The Eastern Oyster. Ed: Kennedy, Newell, & Eble. 1996.

1. Mechanisms and Physiology of Larval and Adult Feeding. Newell & Langdon
   1. Egg yolk provides protein and lipid for embryos to develop essential tissues including alimentary system
   2. Trocophore: shell gland, rudimentary mouth, digestive system
   3. Velum: 24-48 hpf (prodissoconch 1 veliger), capture particles and absorb DOM, mouth and alimentary system fully developed to allow ingestion
   4. Particles captured if enter a specific zone near cirri
   5. Larvae can selectively ingest particles based on size
   6. Evidence in some oysters of particle sorting in stomach
   7. During non-feeding metamorphosis (~ 6d), larva mobilizes lipid reserves; viability and growth of juvenile depends on amount of lipid larva ingests
   8. Lamellar filaments structurally differentiated to principal, transitional, and ordinary = heterohabdic gill
   9. Adults can preferentially ingest organic and expel inorganic – prefer N- over C-rich particles
   10. Palps sort and may play role in DOM absorption – cilia on palps expel rejected particles
   11. Ventilation/pumping rate = flow rate of water through gills
   12. Clearance/filtration rate = volume of water totally cleared of suspended particles per unit time
   13. Ventilation = clearance if particle retention efficiency is 100%
   14. Max clearance rate from gill size: CR = aWb
       1. a = constant, W = dry tissue weight, b = weight exponent
       2. b less than 0.67, smaller oysters have a higher max because of nutrient reserves and germinal tissue in larger
   15. Need moderate water flow rates to thrive, most likely because of food delivery
2. Digestion and Nutrition in larvae and adults. Landgon & Newell
   1. Adults probably take up DOM in labial palps and gills, larvae through velum – carrier-mediated transport
   2. Larvae need more than phytoplankton: nanozooplankton, detritus, bacteria, and DOM
3. Hemocytes: Forms and Functions. Cheng
   1. 2 categories of hemocyte: granulocytes and hyalinocytes
   2. Hyalinocytes
      1. Agranular or slightly granular
      2. Form lobopodial pseudopodia
      3. Can endocytose in phagocytosis
      4. Hypothetical hyalinoblast forms prohyalinocyte then hyalinocyte
   3. Granulocytes
      1. Most active phagocytosis via endocytosis
      2. Filopodial pseudopodia
      3. Hypothetical granuloblast forms granulocyte I, then II, then can become either spent granulocyte if endocytosis occurs or multinucleate macrocyte
      4. There are more granulocytes than hyalinocytes – 60-85% of hemocytes
   4. Serous cells – not “true” hemocyte
      1. Produced in Keber’s glands on auricles or on mantle
      2. Serous cells found in tissue and circulating
      3. Pigmented cytoplasmic globules
      4. Remove degradation products of dead and moribund parasites and metabolic byproducts of parasites – number of serous cells increases in parasite-infected oysters
   5. Hemocytes most likely arise from differentiation of connective tissue cells
   6. Hemocyte migration rate is temperature-dependent; salinity affects granulocyte movement
   7. Cell mobility changes with month – different cells more active at different times of year
   8. Wound repair
      1. Hemocytes (mostly granulocytes) clump
      2. Wound: hemocytes infiltrate, plug, collagen then Leydig cells deposited, phagocytic granulocytes clean up cellular debris
   9. Shell repair
      1. Hemocytes transport Ca and protein to site of repair
   10. Nutrient digestion and transport
       1. Hemocytes effect intracellular digestion – endocytose food particles and nutrients in alimentary tract, transport nutrients back to tissue
   11. Excretion
       1. Serous cells extract acids from hemolymph and carry to kidney
   12. Internal defense
       1. Digestible particles and macromolecules degraded within hemocytes
       2. Indigestible voided by migration of phagocytes across epithelial border
   13. Energy to hemocytes can be provided through anaerobic metabolism
   14. Hemocytes produce reactive oxygen intermediates as part of defense against pathogens
   15. Lysosomal enzymes associated with hemolymph: B-glucuronidase, acid phosphatase, lipase, aminopeptidase, lysozyme
       1. Hemocytes release enzymes during phagocytosis
4. Reproductive Processes and Early Development. Thompson, Newell, Kennedy, and Mann
   1. Gonochoric/dioecious alternate hermaphrodite
   2. Protandric, sex is ~size dependent
   3. Stress, nutritive and others, skews sex ratio towards male
   4. Winter: germinal epithelium undifferentiated
   5. Spring: increased T, germinal epithelium proliferates, game development and growth follicles enlargen and ripen
