ECONOMIC ZOOLOGY (ZOO510)

Economic zoology deals with animal world that is associated with the

- Economy
- Health
- Welfare of humans

Introduction to Aquaculture

Aquaculture

- The art of cultivating the natural produce of water.
- Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc.
- Aquaculture therefore is Farming of aquatic organisms in natural or controlled marine or freshwater environments
- Both under controlled or semi-controlled conditions.
- Mariculture – (old name) marine or brackish water“
- Aquaculture encompass farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants.”
-

Types of Aquaculture

- **Extensive Aquaculture**: Minimal control,   lower density
- E.g., ponds, prevalent in third world countries

- **Intensive Aquaculture**: Highly controlled, high density, RAS, raceways, confined
- E.g. industrialized

History of Aquaculture

- Egyptian tombs have bas-relief (sculpture)of fish (tilapia) being removed from ponds – 2500 B.C.
- Carp were farmed in China as early as 2500 B.C.
  - Wen Fang – founder of the Chou Dynasty is called the first fish farmer
  - (during exile he kept records of fish growth and behavior)
  - Fan Li – wrote first book on fish farming 475 B.C.
  - Lee family – Were the first to polyculture carp during the Tang Dynasty 600 to 900 A.D.
- England – 1500 A.D. carp culture was introduced
- U.S. – first fish hatchery was in Oregon 1877

World Aquaculture

Species Selection

- Producer's expertise
- Water supply and climate
- Species biology
- Marketability
- Production methods
- Production economics

Commonly Cultured Fish species

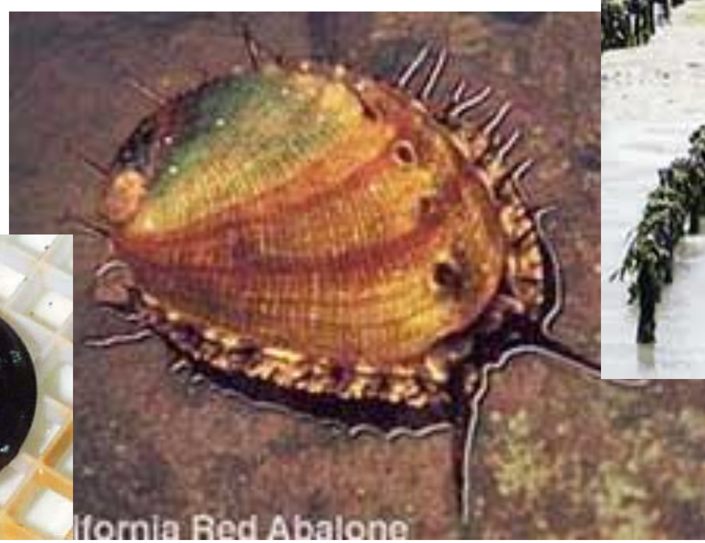
- Food fish
- Many species, Catfish, Tilapia, Rainbow trout, Atlantic Salmon, shrimp, Shellfish, Striped Bass, Others
- Ornamental fish
  - Aquaria
  - Backyard ponds
- Bait fish
  - Minnows
  - Shiners
  - Goldfish (carp)
- Natural stock enhancement
  - Salmon
  - Trout
  - Black sea bass
  - Red Drum
  - Many others…

Commonly Cultured Crustaceans

- Marine (Penaeid) shrimp
- Freshwater shrimp (prawns)
- Crabs
- Crayfish
- Lobsters
- Brine Shrimp

Commonly Cultured Mollusks

- Clams
- Oysters
- Mussels
- Abalone
- Urchins



Additional Cultured Organisms

- Seaweed
  - –Food for Abalone
  - –Extraction of nutrients for vitamins
- Corals / Sponges / Sea Fans
  - –Extraction of medicines
  - –Aquarium trade
- Live rock
  - –Inhabiting macro and micro life Aquarium trade

Status of Aquaculture

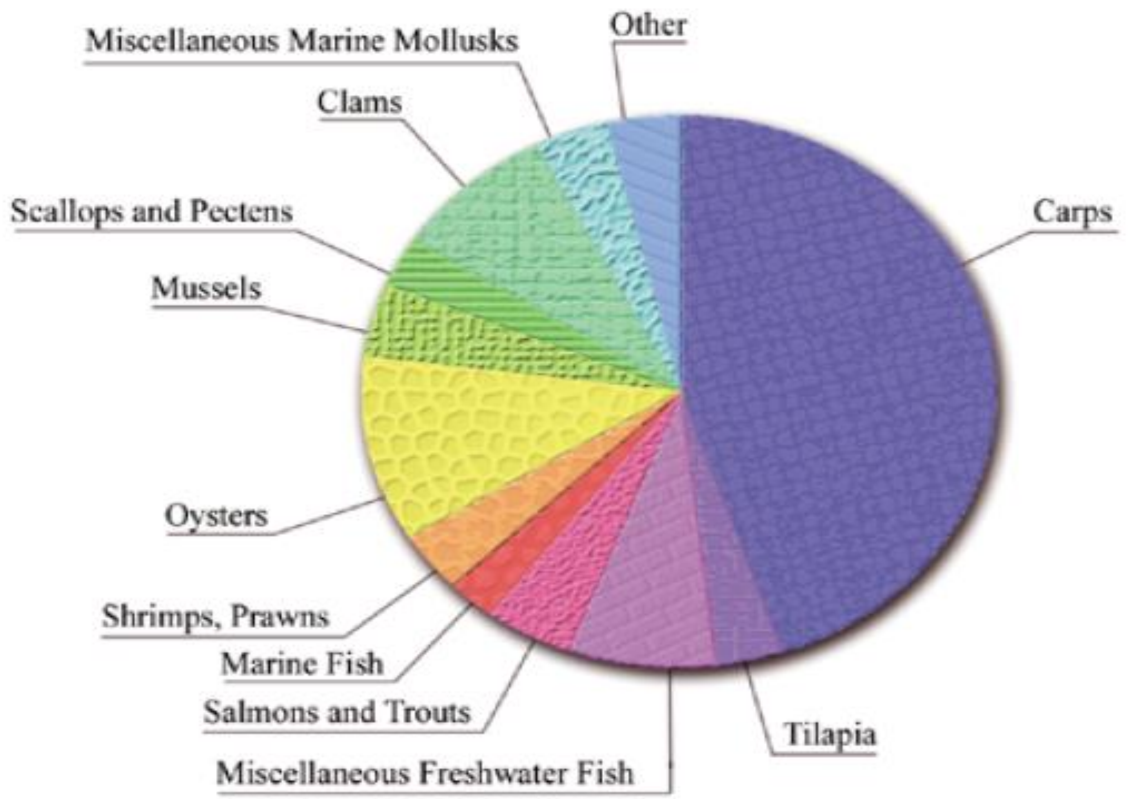
- Aquaculture is the fastest growing sector of agriculture with an approximate annual growth rate of 10%

- Currently aquaculture accounts for 25% of all seafood consumed in the U.S.
- Percentage is very low in Pakistan about 2 kg against world consumption of above 16 kg

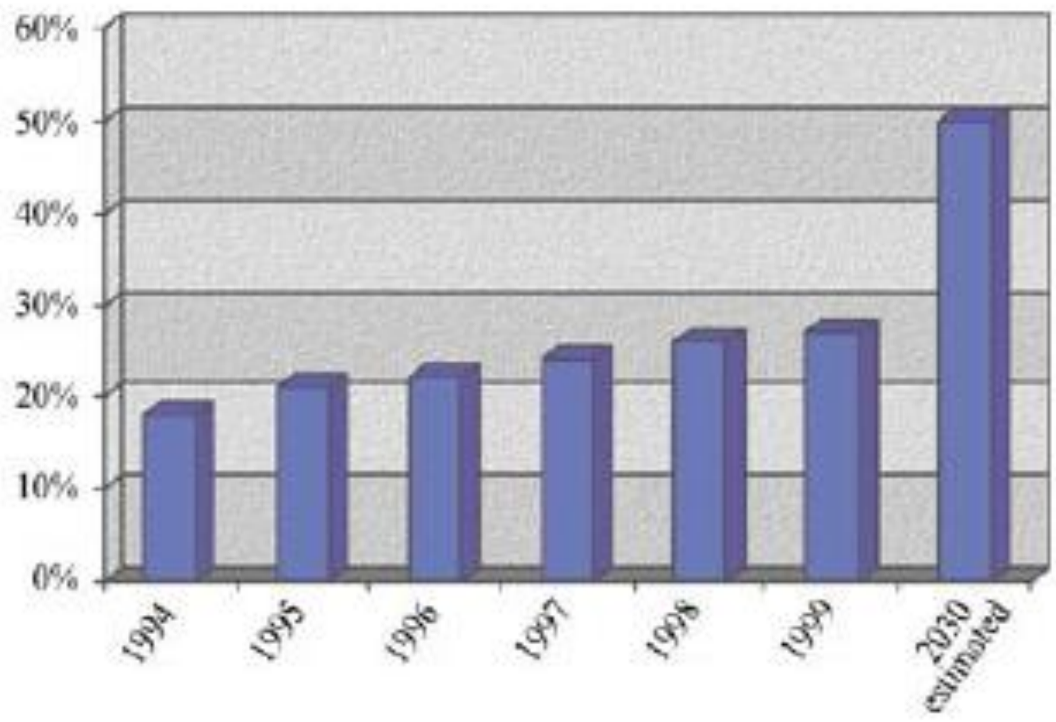
World Aquaculture Production

- In 2000 45.51 million metric tons by weight of aquaculture products
- Equal to US $56.47 billion
- China is the largest aquaculture producing country in the world

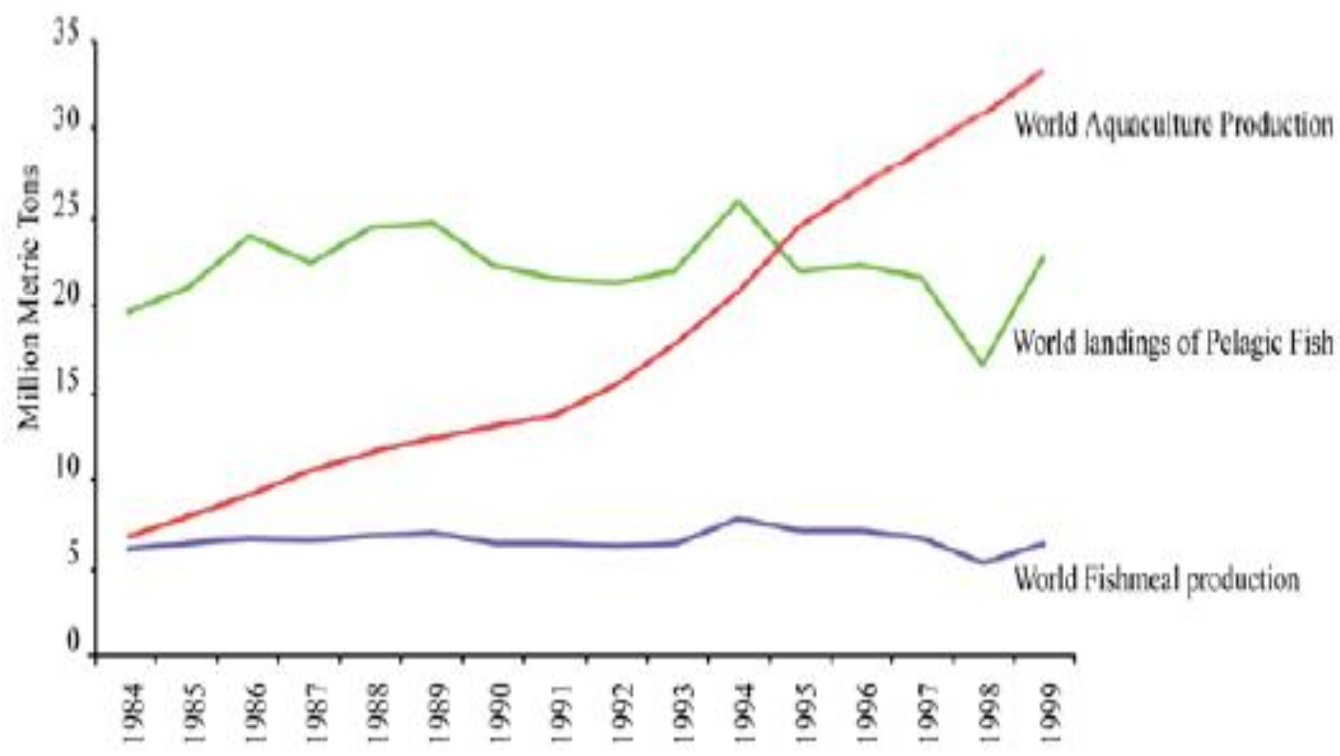
Proportion of Total Aquaculture Production for Different Taxonomic Groups



Percent of Total Food Fish Supplied by Aquaculture



Aquaculture Production, Ocean Fisheries, and Fishmeal Production



Why Aquaculture?

- Control: Food fed, Density, Quality of product
- Sustainable in the face of Finite Resources—overfishing and habitat destruction antagonists
- Diversify farm income
- Proximity—Farms may be closer to local markets.

- Health Consciousness (protein, FA's, micronutrients)

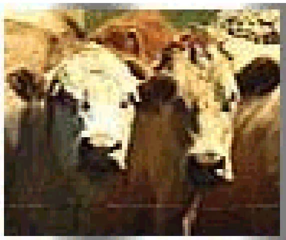
  -2 fish meals/week decreases mortality from heart problems 50%

  -Omega-3 fatty acids decreases occurrence of heart disease (oily marine fish – Salmon)

- American Cancer Association
  - **-**Regular fish consumption decreases chances of colon cancer 50%

- Efficiency of growth

Feed Conversion (grain/feed:flesh)



• Beef cattle on feedlot	8:1
• Swine	3.3:1
• Poultry	2.25:1
• Rainbow trout	1.5:1
• Tilapia	1.25:1

- Why *are* fish so efficient?

Aquaculture is a Diverse Field

- Biology
- Ecology
- Nutrition
- Handling and hauling
- Water quality
- Disease
- Marketing
- Culture techniques

Employment Opportunities

- Fisheries biology
- Public aquariums
- Research positions
- Education
- Laboratories
  - Genetic studies
  - Nutritional studies
  - Disease studies
  - Water quality
- State hatcheries
  - Technicians
  - Biologists
- Private operations
  - Biologist
  - Assistant manager
  - Manager
- Open your own operation

Aquaculture Journals

- Journal of the World Aquaculture Society
- North American Journal of Aquaculture (PFC)
- Aquaculture
- Journal of Applied Aquaculture
- Aquaculture Nutrition
- Aquaculture Research
- Journal of Aquatic Animal Health
- Transaction of the American Fisheries Society

Types of Aquaculture Systems

- Pond Fish Culture
- Raceway Culture
- Cage Fish Culture
- Recirculating Water Fish Culture

Pond construction and Designing

- Ponds were used as one of the first forms of aquaculture.
- Dates back to ancient China.
- Already had the water...just add fish and feed,
- Pond production has come along way since then!

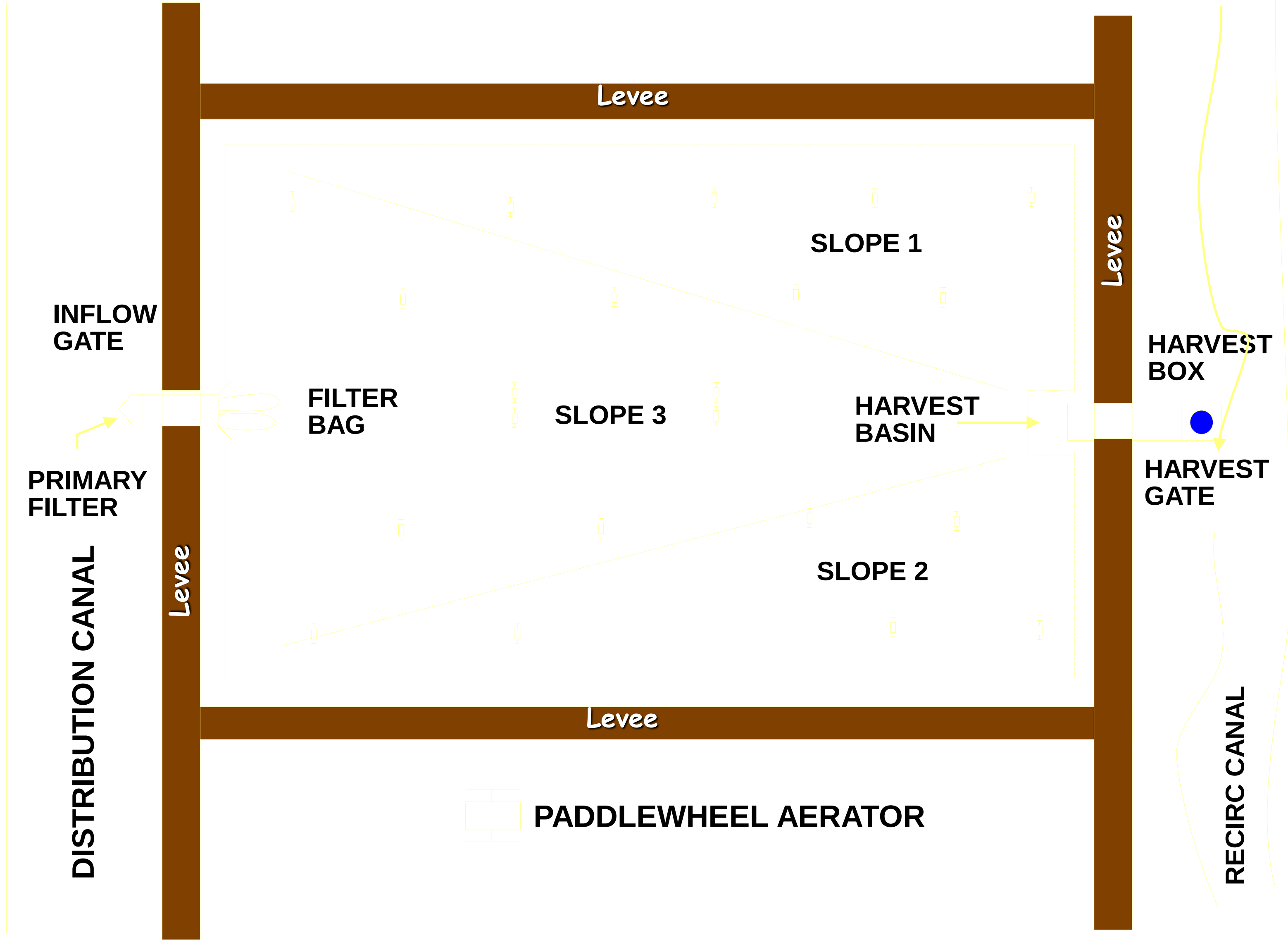
Parameters to Consider

- Site Considerations
  - Water
  - Soil
  - Topography
  - Types of ponds
  - Cost
- Construction of ponds
  - Levee ponds
  - Watershed ponds
  - Lined ponds

Pond Design Criteria

- Screened inflow gates at shallow end of pond
- Screened harvest gates at deep end
- Slope to harvest basin (0.5-1.0%)
- Water depth 1.25 → 2.00 M
- Feeding tray piers(docks)
- Rounded or square corners, steps or ramps for entry
- Primary dikes (levees) wide enough to accommodate vehicles

GENERAL DESIGN, INTENSIVE POND



- Heights determined by pond bottom elevation, tidal amplitude
- Perimeter levee often required for protection in flood areas
- Levees with slopes 1:2 for high clay, 1:3-4 low clay
- Levee crown width varies with use
- Width of crown: 5 m (driving), 3m (walking)
- Crown is sloped to reduce puddles on levee top
- Once formed, levees are sprigged with grass to reduce erosion

- Levees are typically constructed by Caterpillar sized bulldozers
- Construction is first undertaken on ponds nearest the sedimentation basins and pump station
- Bulldozers push earth up to create general form of the levee walls
- Follow stakes set along the length of the pond
- Smaller dozers used to put on finishing touches

- Erosion is the main problem in maintaining levee slopes
- Source: both rainfall and wave action
- Solution: plants and vegetation (local grasses or *Salicornia sp.*) as soon as possible
- Pond sides receiving wind could be reinforced with rocks (contractor services)
- Tops of levees definitely need layer of rocks, especially if high clay content

Water

- Availability
  - 25 gallons per minute per acre
- Source
  - Wells
  - Springs
  - Streams
- Pesticides
  - TEST Water!!
- Alkalinity
  - 80 ppm minimum

Soil

- Clay Content
  - Take samples at various locations.
- Water Table
- Wet soils aren't best!
- Pesticides
  - TEST Soil

Topography

- Slope
  - 2-10% best
- Flooding
  - Do not build on floodplain

Levee Pond Construction

- Freeboard and Depth
  - 1-2 feet freeboard
  - Depth 5 feet in shallow end
  - 7 feet in drain end
- Slope of Levees
  - 3: 1 minimum
  - 4: 1 maximum

Levee Pond Construction

- Size
  - Larger ponds are cheaper per acre
  - 1-10 acres for new farmers
- Shape
  - 10 acre square
    - requires 2,569 linear feet
  - 10 acre rectangular
    - requires 2,729 linear feet
- Levee width
  - 20 ft for main
  - 16 ft for others

Levee Pond Construction

Photos by Cortney Ohs

Levee Pictures

Newly Constructed Pond

Photo by Cortney Ohs

Small Research Pond

Photo by Cortney Ohs

Graveled vs. Not Graveled Levees

Photos by Auburn University Department of Fisheries and Allied Aquaculture

Orientation

- Right angle to prevailing winds reduces levee erosion
- Parallel increases wind action and aeration
- Site Preparation and Construction
  - Remove vegetation and topsoil.
  - Compaction is critical

Pond Drains

- Typically 6 inch pipe is sufficient for ponds less than 10 acres
- If ponds must be drained to harvest (shrimp) then use one 10 inch per acre of water
- PVC pipe is preferred
- Use anti-seep sleeve around pipe deep in levee

Water Inlets

- Water source pipes should have control valves on them
- May be designed to flow into adjacent ponds
- An independent **Electrical source** for each pond if filled by tube well

Lined Ponds

Watershed Ponds

- Watershed is containment (control)free
- Depth is a function of topography
- Requires 5-7 acres of watershed per acre of water
- Must have emergency spillway

Preventing Leaks

- Minimize amount of loss due to seepage
  - Proper compaction
  - Core trenching
- - Optimum clay content
  - Vertical plastic membranes
  - Vegetative coverage

- Remove burrowing animals (turtles, muskrat)

  Optimal clay content

- Construction during dry season

Pond Bottom
CONSTRUCTION CRITERIA

- If detailed pond bottom slopes are required, usually accomplished by scrapers
- Small 4-6 m^3 earthmovers towed by 4X4 tractors, laser-guided
- Bottom slope from upper end to lower end of pond usually 1m:250-500m or 0.4-0.2% for large ponds, pond should be drainable all the time
- In simple ponds, follows natural slope to estuary
- Must insure at least 20 cm height of harvest gate above high tide elevation (varies considerably by site)

Pond Control Structures
Inflow gates

- Used for control of pond water exchange
- Concrete structures with screen/bag filters on both sides of Levee
- Dual primary screens for pre-filtration (1/4"
- to 1/2“)
- Secondary filtration screen bag eliminates Potential predators (250-500 µM)
- Flashboards for controlling flow rate of water entering pond
- Multiple gates in larger ponds

WATER CONTROL STRUCTURES

HARVEST GATE

- Concrete w/harvest basin in pond
- Number/size of gates depends on speed of harvest required
- Screen to retain shrimp, mesh according to size
- Use of flashboards
- Canal side often modified for harvest pump

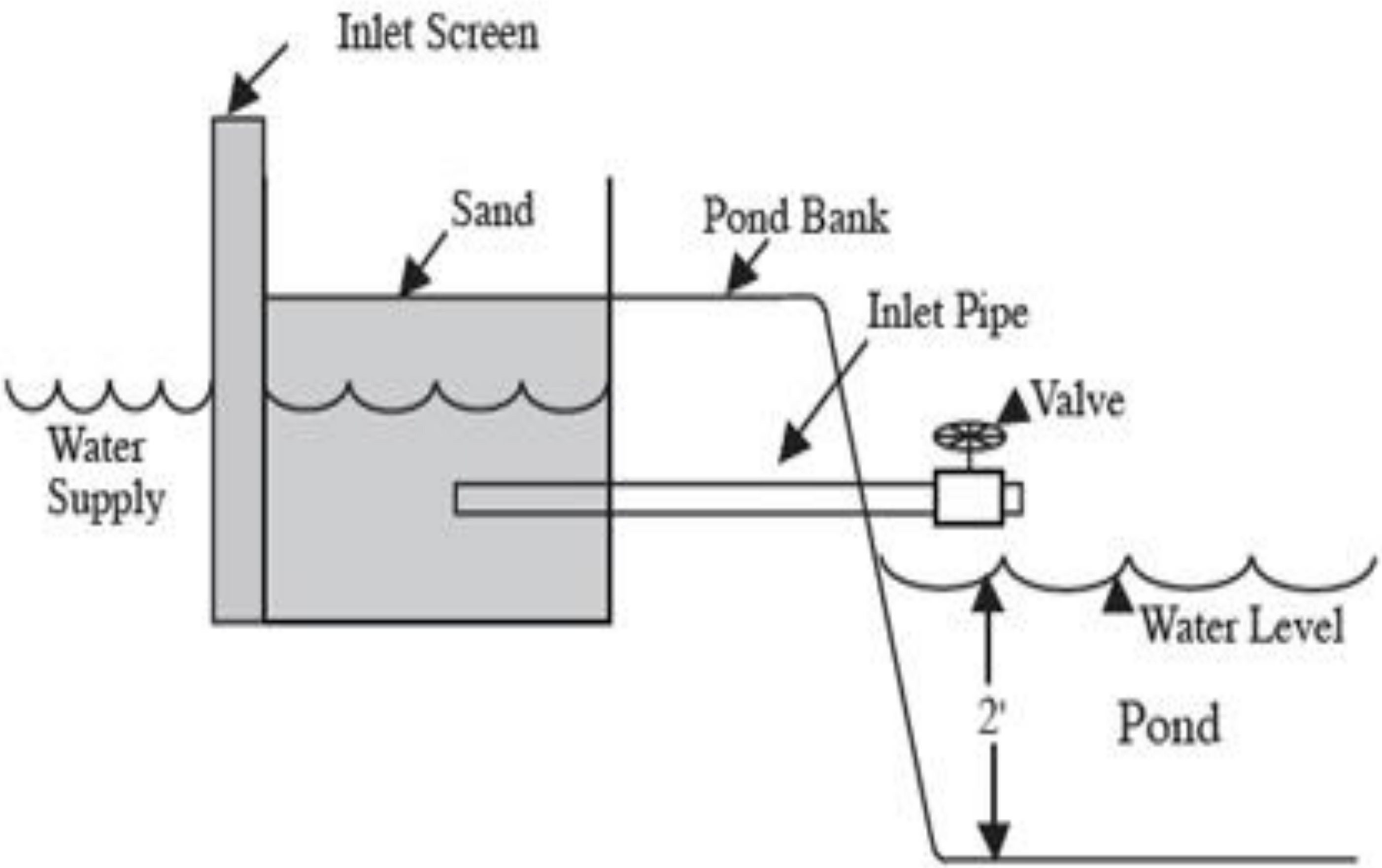

Inlet Screen
Sand
Pond Bank
Inlet Pipe
Valve
Water
Supply
Water Level
2'
Pond

Figure 3

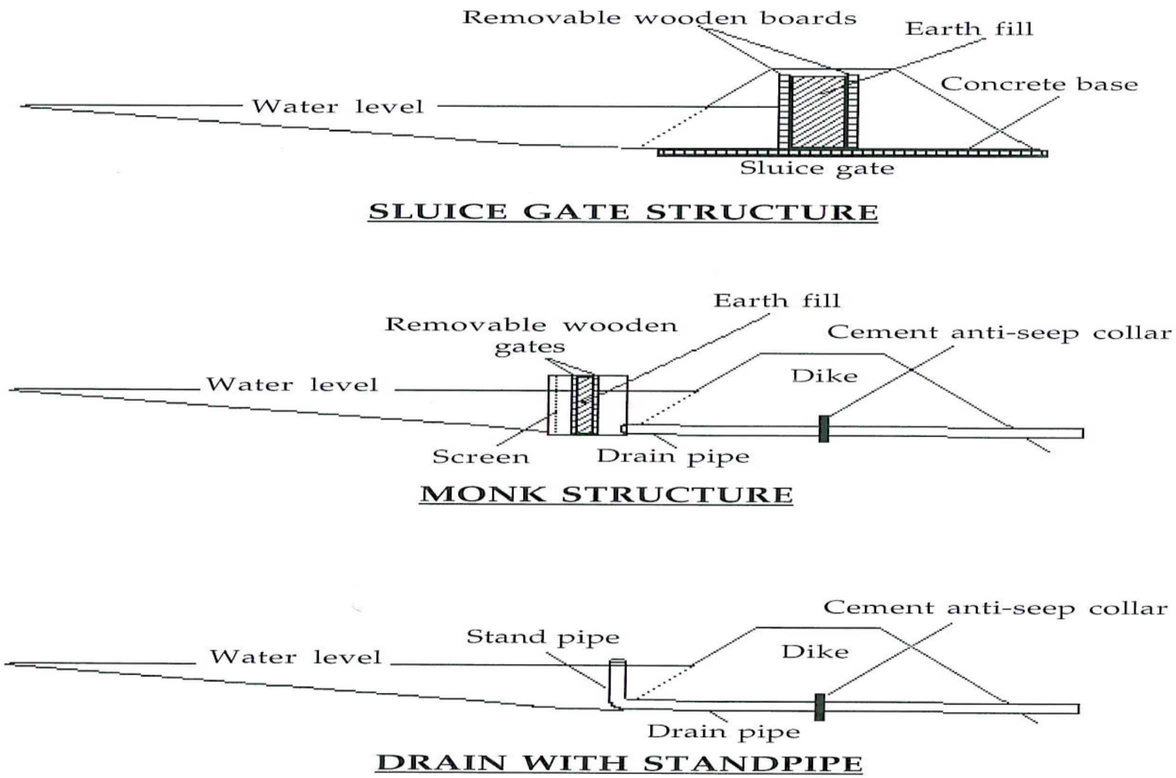


Figure 15: Cross sections of three structures used for draining ponds.

