Course: Molecular Neurobiology

Course Numbers: GS14063

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Basics: 3 credit course

Meets: Tues/Thurs from 10:30-noon, Room 7.037 MSB

Textbook: “Elements of Molecular Neurobiology” 3rd Edition by C.U.M. Smith; $100 at Amazon.com

Lecturers: Dr. Andy Bean, Dr. Steve Wang, Dr. Roger Janz, Dr. Jack Waymire, Dr. Neal Waxham

Evaluation: Three take home examinations will be used to assess the student’s acquisition of presented information. Grades, A, B, C, F will be assigned based on exam performance and student participation in class.

Lecture outline:

1) Introductory Orientation
   1 Lecture Waxham Tues, Aug 31
   a) Outline of nervous system
   b) Vertebrate nervous system
   c) Cells of the nervous system
      i) Neurons
      ii) Glia
   d) Organization of synapses
   e) Organization of neurons in the brain

2) The conformations of Informational Macromolecules
   1 Lectures Waxham Thurs, Sept 2
   a) Proteins
      i) Primary structure
      ii) Secondary structure
      iii) Tertiary structure
      iv) Quaternary structure
      v) Molecular chaperones
   b) Nucleic acids
      i) DNA
      ii) RNA

3) Information Processing in Cells
   2 Lectures Janz Tues/Thu. Sept 7/9
   a) The genetic code
   b) Replication
   c) Information flow
      i) Transcription
      ii) Post-transcriptional processing
      iii) Translation
   d) Control of genetic information flow
      i) Genomic control
      ii) Transcriptional control
      iii) Post-transcriptional control
      iv) Translational control
      v) Post-translational control

4) Molecular Evolution/Genomics
   1 Lecture Janz Tues, Sept 14
   a) Mutations
   b) Protein evolution
   c) Salient features of the human genome
   d) Genes of neuropathology

5) Biomembranes
   2 Lectures Waxham Thurs/Tues Sept 16/21
   a) Lipids
   b) Membrane order and fluidity
   c) Membrane asymmetry
d) Proteins
  
e) Mobility of membrane proteins
  
f) Synthesis of biomembranes
  
g) Myelin and myelination
  
h) Submembranous cytoskeleton
  
i) Junctions between cells
    i) Tight Junctions
    ii) Gap junctions
    iii) Gap junctions and neuropathology
      (1) Deafness
      (2) Cataracts
      (3) Spreading hyperexcitability (epilepsy)
  
6) Pumps
    a) Energetics
    b) The Na+/K+ pump
    c) The Ca2+-pump
    d) Other pumps and Transporters
  
7) Ligand-gated ion channels
    a) The nAChR
      i) Structure/Function
      ii) Development
      iii) Pathologies
      iv) CNS Ach receptors
    b) GABAa receptors
    c) Glycine receptors
    d) Ionotrophic Glutamate receptors
      i) AMPA
      ii) KA
      iii) NMDA
  
8) Purinergic receptors G-protein coupled receptors
    a) Messengers and receptors
    b) 7 Tm structure
    c) G-proteins
    d) Collision Coupling
    e) Effectors and Second Messengers
      i) Adenyl cyclase
      ii) PIP2 phospholipase
    f) Synaptic significance of “collision coupling” systems
    g) Network of G protein Signaling Systems
    h) The adrenergic receptor
      i) The muscarinic receptor
    j) Metabotropic glutamate receptor
    k) Neurokinin and cannabinoid receptors
    l) Rhodopsins and opsins
  
9) Voltage-gated Channels
    a) KCsA
    b) Neuronal K channels
      i) 2 TM
      ii) 4 TM
      iii) 6 TM
    c) Ca2+-channels
      i) Structure
      ii) Diversity
      iii) Biophysics
    d) Na+-channels
      i) Structure
      ii) Diversity
      iii) Biophysics
    e) Ion selectivity and voltage sensitivity
  
1 Lecture Janz Thur Sept 23
  
2 Lectures Waxham Tue/Thur Sept 28/30
  
2 Lectures Waymire Tue/Thur, Oct 5/7
  
2 Lectures Waxham Tue/Thur, Oct 12/14
f) Voltage-sensitive Cl- channels

g) Channelopathies
   i) K+-channels
   ii) Ca2+-channels
   iii) Na+-channels
   iv) Cl—channels

h) Evolution of ion channels

10) Resting potentials and Cable conduction
   a) Measuring resting potential
   b) The origin of the resting potential
   c) Electrotonic and Cable Conduction
      i) Length
      ii) Diameter

11) Sensory transduction
   a) Chemoreceptors
   b) Photoreceptors
   c) Mechanoreceptors

12) The action potential
   a) Voltage-clamp
   b) Patch-clamp
   c) Propagation of the AP
   d) Initiation of the impulse
   e) Rate of propagation

13) The neuron as a secretory cell
   a) Neurons and secretion
   b) Synthesis in the prokaryon
      i) Co-translational insertion
      ii) The Golgi and post-translational modification
   c) Transport along axons
      i) Microfilaments
      ii) Intermediate filaments
      iii) Microtubules
      iv) The axonal cytoskeleton
      v) Axoplasmic transport
   d) Exocytosis and endocytosis at the synaptic terminal
      i) Vesicle mustering
      ii) The Ca2+ trigger
      iii) Vesicle docking
      iv) Transmitter release
      v) Dissociation and retrieval of fusion complexes and vesicle membrane
      vi) Refilling of vesicles
      vii) Termination of release
      viii) Modulation of release

14) Neurotransmitters and neuromodulators
   a) Acetylcholine
   b) Amino acids
      i) Excitatory
      ii) Inhibitory
   c) Serotonin
   d) Catecholamines
      i) Dopamine
      ii) Noradrenaline
   e) Purines
   f) Cannabinoids
   g) Peptides
   h) Cohabitation of peptides and non-peptides
      i) Nitric oxide

15) The postsynaptic cell
   a) Synaptosomes
   b) The postsynaptic density
c) Electrophysiology of the postsynaptic membrane
   i) Excitatory synapses
   ii) Inhibitory synapses
   iii) Interactions of EPSPs and IPSPs

d) Ion channels of the postsynaptic membrane

e) Second messenger control of ion channels

f) Second messenger control of gene transcription

16) Developmental Genetics of the Brain

   a) Ontology-Phylogeny
   b) The Anterior/posterior axis
   c) Initial subdivision of the drosophila embryo
   d) The A-P axis in vertebrate CNS
   e) Segmentation genes
   f) Homeosis and homeotic mutations
   g) Homeobox genes
   h) POU genes and neuronal differentiation
   i) Sequential expression of transcriptional factors
   j) Pax6 and the development of eyes and olfactory system
   k) Other genes involved neuronal differentiation

17) Epigenetics of the brain

   a) The origins of neurons and glia
   b) Neural stem cells
   c) Tracing neuronal lineages
      i) Retrovirus tagging
      ii) Enhancer tagging
   d) Morphogenesis of neurons
   e) Morphogenesis of the drosophila eye
   f) Growth cones
   g) Pathfinding
   h) Cell adhesion molecules
   i) Growth factors and differential survival
   j) Morphopoetic fields
   k) Functional sculpting

18) Some Pathologies

   a) Neuroses/psychoses
   b) Prions and prion diseases
   c) Phenylketonuria
   d) Fragile X syndrome
   e) Neurofibromatosis
   f) Motor neuron disease
   g) Huntington’s disease
   h) Depression
   i) Parkinson’s disease
   j) Alzheimer’s disease
      i) Molecular pathology
      ii) Environmental influences
      iii) The amyloid cascade hypothesis
      iv) Therapy