   6. Pre-spawn: maximum follicular proliferation, vitellogenesis, mature gametes
   7. T and food supply important for bay scallop reproductive cycle
      1. Need minimum food for gonad development, then T is important for cycle
   8. Seasonal cycle in synthesis, use, and storage of biochemical energy reserves for gametogenesis and sustenance during low food supply
      1. Most important = glycogen for gametogenesis and synthesis of lipids for developing oocytes
   9. Glycogen is stored in interstitial tissues of gonad, DG, and Leydig cells (between DG and gut wall)
   10. Glycogen at minimum right after spawn, increases during fall and early winter and at maximum in March, decreases again during gametogenesis
       1. This cycle can be different by population and year
   11. Protein and lipid content also rise and fall with reproduction
   12. Stress: carbohydrate catabolism as initial response, then protein if stress continues
   13. Stressors, including disease, can cause shift in biochemical composition of tissues because preferential use of certain energy stores
   14. As oysters get larger/older they dedicate greater proportion of energy to gonad development (exponential, e>2)
   15. *Ostrea* spp. that brood tend to have less reproductive output per gram body weight than *Crassostrea*
   16. Triggers for spawning: phytoplankton (males), conspecific gametes (females), and temperature
   17. Larvae require certain amount of lipid for yolk
5. Biology of Larvae and Spat. Kennedy
   1. Larval movement in water dominated by viscous forces; if larva stops swimming all forward motion will cease
   2. Prototroch (ciliated crown) allows disorganized movement
   3. Velum develops from prototroch in 1-2 days
   4. Vertical swimming most common movement
   5. Halocline limits larval vertical distribution
   6. Salinity and current speed cause larvae to actively change vertical position
   7. Disagreement as to whether tides and circulation (passive) forces are dominant in larval distribution
   8. Cues to settle
      1. Prefer undersurfaces
      2. Conspecific adults or spat (phermomones)
      3. Bacterial films on cultch
6. Natural Environmental Factors. Shumway.
   1. Adults have extremely wide range of thermal tolerance and salinity tolerance
      1. Rate of change of T matters for determining limits
      2. Do exist physiological optima
   2. Larval distribution determined by swimming, salinity, current and halocline – if halocline present larvae stay just above; if not, will go where current is strong
   3. Larvae go to bottom of water column during tidal ebb (low salinity, weak current); during flood tide, salinity increases and larvae swim up
   4. Poikilosmotic – osmoconformers, on regulation in hemolymph
      1. Burden on cells, changes in salinity can cause stress
      2. Cell volume maintained by changes in metabolism of free amino acids
7. Environmental Factors: Response to Metals. Roesijadi
   1. Mostly ionic form of metal is bioavailable
   2. Decreased salinity increases bioaccumulation of Cd and silver because of complexing with Cl-
   3. Cu and silver bind to particulate matter to be less available
   4. T affects rate of accumulation
   5. Oysters have relatively slow turnover of metals
   6. Cellular mechanisms of metal sequestration
      1. Granular deposits
         1. Green oysters because granulocytes concentrate Cu and Zn in organelles similar to lysosomes
         2. Cd accumulates in at least C. gigas granulocytes
         3. Metals may be used in pathogen defense
      2. Metallothioneins and metal binding proteins
         1. MT-induction associated with tolerance
8. The Bioaccumulation and Biological Effects of Lipophilic Organic Contaminants. Capuzzo
   1. Physiological mechanisms that influence uptake: filtration rate, body lipid content (seasonal), habitat differences
   2. Petroleum hydrocarbons
      1. Depuration rate faster for shorter exposures
      2. Properties of hydrocarbons affect how released
   3. PCBs and other chlorinated compounds
      1. Bioconcentration of certain compounds to greater than environmental levels
   4. Organotin compounds (TBT)
      1. Seasonal trends, bioconcentration to plateau then depurate
9. Diseases and Defense Mechanisms. Ford & Tripp
   1. Infection = presence of infectious or foreign organism in host tissue
   2. Disease = cellular damage sufficient to cause organismal dysfunction
   3. Epizootic = disease rapidly spreading throughout population
   4. Enzootic = disease prevalent in population
   5. Leptins – protein or glycoprotein that bind to sugars on pathogens and phagocytes to create bridge between
   6. Lysozyme – nonspecific defense, destroys gram-positive bacteria