1 2

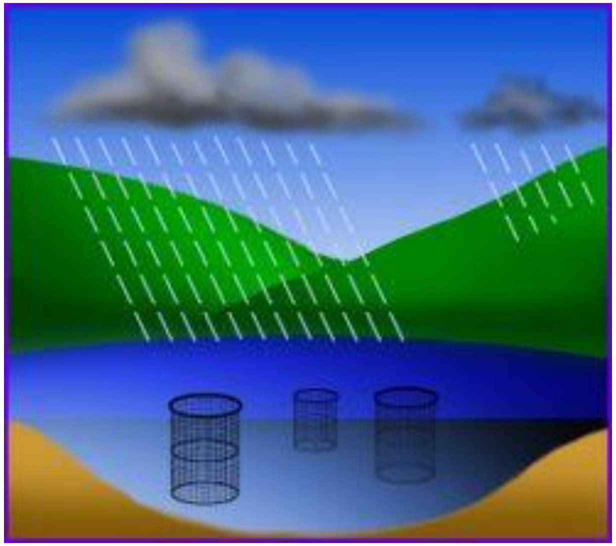
Harvest Gate: outflow

Harvest Gates: outflow

Water Sources

- Rivers, lakes and streams
- Advantages
  - large volumes
  - inexpensive
- Disadvantages
  - excessive nutrients
- Springs
- Advantages
  - few or no predators
  - no pathogens

- Wells
- Advantages
  - no predators
  - no pathogens
- Disadvantages
  - low O_2
- Surface
- Advantages
  - inexpensive
- Disadvantages
  - contaminates
  - 5-7 acre watershed per surface acre of water



Qualities of Cultured Fish species

- Hardy (resistance to diseases)
- Fast growth
- Easy adaptability
- Easy to breed
- Cheaper to culture
- Compatibility with other species
- High market demand
- Ability to tolerate low oxygen levels if it happens

Species cultured in ponds

- Rohu *Labeo rohita*
- Morakhi *Cirrhinus mrigala*
- Catla/Thaila *Catla catla*
- Grass carp *Ctenopharyngodon idella*
- Silver carp *Hypophthalmichthys molitrix*
- Big head carp *Aristichthys nobilis*
- Common carp *Cyprinus carpio*
- Tilapia *Oreochromis niloticus*

Stocking density and ratio

- Stocking density
- 800 to 1000 fish per acre
- 3 species culture
- Rohu 50% Morakhi (Mori)20% Catla 30%
- 5 species culture
- Rohu 35%, Morakhi 20%, Grass carp 15%, Silver carp 30%
- 6 species culture
- Rohu 35%, Morakhi 20%, Grass carp 15%, Catla 20%, Silver carp 10%

Addition of fertilizers

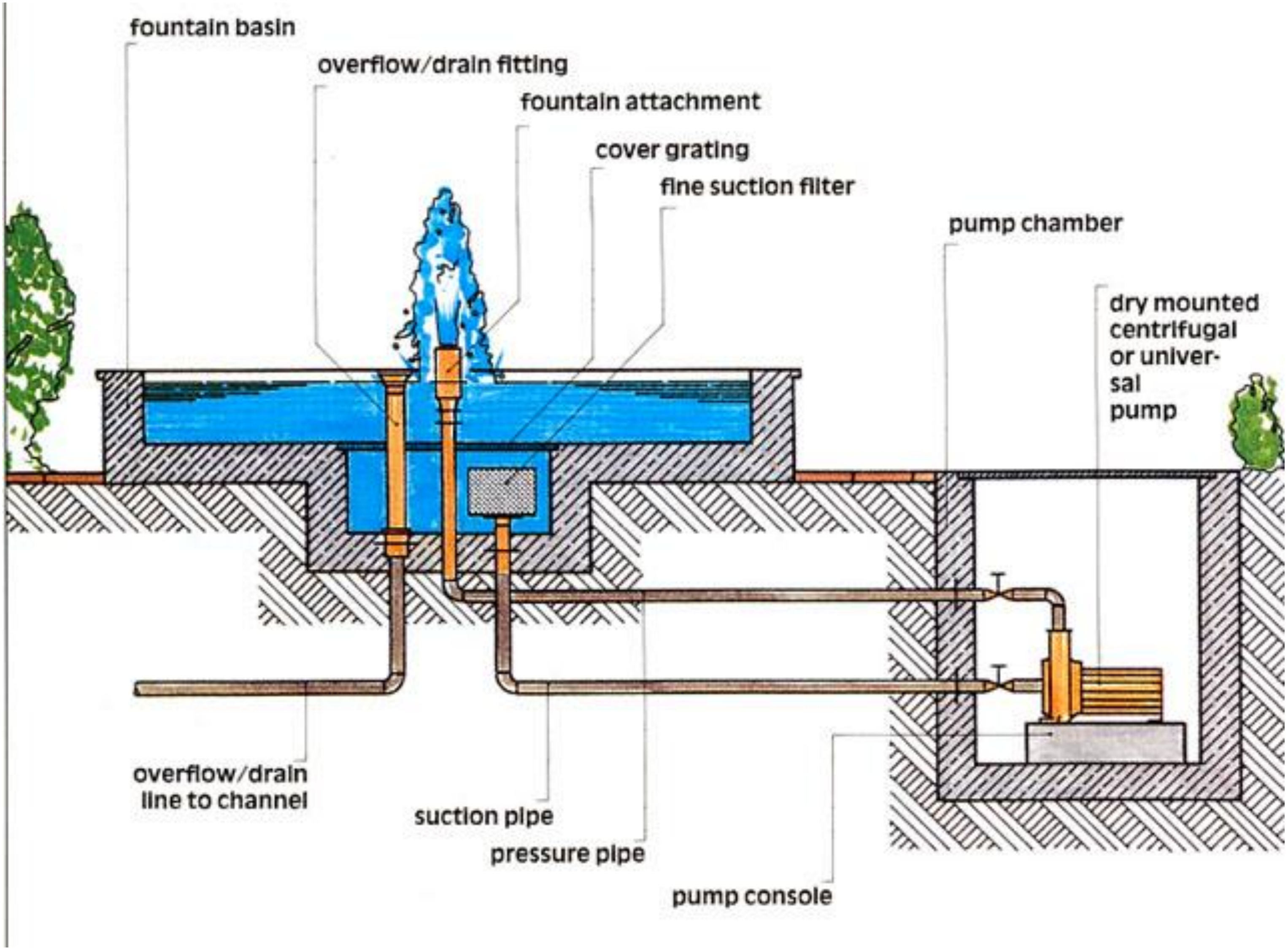
- Natural feeding
- Inorganic fertilizers
- DAP, NH4SO4, NaNO3, SSP, Nitrophos, triple super phosphate, Urea
- Organic fertilizers
- Cow dung, poultry waste, duck waste, green manure, compost
- Artificial feeding
- Rice polish, maize gluten meal, sunflower meal, cotton seed meal, soybean meal, wheat bran, canola meal, mustard oil cake

Time and ratio of artificial feeding

- Up to 400gm 360 kg per acre feed 9% protein feed
- Up to 700 gm, 560 kg per acre 22% protein feed
- >700 gm, 560 kg per acre feed >22% protein
- Share of natural feed
- Up to 100 gm fish 100% Natural food
- Up to 400 gm natural food 50%
- Up to 700 gm natural food 32%
- > 700 gm natural food 25%

POND AERATION/OXYGENATION

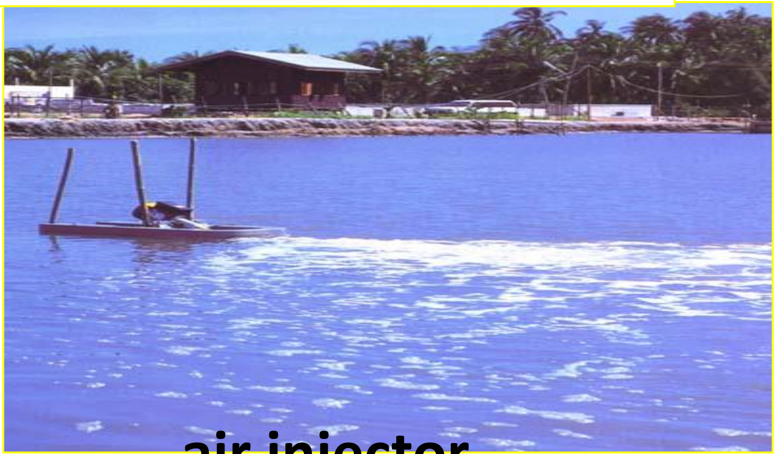
- level determined by oxygen demand
- pumping vs. artificial aeration
- used for oxygenation and solids mobilization
- efficiency of devices varies
  - paddlewheels: 2.13 kg O_2/kwh
  - propeller/aspirator: 1.58 kg O2/kwh
  - diffusors: 0.97 kg O2/kwh


fountain basin
overflow/drain fitting
fountain attachment
cover grating
fine suction filter
pump chamber
dry mounted
centrifugal
or univer-
sal
pump
overflow/drain
line to channel
suction pipe
pressure pipe
pump console

- If oxygen deficiency occurs;
- Pump water preferably with sprinklers
- Stop feeding and fertilizers forthwith
- Turn on emergency aeration
- If problem becomes chronic then stop feeding and fertilizers for several days

- Typical Aerators

paddlewheel



air injector

Estimating Oxygen Requirement

- During paddlewheel aeration and high density culture O_2 requirement is usually estimated on the basis of feed application to pond e.g.

- 1 kg of feed = 0.2 kg O_2 consumed via respiration
- 300 kg feed = 60 kg O_2 consumed/day

- Caveat(caution): Some O_2 consumed by shrimp/fish, but more by primary productivity

Estimating Paddlewheel Requirements

Biomass density (kg/ha)	Hp (flow-through)	Hp (limited water exchange)
< 1,000	None	None
1,000 – 2,000	2-4	4-8
2,000 – 4,000	4-8	8-16
4,000 – 8,000	8-10	16-20
Above 8,000	Above 10	Above 20


Raceways

Introduction

- Raceways are considered flow-through systems.
- Being simple to construct they are some of the oldest designs in aquaculture.
- Water sources for raceway aquaculture operations are usually streams, springs, reservoirs or deep wells.

Construction material and length

- Raceways are made of concrete!
- Length x width of 6:1 is recommended.
- This prevents the fish stock from swimming in circular movements, which would cause debris to build up in the center.
- If the width is too large this could result in a feeble current speed which is not desirable
- Length is usually constrained by the water quality or stocking density.

Determination of Raceway volume

- If water Flow rate is 20 L/sec X3600 sec/hr ÷ 4 exchanges /hr X m3/1000 = 20 x 3600/4x1000 = 18 m3 /exchange
- Now if flow is 0.020 m3 =W(width) x0.2(depth) x 0.033(velocity meter/second) = 3.0 m then length will be
- L = 18/3.0 x 0.2 = 30 m

Depth and stocking density

- Average depth of a raceway for fin fish, such as rainbow trout, is about three feet.
- So raceway should be about 90 ft long, 6-9 ft wide with slope of 1-2%
- For trout, stocking rates of 30 to 50 kg/m^3 are normal at the end of a rearing cycle!
- While for marine species, such as sea-bass and sea-bream, the achievable load is lower, between 15 and 20 kg/m^3.
- Raceway volume required = total amount of fish in kg/stocking rate in kg per m^3.

- Loading rate = lb fish /gpm
- = (Oa-Ob)(0.0545)/F
- Where Oa and Ob are incoming and outgoing oxygen and F= lb feed/lb fish per day
- Oxygen consumption in mg/kg of fish/hr = Oc ={3xCxΔL/L}9155.23
- Ammonia production and toxicity
- A= 56 P (decimal fraction of protein)
- Oxygen consumption (mg DO/kg of fish per hr = 200 mg in raceway
- In case of feeding O2 consumed per kg of feed is 0.2 kg O2

Recirculating Aquaculture Systems

Recirculating aquaculture systems (RAS) are systems in which aquatic organisms are cultured in water which is serially reconditioned and reused.

Why recirculation

- Conserves water
- Permits high density culture in locations where space and or water are limiting
- Minimizes volume of effluent, facilitating waste recovery
- Allows for increased control over the culture environment, especially indoors
- Improved biosecurity
- Environmentally sustainable

Integrated Treatment

An assembly of components that creates an artificial environment suitable for production, breeding or display of aquatic animals

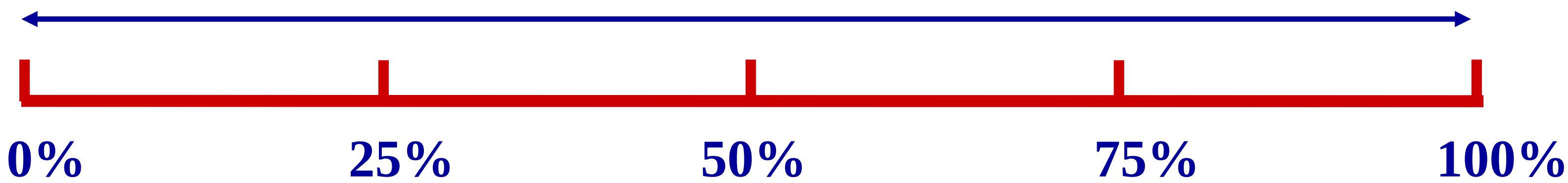
- Must be reliable
- Must be cost effective
- Must be compatible with the intended user group

Water Reuse Rates

Open or Flow-through System

Semi-Closed System

Closed System



Characteristics of Culture Tank Effluent

- High concentrations of suspended and dissolved solids
- High ammonia levels and high concentration of CO_2
- Low levels of dissolved oxygen
- Application of Recirculation system
- Brood stock maturation
- Nursing and Larval rearing systems
- Nutrition and health research systems
- Short-term holding systems
- Ornamental and display tanks
- High density grow-out of food fish

Factors those dictate Classification of Culture Systems

- Trophic Level
- Temperature
- Salinity

Trophic Level

Distinguishes the level of nutrient enrichment

- **Oligotrophic**
- **Mesotrophic**
- **Eutrophic**

Oligotrophic

- Excellent water quality
- Very Clear
- Used in display aquaria
- Most frequently used for breeding purposes
- Some species are kept in these conditions all of their lives, while others for a period of time

Mesotrophic

Describes the bulk of high-density production systems where risk and economics must be carefully balanced to achieve profitability

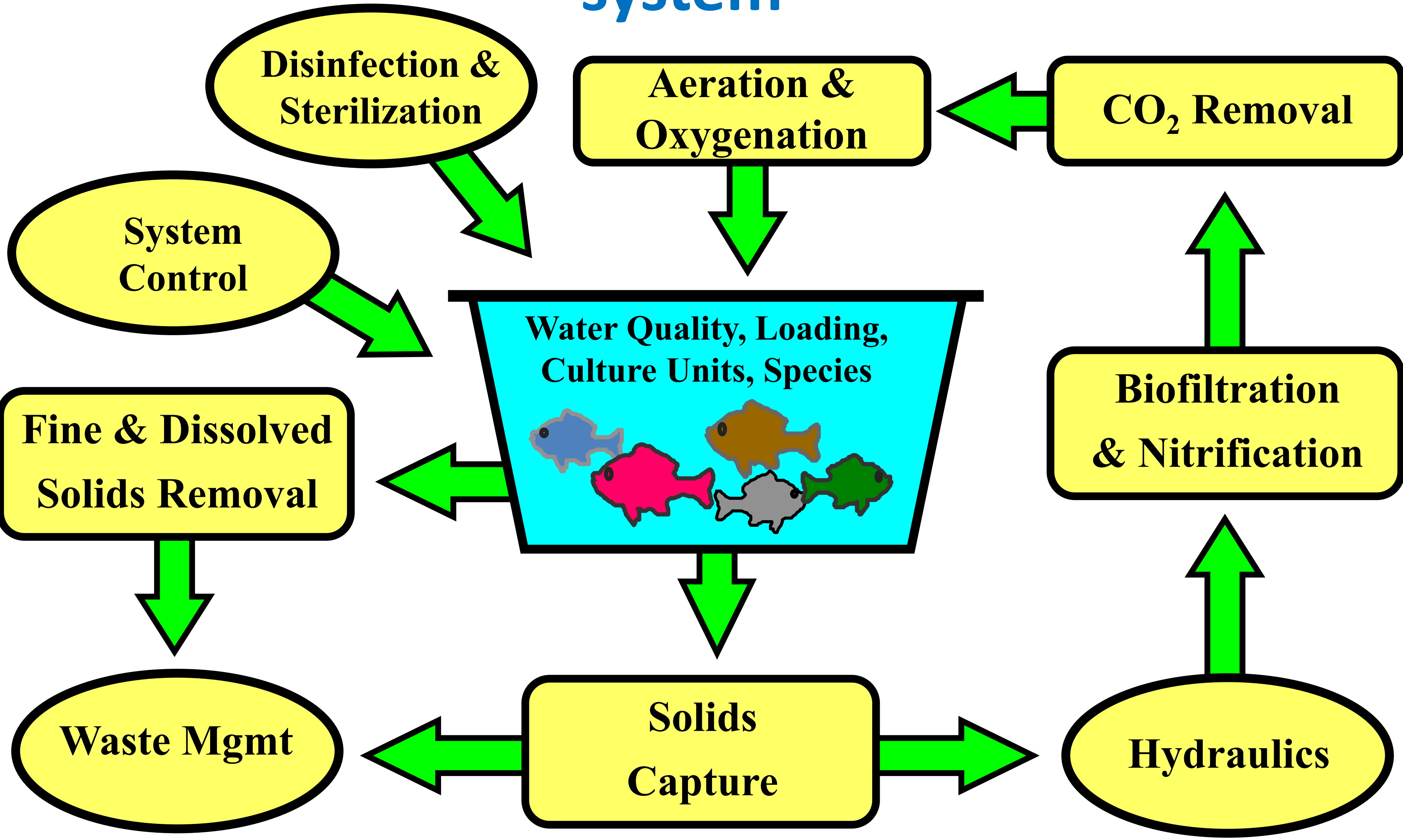
- **Some deterioration in aesthetics**
- **Water quality at safe levels**
- **Dissolved Oxygen- above 5 mg/L**
- **TAN & Nitrite – less than 1mg-N/L**
- **Total suspended solids – less than 15 mg/L**

Eutrophic

Exist for the grow out of the most tolerant species that show vigorous growth under moderately deteriorated water quality conditions

- **Dissolved oxygen levels- economic optimum level**
- **Ammonia & Nitrite – less than 2mg-N/L**
- **Water quality – marginal**
- **Species evolved under similar natural conditions prosper in these conditions**

Components of Recirculating Fish culture system



Management Decisions

Economics

System Design & Construction

Nutrition

Monitoring & System Control

Biosecurity

Temperature

Impacts the rates of chemical and biological process at the most fundamental level

Affects: bacterial growth, respiration, nitrification efficiency
Cool-water species: below 20º C
Warm-water species: above 20º C



Salinity

Major effect on the oxygen saturation level

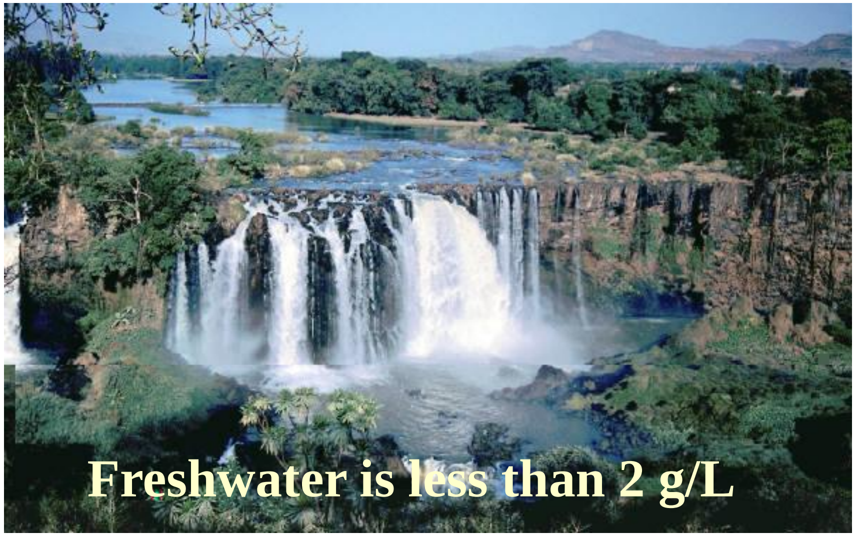
Freshwater

Less than 10 ppt

Marine

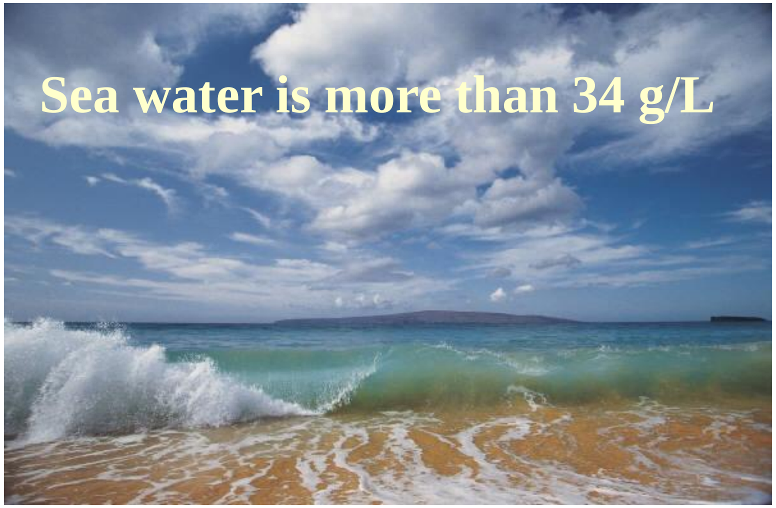
Greater than 10 ppt

Salinity


Freshwater is less than 2 g/L


Brackish water is 2 g/L to 34 g/L


SALT
NaCl


Sea water is more than 34 g/L

Types of Filtration

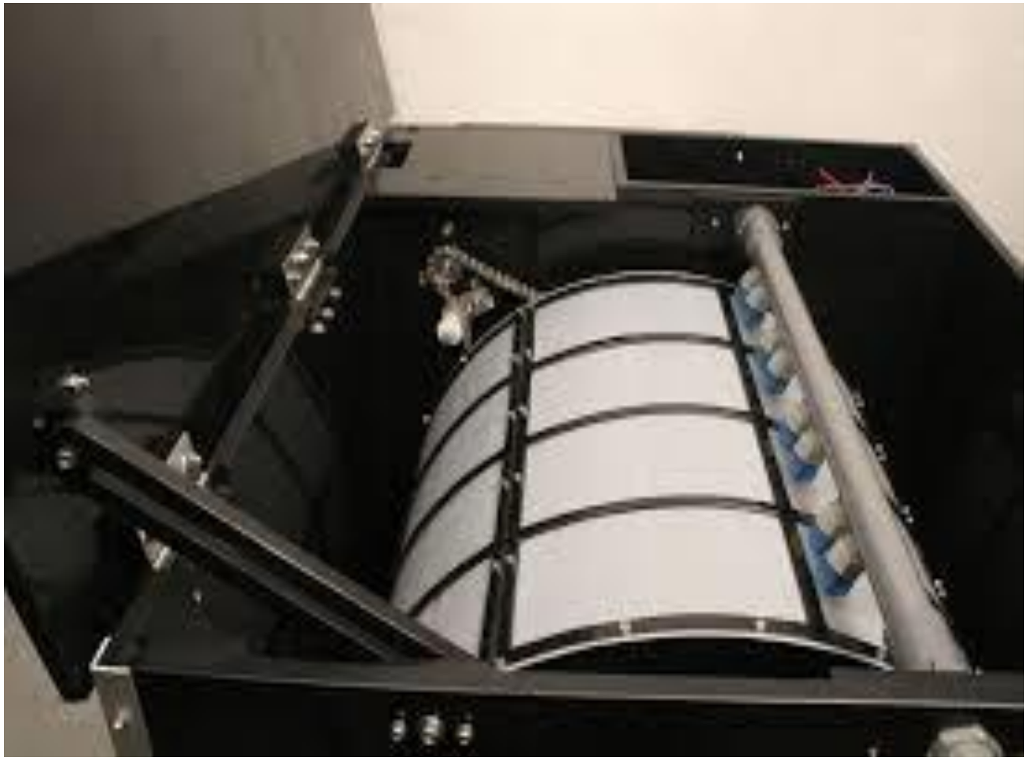
- Mechanical filtration

  1: Screen filters

  2: Granular Media filters

- Biological Filtration

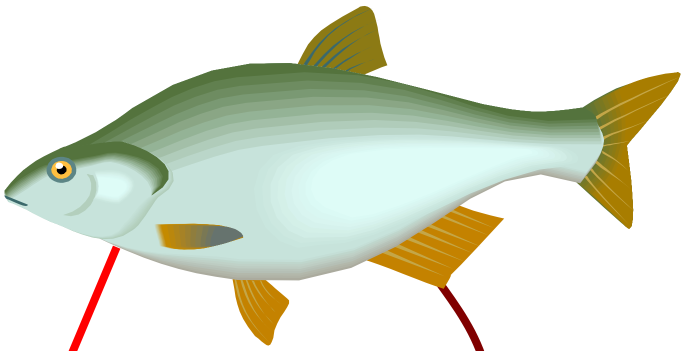
- Screen Filters
- Used with various mesh screens



Biological filtration

- Nitrogen is an essential nutrient for all living organisms and is found in proteins, nucleic acids, adenosine phosphates, pyridine nucleotides and pigments
- In aquaculture there are 4 primary sources of nitrogenous wastes:
- 1: Urea, uric acid and amino acids excreted by fish
- 2: Organic debris from dead and dying organisms
- 3: uneaten feed and feces and
- 4: Nitrogenous gas from atmosphere

Nitrite/Nitrate



feces

$NH_4^+ + 1.5\ O_2$ + Nitrosomonas $\longrightarrow$ $NO_2^- + 0.5\ O_2$ + Nitrobacter $\longrightarrow$ NO_3^-

Bacterial decomposition

- NH_3, NO_2 and NO_3 are highly soluble in water
- NH_3 exist in water in two forms dependent on temperature and pH of water
- NH_3 is converted to NO_3 by oxidation process and overall process is called Nitrification while reversal is called denitrification

- $NH_4^+ + 1.5O_2 \geq NO_2^- + 2H^+ + H_2O$
- $NO_2^- + 0.5O_2 \geq NO_3^-$
- These reactions need 4.57 g of O_2 and approximately 7.14 g of alkalinity as $CaCO_3$ for complete oxidation of 1 g of NH3

Nitrogenous compounds from Nitrification

$$NH_3 \xrightarrow[\textit{nitrosomonas}]{1\frac{1}{2}\ O_2} NO_2^- \xrightarrow[\textit{nitrobacter}]{1\frac{1}{2}\ O_2} NO_3^-$$

- Requires 3 moles oxygen to convert one mole of ammonia to nitrate
-

- Maximum safe unionized ammonia level is 0.025 ppm
- or 1 mg/L or ppm for total NH_3-N for cool water fish and 2-3 mg/L for warm water fish
- production rate of NH_3 (TAN) is

$$P(TAN) = F \times PC \times 0.092$$

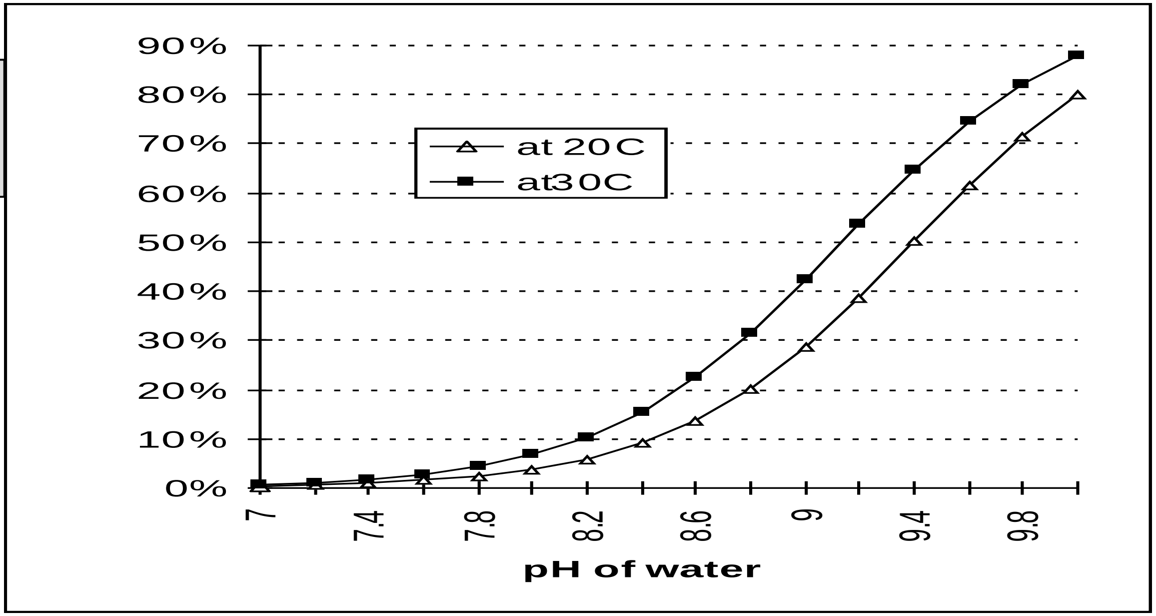
- Where F is daily feeding level and PC is protein content in feed for one day period

Total Ammonia Nitrogen concentration varies with Temperature and pH

Total ammonia nitrogen (TAN) is a measure of the NH_3 and ammonium levels (NH_4^+) in the water

The ratio of ammonia and ammonium varies in an equilibrium determined by pH and water temperature.

