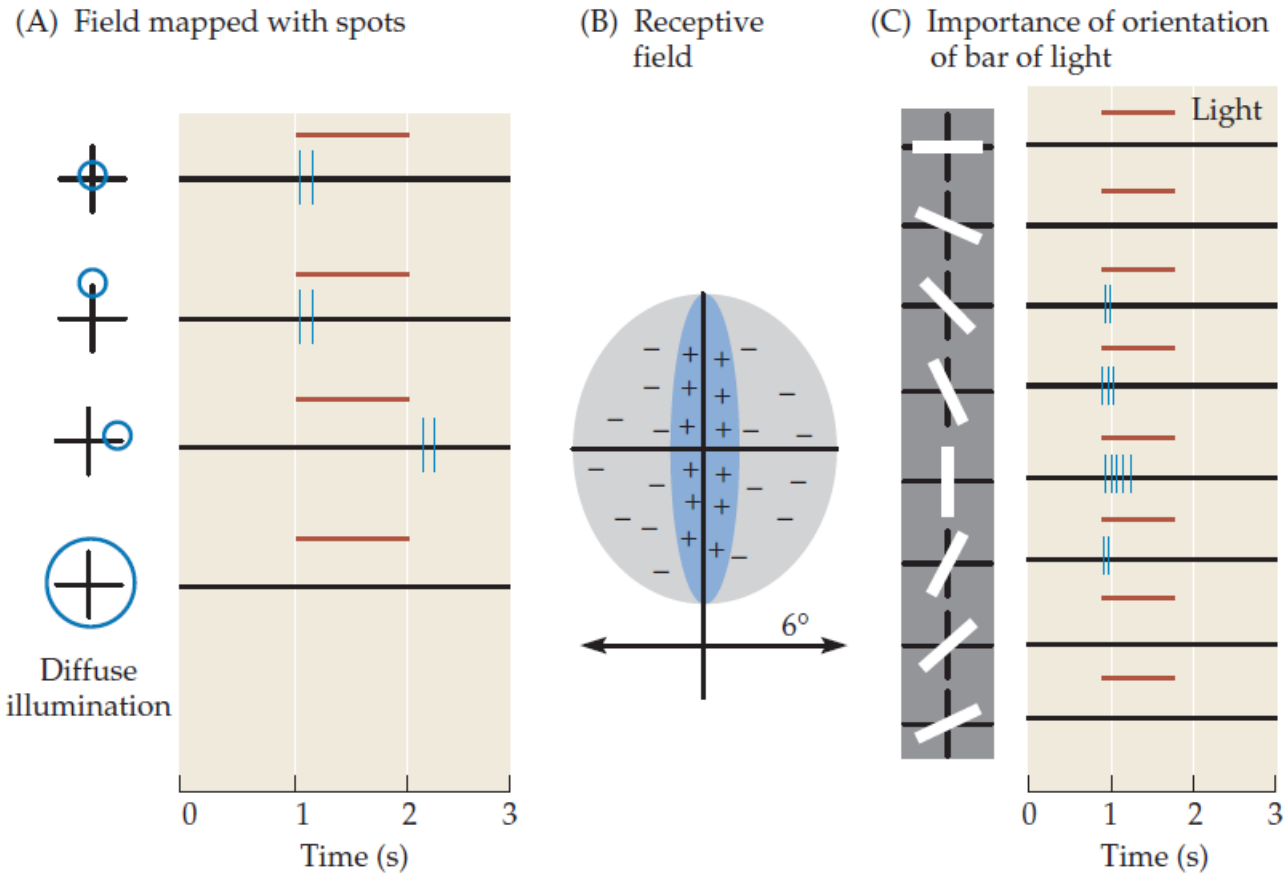
（局部）视野域
（Local）Receptive Field

- 对于视野域，区域大小与区域特征同样重要；例如，如下的漫射光虽然可以覆盖视野域，但不会引发动作电位，因为激发与抑制相抵消

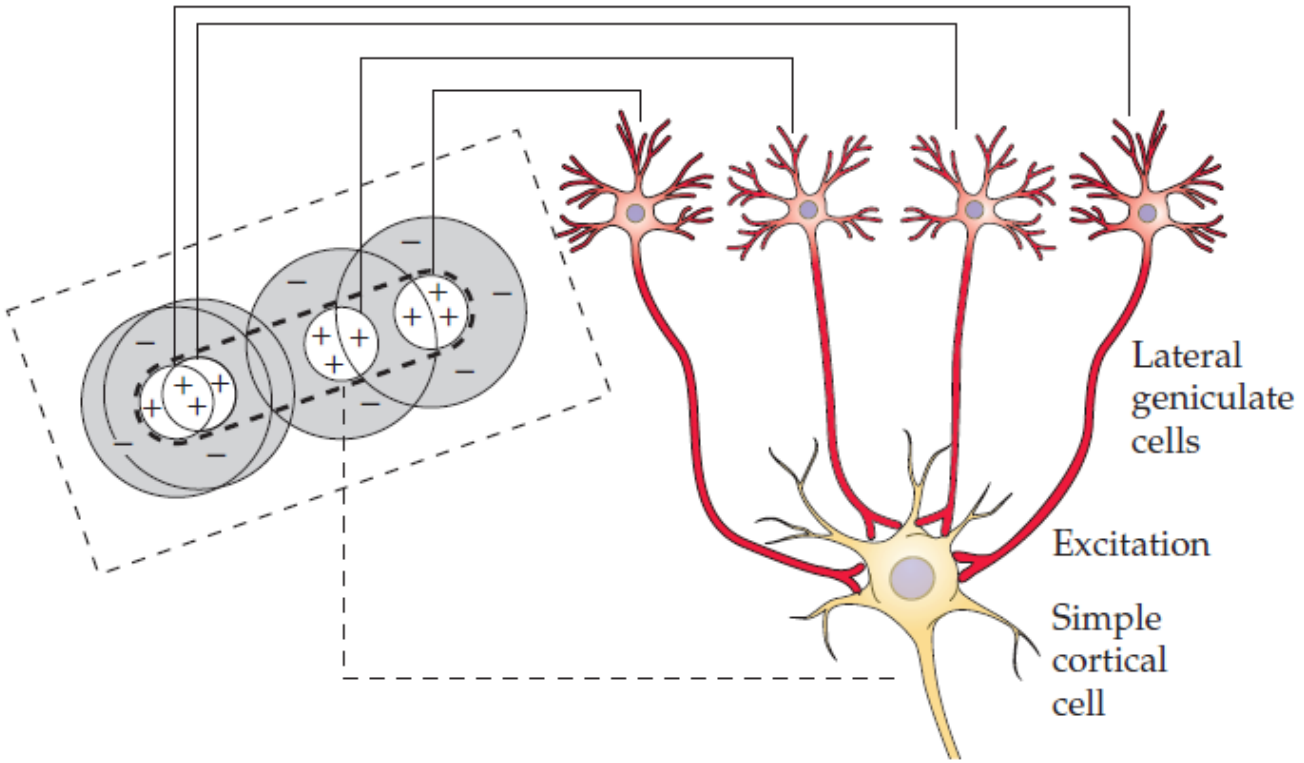
  The size of the receptive fields indicates its pattern as well. For example, the diffuse light covering the field leads no action potential since inhibitive activation cancels the excitatory activation.



（局部）视野域
（Local）Receptive Field



（局部）视野域
（Local）Receptive Field



习题
Problems

1. 列举树突与轴突的不同之处

   Enumerate the differences between dendrite and axon.

2. 为什么动作电位非有即无（all-or-none）

   Why for action potential, it is with the property of all-or-none?

3. 阅读相关文献，找出胶囊网络的神经学依据

   Find the neurophysiological inspiration for capsule network by literature review.

习题
Problems

4. 描述下图中的视野域的特征

   Describe the characteristic of the following receptive field.