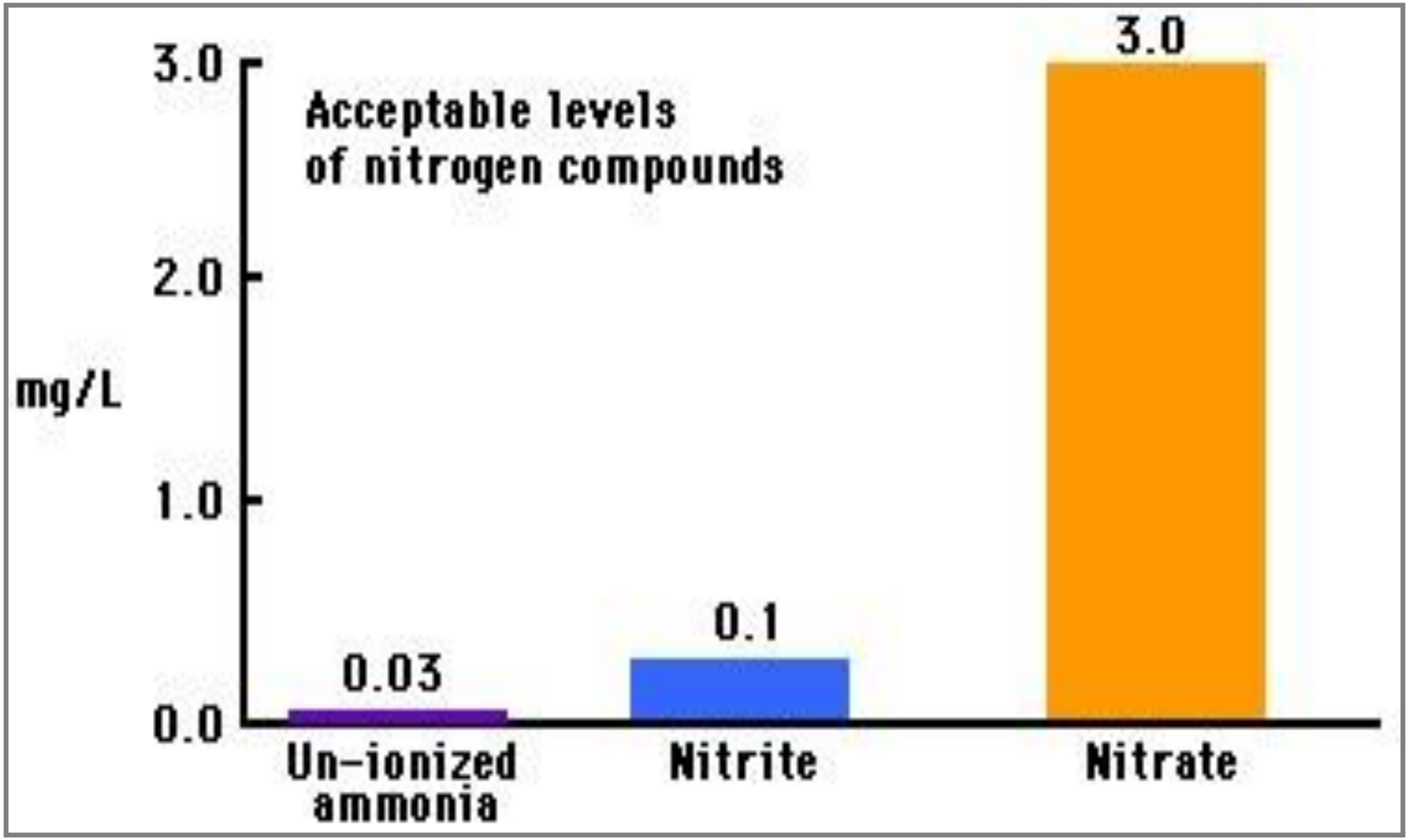
Ammonia as a % of total ammonia nitrogen



Percent of Total Ammonia in the Un-Ionized Form at Various Temperatures and pH

		Percent Ammonia		
Temperature (F)	(pH)	7.0	8.0	9.0
50		0.19	1.83	15.7
68		0.40	3.82	28.4
86		0.80	7.46	44.6

Nitrogenous compounds
Acceptable ranges



- Types of Bio filters Used
-
- commonly used in commercial intensive recirculating aquaculture systems are:
- Trickling filters
- Floating bead filters
- Fluidized bed filters
- Down flow micro-bead filters

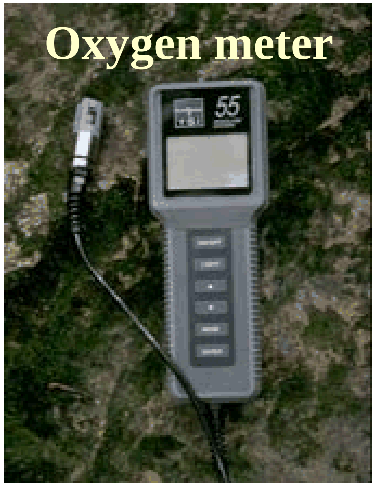
Aeration and Oxygenation

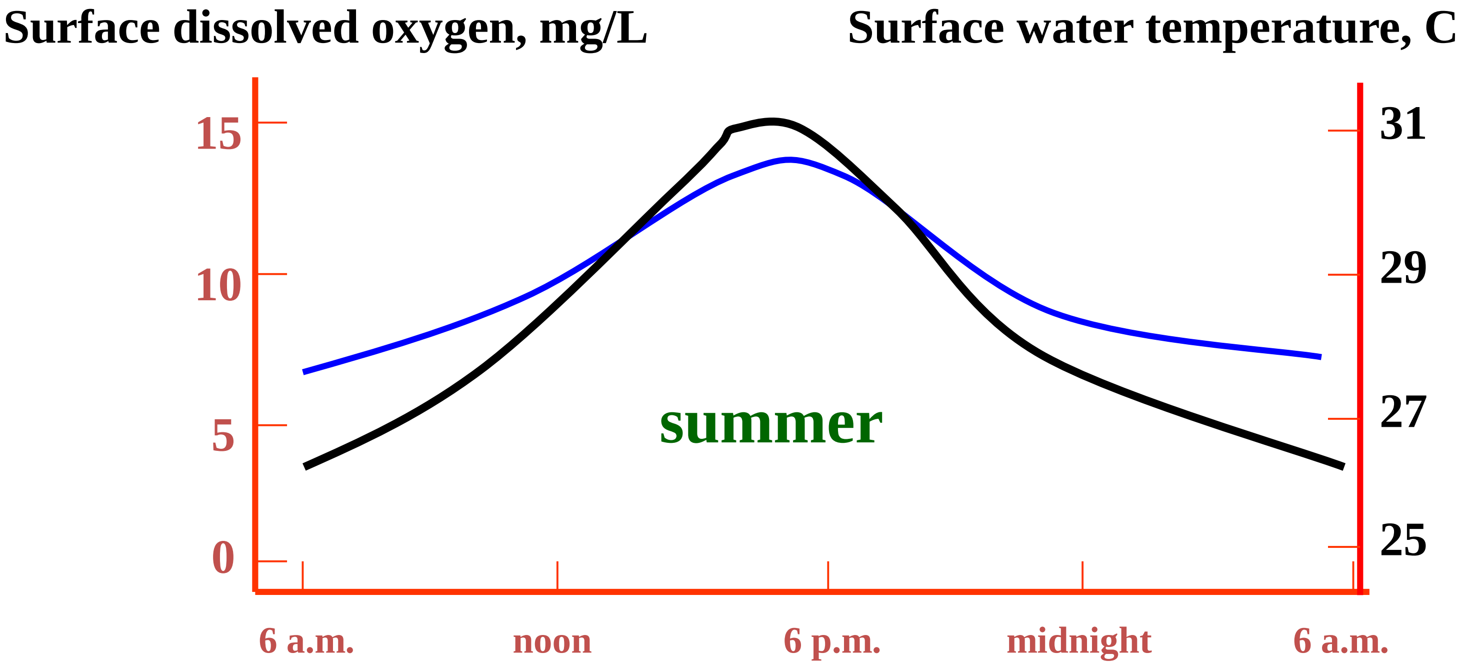
- Oxygen first limiting factor in recirculation fish culture system
- O_2 is consumed by fish and bacteria inhabiting bio filter
- In fish tank O_2 should not be less than 5 ppm and in outgoing bio filter water not less than 2 ppm
- When these levels drop below these concentrations aeration becomes necessary
- Induction air into water is called aeration while induction of pure oxygen is oxygenation
- For stocking density up to 45kg/m^3 aeration is enough but for higher stocking densities oxygenation is must

- Following production term is used for oxygen
- $P_{(Oxygen)}$ = -0.25 kg per kg feed consumed by fish – 0.12 kg per kg feed consumed by nitrifying bacteria -0.13 kg per kg feed consumed by heterotrophic bacteria(can be as high as 0.5) = -0.5 kg(sum of the above) per kg feed for system
- Poor mechanical filtration will let the solid accumulate in the system which will increase O2 consumption
- Safe level is 1 kg O_2 consumption for each 1 kg of feed used

Dissolved oxygen and water temperature

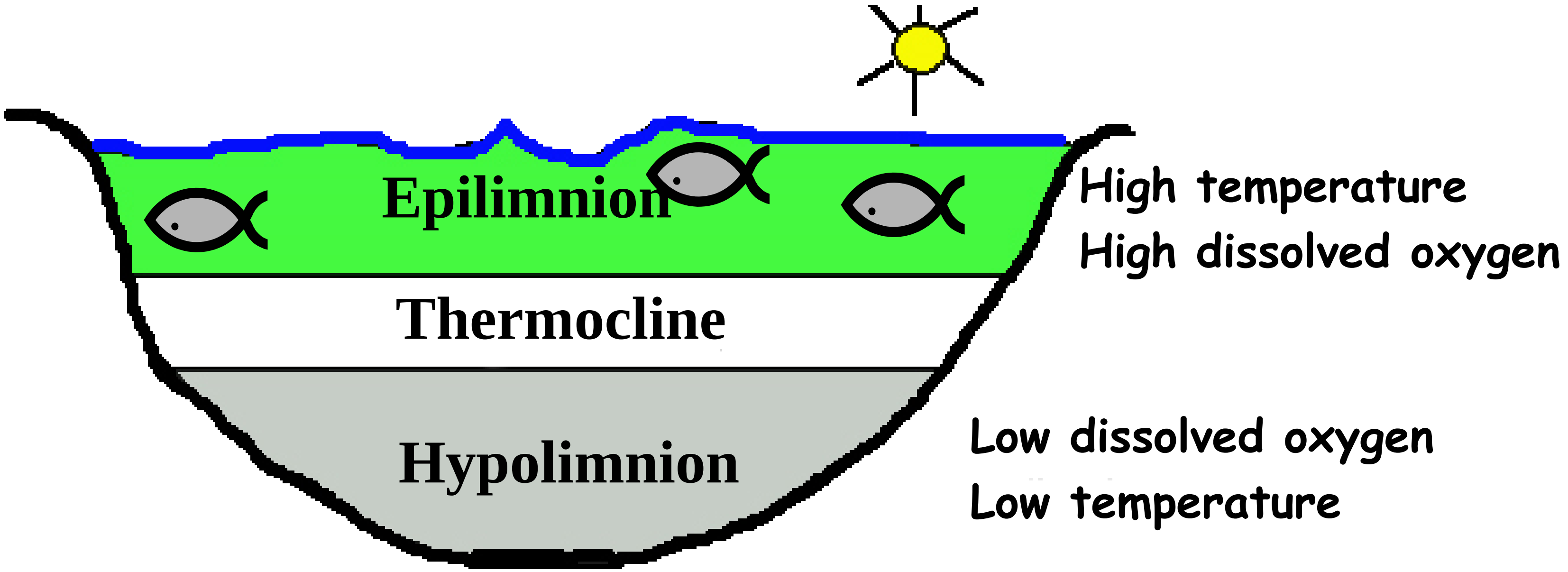
dissolved oxygen and water temperature usually vary over a 24 hour cycle.

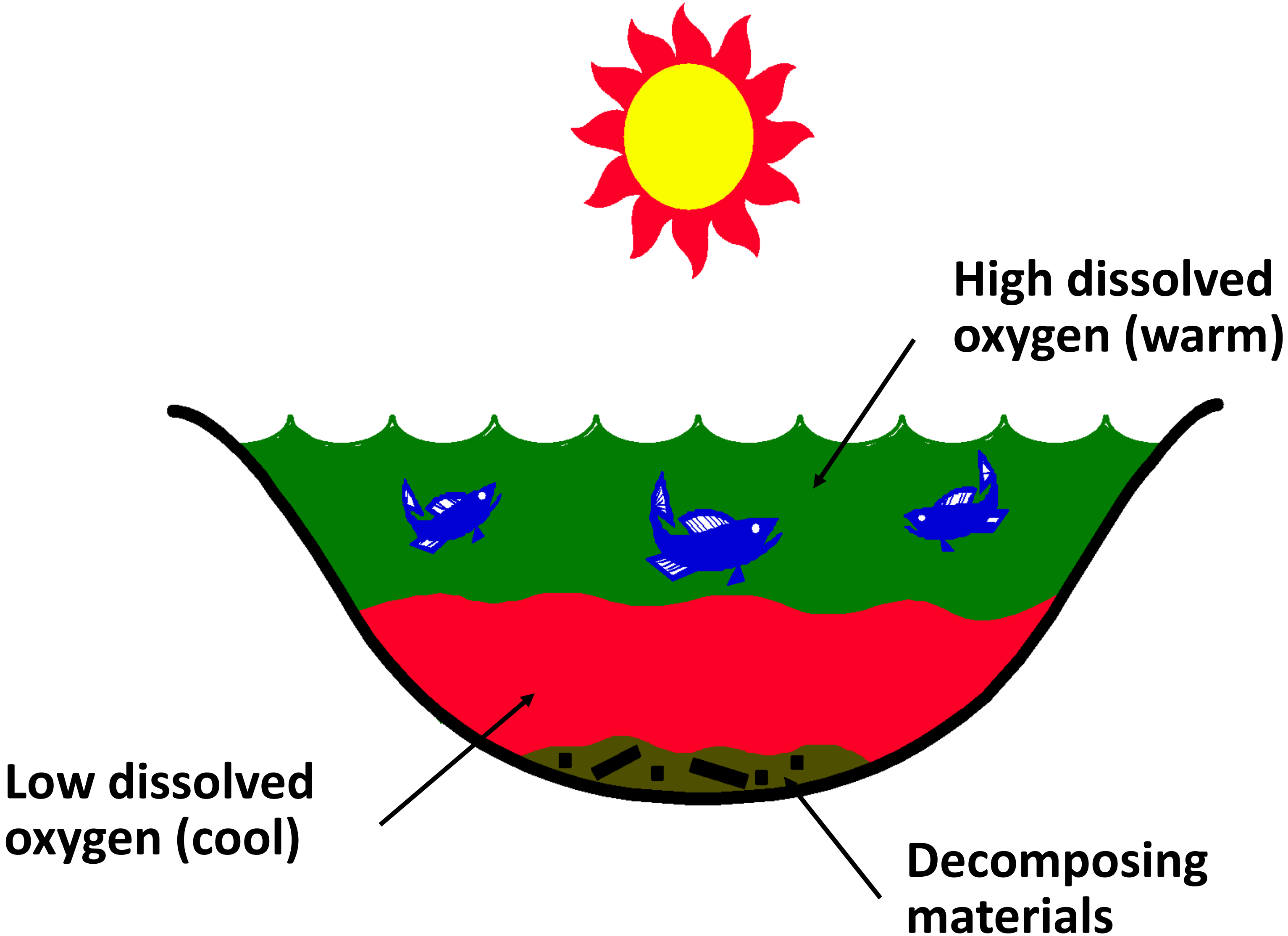




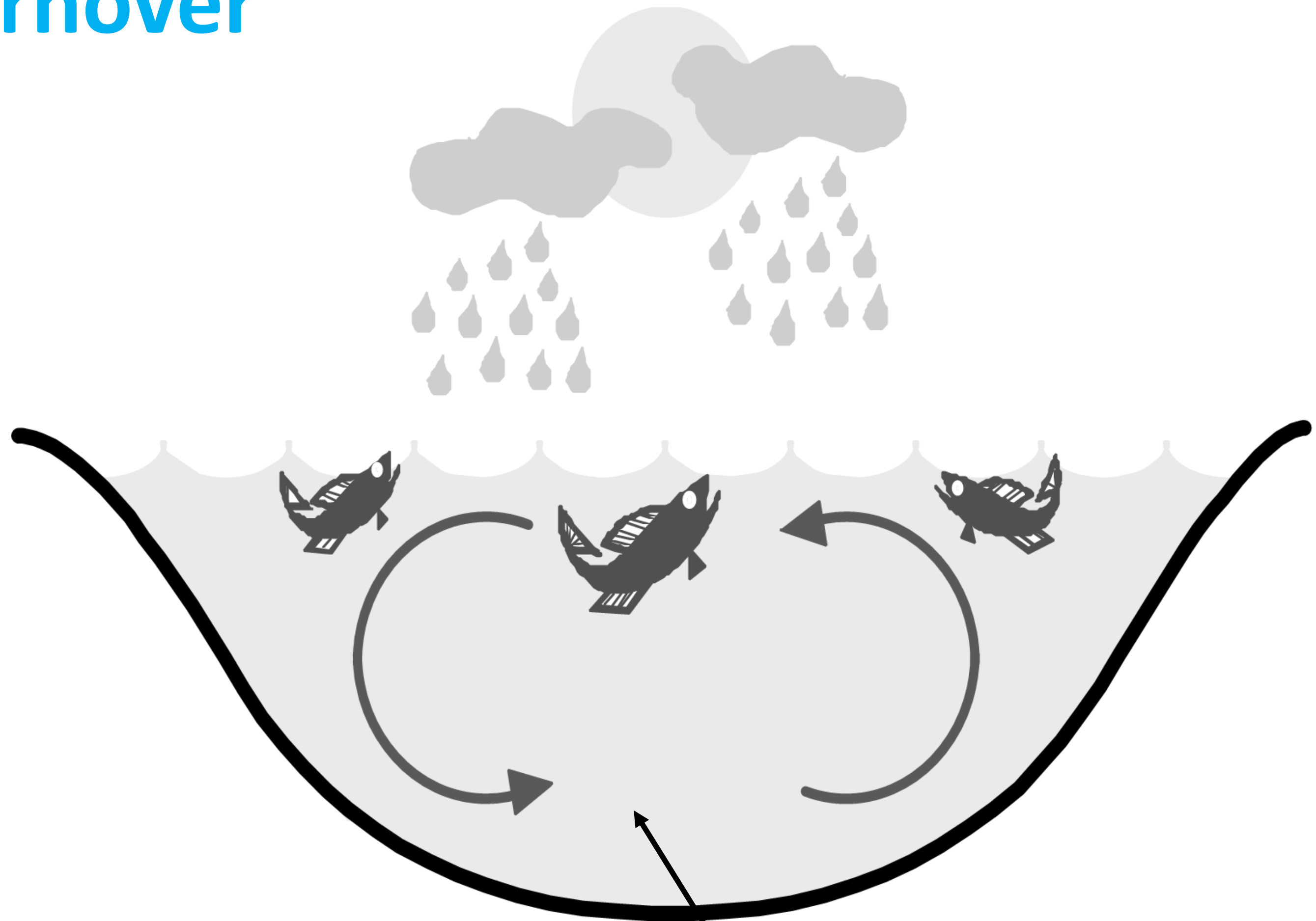
Dissolved oxygen and water temperature

Stratification can cause dissolved oxygen and temperature to vary at different depths in the same system.




High dissolved
oxygen (warm)
Low dissolved
oxygen (cool)
Decomposing
materials

Turnover



Low dissolved oxygen - possible fish kill

Carbon Dioxide Removal

- CO_2 is product of fish and other organisms in the system
- P_{CO2} = 1.375gram produced for each gram of O_2 consumed
- CO_2 obstructs fish respiration by reducing capacity of blood to transport O_2 by Bohr effect
- It decreases pH of the system and decreases bacterial efficiency
- It can be removed by trickling filter by keeping gas/liquid ratio of 5:1.

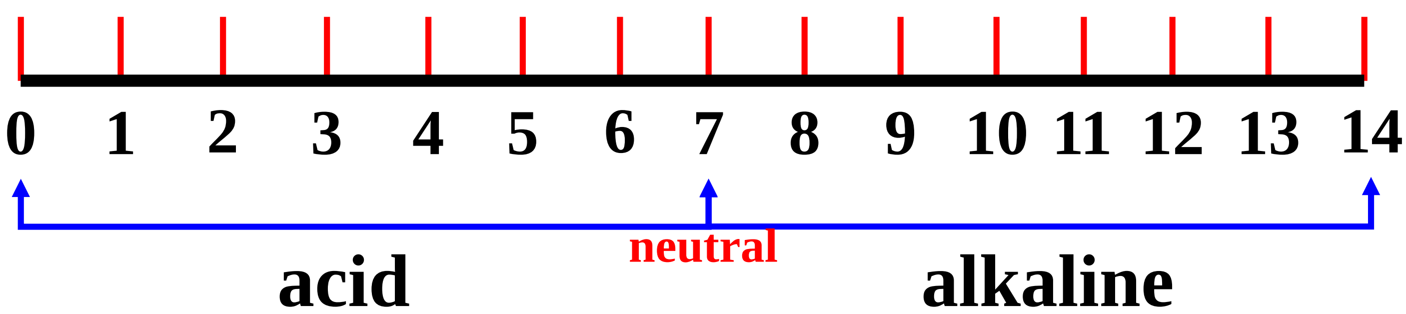
Suspended solids

- Effective control of suspended solids probably most important task that must be accomplished to ensure long term successful operation of RAS
- P_{solids} = TSS = 0.25 x kg feed fed (dry matter basis)

pH

pH is a measure of acidity (hydrogen ion concentration) in water or soil.

$$pH = -\log [H^+]$$



Alkalinity and Hardness

alkalinity

hardness

Total titratable bases

bicarbonate HCO_3^-

carbonate $CO^{2}{}_{3}^{-}$

Total divalent salts

calcium Ca^{2+}

magnesium Mg^{2+}

Calcium bicarbonate
$Ca(HCO_3)_2$

Calcium carbonate
$CaCO_3$

Magnesium bicarbonate
$Mg(HCO_3)_2$

Magnesium carbonate
$Mg\,CO_3$

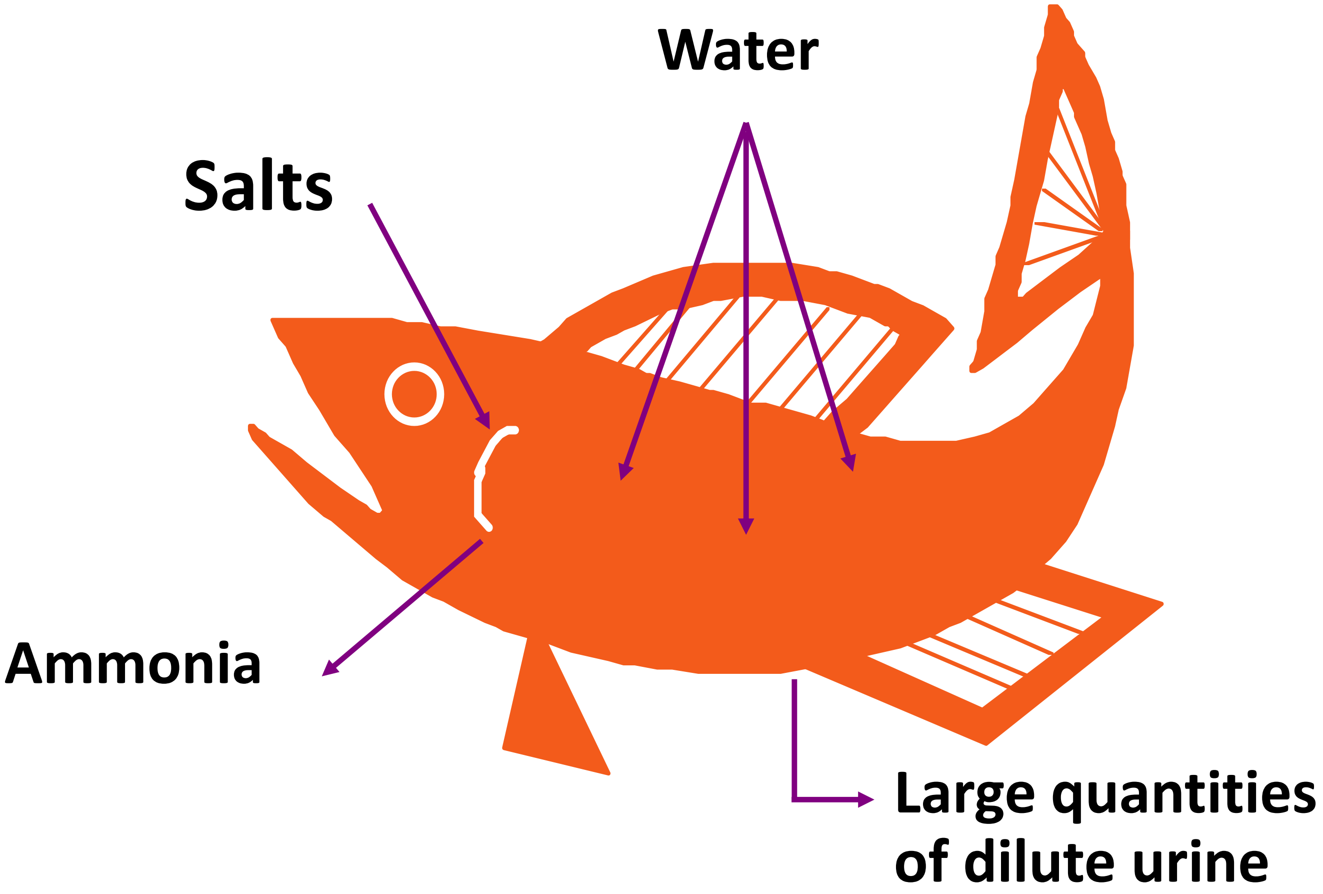
Why water quality for fish

Because fish need good water quality to;

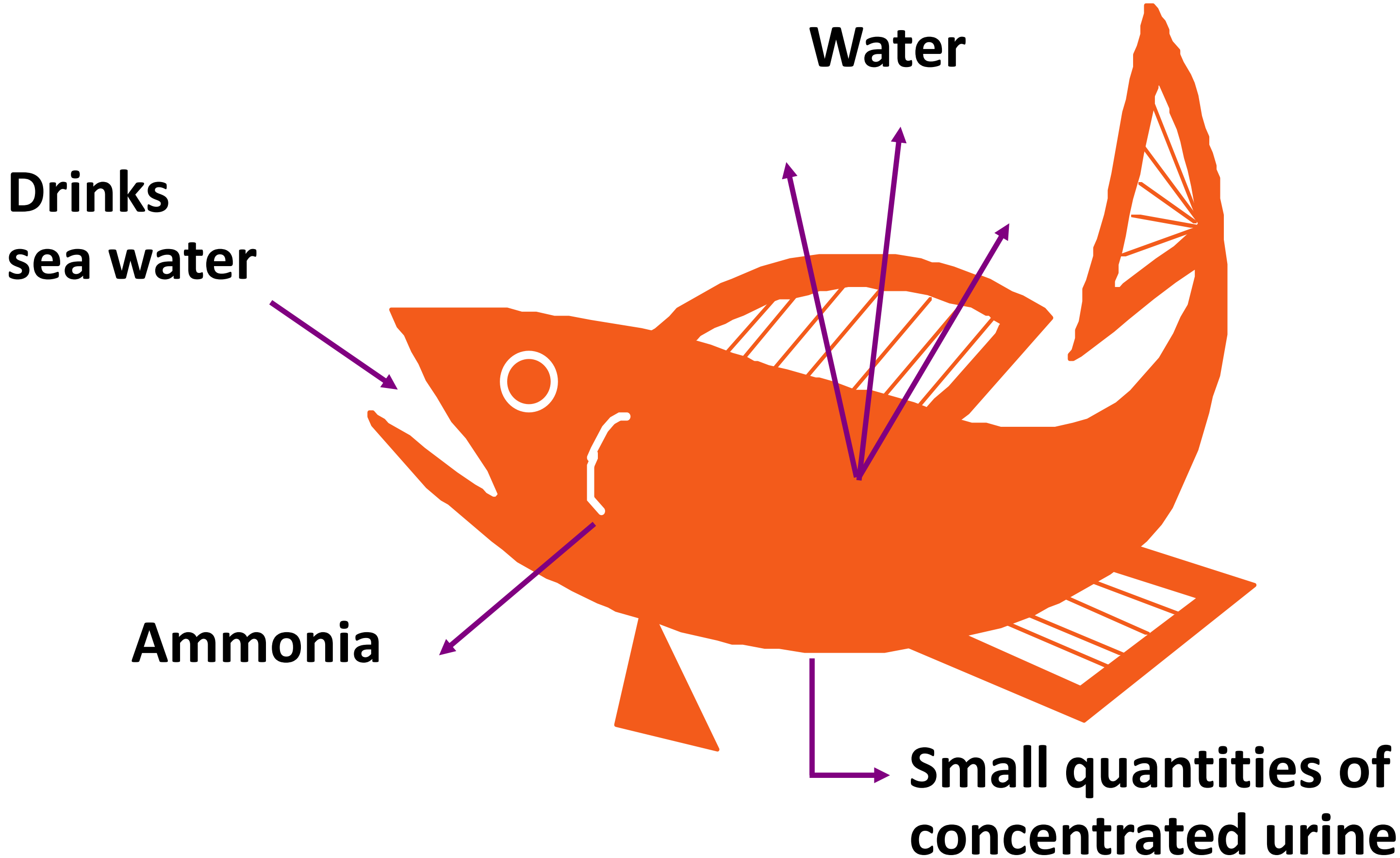
perform all bodily functions in water like

- Eating
- Breathing
- Taking in and losing salts

Water Balance in Freshwater Fish



Water Balance in Saltwater Fish



Testing Water Quality

Water quality parameters often tested are:

- Dissolved oxygen
- Water temperature
- pH
- Total Ammonia Nitrogen
- Nitrite/Nitrate
- Alkalinity/Hardness
- Salinity

How water quality values are expressed

Parameter	Value
Dissolved oxygen	ppm or mg/L O_2
Water temperature	C (Celsius)
pH	
Total ammonia nitrogen	mg/L N
Nitrite	mg/L NO_2^-
Nitrate	mg/L NO_3-
Alkalinity/Hardness	mg/L $CaCO_3$
Salinity	g/L salt /ppt(‰)

FEEDING OF FISH

FEEDING OF FISH

B-According to environment:

1-Warm water fish: Tilapia & Carp

2-Cold water fish: Rainbow trout

C-According to water:

1-Fresh-water fish

2-Marine fish

FEEDING OF FISH

Nutrient requirements of fish:

- The Standard Environmental Temp. (SET) for cold-water fish about 10C (salmon) & warm-water fish 30C (channel catfish).
- If water temp. deviates upward than SET , nutrient requirements increased & vice versa
- Most requirements for nutrients that have been published focus on juvenile fish/shrimp
- many represent single lab experiments, unchallenged, unsupported by others
- optimum performance can be affected by management, environmental factors and fish/shrimp size
- in formulating diets for a species for which nutrient requirements are unknown, those for a related species are used

Nutrient Requirements

- Most variation among aquatic species can be associated with whether the animals are:
- 1) cold water vs. warm water; 2) freshwater or marine; 3) finfish vs. crustaceans as mentioned earlier
- values in nutrient requirement tables only represent minima, don't allow for processing or storage losses
- AA's, minerals stable with reference to heat, moisture, oxidation
- vitamins and lipids are not stable (affected by heat, oxidation, light, moisture, etc.; store in cool area)
- 50% of ascorbic acid is lost in processing, half-life of 2-3 months in storage
-

FEEDING OF FISH

- Most important nutrient
- Main source of essential amino acids
- The most expensive source
- Carnivorous fish consume foods with ~50% of protein
- Herbivorous & omnivorous = less

1-Protein requirements:

- Function of protein for fish:

A-Provide energy

B-To supply amino acids

C-Functional proteins, hormones & enzymes

•

- Functions:
- 1) Component for muscle tissue formation
- 2) Component for enzyme, antibody, hormone & blood protein serum
- 3) Tissue recovery
- 4) Growth
- 5) Reproduction

Sources of protein:

A-Animal products (fish & meat meal)

B-Agriculture by-products (algae, cereals, legumes)

C-Industrial waste products

- Protein from animal

Fish meal, meat & bone meal, feather meal, by-product slaughtery (bones, organs)

- Protein from plants

Soybean meal, maize meal etc.

Protein Requirements of Fish

- Fish contain 60-93% crude protein, thus, fish diets are higher in protein than birds & animals.
- Fish appear to be relatively efficient utilizer of protein to energy with 84%.
- Fish can not synthesize their amino acids & obtain chiefly from the diet & absence affects growth of fish

FEEDING OF FISH

Item	Starter	Grower	Finisher
Cold water fish	40-50	35-40	30-40
Warm water fish	35-50	25-50	28-32

Protein requirements

- Species
  - Tilapia - 28-40% diet
  - Baung - 42-55%
  - Keli - 30-40%
  - Lampam - 30-50%
- Size (e,g,, Tiger shrimp)
  - Larva-PL_9 - 50-55%
  - PL_{10-24} - 46%
  - PL_{25}-1g - 40%
  - 1-10g - 38%
  - >10g - 35%
  - Minimum dietary requirement = balanced mixture of amino acids

- Fish synthesize body proteins from amino acids

Table 1. Two major classes of amino acids.	
Indispensable (essential)	**Dispensable (nonessential)**
Arginine	Alanine
Histidine	Asparagine
Isoleucine	Aspartic acid
Leucine	Cystine
Lysine	Glutamic acid
Methionine	Glutamine
Phenylalanine	Glycine
Threonine	Proline
Tryptophan	Serine
Valine	Tyrosine

Deficiency in essential acids = limit protein synthesis

=> Consequences: Reduced weight gain etc

More Waste Limited Digestion

- About 36% of feed is excreted as organic waste
- Live fish biomass = 5x more waste than human
- Why?

- Limited digestion
- Large fraction of feed remain undigested & is excreted

FEEDING OF FISH

Factors affecting protein requirement:

1-Species

2-Age

3-Stocking density

4-Water temperature

5-Production stage

FEEDING OF FISH

Deficiency symptoms of amino acids:

- Def. of lysine $\Rightarrow$ dorsal & caudal fin erosion & increased mortality
- Def. of methionine $\Rightarrow$ cataract
- Def. of tryptophan $\Rightarrow$ scoliosis, renal calcinosis, cataract, caudal fin erosion & decreased carcass lipid content

FEEDING OF FISH

Energy requirements:

A-Carbohydrates:

- Fish digest simple sugar efficiently & decrease digestibility of large molecule.
- Efficiency of carbohydrate in fish 39% compared to 96% in mammals.
- Carbohydrates can be used to spare protein since less protein will be used for energy.
- Fibers as cellulose & hemicellulose controlling passage of feed through gut & not exceed 8%, while 10% $\Rightarrow$ reduction in nutrient intake & digestibility.

Carbohydrates

- Fish do not have a specific dietary requirement for carbohydrates
- Most abundant & least expensive
- Carbohydrates => simple sugars
- Range from easily digested sugars to complex cellulose
- Complex cellulose = Hard to digest
- Intake of carbohydrates depend on enzyme production

-Carbohydrates also gives pellets integrity & stability (less dense)

<u>Prepared feed</u>

- Carnivorous fish = <25%
- Omnivorous = 25- 45%

- Amylase
- In herbivores => amylase occurs through entire digestive tract

Requirements in Fish feed

- 20% carbohydrates = cold-water fishes
- 30% carbohydrates = warm water fishes

- Carbohdyrates from plants

- Starch in seeds, tubers, wheat, paddy

FEEDING OF FISH

Energy metabolism in fish:

- Fish do not spend much energy towards maintaining body temperature (cold blooded).

Factors affecting energy requirement:

1-Species
2-Size
3-Light exposure
4-Composition of diet
5-Physiological activity
6-Age
7-Temperature of water
8-Other environmental factors (water flow, water composition, pollution)

FEEDING OF FISH

Fat:

- Fat-soluble compounds occurring in plant & animal tissues
- Consist of fats, phospholipid, sterols, fatty acids etc.
- Excessive dietary lipid = nutritional disease e.g., fatty liver or visceral fat

Fish can utilize energy of fat by 84% efficiency

Functions of fat:

1-Providing energy

2-Cushions for vital organs

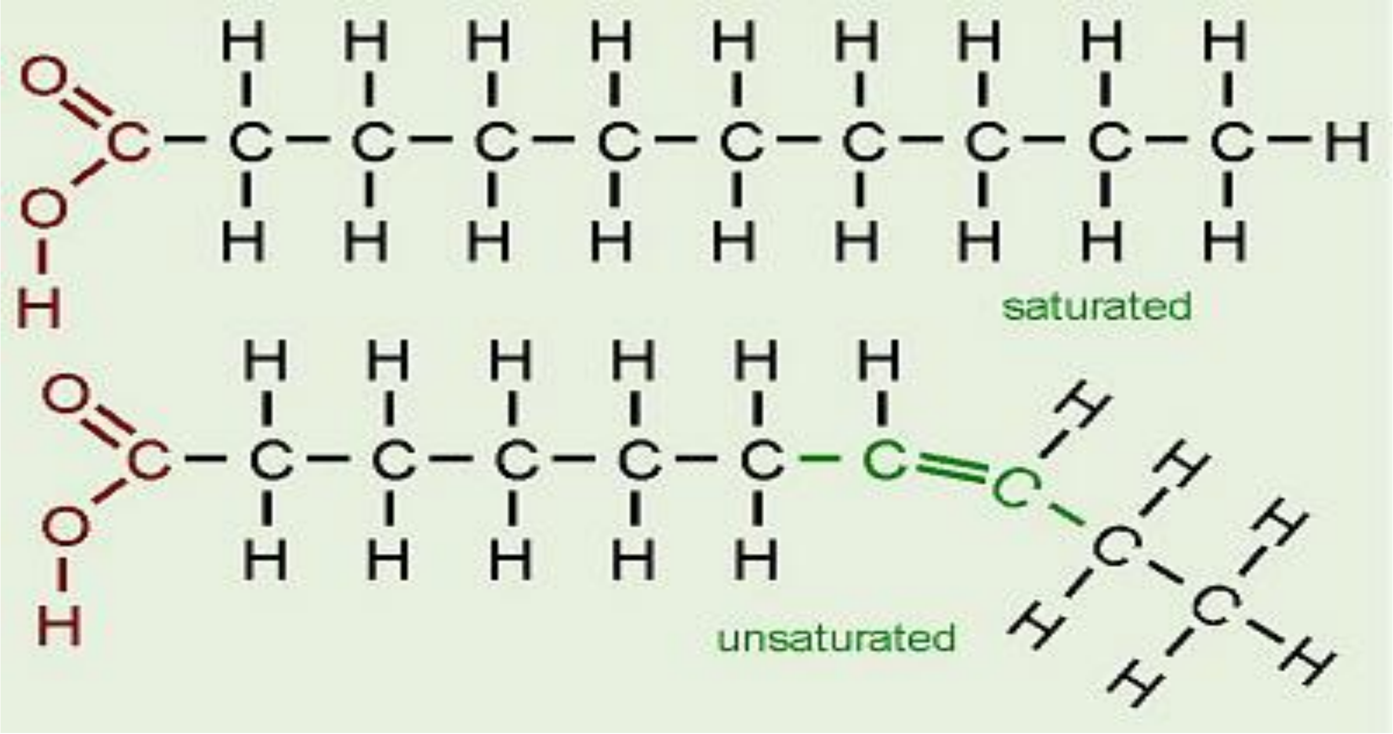
3-Energy reserves

4-Insulators & lubricants

5-Transports of fat-soluble vitamins

Fatty acids

- Saturated FA = no double bonds
- Unsaturated FA = double bonds

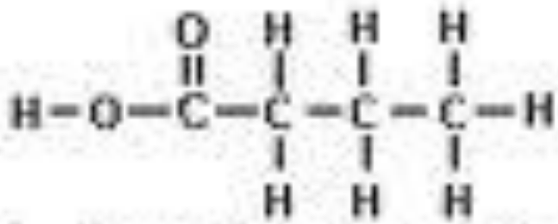


- Most important = EFA
- EFA = Organisms need it but can’t synthesize it

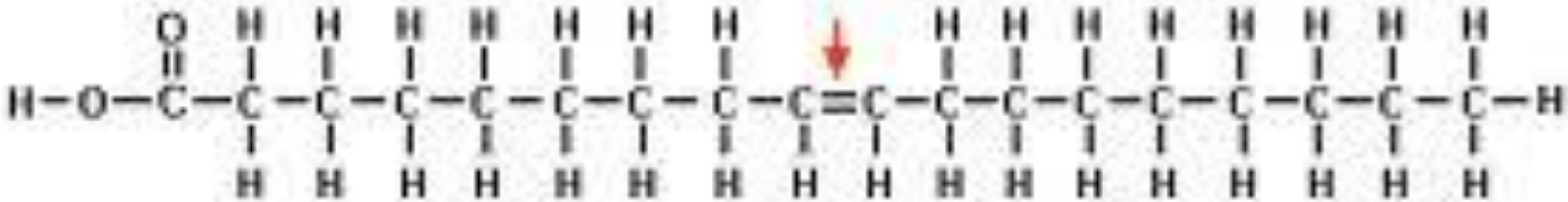
<u>Example</u>

- PUFA =

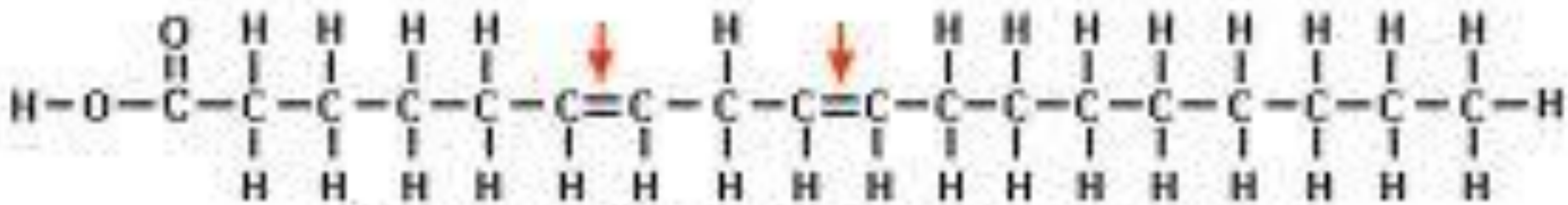
Saturated and Unsaturated Fatty acids



Butyric Acid- Saturated Fatty Acid



Oleic Acid- Monounsaturated Fatty Acid



Linoleic Acid- Polyunsaturated Fatty Acid

FEEDING OF FISH

- The best supplement of fat are fish oils & SBOM.

Fish oil (5%) is the best source of EFAs

Def. of EFAs:

1-Reduced growth & poor feed conversion

2-Increased mortality

3-Elevated muscle water content

4-Increased susceptibility to caudal fin erosion

5-Fatty infiltration in liver

Lipid for tiger shrimp

Size	lipid (% diet)
Larva-PL9	10-15
PL10-24	7.5
PL 25- 1 g	> 3.3
1-10 g	>3.0
> 10 g	> 2.8

Vitamins

- Only needed in small amount
- Critical for the maintenance of normal metabolic & physiological functions
- Water soluble & fat soluble
- Problem:

- Leaching of water soluble vitamins
- Hypervitaminosis, rare but causes enlargement of liver & spleen, abnormal growth, bone formation etc.

Vitamin requirements:

- Vitamin req. of fish resemble those of poultry.
- There is not enough bacterial activity in gut to satisfy B-complex & vit.K requirements
- Fish feed contain high levels of oils $\Rightarrow$ oxidation may result inactivation $\Rightarrow$amounts must be in excess to ensure adequate levels of requirements.

- Vitamins can be of two types
- Fat-soluble vitamins : Vit. A, D, E, K

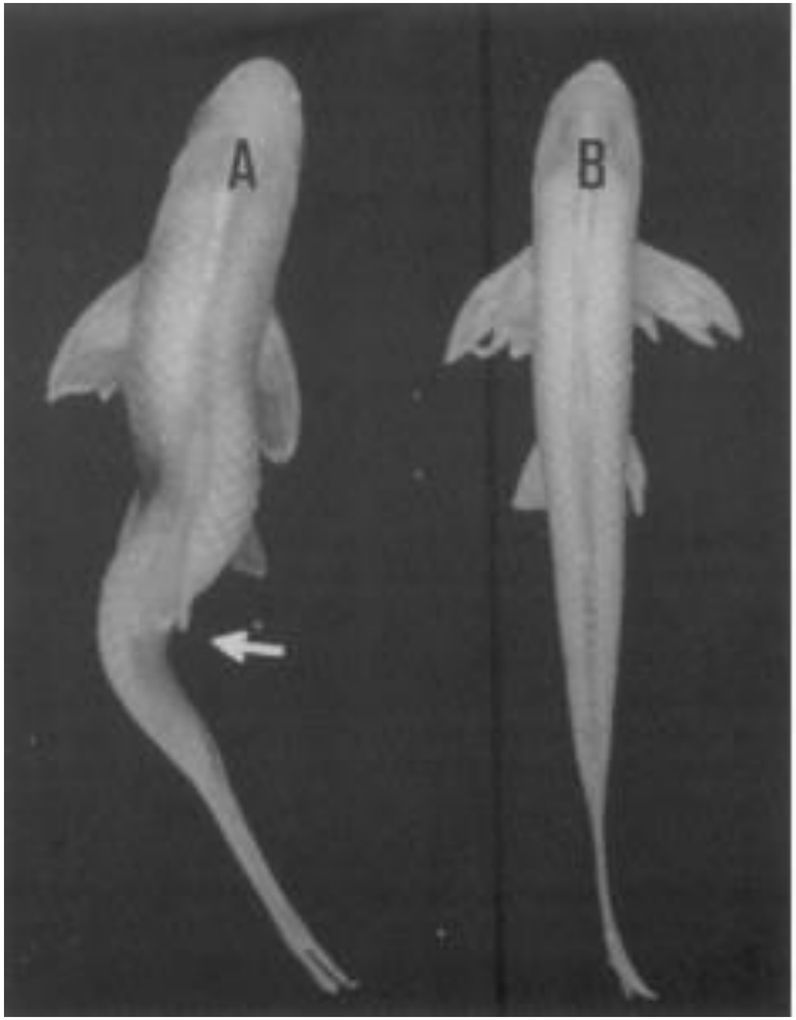
- Water- soluble vitamins : Vit. C, Vit B12, thiamin, riboflavin etc.

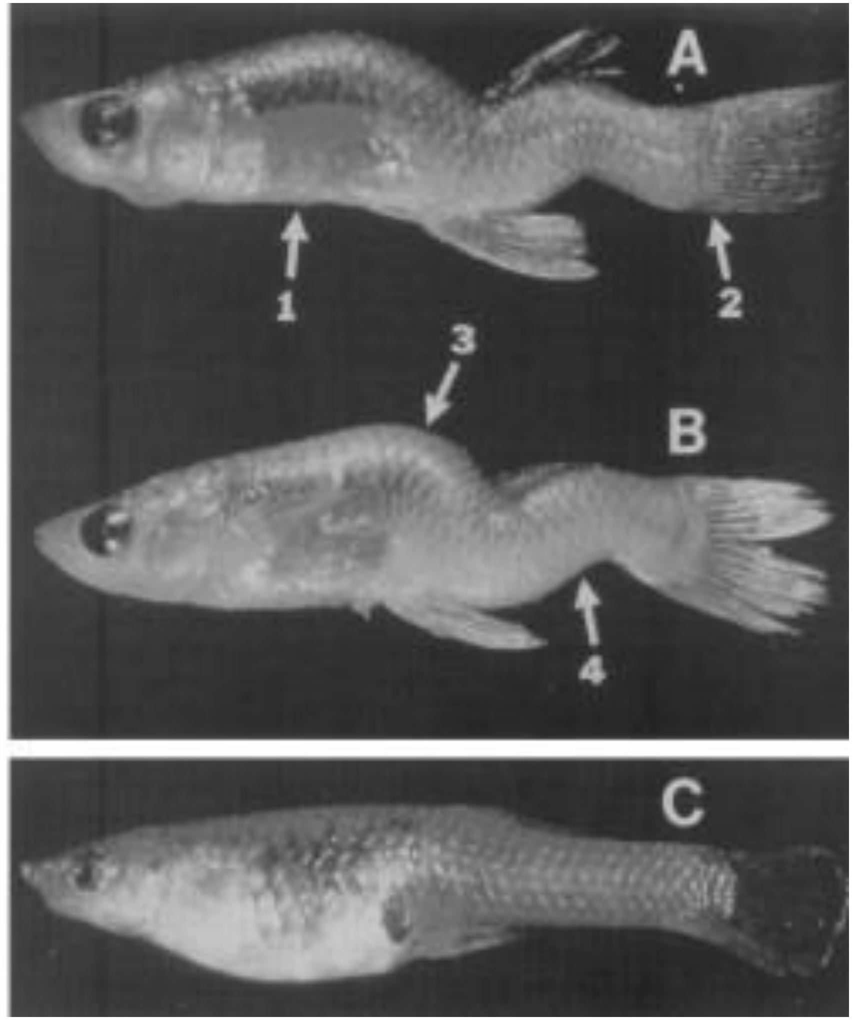
- Vitamin in feed = Sold as vitamin premixes

Table 3. Vitamins and some of their major functions as established in fish.

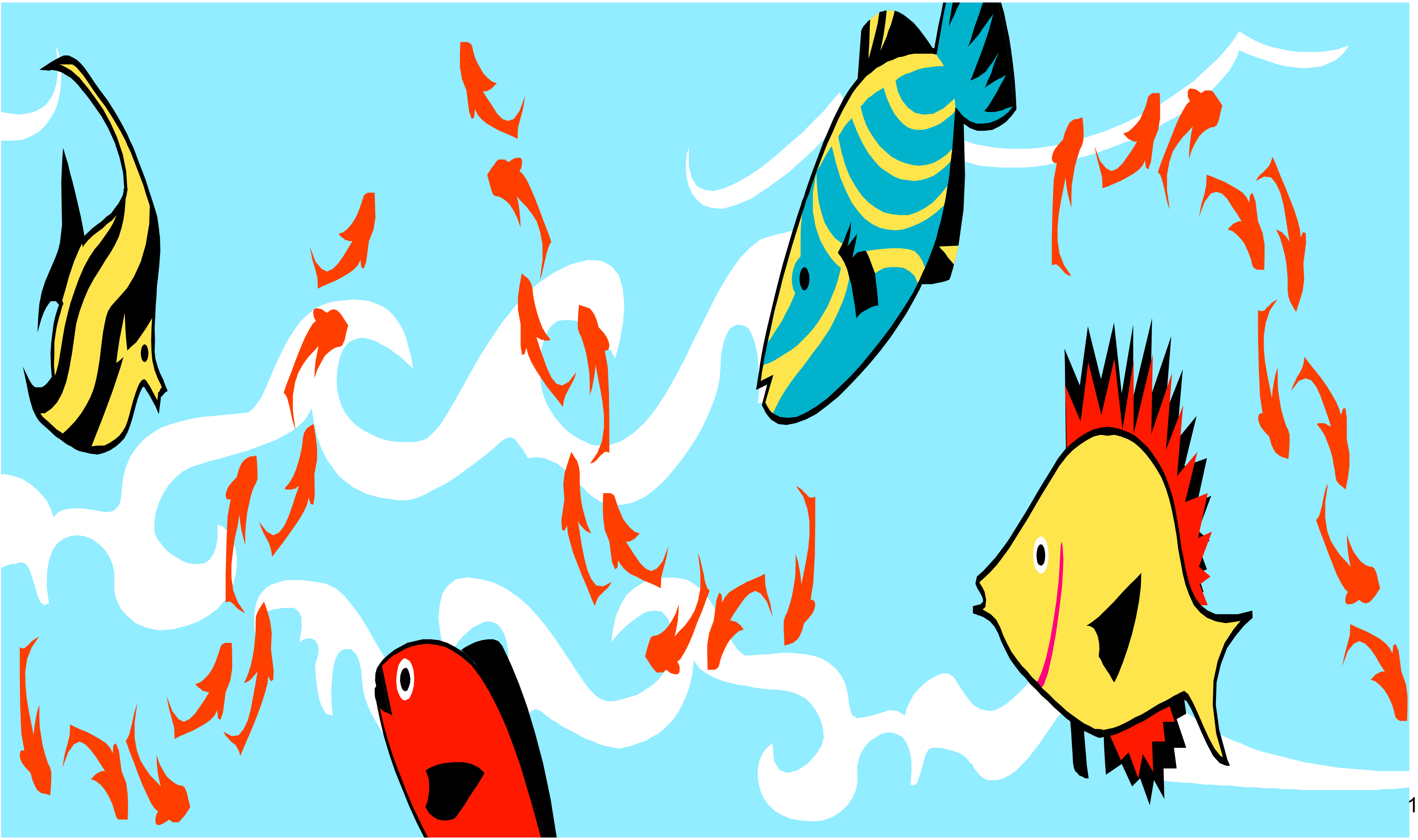
Fat-soluble vitamins	Function
vitamin A, retinol	epithelial tissue maintenance, vision
vitamin D, cholecalciferol	bone calcification, parathyroid hormone
vitamin E, tocopherol	biological antioxidant
vitamin K	blood clotting
Water-soluble vitamins	
thiamin, B_1	carbohydrate metabolism
riboflavin, B_2	hydrogen transfer
pyridoxine, B_6	protein metabolism
pantothenic acid	lipid & carbohydrate metabolism
niacin	hydrogen transfer
biotin	carboxylation & decarboxylation
choline	lipotrophic factor, component of cell membranes
folic acid	single-carbon metabolism
cyanocobalamin, B_{12}	red blood cell formation
ascorbic acid, vitamin C	blood clotting, collagen synthesis
inositol	component of cell membranes

Scoliosis (Vit. C deficiency)





FEEDING OF FISH
Mineral Requirements



Minerals

- Inorganic elements for Calcium, phosphorus
- Function:
- Formation of skeletal tissue, respiration, digestion & osmoregulation
- Macromineral & micromineral (based on quantities required in the body)
- Calcium, phosphorus, magnesium etc. are Macrominerals
- While cobalt, chromium, copper, Zn, Selenium are Microminerals (trace minerals)

-Minerals requirements:

- Fish have the ability to absorb a number of minerals directly from water $\Rightarrow$ reducing mineral requirements in the diet.
- Fish require all macro-and micro-elements required by other animals for enzymes & cofactors.
- Fish in soft water (low mineral content) require additional supplements in diet.

Table 2. Trace minerals and some of their prominent functions.

Trace mineral	Function
Copper	metalloenzymes
Cobalt	vitamin B_{12}
Chromium	carbohydrate metabolism
Iodine	thyroid hormones
Iron	hemoglobin
Manganese	organic matrix of bone
Molybdenum	xanthine oxidase
Selenium	glutathione peroxidase
Zinc	metalloenzymes

Table 7.8 Mineral requirements of certain finfish, in percentage or amount per kg feed. (After Castell *et al.*, 1986.)

Species	Ca (%)	P* (%)	Mg (%)	Fe (mg)	Cu (mg)	Zn (mg)	Mn (mg)	I (μg)	Se (mg)
Rainbow trout (*Salmo gairdneri*)	0.02	0.7–0.8	0.05–0.07	—	3	15–30	12–13	—	0.15–0.38
Atlantic salmon (*Salmo salar*)	0.03	0.6		R	R	R	R	R	R 0.1
Chinook salmon (*Oncorhynchus tshawytscha*)	—	—	—	—	—	—	—	0.6–1.1	—
Chum salmon (*Oncorhynchus keta*)	—	0.5–0.6	—	—	—	—	—	—	—
Catfish (*Ictalurus punctatus*)	0.03	0.6–0.7	0.04–0.05	—	3	15–30	12–13	—	—
Tilapia (*Tilapia nilotica*)	—	0.9	—	—	—	—	—	—	—
Eel (*Anguilla japonica*)	0.27	0.30	0.04	170	—	—	—	—	—
Red sea bream (*Pagrus major*)	0.34	0.56–0.6	NR	150	—	—	—	—	—

* Inorganic.
R: Required.
NR: not required.

Table 7.9 Mineral deficiency symptoms in certain finfish. (After Castell *et al*., 1986.)

Mineral	Deficiency symptoms
Calcium	Poor growth and feed efficiency,[1,8] high mortality.
Phosphorus	Skeletal abnormalities,[5,7,8] poor growth and feed efficiency and bone mineralization.[1,3,5,7,8]
Magnesium	Renal calcinosis,[1] loss of appetite,[1,8] poor growth,[1,8] high mortality, sluggishness, skeletal abnormalities.
Iron	Hypochromic microcytic anaemia.[2,7,9]
Copper	Poor growth.[7]
Manganese	Poor growth,[1] short and compact body,[1] abnormal tail growth.[7]
Iodine	Thyroid hyperplasia.[6]
Zinc	Cataract,[1] caudal fin and skin erosion,[1,7] growth depression.[1]
Selenium	Muscular dystrophy,[3] exudative diathesis.[3]

[1] *Oncorhynchus mykiss* [2] *Salmo fontinalis*, [3] *Salmo salar*, [4] *Oncorhynchus keta*, [5] *Ictalurus punctatus*, [6] *Oncorhynchus tshawytscha*, [7] *Cyprinus carpio*, [8] *Anguilla japonica*, [9] *Chrysophrys major*.

Type of fish feeds

- Finely ground meals
- Crumbles
- Flakes
- Pellets of various size & density

$\Rightarrow$ Sinking

$\Rightarrow$ Floating

$\Rightarrow$ Slow sinking

- Microdiet


Extruded
Sweet Feed
Chunks
www.semachinery.net
Multi-Particle
Pellets

Diet preparation

- Grinding, mixing & pelleting

- <u>Grinding</u>

reduce ingredient particle size to

1) Easy handling of ingredient

2) Improve feed digestibility, acceptability, mixing properties & pelletability

- Mixing

Achieve uniformity of ingredients

- Pelleting

Transformation from soft, dusty mixture to compacted form

- Compression pelleting = sinking pellet

Cooking extrusion = floating pellet

Extrusion process

⇒ Feed mixture subjected to heat & moisture

⇒ Pellets expand, reducing density

⇒ <u>Advantages</u> = Expanded pellet able to absorb more lipid

Proper Feed Storage

- Because feeds contain ingredients that are susceptible to degradation, you are concerned with storage conditions and shelf life
- **What breaks down?** Vitamins, lipids, proteins
- fats and oils break down via rancidification
- proteins can become deaminated: do not use any feed over 3 months old
- big problem for those who import feed

Proper Feed Storage

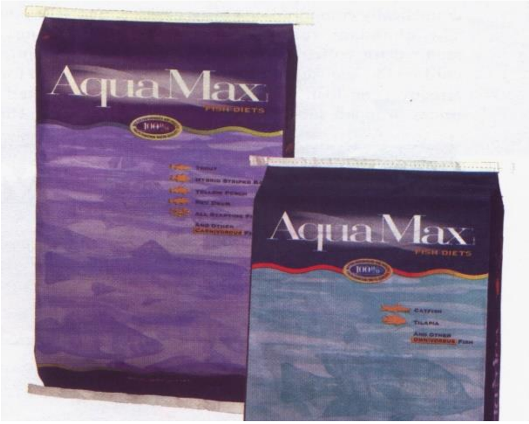
- Proper storage = protection against high temperature, humidity, moisture, insect & rodent infestations
- Minimum length of time
- Feed sacks should not touch the floor or side walls
- Store = 100% waterproof
- Cool, dry environment
- Formulations affect storage – fish meal and oil
- Nutrient losses – fatty acids, vitamins
- Contamination – rodents, fungal, bacterial

Proper Feed Storage

- Watch out if your are importing!! = delays
- Delays can turn feed into high-priced fertilizer or make it downright toxic!
- Feed typically shipped in 100 lb bags
- sea freight or over-land trucking
- **normal shipment**: 450 x 100 lb bags in one 40 ft container
- **if mill is nearby**: shipment is *a granel* or loose-pelleted
- *a granel* would imply that the farm has a silo and bagging system

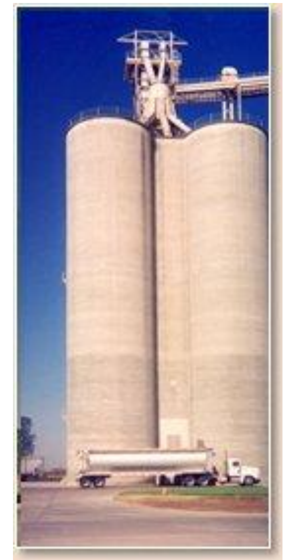
Proper Feed Storage

- Feed bags are made of many materials:
- paper on outside, plastic liner
- continuous plastic (no weave, no air holes)
- woven polymer
- typically contain labels stating feed type, pellet size, proximate analysis, ingredients, date of manufacture, etc.
- must be unloaded immediately and placed in proper storage



Proper Feed Storage

- Direct sunlight will adversely affect the vitamin and lipid quality of the feed
- do not store feed more than 3 months *post manufacture*
- feeds should be purchased, delivered, and utilized on a monthly basis (2-3 containers per month for large farms)
- spoiled, wet or old feeds cannot be used
- economic loss of feeding deficient feed may be greater than cost associated with discarding it



Proper Feed Storage

- Feeds should be stored in a dry, cool and well-ventilated area
- spoilage will occur immediately if feeds become wet: temperature needs to be consistent
- bags stored on wooden pallets, not on floor
- no more than 5 bags high between pallets
- allows for adequate air circulation between bags, constant or similar moisture, temperature

Proper Feed Storage

- Do not store bags directly on concrete floors or touching walls of building
- surfaces are often cooler than the bag: moisture migration
- feed moisture (around 8-12%) will migrate to the cool area, accumulate
- this encourages growth of molds (REM: *Aspergillus flavius*, aflatoxin??)
- also avoid direct sunlight: diurnal temperature flux

Storage problem

- Oxidative damage

- Oil rancidity, oxidation PUFA

- Microbial damage

- Fungi & bacterial growth

- Insect/rodent damage

- Ingestion & contamination (feces)

- Chemical damage

- Breakdown of fatty acids, reduced amino acids & vitamins (esp. vit C)

What are some common methods of feeding fish?

- Feeding fish is very important.
  - Provide the appropriate nutrition.
  - Opportunity to observe fish for any abnormal signs.
- Feeding systems differ based on size of the operation.
  - Small operations
  - Large operations

What are some common methods of feeding fish?

- Small Operations
  - ***Hand feeding***
    - Feed is distributed by hand, shovels, or other non-automated means.
    - Most common method.
    - Used for feeds not suited for automated systems.
    - Meat scraps are hand fed.

Advantages:

1-Operator can note feeding behavior $\Rightarrow$gauge the feed required

2-Operator can ensure that feed is dispersed over wide area.

Disadvantages:

1-high labor cost

2-increased handling of the feed.

What are some common methods of feeding fish?

- Large Operations
  - ***Automated feeding systems***
    - Utilize machinery to distribute the feed.
    - From relatively simple to very complicated, computer-controlled.
    - Blowers
    - Demand feeders
    - Auger feeding systems

Advantages:

1-Reducing labor cost

2-Known quantity of feed dispersed to fish

Disadvantages:

1-Less observation of the fish

What are some common methods of feeding fish?

- ***Blowers***
  - Drive along the side of the pond and blow feed out into the pond.
  - Attached to trucks or tractors.
  - Common in levee pond and watershed pond operations.

www.sweeneyfeeders.com/aquaculture.htm

What are some common methods of feeding fish?

www.missourifishfarms.com/.../automatic_feeders.htm

- ***Demand feeders***
  - Allow fish to bump a rod and release feed when they are hungry.
  - Used in raceways.
  - Fish must be trained how to use them.

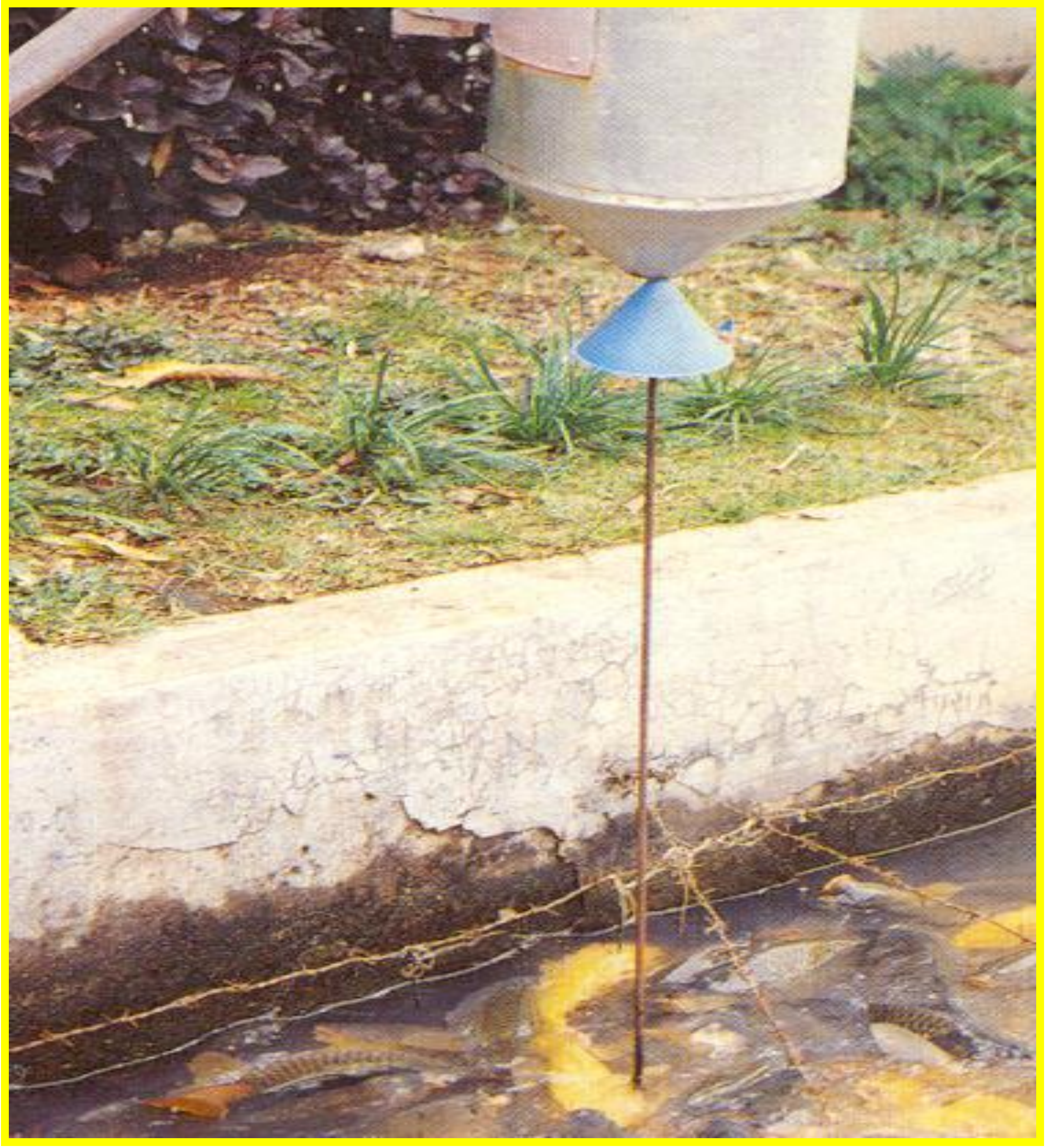
Fish can obtain food on demand by depressing a trigger.

Advantages:

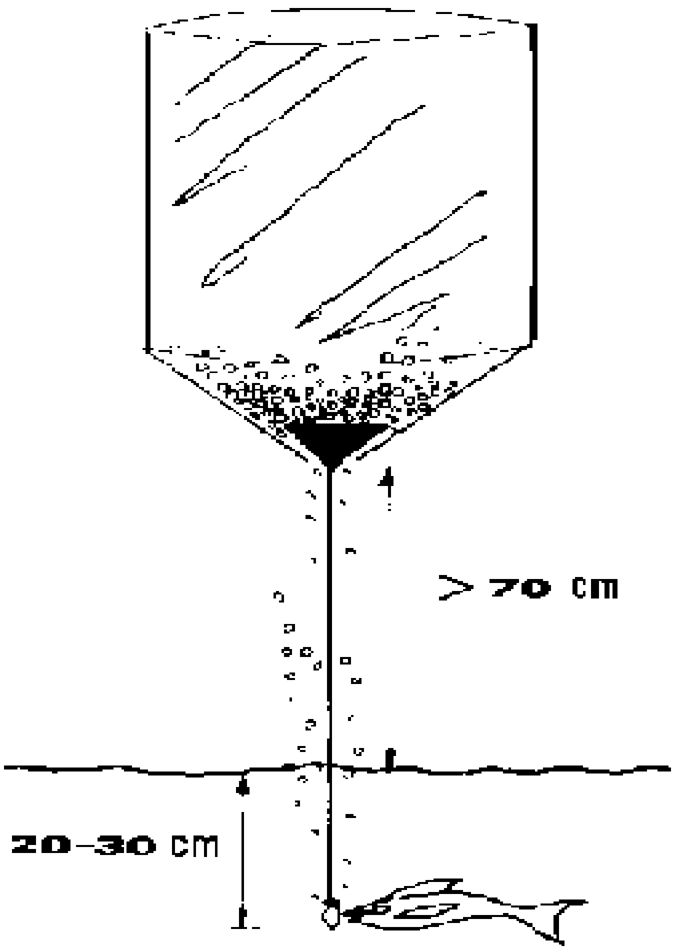
Fish can obtain much food as required

Disadvantages:

Trigger happy $\Rightarrow$ feed wastage & water pollution



- Demand feeders



What are some common methods of feeding fish?

- ***Auger feeding***
  - Similar to systems used by swine and poultry farmers.
  - Feed stored in large tanks
  - Moved by augers that drop feed in pond
  - Common in tanks and raceways

www.ars-grin.gov/ars/PacWest/Aberdeen/overturf.htm

Nitrogen excretion

- Animal = Urea
- Fowl = Uric acid
- Fish = Ammonia

Feeding Frequency

- Small = 4-8 times/day
- Big = 2-3 times/day

Fish = One specific place at a time

Shrimp = whole or half of the pond at a time

174

Fish Health and Disease

- Health or well being important for
- feeding
- Growth
- Reproduction
- Diseased fish results in poor growth and ends up in losses
  - Further when diseased fish is sent to consumer, it changes
  - Texture
  - Appearance
  - Taste

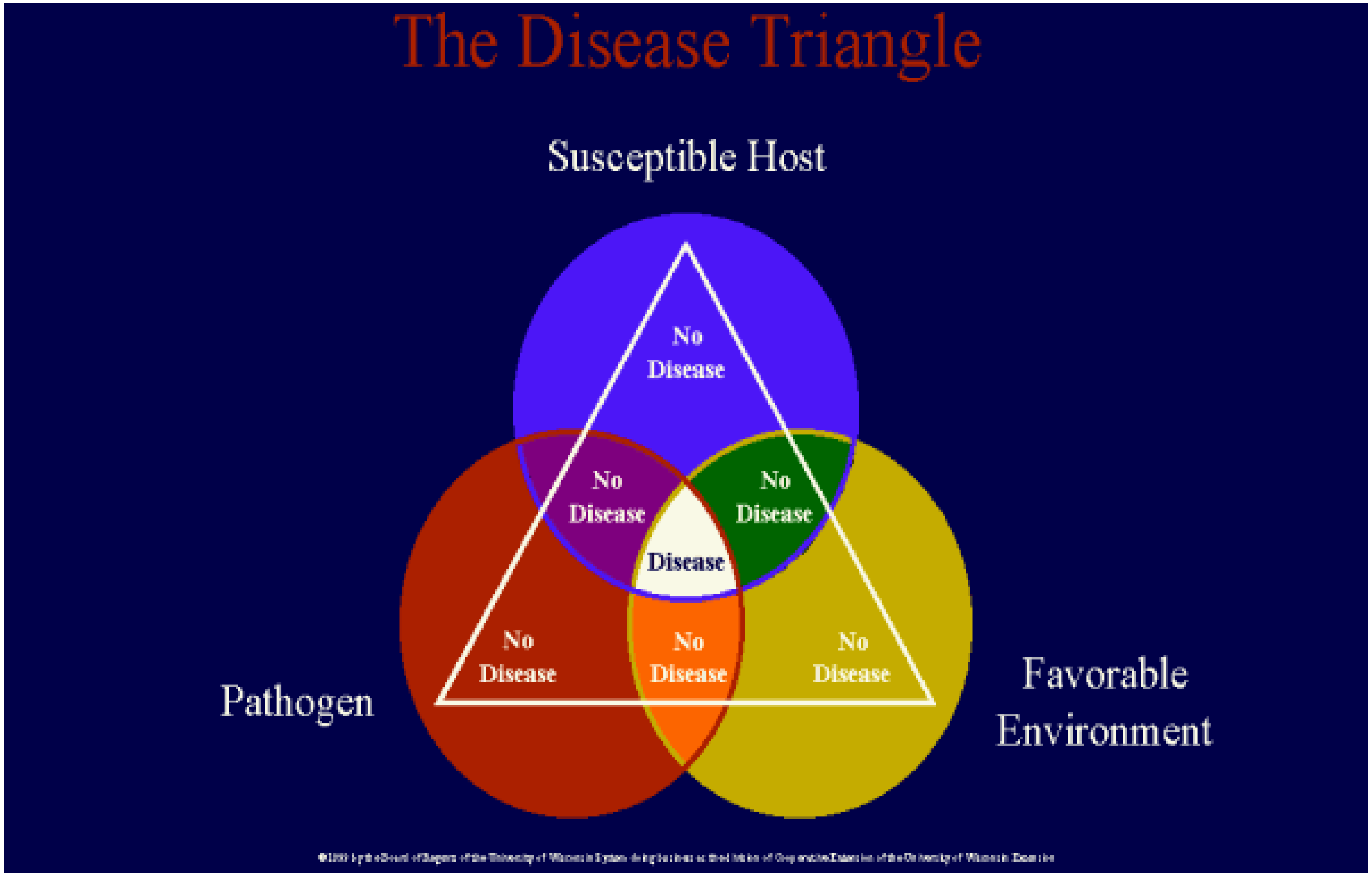
- Now what causes disease
- Pathogens

- Disease causing organisms
- If present in fish environment, fish is always at risk
  - pathogens attack fish,
  - It shows abnormal behavior,
  - Stop feeding and
  - growth
  - if conditions prevail fish succumb(surrender) to death

- Which system has maximum possibilities to accept disease

- extensive , semi-intensive and intensive
- Intensive system
- Reasons
  - Crowding
  - Competition
    - Food
    - Space

Requirements for Disease



- All 3 must be present for an outbreak

Introduction

- **We will focus on**
- **How** do you recognise that a fish might be ill?
- **What** are the causes of fish disease?
- **How** do you know that a fish has a parasite?
- **What** can you do to prevent a disease / parasite?
- **How** do you treat diseased fish?

Fish Diseases

How do you recognise that a fish might be ill?

- Colour may fade out / change
- Body shape, condition and / or behaviour will be abnormal
- The fish may refuse to feed or overfeed and trailing faeces appear at vent.
- Condition of the fins and gills will deteriorate.
- Fins may be clamped close to body.
- The fish may not keep its swimming position.
- There may be signs of injuries, outgrowths or abnormalities.

Fish Diseases

What are the causes of fish disease?

- Bad water quality
- Inappropriate diet
- Temperature (too high or too low)
- Stress
- Bullying(mistreatment, oppression)
- Viral diseases
- Fungal infections
- Bacterial infections
- Parasites

Parasitic conditions: What is a parasite?

- A parasite is an organism that lives off another often to the detriment of the hosts health.
- Parasites can be internal (endo-parasites) or External (ecto-parasites).

- They can be:
- Protozoan (single celled)
- Nematodes/ cestodes / trematodes (worms)
- Crustacean (e.g. louse)

Parasitic Fish Diseases

- Itch or White Spot Disease (*Ichthyophthirius)*

  Causes

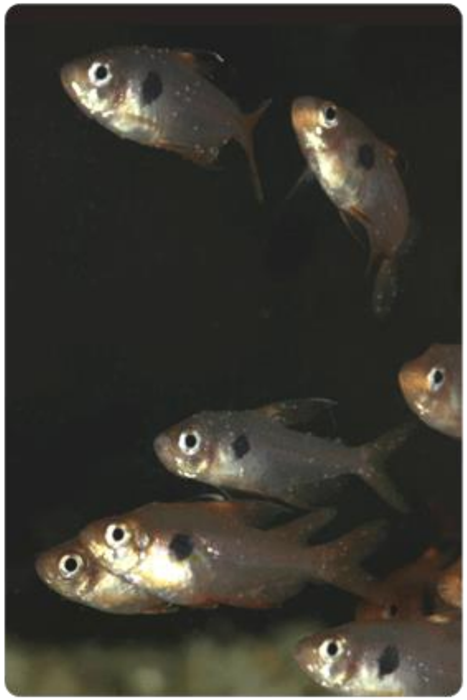
  Protozoan parasite either free swimming in the water or carried in with new fish or plants.
  Fish under stress from bad water conditions are more susceptible.

Symptoms

- The fish’s skin and fins are covered in tiny white spots
- A badly affected fish may make rapid gill movements

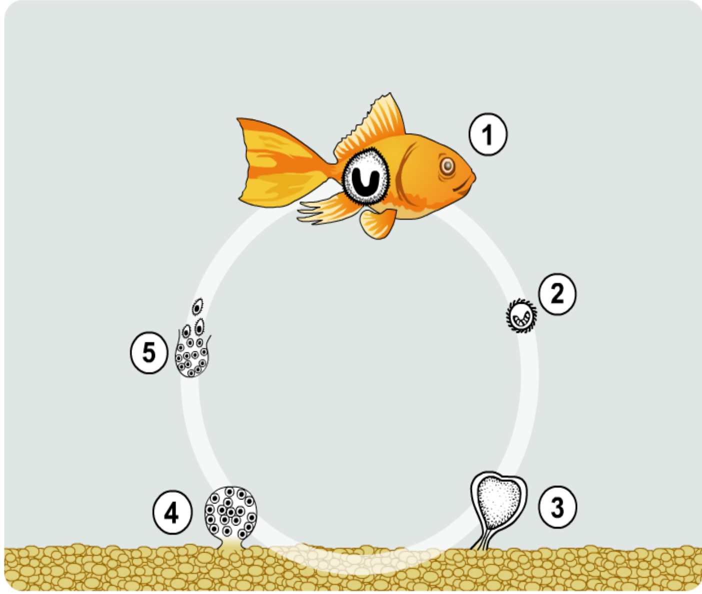
Treatment

- Remove plants and the activated carbon from filters as they can affect / be affected by the medicine.
- Treat with a methylene blue based medicine which kills the free swimming larval stage (theronts)



White Spot Lifecycle

1. After finding their new host, they will eat into the fish's skin.
2. Adults fall from the fish and become free swimming till it settles on the gravel.
3. Once settled it forms a cyst which begins to reproduce by dividing itself up to as many as 2,000 times.
4. The result of this division produces what is called Tomites.
5. These emerge from the cyst when it bursts as free swimming Theronts ready to re-infect the fish.



N.B. If a Theronts is unable to find a new host within 24 – 48 hours they will usually die.

- Whirling disease *Myxobolus cerebralis*
  - Caused by protozoan

Skull deformation from *Myxobolus cerebralis*

TREMATODES
Gill flukes and skin flukes (*Dactylogyrus* & *Gyrodactylus*), monogeneans

Cause

- Trematode (flatworm / flukes) attack by direct contact with contaminated fish, eat gill/skin tissue and blood, free swimming larval stages can attach to the bottom and side of housing.
- **Symptoms**
- The gills may move rapidly and fish may gasp at the water surface
- The fish may scrape itself against objects
- Colours fade as damaged areas are covered in mucus.
- The skin may redden in places
- The fins may become ragged

Treatment

- These parasites can be treated with a formalin based medicine.

- Skin & gill fluke *Gyrodactylus salaris*
  - flatworm

Darkening of skin from anus to tail

Atlantic salmon with Gyrodactylosis

Ecto-parasites: Crustaceans

- Sea lice

CRUSTACEAN
Anchor Worm *(Lernaea)*

Cause

- The crustacean parasite *Lernaea* it can grow up to 12mm. Usually brought in by non quarantined fish.

Symptoms

- Whitish-green threads hang out of the fish's skin, with an inflamed area or ulcer at the point of their attachment.

Treatment

- The water can be treated with insecticide. The adult parasite can be removed manually and the wound treated with antiseptic to prevent bacterial infection.

Fungal infections: What is a fungus?

- Fungus are multi-cellular, spore producing organisms that live off other organisms, and dead matter, some are parasitic.
- Fungal spores are commonly found in aquarium water.
- Healthy fish have a protective mucus covering which can prevent infection by fungal spores.

Fish fungus

Cause

- Aquatic fungi e.g. *Saprolegnia*.
- Fish that are in poor health and have damaged mucus membranes through bad water quality, rough handling, fighting or physical injury are more prone to infection. Fungus can be a secondary infection to other conditions.

Symptoms

- Grey white or brown cotton wool like growths on the skin or fins.

Treatment

- Medicines containing malachite green can be used and salt baths help recovery.

Bacterial Infections : What are Bacteria?

- Bacteria are microscopic single celled organisms that can reproduce rapidly.
- They are naturally present in aquarium water.
- Fish in good health kept in good water conditions can fight bacterial infections.
- Fish are most prone to such infections if in poor condition as a result of bad or sudden changes in water quality, over crowding or bullying, bad handling or transportation.
- A poor diet lacking in sufficient protein, fatty acids and vitamins can reduce fish resistance to such disease.

Pseudomonas fluorescens

- Causes
- pseudomonas Septicemia (blood poisoning due to bacteria) mainly in general pond fish, seldom in salmonids
- normally a secondary invader, hard to distinguish from Aeromonas Septicemia, not a huge concern in fish
- Agent: ubiquitous bacterium of soil, water,
- culture: standard media, round glistening colonies w/undulating edge, radial striations, easily seen green pigment under UV light

Pseudomonas fluorescens

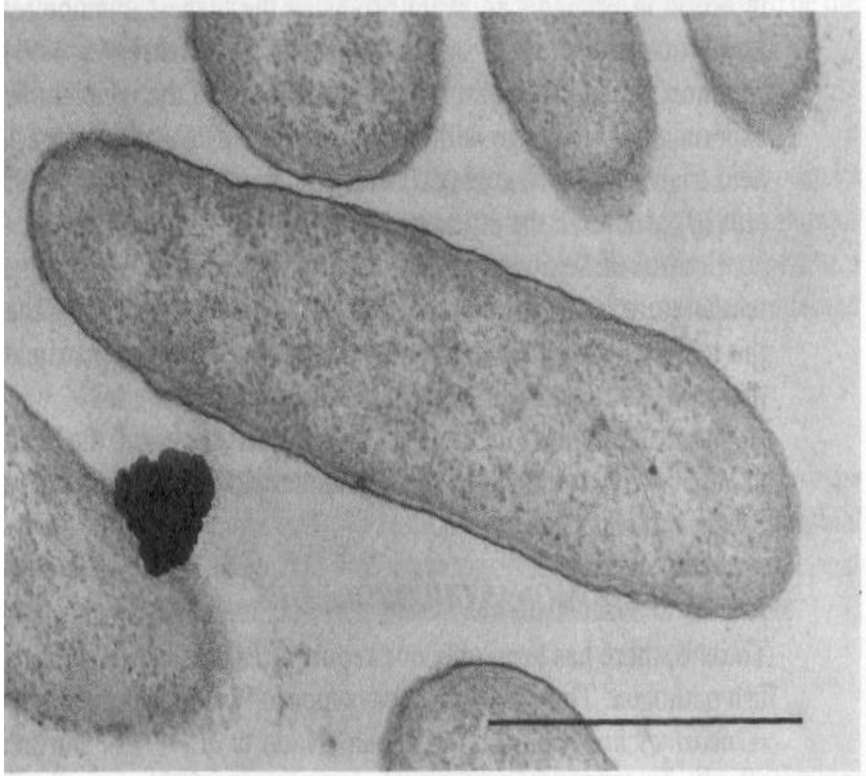


Fig. 12.5 — Transmission electron micrograph of a thin section of *Pseudomonas anguilliseptica*, lacking any signs of an extracellular layer. Bar equals 1 μm. (Photograph courtesy of Dr G. Dear.)

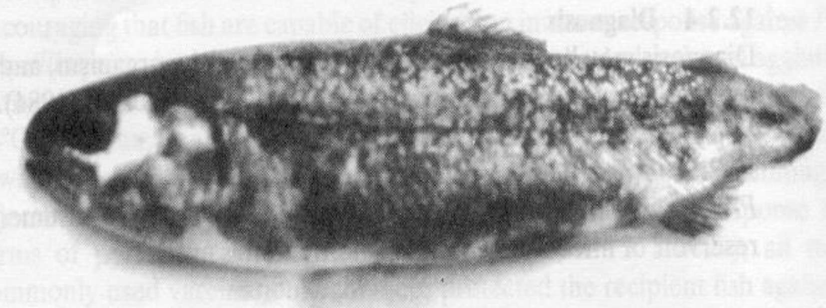


Fig. 12.6 — An advanced case of tail rot. (Photograph courtesy of Mr. D. MacGregor).

Pseudomonas fluorescens

- Epizootiology: worldwide in fw/sw, all fish susceptible but mainly ww, problem for aquarium fish
- reservoirs: mud and water; infected or carrier fish and others (frogs)
- transmission: horizontal, no vertical
- environment: stress, mainly elevated temps
- Pathology: in catfish, largely hemorrhaging and necrosis of internal organs, external lesions, loss of pigmentation
- individuals can withstand large losses, bone exposure

Pseudomonas fluorescens

- Diagnosis: isolation from kidney on TSA Tryptic soy agar
- confirmation via serology
- Control: remove stressor, drug therapy as with other G- (oxytet @50-75 mg/kg/f/day for 10 days)
- no vaccine yet

Fin Rot / Mouth Fungus

Cause

- Bacteria such as *Aeromonas, Pseudomonas (fin rot) and Flavobacterium (mouth fungus)*

Symptoms

- Damaged, split or ragged looking fins (fin rot)
- Cotton wool like tufts around the mouth (mouth fungus)
- May cause loss of appetite and listlessness (lethargy)
- When chronic may develop ulcers on the body.

Treatment

- Aquarium anti-bacterial medicines are available and in serious cases veterinary treatment is needed.
- It is easier to prevent bacterial infections than cure them.

Aeromonas hydrophila (MAS)

- Causes
- Motile Aeromonas Septicemia(blood poisoning), often referred to as a complex of species, mainly affecting warm water fish, opportunistic pathogen, can cause red-leg in frogs
- culture: TSA; can grow at 4^{o}C, but best at 18-25^{o}C;
- white, circular, convex colonies, often confused w/*Citrobacter*

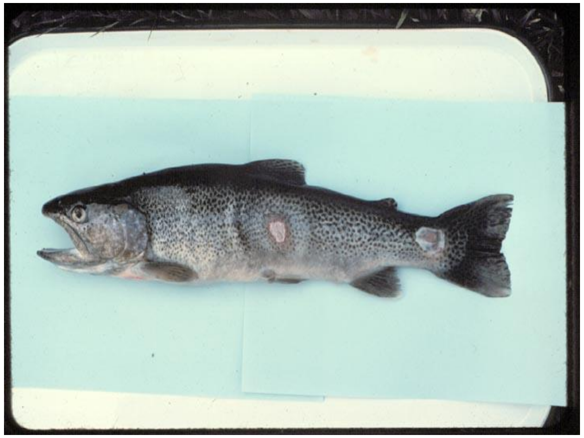
Aeromonas hydrophila (MAS)

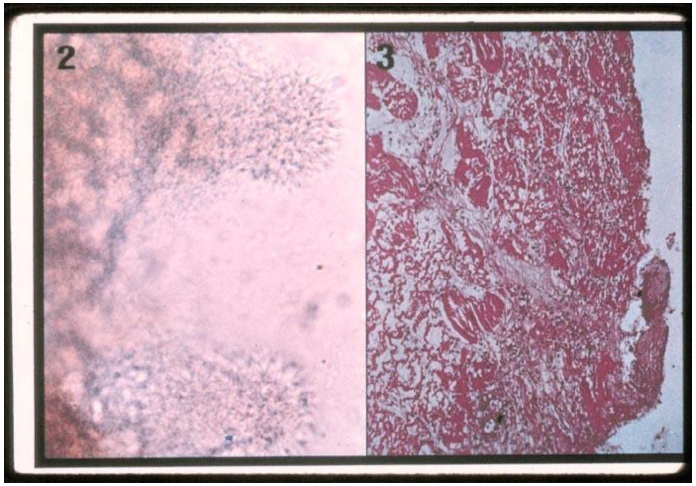
- Epizootiology: worldwide in fw, all fw species susceptible (both ww and cw); others such as frogs, alligators, snails, shrimp and humans
- reservoir: freshwaters w/high organic loads, usually in sewage, normal gut flora of healthy fish; diseased fish/frogs; survivors are carriers
- transmission: horizontal only from intestinal tract, external lesions, through water, via external parasites
- environment: stress from crowding, variable temperatures, changes in weather; rough handling, low DO, high organics

Aeromonas hydrophila (MAS)

- External pathology: usually hemorraghia + necrosis or internal organs + necrotic lesions on skin/muscles
- superficial circular or greyish-red ulcerations
- lesions around mouth similar to ERD(esophageal reflux disease)
- hemorrhaging of fins, exopthalmia
- Internal pathology: swollen, soft kidney;
- petechiae (little red spots) of musculature, intestines free of food

Aeromonas hydrophila





Aeromonas hydrophila (MAS)

- Diagnosis: isolation from kidney into TSA Tryptone or tryptic soy agar
- presumptive: G- motile rod
- ferments in glucose, no fluorescent pigment
- Control: prevention via good management, injection w/chloramphenicol, no vaccines;
- therapy via oxytet (50-75mg/kg fish/day for 10 days), chloramphenicol in Europe

Aeromonas salmonicida (furunculosis)

- First isolated from farmed trout in 1894
- name of disease derived from boil-like lesions known as “furuncles”
- at one time very common, resulted in Furunculosis
- diminished as of late due to better management
- Agent: comes in three subspecies, the most common is salmonicida (produced pigment),
- G- non-motile rod, bipolar staining

Aeromonas salmonicida (furunculosis)

- Culture: TSA, brown pigment in presence of TYR/PHE, grows well at 18-25^{o}C, small white round raised convex colonies
- Pathogenicity: both virulent and a-virulent strains, produces endotoxin
- Epi-zootiology: wherever salmonids are cultured in fw (besides Tasmania/NZ), entered Australia via goldfish, brook trout most susceptible
- reservoirs: obligate fish pathogen, found in waters w/infected or carrier fish

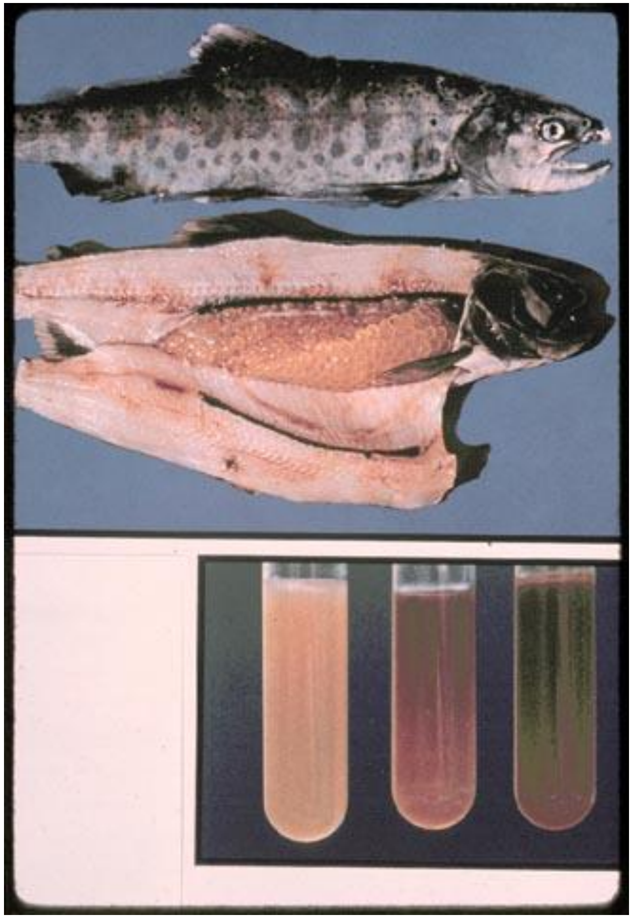
Aeromonas salmonicida (furunculosis)

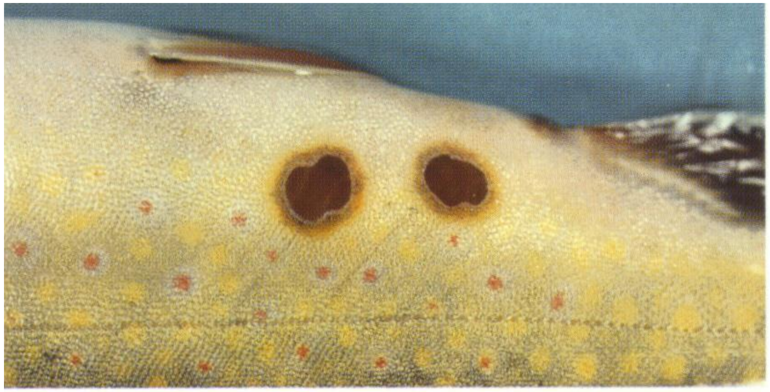
- transmission: primarily horizontal, contaminated water, eggs, carriers, equipment, clothing, surface of aquatic birds; no vertical demonstrated
- pathogenesis: acute, sub-acute, chronic forms (dose, temp, host resistance, virulence of strain)
- environment: severity increases w/temp, nutrition, handling stress

Aeromonas salmonicida (furunculosis)

- Pathology: similar to other G- septicemias w/hemorrhaging, necrosis of internal organs, external lesions
- external: focal necrosis in muscle develops to abscess, hemorhaging and lesions at base of fins, fraying of fins, bloody discharge from vent; blue irridescent sheen on body near eyes, bleeding from gills
- internal: petechiae(purple or red spot due to bleeding) in body musculature, congestion (cramming)of posterior intestine, no inflammatory response

Furunculosis





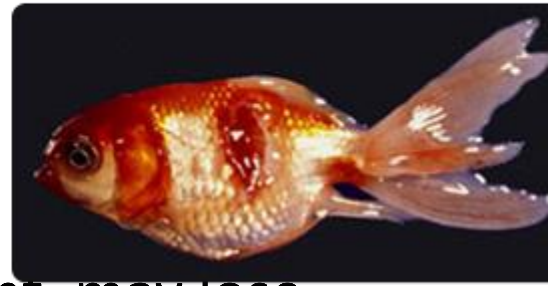
Aeromonas salmonicida (furunculosis)

- Diagnosis: look at hatchery history with disease; isolation easy from kidney into TSA, BHI(Brain heart infusion for fastidious bacteria);
- presumptive: G-, non-motile rod, brown diffuseable pigment, oxidase +
- definitive: serological (rapid slide agglutination)
- Control: avoidance via clean water/fish; several vaccines on the market; selective breeding??
- therapy: oxytet @ 50-75mg/kg fish/day for 10 days, sulfamerazine, sulfonamide (Romet)

Ulcer Disease & Haemorrhagic Septicaemia

Cause

- A number of different bacteria including *Aeromonas* and *Pseudomonas*. These could be transmitted from other infected fish, and /or bad water conditions.



Symptoms

- Open sores and ulcers, reddening of fins and vent, may lose their appetite and colour may change.

Treatment

- Fish can be fed antibiotic medicine in feed. If severe fish should be isolated and antiseptic applied to infected areas. May require veterinary injection of antibiotics.
- Ensure tank conditions are correct.

Viral infections: What is a virus?

- A virus is a microscopic organism that can only reproduce by inhabiting host cells and using the genetic material in the cells of a host.

- Healthy fish that have a balanced diet and good water conditions have strong immune systems to fight off such infections.

Cyprinid Herpes Virus

Causes

- A herpes virus

Symptoms

- Causes growths that are white or grey in colour and look like melted candle wax.

Treatment

- Fish with a strong immune system can fight off the infection but retain the virus within the body.
- When in poor health the virus symptoms can re – appear.

Spring Viremia of Carp

Cause

- A viral infection caused by *Rhabdovirus carpio*.

Symptoms

- Darkening of skin, pale gills, pop eye, protruding vent, bleeding in gills skin and eyes.
- Lethargy, abnormal swimming positions, sitting on bottom of the tank.

Treatment

- No known treatment .

What is a Swim Bladder problem?

Cause

- This can be caused by a number of things, from internal swellings, tumours, viral and bacterial infections, internal deformities, constipation, parasites etc, to overfeeding.

Symptoms

- Bobbing/jogging to the surface, swimming upside down or listing to one side with abnormal swimming patterns.

Treatment

- Unless the cause can be identified this is difficult to treat. Starvation of fish for a few days might correct the problem if it is as a result of overfeeding.

What can cause growths and abnormalities?

Abnormalities can be brought about by :

- Inbreeding and congenital deformities
- Tumours and swellings
- Viral growths
- Malnutrition or inappropriate diet
- Internal disorders / parasites that cause fluid retention & swelling.

Fish Injuries

- Injured fish have often been bullied by tank mates.
- Injuries can be the site of secondary infections, bacterial and fungal.
- Stress caused by bullying, injuries and infections can lower their immune system further which can in some cases be fatal.

Prevention of diseases and parasites

- Provide an appropriate well filtered tank with suitable water conditions for the species, i.e. correct
- Appropriate ranges of temperature, pH, water hardness, low nitrate levels etc.
- Provide appropriate diet to meet species needs.
- House only suitable species together, make sure they are compatible and not likely to bully or eat each other.
- Only select healthy looking fish to add to the tank and do not overstock.
- Quarantine new fish to ensure they are healthy before introducing them to an established tank.
- Sterilize décor and clean new plants to ensure they are not carrying parasite eggs / larvae.

Prevention, Prevention, Prevention!

- The ultimate way to stop an outbreak is to prevent it
- Prevent stressful situations
  - Proper stocking situations
  - Proper management practices
  - Ideal water treatment

Prevention measures

- Vaccinations
- Stress-treatments (chemical)
- Anti-biotics
- Selective breeding (unintentional & intentional)
  - Disease-free brood stocks
  - Batch culture/ single batches reared to size
  - Fungal control of eggs
- Intensive systems
  - Control of multiple environmental factors

Silk and Rearing of Silkworm
Bombyx mori
or
Sericulture

Overview

- History
- Silkworm: *Bombyx mori*
- Mulberry tree
- Cocoon
- Silk
- Effect of nutrition
- Problems
- Conclusion

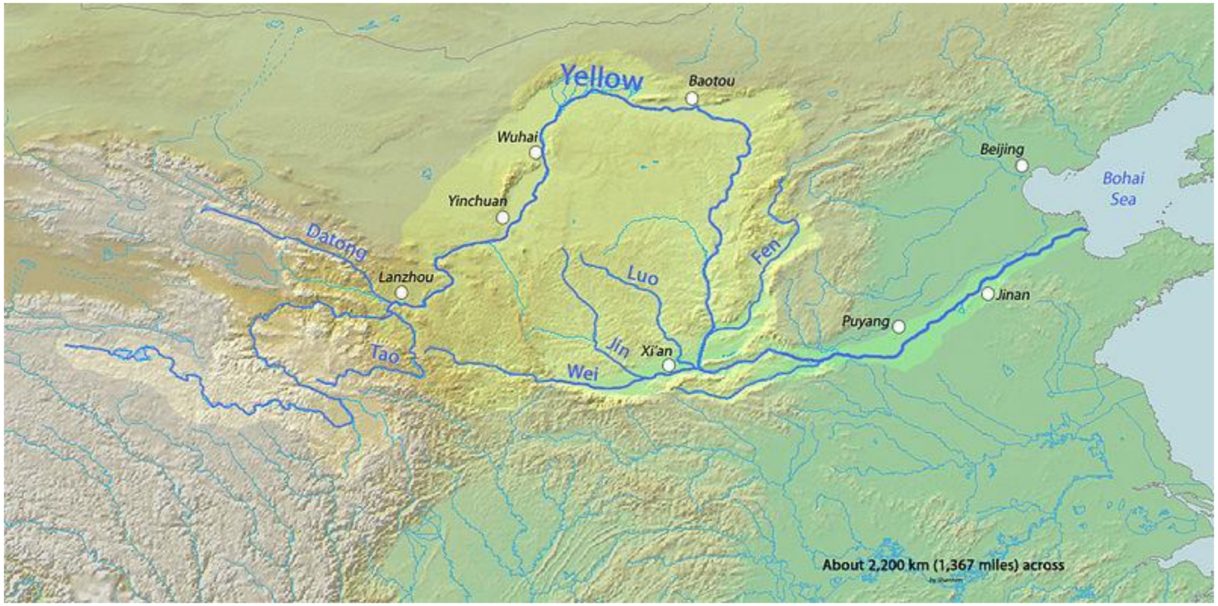
History of Silk

- Begins over 5000 yrs ago
- Debates over the origins of sericulture

http://www.silk-road.com/artl/silkhistory.shtml

History of silk- Origins (China)

- "Chronicles of Chou-King"
- 2200 BC
- Yellow River (Hwang He/Hwang Ho)



http://en.wikipedia.org/wiki/Yellow_River

History of silk- Legends

- Multiple legends
- Empress Ksi-Ling-Shih (2500BC)

History of silk

- China kept the secret of sericulture for 3000 yrs.
- Chinese traded silk for gold
- Smuggling silkworm eggs or mulberry seeds was punished by death

History- From China to Japan

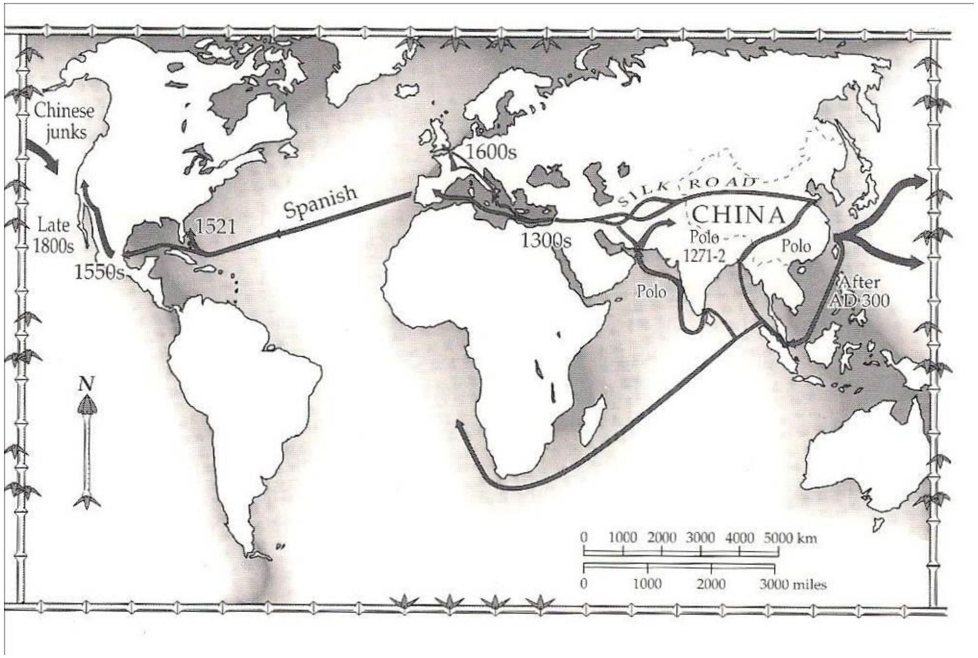
- Chinese emigrants smuggled silk cultivation into Korea
- From Korea, it was taken to Japan

History- India

- Silk culture dates to antiquity
- Mulberry culture spread in India by 140BC from China

History- Silk Road

- Contact between East and West
- Silk, silver, porcelain etc.
- China to Europe
- 6400km.
- Cultural, religious and economic importance



(Feltwell, 1990)

History- Han Dynasty

- 202BC-220AD
- Silk trade prospered
- By 126BC silk was the most important traded material

History- Europe

- In mid 6th cent.
- Emperor Justinian sends 2 Persian monks to steel the secret of sericulture
- The supplies they smuggled supplied the western world for 1200yrs.

History- Europe

- The 1st king of Sicily invaded Greece in 747AD
- Captured silk weavers
- Sericulture began in Italy

History- Europe

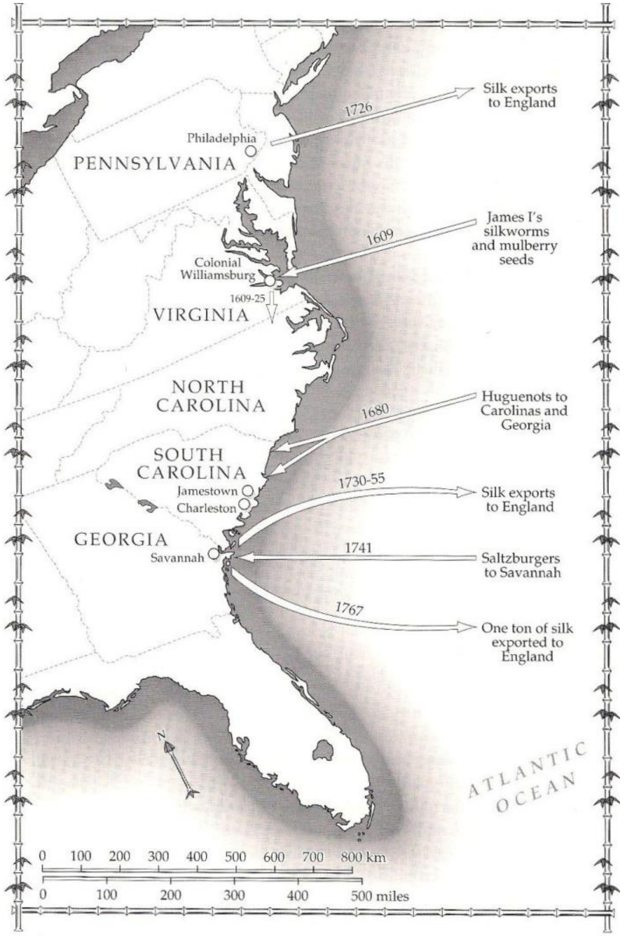
- From Sicily to France
- Tours and Lyon
- Henri IV introduced rearing

http://www.map-of-europe.us/

History- Europe

- James I introduced sericulture to England
- He also took sericulture to America

(Feltwell, 1990)



(Feltwell, 1990)

History- 20th century

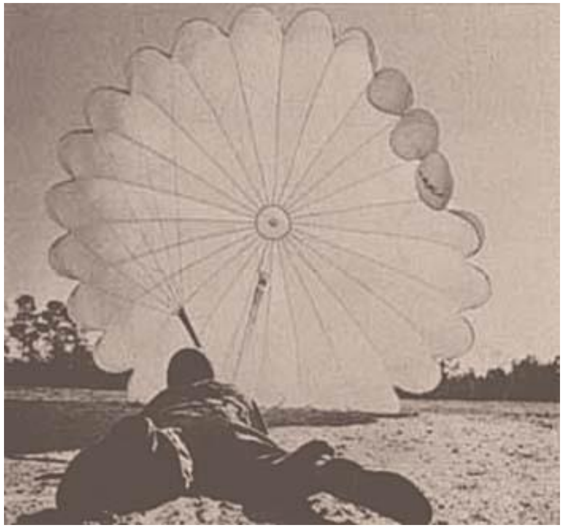
- Sericulture stopped because of war
- In 1940 it boomed with the use of silk for parachutes
- Silk re-emerged
- China, India and Japan brought it to global market

SILK PARACHUTES

WHITE HEAVY PURE SILK PARACHUTES for Blouses, Slips, etc. Brand New, 65 sq. yds. of material and 3000 feet of silk crochet cord: $14.95 plus $1 for postage and handling. FREE Instruction Patterns included. SIX SILK PARACHUTE PANELS (16 sq. yds.), $4.95 postpaid. If COD send $1 deposit.

65 Yds. Sq.

AMERICAN AGENCY, 799-S Broadway, New York 3, N. Y.



Silkmoths

Major Silkmoths of the World

Antheraea assamensis	Muga silkmoth
Antheraea mylitta	Tusseh silkmoth
Antheraea peryni	Chinese oak silkmoth
Antheraea polyphemus	Polyphemus silkmoth
Antheraea yamamai	Japanese oak silkmoth
Attacus atlas	Atlas silkmoth
Automeris io	Bullseye silkmoth, Io silkmoth
Bombyx mori	Bombyx silkmoth
[illegible]methea	Spicebush silkmoth
Hyalophora cecropia	Robin or cecropia silkmoth
Hyalophora gloveri	Glover's silkmoth
Pachypasa otus	Syrian silkmoth
Samia (Eri) cynthia	Eri or Ailanthus silkmoth

Bombyx mori

- Produces over 90% of the world’s raw silk
- Common model for research and study
- Genome decoded in 2004
- 432Mb
- 3000 genes with no other homologs
- Important in evolution studies and in combating pests.
- Silkworm classified according to origin and voltinism

Voltinism

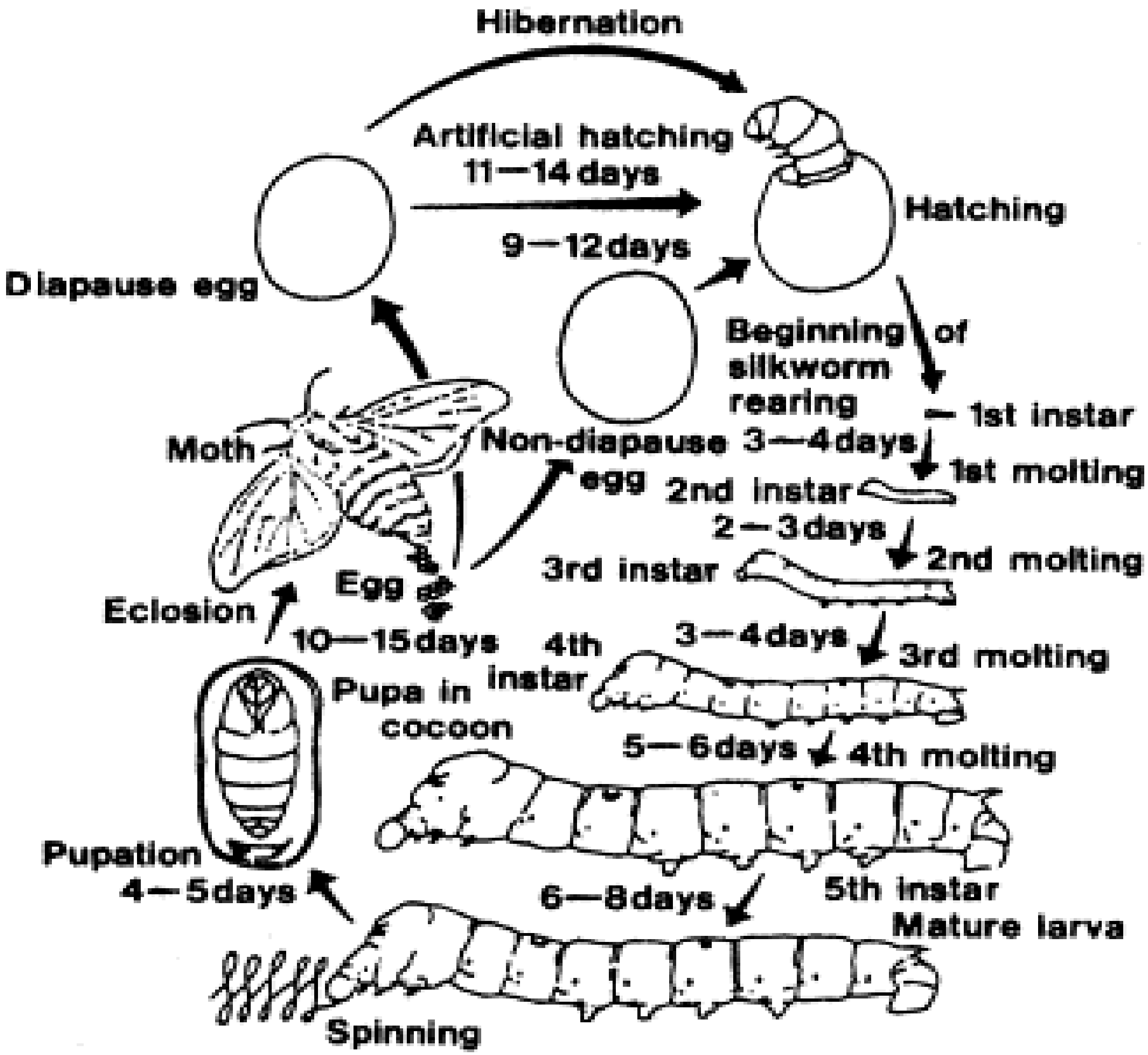
- Univoltine
- Bivoltine
- polivoltine

Refer to the number of generations that is produced per year

Characteristics

- It cannot fly
- Caterpillars with no real locomotion
- Female larger than male
- Male has big plumose antennae

Life cycle

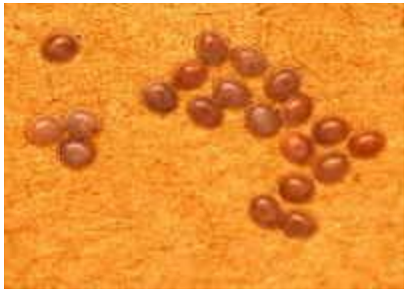


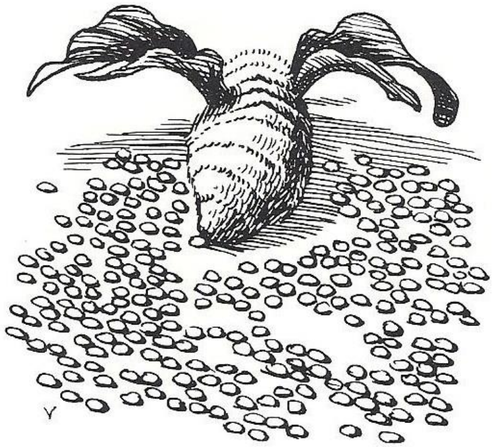
(Zhao and Asakura, 2001)

Life cycle

- After mating, the female lays 300-400 eggs
- 1g of eggs = 2000 eggs
- Eggs enclosed in gluten
- Yellowish then darker

- Each egg has a micropyle





(Feltwell, 1990)

Polyvoltine vs. Uni/bivoltine

Polyvoltine

- Hatch after 10 days
- Life cycle repeats itself 6 to 7 times a year

Uni/bivoltine

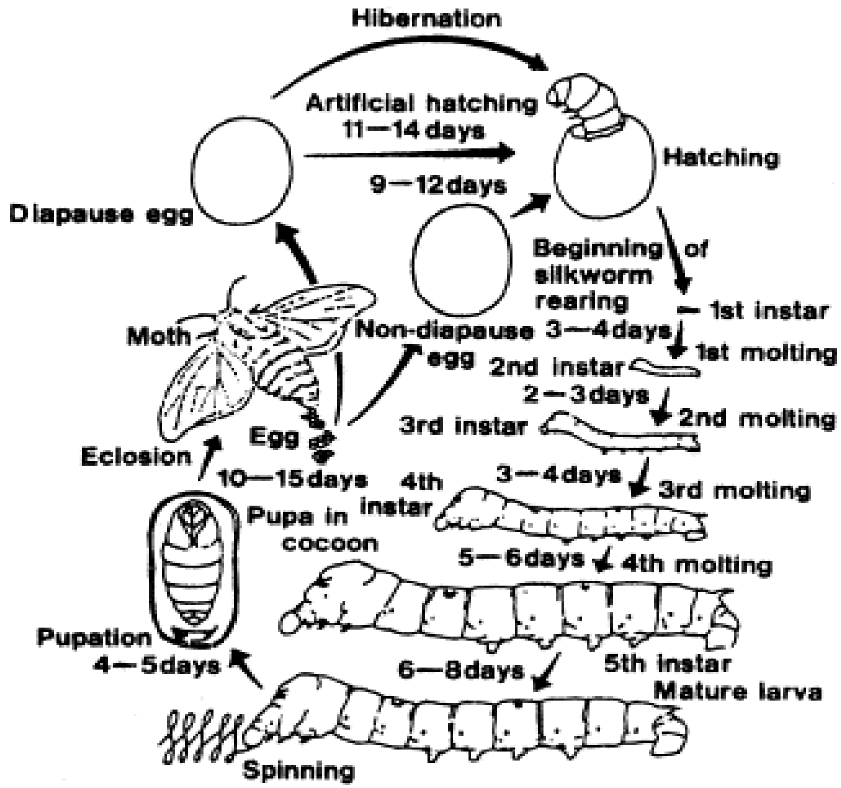
- Eggs go through diapause
- Hatch in time for spring
- Temperature is the main trigger

Life cycle

- When first hatched they vary from 1/8 to 3/8 of an inch in length
- Diameter of a human hair
- 1 ounce= 50-60000 worms
- Go from black to brownish yellow to white

Life cycle

- Polyvoltine species go through the 5 instars in 20-24 days
- Uni/bivoltine go through them in 24-28 days
- Total of 4 molts



(Zhao and Asakura, 2001)

Mulberry tree

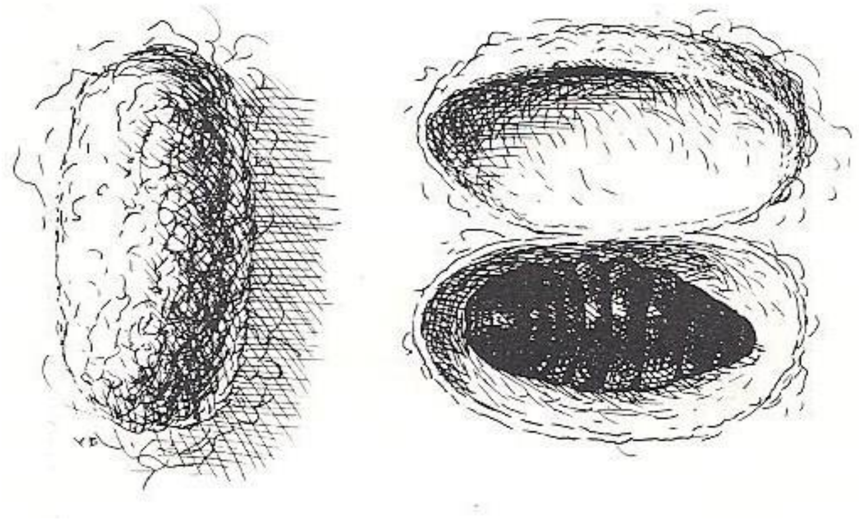
- Fast growing
- Tropical and temperate habibtat
- *Morus spp.*
- *Moracea* familly
- 95 species in total
- *M. alba, M. nigra, M. indica, M. rubra etc.*

Life cycle

- During the first 3 instars, the larvae feed on chopped leaves.
- When they grow, they become able to chew on whole leaves
- The silkworm goes from
  - 3.0mm to 95mm in length
  - 0.00045gm to 5gm

5th instar

- Silkworm attains max size
- JH decreases
- Ecdysone triggers metamorphosis
- Color change
- Cocoon making
- Pupation occurs



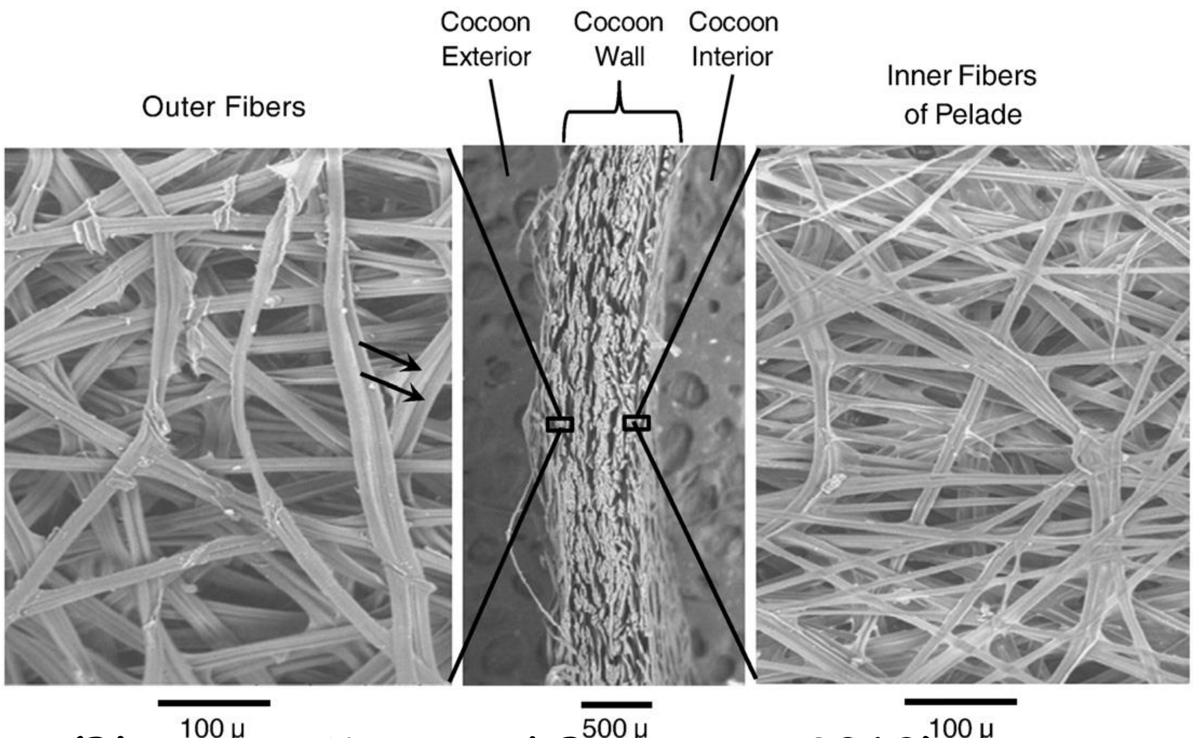
(Feltwell, 1990)

Cocoon

- 5 day process
- Silk laid with figure-8 movement
- Why spin a cocoon?
  - Protection
  - Silk as a way of excretion

Cocoon

- Heterogenous:
  - Inner silk filaments are tightly packed
  - Inner silk filaments have a smaller diameter



(Blossman-Myer and Burggren, 2010)

cocoon

- Shape variable
  - Breed
  - disease

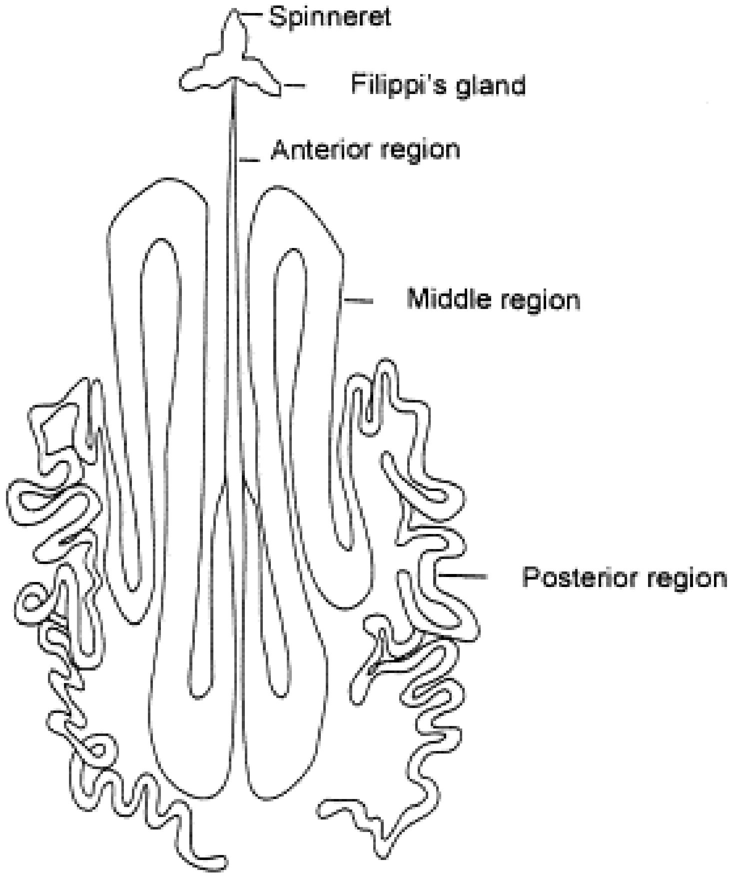
http://www.wildfibres.co.uk/html/silk.html

Life cycle

- Metamorphosis occurs
- The moth emerges
- Cocoonase

Silk gland

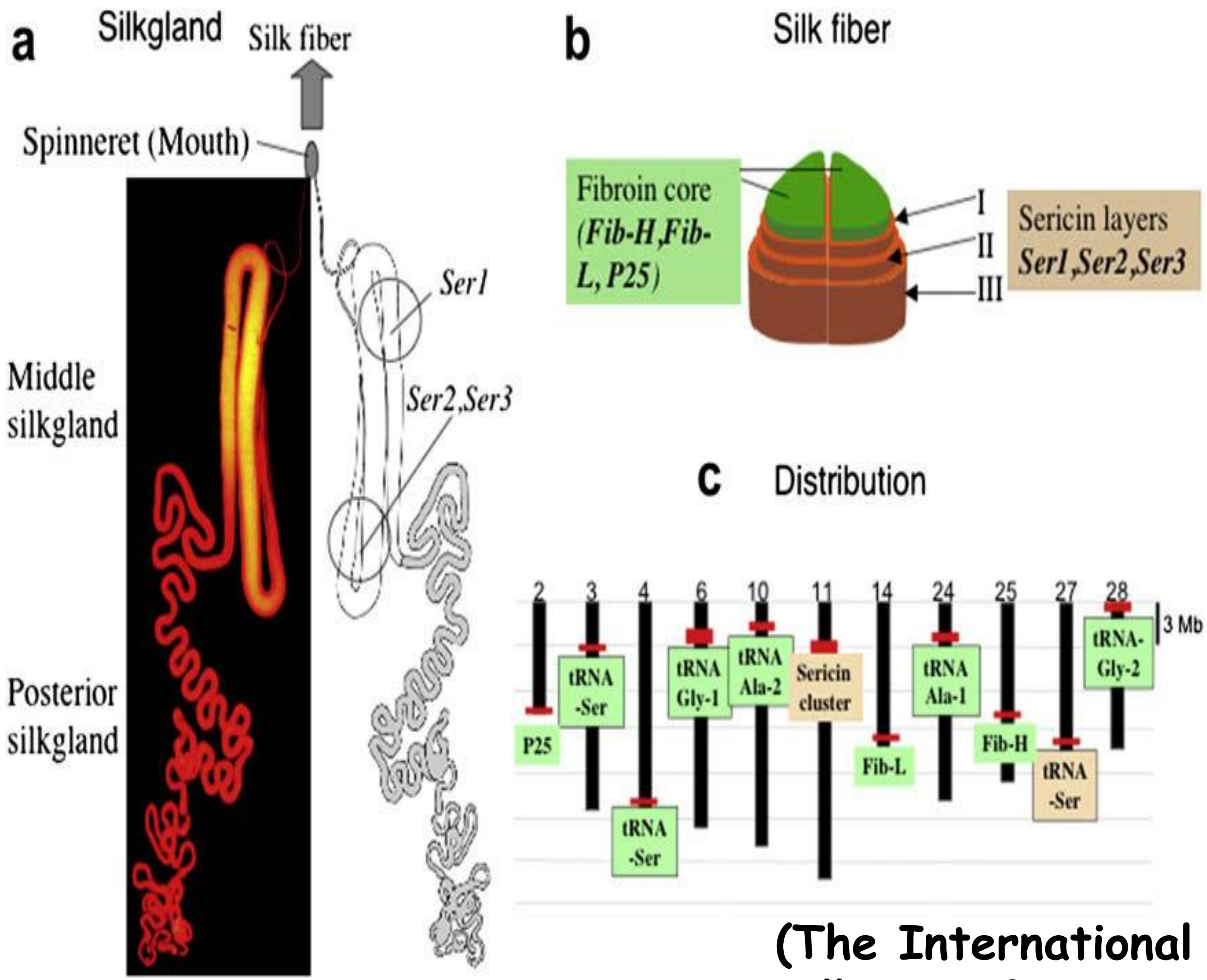
- Runs all along the body
- At 5th instar it becomes the largest tissue
- Ectodermal
- One cell layer
- 2 types of secretory cell
  - Fibroin secretory cells
  - Sericin secretory cells
- 3 parts: ASG, MSG and PSG



(Zhao and Asakura, 2001)

Silk filament

- Sericin 18-20%
- Fibroin 75-80%
- Carbohydrates 1.2-1.6%
- Lipids and wax 0.5-1%
- Colors and minerals 1.0-1.4$



(The International Silkworm Genome Consortium, 2008)

Effect of nutrition

- Composition
- Quantity
- Mulberry leaves satisfy the min. need of the larvae
- Amount of vitamins found in them varies
- Focus is on giving young and healthy leaves

Artificial diet

- Since processing of leaves is costly
- Introduced in 1960s
- Mulberry leaf powder
- By 1970, they had made a dry powder with no mulberry in it

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Problems

- Diseases and pests
- 20 mulberry diseases were isolated
- Fungal, bacterial or viral

Leaf spot

http://msucares.com/newsletters/pests/infobytes/19980324.htm

mildew

http://en.wikipedia.org/wiki/Mildew

Root- Knot

http://aggie-horticulture.tamu.edu/publications/cucurbitproblemsolver/root/root-knot.html

Problems

- Pests

Leaf roller

Adult of Bihar hairy caterpillar

Wingless grasshopper

Problems

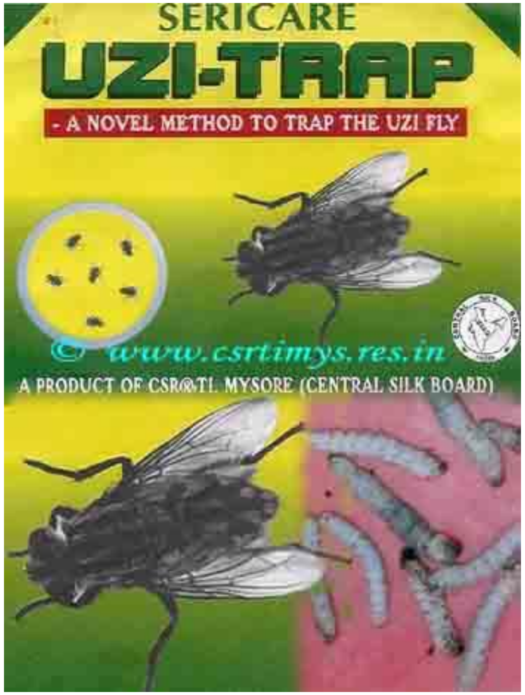
- Silkworm diseases: pebrine, flacherie, muscardine

Pebrine, *Nosema bombycis*

grasserie

Problems

- Pests: ants, wasps, crickets, praying mantis, Uzi fly



Nesolynx thymus

LAC CULTURE

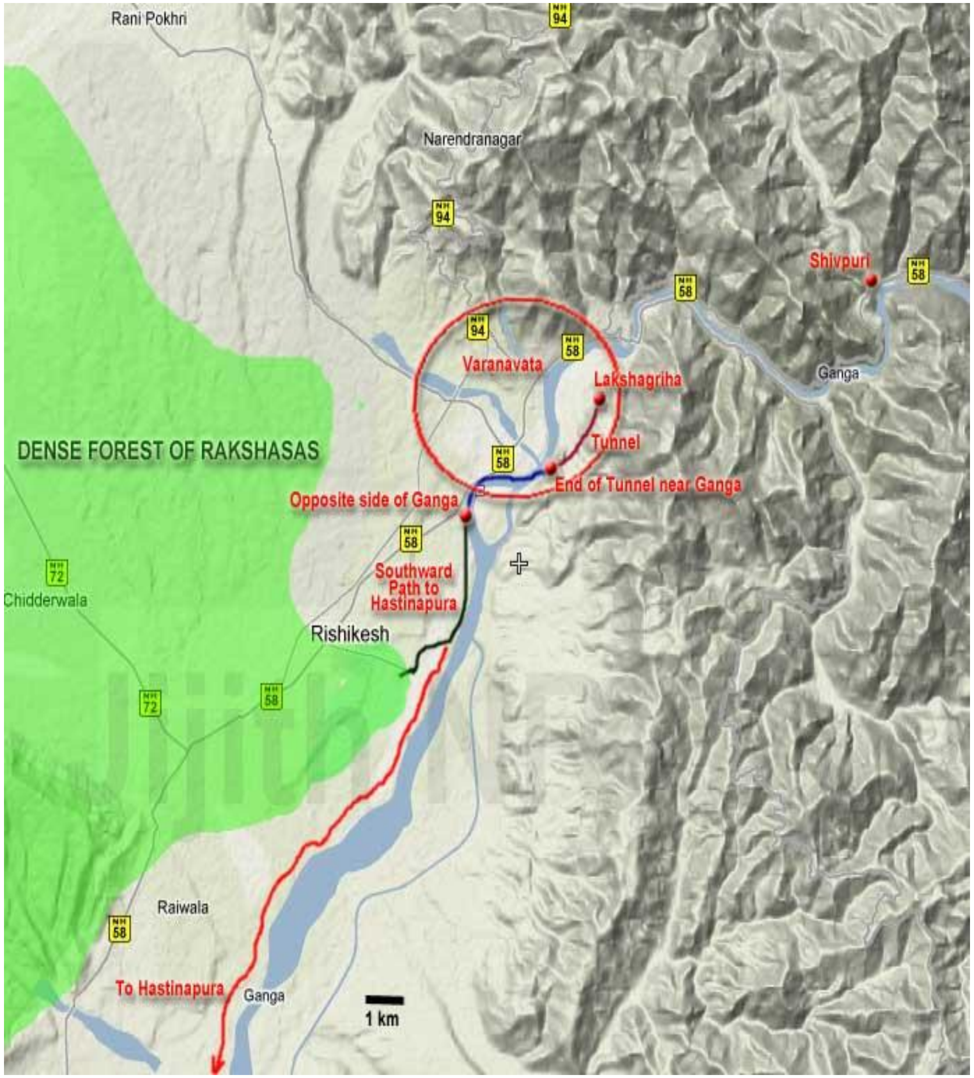
Lac Culture

- **Nature has given much for welfare of human beings through animals and their products.**
- **On the other hand human beings never seem to tire of discovering the mysteries of nature. But the animals seem to be greater experimenters as some of them have astounded most human beings by their complex, strange and at times bizarre performance.**
- **One of such performer known to man from good old days is the tiny insect that has given a very valuable product in the form of lac, to the civilization of man.**
- **Lac is a natural resin of animal origin. It is secreted by an insect, known as lac-insect in order to obtain lac, these insects are cultured and the technique is called lac-culture. It involves proper care of host plants, regular pruning of host plants, propagation, collection and processing of lac.**

Lac Culture

- Lac is a resinous exudation from the body of female scale insect. Since Vedic period, it has been in use in India.
- Its earliest reference is found in Atherva Veda. There, the insect is termed as ‘Laksha’, and its habit and behavior are described.
- The great Indian epic‘Mahabharata’ also mentions a ‘Laksha Griha’, an inflammable house of lac, cunningly constructed by ‘Kauravas’ through their architect ‘Purocha’ for the purpose of burning their great enemy ‘Pandavas’ alive.

‘LAKSHA GRIHA’, AN INFLAMMABLE HOUSE OF LAC,



- **History:**
- Lac has been used in India from time immemorial for several purposes, from the epic of Mahabharat it has been recorded that Kauravas built a palace of lac for the destruction of Pandavas.
- We come across references of lac in the Atharvaveda and Mahabharata, so it can be presumed that ancient Hindus were quite familiar with lac and its uses.
- Scientific study of lac started much later. In 1709 Father Tachard discovered the insect that produced lac. First of all Kerr (1782) gave the name *Coccus lacca* which was also agreed by Ratzeburi (1833) and Carter (1861).
- Later Green (1922) and Chatterjee (1915) called the lac- insect as *Tachardia lacca* (kerr).
- Finally, the name was given as *Laccifer lacca*.

Lac --- Nature's gift to mankind

- Lac is the only known commercial resin of animal origin.
- It is the hardened resin secreted by tiny lac insects belonging to a bug family.
- To produce 1 kg of lac resin, around 300,000 insects lose their life.
- The lac insects yields

1. **Resin**
2. **Lac dye**
3. **Lac wax.**

- Application of these products has been changing with time. Lac resin, dye etc. still find extensive use in Ayurveda and Siddha systems of medicine.

Importance of Lac

- With increasing universal environment awareness, the importance of lac has assumed special relevance in the present age, being

1. An eco-friendly
2. Biodegradable
3. Self-sustaining natural material

- Since lac insects are cultured on host trees which are growing primarily in wasteland areas, promotion of lac and its culture can help in eco-system development as well as reasonably high economic returns.
- It is a source of livelihood of tribal and poor inhabiting forest and sub-forest areas.

LAC INSECTS

- The English word lac synonyms Lakh in Hindi which itself is derivative of Sanskrit word Laksh meaning a lakh or hundred thousand.
- It would appear that Vedic people knew that the lac is obtained from numerous insects and must also know the biological and commercial aspects of lac industry.
- It is also worth to mention that a laksh griha would need a lot of lac which could only come from a flourishing lac industry in that period.

LAC INSECT TAXONOMY

- The first scientific account of the lac insect was given by J. Kerr in 1782 which was published in Philosophical Transaction of Royal Society of London (vol. 71, pp.374-382).
- The first scientific name given to it was *Tachardia lacca* following the name of French Missionary Father 'Tachardia'.
- It was later changed to *Laccifer lacca Kerr.*
- The other name given to it has been *Kerria Lacca Kerr.*

Phylum -	Arthropoda
Class -	Insecta
Order -	Hemiptera
Super family -	Coccoidea
Family -	Lacciferidae
Genus -	*Laccifer*

Metatachardia

Laccifer

Tachordiella

Austrotacharidia

Afrotachardina

Tachardina

- **Systematic Position:** *Laccifer lacca*
- A number of species of lac insects are known, of this *Laccifer lacca* is by far the most important and produces the bulk of the lac for commerce. It belongs to—
- Phylum — Arthropoda
- Class — Insecta
- Order — Hemiptera
- Super-family — Coccidae
- Family — Lacciferidae
- Genus — Laccifer
- Species — Lacca

STRAINS OF LAC INSECT:

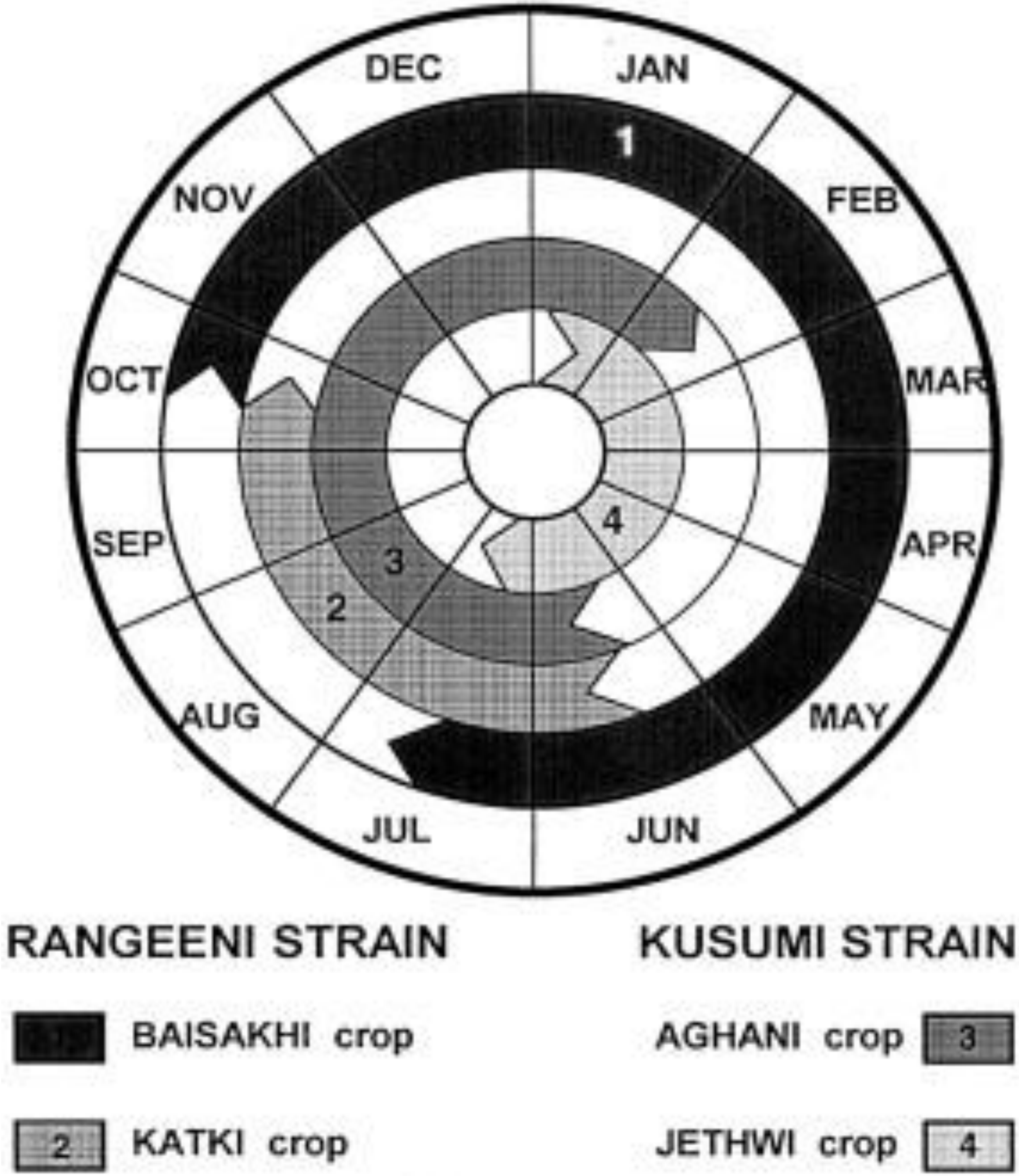
- In India, *lac insect* is known to have two distinct strains: **Kusumi and Rangeeni.** The Kusumi strain is grown on Kusum or on other host plants using Kusumi brood.
- The Rangeeni strain thrives on host plants other than Kusum.
- The life cycle of lac insects take about six months, hence, two crops a year can be obtained.
- **<u>In case of kusumi strain, two crops are:</u>**

I) Jethwi (June / July) and II) Aghani (Jan. / Feb).

II) <u>In case of Rangeeni, two crops are:</u>

I). Karrtiki (Oct. / Nov.) and II) baisakhi (May / June).

- The crops have been named after Hindi months during which these are harvested.
- The lac of Rangeeni crops is harvested while it is still immature.
- Aghani and baisakhi strain are the main corps contributing about 90% of lac production.
- The kusumi crop lac is considered superior resin, because of the lighter color of resin, and it fetches better price.


DEC
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
1
2
3
4
RANGEENI STRAIN
KUSUMI STRAIN
BAISAKHI crop
AGHANI crop
3
2
KATKI crop
JETHWI crop
4

Kusumi lac

- lac is directly related to the host plant and to the strain of lac insects.
- Based on industrial parameters, kusumi lac is better and fetches higher price in market.
- **In this respect, ber tree as** a potential kusumi lac host is already getting momentum.
- This host species is available in plenty and can supplement and fulfill the kusmi brood lac requirement in many areas.
- Similarly, siris (*Albizzia sp.) has also been identified as good host for kusumi brood lac.*
- *The* trees can be raised and utilized within a period of 5-6 years of plantation in comparison to around 15 years for kusum.

ARI LAC AND PHUNKI LAC

If lac crops are harvested by cutting down the lac bearing twigs a little before the larval emergence, that lac is known as ARI LAC (immature lac)

If lac crops are harvested by cutting down the lac bearing twigs a little after the emergence is over, that is called PHUNKI LAC (empty lac).

LAC AND ITS FORMS

STICK LAC : The lac encrustations is separated by knife or broken off with finger from the twig of host plants and is known is STICK LAC or CRUDE LAC or RAW LAC.

SEED LAC : The stick lac, after grinding and washing, is called SEED LAC or CHOWRI.

SHELLAC : The manufactured product prepared from stick lac after washing and melting, which takes the form of yellow colored flakes, is called SHELLAC.

BUTTON LAC : After melting process, lac is dropped on a zinc sheet and allowed to spread out into round discs of about 3” diameter and 1/4” thickness is called BUTTON LAC

GARNET LAC : It is prepared form inferior seed lac or kiri by the solvent extraction process. It is dark in colour and comparatively free from wax.

BLEACHED LAC : It is a refined product obtained by chemical treatment. It is repared by dissolving shellac or seed lac in Sodium carbonate solution, bleaching the solution with Sodium hypochlorite and precipitating the resin with sulphuric acid. Bleached lac deteriorates quickly and should be used within 2-3 months of manufacture.

DISTRIBUTION

- Lac is currently produced in

1. INDIA
2. MYANMAR
3. THAILAND
4. MALAYA
5. YUAN PROVINCE OF CHINA.

- India and Thailand are main areas in the world, while India has prime position in relation to lac production.
- Lac cultivation is introduced into Thailand from India.

HOST PLANTS

- Lac insects thrive on twigs of certain plant species, suck the plant sap, and grow all the while secreting lac resin from their bodies.
- These plants are called host plants. Although lac insect is natural pest on host plant, these insects enjoy the privileged position not being treated as pest.
- This is because:

i) **They yield a useful product,**

Ii) The host plants are economically not so important

Iii) The insects cause only temporary and recoverable damage to the host plants.

- About 113 varieties of host plants are mentioned as lac host plant. Out of which the followings are very common in India:

1. ***Butea monosperma (Vern. Palas)***

2. ***Zizyphus spp (vern. Ber)***

3. ***Schleichera oleosa (Vern. Kusum)***

4. ***Acacia catechu (Vern. Khair)***

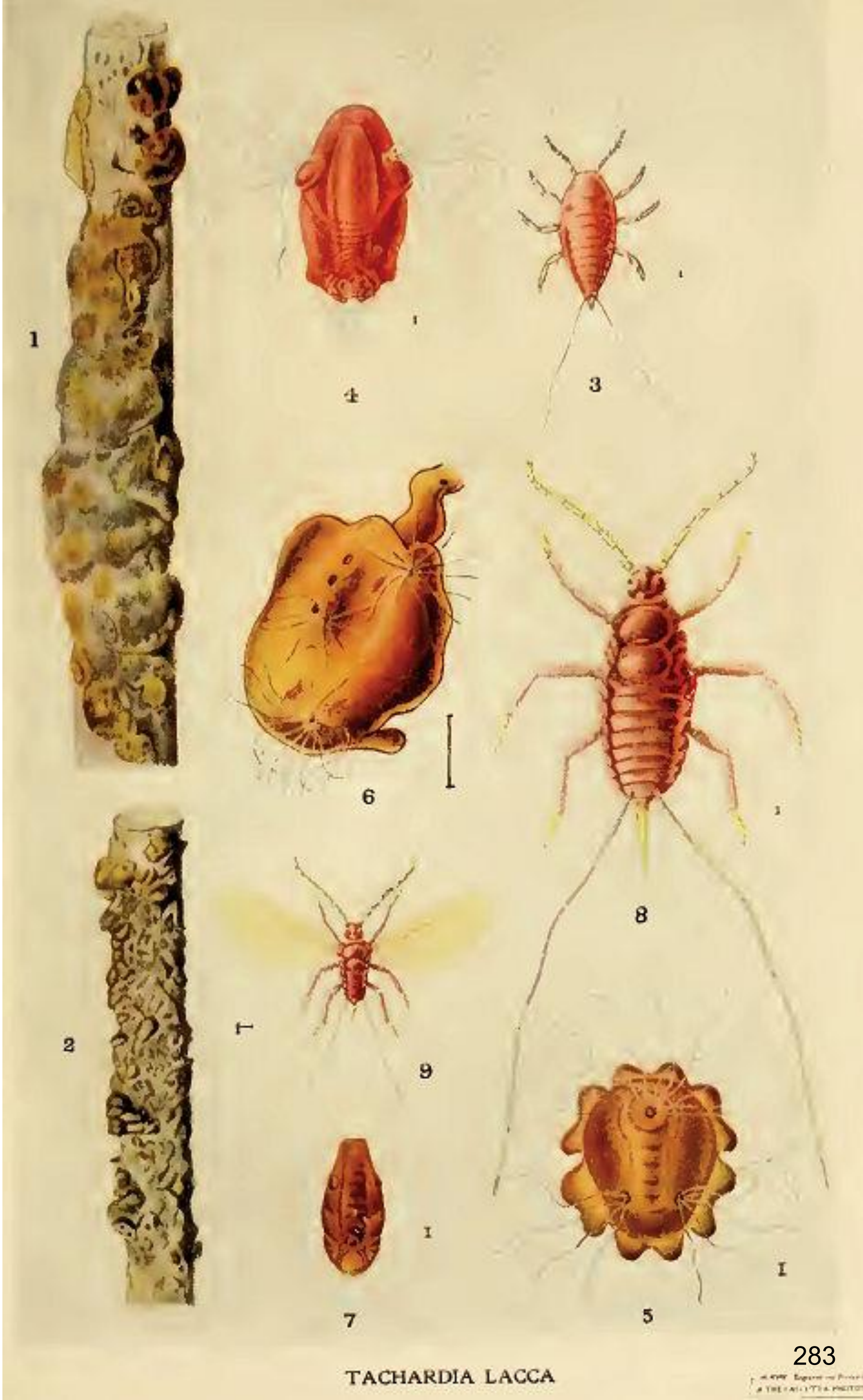
5. ***Acacia arabica (Vern. Babul)***

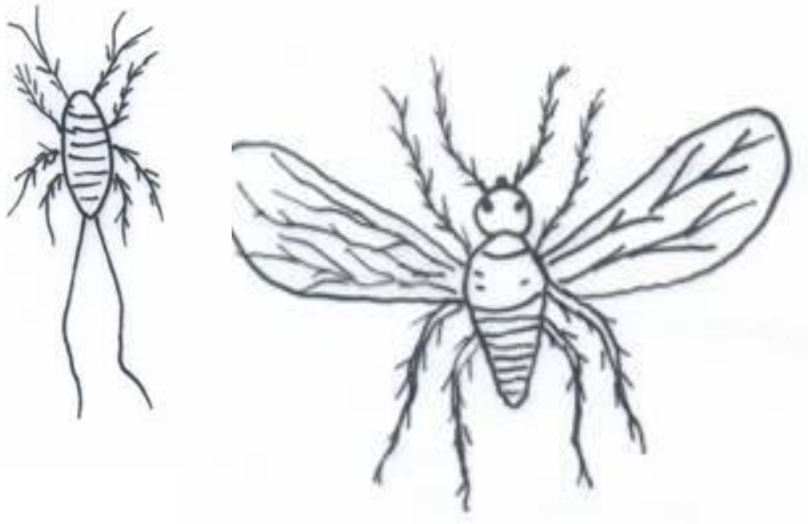
6. ***Acacia auriculiformis (Vern. Akashmani)***

- Arhar (*Ca]anus indicus*)
- The insects live as a parasite, feeding on the sap of certain trees and shrubs. The lac insects breed and thrive well on them until they start producing lac.
- Before coming to the actual mechanism of lac secretion and its processing, it is advisable for a lac-culturist to have detailed knowledge of lac insect and its life cycle.
- The adult lac insect shows a marked phenomenon of sexual dimorphism.
- The male and female insect varies in shape, size and also in presence or absence of certain body parts.

lac insect

- Lac insect is a minute crawling scale insect which inserts its suctorial proboscis into plant tissue, sucks juices, grows and secretes resinous lac from the body.
- Its own body ultimately gets covered with lac in the so called 'CELL'.
- Lac is secreted by insects for protection from predators.





Male lac insect

- Male is red in colour and measures 1.2 - 1.5mm in length.
- It has reduced eyes and antennae.
- Thorax bears a pair of hyaline wings.

- **Structure of Male Lac-insect:**

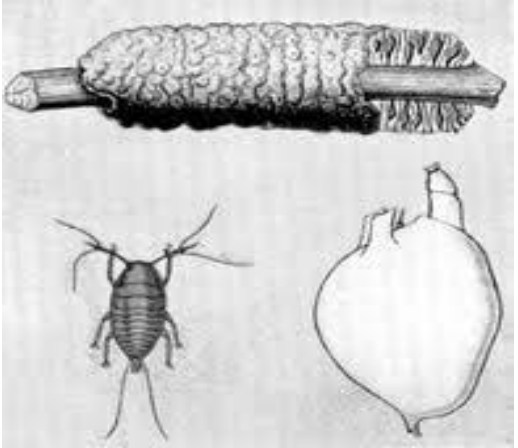
- It is red in color. The body is typically divided into head, thorax and abdomen.
- The head bears a pair of antennae and a pair of eyes. Mouth parts are absent so a male adult insect is unable to feed. Thorax bears three pairs of legs.
- Wings may or may not be found.
- Abdomen is the largest part of the body bearing a pair of caudal setae and sheath containing penis at the posterior end.

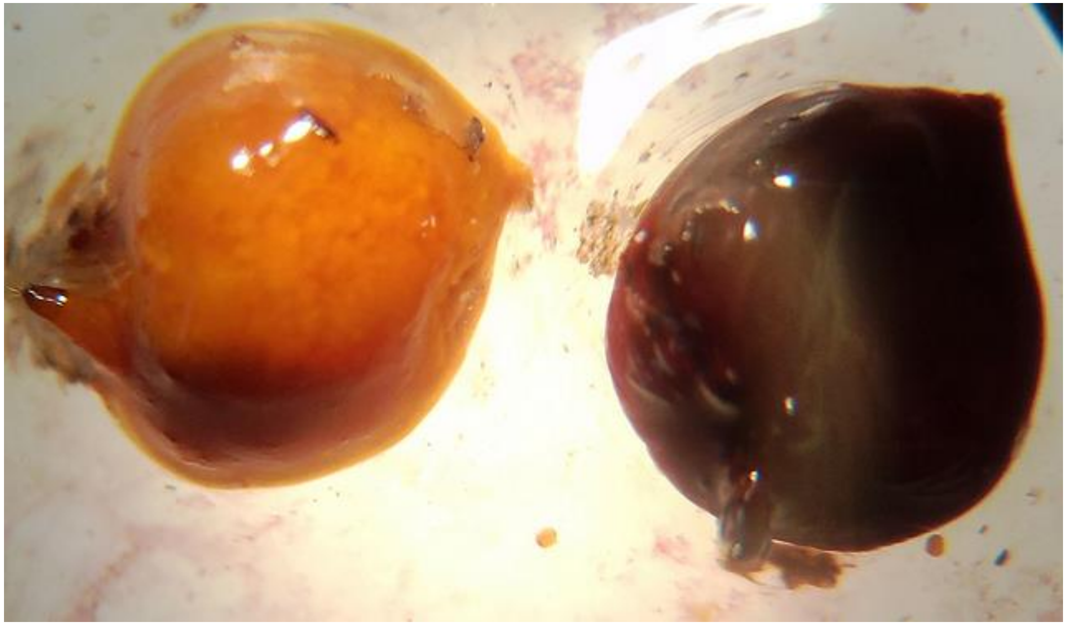
Male Lac Cell

- After the first molt, both male and female nymphs lose their appendages, eye and become degenerate.
- While still inside their cells, the nymphs cast off their second and third molt and mature into adult.
- Both the male and female larvae become sexually mature in about eight weeks.
- Only the male one undergoes a complete metamorphosis or transformation into another form; it loses its proboscis and develops antennae, legs and a single pair of wings.
- It is contained in a brood cell somewhat slipper like with a round trap door (operculum) through which it emerges.
- The adult male is winged and walks over the females to fertilize them.

Female lac insect

- Female is larger than male, measures 4-5 mm in length and has a pyriform body.
- The head, thorax and abdomen are not clearly distinct.
- The antennae and legs are in degenerated form, and wings are absent.

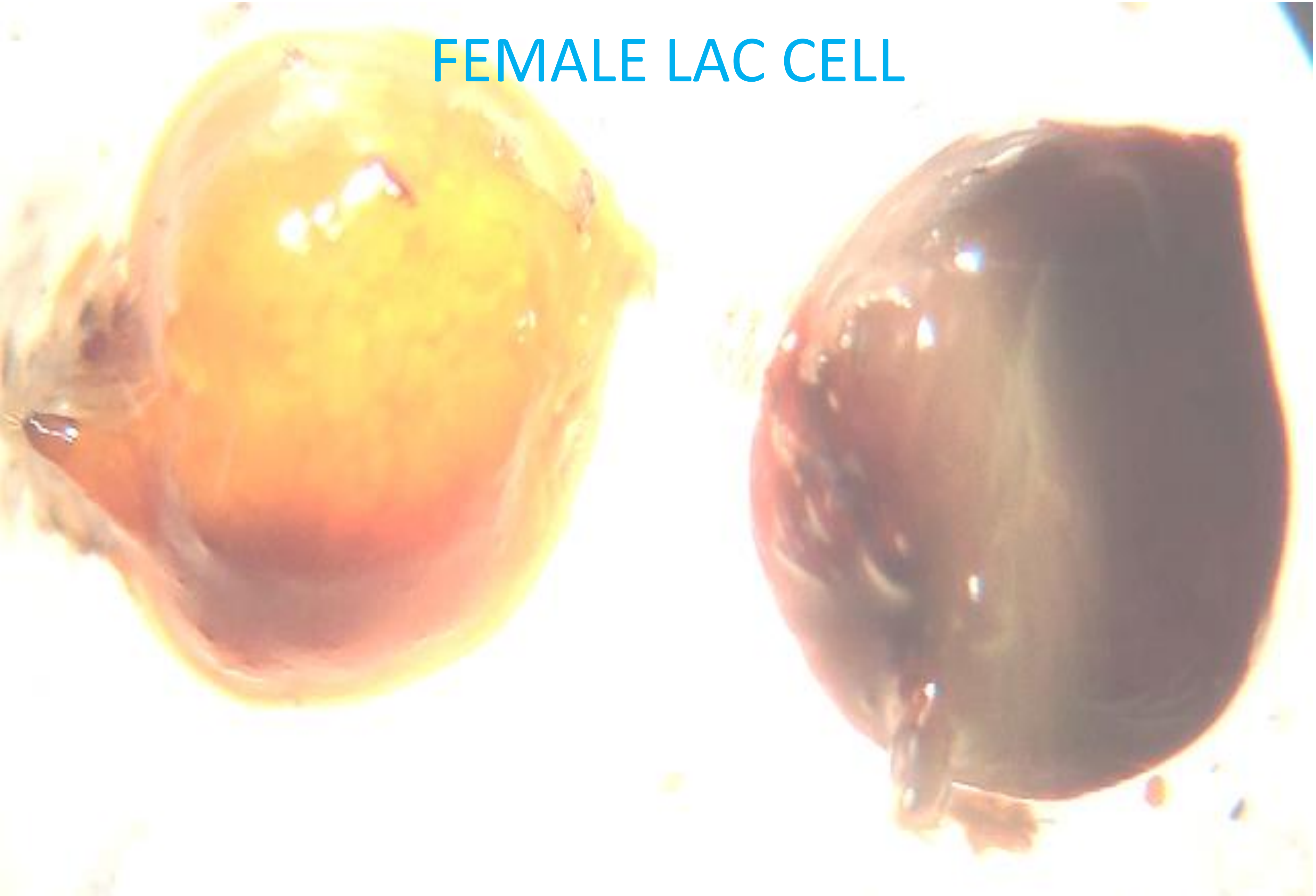




- **Structure of Female lac-insect:**

- Head bears a pair of antennae and a single proboscis. Eyes are absent.
- Thorax is devoid of wings and legs. The loss of eyes, wings, and legs are due to the fact that the female larvae after settling down once never move again and thus these parts become useless and ultimately atrophy.
- Abdomen bears a pair of caudal setae. It is female lac insect which secretes the bulk of lac for commerce.
- The female brood cell is larger and globular in shape and remains fixed to the twig.
- The female retains her mouth parts but fails to develop any wings, eyes or appendages.
- While developing, it really becomes an immobile organism with little resemblance to an insect.
- Females become little more than egg producing organisms.

FEMALE LAC CELL



Lifecycle of lac insect

- The Life cycle of lac insect takes about six months and consists of stages:

1. EGG,
2. NYMPH
3. INSTARS,
4. PUPA AND
5. ADULT.

- The lac insects have an ovoviviparous mode of reproduction.
- Female lays 200-500 ready to hatch eggs, i.e. the embryos are already fully developed in eggs when these are laid.

- **Fertilization:**
- After attaining the maturity, males emerge out from their cells and walk over the lac incrustations(crusts).
- The male enters the female cell through anal tubular opening and inside female cell it fertilizes the female.
- After copulation, the male dies. One male is capable of fertilizing several females.
- Females develop very rapidly after fertilization.
- They take more sap from plants and exude more resin and wax.

Brood lac is used for inoculation

- When the eggs hatch, larvae emerge and the whole process begins all over again
- After the cycle has been completed and around the time when the next generation begin to emerge, the resin encrusted branches are harvested.
- They are scraped off, dried and processed for various lac products.
- A portion of brood lac is retained from the previous crop for the purpose of inoculation to new trees.

- **Life Cycle of Lac Insect:**

- The females after fertilization are capable of producing eggs. But it has been noticed in case of lac insects that the post fertilization developments start when the eggs are still inside the ovary.
- These developing eggs are oviposited into the incubating chambers (formed inside the female cell by the body contraction of females).
- A female is capable of producing about one thousand eggs (average 200-500). Inside incubating chamber, the eggs hatch into larvae.

- Female cell is oval, having a pair of small branchial pores in anterior side and a single round anal tubular opening in posterior side.
- Through the anal tubular opening are protruding waxy white filaments, secreted by the glands in the insects body, which is an indication that the insect inside the cell is alive and is in healthy condition.
- These filaments also prevent the blocking of the pore during excess secretion of lac.

- The cell produced by male and female differ in shape, and can be easily distinguished sometimes later.
- Male cells are elongated and cigar shaped.
- There is a pair of branchial pores in the anterior side and a single large circular opening covered by the flap in the posterior side.
- It is through the posterior circular opening that the matured male lac insect emerges out of its cell.

- **Life Cycle of Lac Insect:**

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- **The Life Cycle of Lac Insect**

- The larvae are minute, boat shaped, red colored and measure little over half millimeter in length.
- Larva consists of head, thorax and abdomen. Head bears a pair of antennae, a pair of simple eyes and a single proboscis. All three thoracic segments are provided with a pair of walking legs.
- Thorax also bears two pairs of spiracles for respiration. Abdomen is provided with a pair of caudal setae.
- These larvae begin to wander in search of suitable center to fix them. This mass movement of larvae from female cell to the new off-shoots of host plant, is termed as “swarming”.

Lifecycle of lac insect

- Swarming occurs after the emergence of nymph and it may continue for 5 weeks.
- The nymphs crawl about on branches.
- On reaching soft succulent twigs, the nymphs settle down close together at rate of 200-300 insects per squire inch.
- At this stage, both male and female nymphs live on the sap of the trees.
- They insert their suctorial proboscis into plant tissue and suck the sap.

- The emergence of larvae from female cell occurs through anal tubular opening of the cell and this emergence may continue for three weeks.
- The larvae of lac are very sluggish and feed continuously when once they get fixed with the twig.
- In the meantime the larvae start secreting resinous substance around their body through certain glands present in the body. After some-time the larvae gets fully covered by the lac encasement, also known as lac cell.
- Once they are fully covered, they molt and begin to feed actively.

Lifecycle of lac insect

- After a day or so of settling, the nymphs start secreting resin from the glands distributed under the cuticle throughout the body, except mouth parts, breathing spiracles and anus.
- The resin secreted is semi-solid which hardens on exposure to air into a protective covering.
- The nymphs molt thrice inside the cells before reaching maturity.
- The duration of each instar is dependent on several factors, viz. temperature, humidity and host plant.

Ovoviviparous nature

- The female increases in size to accommodate her growing number of eggs.
- Lac resin is secreted at a faster rate, and a continuous layer coalesces or grows into one body.
- After fourteen weeks, the female shrinks in size allowing light to pass into the cell and the space for the eggs.
- About this time, two yellow spots appear at the rear end of the cell.
- The spots enlarge and become orange colored.
- When this happens, the female has oviposit a large number of eggs in the space called 'Ovisac'.
- The ovisac appears orange due to crimson fluid called lac dye which resembles cochineal.
- It indicates that the eggs will hatch in less time.

- Eggs deposited hatch within a few hours of laying, and a crimson-red first instar nymph called crawlers come out.
- The crawler measures 0.6 x .25 mm in size.

Lac Insect; Nature of Attack

Adult female scales produce a high-domed 'test' or shell with four to six lobe-like projections that anchor the test to the plant surface.
The test is hard and glossy with a reddish-orange tint around the edges, and darker toward the center.


2

- In some specimens, white string-like wax fiber extrusions project from the dorsum of the test, but these may break off.

- In heavy infestations, the tests of multiple females will develop into a single, aggregated mass such that the distinctive appearance of the individual tests is lost.
- The test darkens as the scale matures.
- The female scale, which is a deep red color, lives inside the test and requires a special procedure to remove without damage.


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- The sticklac is a protection for the insects.
- By excreting sugars they also attract the Praetorian Guard (weaver ants, *Oecophylla smaragdina*).

- **Lac Secretion:**
- Lac is a resinous substance secreted by certain glands present in the abdomen of the lac insects. The secretion of lac begins immediately after the larval settlement on the new and tender shoots. This secretion appears first as a shining layer which soon gets hardened after coming in contact with air.
- This makes a coating around the insect and the twig on which it is residing.
- As the secretion continues the coating around one insect meet and fuses completely with the coating of another insect.
- In this way a continuous or semi-continuous incrustation of lac is formed on the tender shoots.

- **Cultivation of Lac:**

- Cultivation of lac involves proper care of host plants, regular pruning of host plant, infection or inoculation, crop-reaping, control of insect pests, and forecast of swarming, collection and processing of lac.

- The first and perhaps the most important prerequisite for cultivation of lac is the proper care of the host plant.
- It is the host plants on which lac insects depend for their food, shelter and for completion of their life cycle.
- There are two ways for the cultivation of host plants. One is that plants should be allowed to grow in their natural way and the function of lac-culturist is only to protect and care for the proper growth of plants.

- Another way is that a particular piece of land is taken for the purpose and systematic plantation of host plant is made there.
- Regular watch is necessary in this case by providing artificial manures, irrigation facilities, ploughing and protecting the plants from cattle and human beings for which the land should be fenced.
- The larvae of lac insects are inoculated on host plants only after the host plants have reached a proper height.
- The lac larvae feed on the cell sap by inserting their proboscis in the tender twigs. The proboscis can only be inserted in the tender young off-shoots. For this before inoculation, pruning of lac host plants is necessary. The branches less than an inch in diameter are selected for pruning.
- Branches half inch of less in diameter should be cut from the very base of their origin. But the branches more than half inch diameter should be cut at a distance of 1 ½ inch from the base.

- **Inoculation:**

- The method by which the lac insects are introduced to the new lac host plant is known as inoculation.
- This may be of two types, namely “Natural infection” and “Artificial infection”. When infection from one plant to other occurs by natural movements of insect, it is called natural infection. This may be due to overcrowding of insect population and non-availability of tender shoots on a particular tree.
- Artificial infection takes places through the agencies other than those of nature. Prior to about two weeks of hatching, lac bearing sticks are cut to the size of six inches. They are called “Brood lac”.
- Brood lacs are then kept for about two weeks in some cool place.

- When the larvae start emerging from this brood lac, they are supposed to be ready for inoculation.
- Strings can be used for tiding the brood lac with the host plant may be of different types in longitude infection the brood lac is tied in close contact with host branches.
- In lateral infection the brood lac is tied across the gaps between two branches.
- In interlaced method, brood lac is tied among the branches of several new shoots.

- **Lac Crops:**
- The lac insects repeat its life cycle twice in a year. There are actually four lac crops since the lac insects behave in two ways either they develop on Kusum plants or develop on plants other than Kusum.
- The lac which grows on Non-Kusum plants is called as "Ranjeem lac," and which grows on Kusum plant is called as "Kusumi lac.
- Four lac crops have been named after four Hindi months in which they are cut from the tree. They are as follows:

- **Ranjeeni Crop:**
- **(i) Katki:**
- Lac larvae are inoculated in June-July. Male insect emerges m August-September. Female give rise to *swarming larvae* in October-November and the crop is reaped in Kartik (October and November).
- **(ii) Baisakhi**:
- Larvae produced by Katki crop are inoculated in October-November, male insects emerges in February-March, females give rise to swarming larvae in June-July, the crop is reaped in Baisakh (April-May).

- **Kusumi Crop:**

- **(i) Aghani**:
- Lac larvae are inoculated in June-July, male insect emerges m September, female give rise to swarming larvae in January-February and crop is reaped in Aghan (December-January).

- **(ii) Jethoi**:
- The larvae produced by Aghani crop is inoculated in the month of January- February, male emerges in March-April, female give rise to swarming larvae in June- July and the crop is reaped in the month of Jeath (June-July).
- The time of infection with swarming larvae, the time of emergence of male insects, the time of reaping the crop, and the time of producing swarming larvae by female etc., are shown m tabular form below
-

- **Scraping and Processing of lac:**

- Lac cut from the host plant is called as "stick lac". Lac can be scraped from the twigs before or after the emergence of larvae. If it is used for manufacturing before the emergence of larvae, the type of lac produced is called as "Ari lac" and if it is used for manufacturing purpose after swarming of larvae has occurred, the lac is said to be "Phunki lac".

- The scraping of lac from twig is done by knife, after which they should not be exposed to sun. The scraped lac is grinded in hard stone mills. The unnecessary materials are sorted out In order to remove the finer particles of dirt and color, this lac is washed repeatedly with cold water.

- Now at this stage it is called as “Seed lac” and is exposed to sun for drying. Seed lac is now subjected to the melting process. The melted lac is sieved through cloth and is given the final shape by molding. The final form of lac is called “Shellac”.
- Colour or different chemicals may be mixed during melting process for particular need.

- **Lac Enemies and Their Control:**

- A lac enemy imposes a challenge to the lac culturist, as they not only decreases the population of lac insects, but also retard the production and quality of lac. Damage caused to lac insects may be grouped under two heads, (a) damage caused by insects (b) damage caused by animals other than insects. Insect enemies of lac crop may be predators and parasites.

- The common parasites of lac insect are known as "Chalcid." They are small, winged insects which lay their eggs inside the lac coat either on the body of the lac insect or inside the body of the lac insect.
- The larva which hatches from these eggs feed upon the lac insects, thereby causing mortality of their host. Damage done by this parasite constitute about 5-10% of the total destruction of the lac crop.

- Damage done by the predators is of greater intensity (35% of the total destruction).
- The major predators of lac insects are *Eublemma amabilis* (the white moth) and *Holococera pulverea* (the blackish grey moth).
- They not only feed on lac insects but also destroy the lac produced by term. Squirrels, monkey, rat, bat, birds (wood peckers), man etc., are the enemies other than insects which destruct the lac crop in different ways.
- Damage is also done by climatic factors such as excess heat, excess cold, heavy rain, and storm and partly by the faulty cultivation methods.

- **Control:**
- Damage caused by the above mentioned animals can be reduced to certain extent by the use of the following methods.

- **Cultural Method:**
- The amount of damage by infection can be reduced to a greater extent by taking care during the culture of lac insects, especially at the time of inoculation.
- The brood lac showing the minimum enemy attack should be selected for inoculation and should be cut from the host plant very near to the time of emergence of larvae (about one week before the emergence).
- This will reduce the chances of parasite attack on the emerging larvae at new place (host).

- The brood lac used for inoculation should be removed from the new host’s branches as soon as the emergence of larvae stops (approx. 3 weeks after inoculation). It reduces the chance of transference of enemies to the new host plant from the brood lac.

- The infected brood lac not fit for inoculation or the used up brood lac should not be retained for long. The lac should be scrapped at once and the rest may be crushed or dropped into fire in order to destroy the predators and parasites.

- The delay in processing also gives chances to the enemy insects to escape into field.
- So the manufacturers should try to convert stick lac into seed lac as soon as possible.
- By these cultural methods the future production can be saved from infection to some extent.

- **Artificial Method:**

- During the crop reaping, it is not always possible for the manufacturers to convert the huge amount of stick lac to seed lac at a time.
- To avoid the spreading of enemies at this time from stocked stick lac simple artificial method can be used. Bundles of stick lac should be tied with stones and immersed in fenced water (river or ponds) for about a week.
- This kills all the parasitic and predator insects as they cannot survive in water.

Biological Method:

- It is an indirect method for killing the parasitic and predator insects.
- For this purpose hyper-parasitic insects are used which attacks the parasitic insects of lac and kill them.
- These hyper-parasitic insects are however, not harmful for lac crop.

Use of Lac:

- Lac has been used for the welfare of human beings from the great olden days
- No doubt the development of many synthetic products have made its importance to a little lesser degree, but still it can be included in the list of necessary articles.
- Lac is used in making toys, bracelets, sealing wax, gramophone records etc.
- It is also used in making grinding stones, for filling ornaments, for manufacturing of varnishes and paints, for silvering the back of mirror, for encasing cable wires etc.,
- Waste materials produced during the process of stick lac is used for dying purpose. Nail polish is a good example of the by-product of lac.

- **Composition of Lac:**

- Lac is a mixture of several substances, of which resin is the main constituent. The approximate percentage of different constituents of lac is given below:
- Resin – 68 to 90%
- Dye – 2 to 10%
- Wax – 5 to 6%
- Mineral matter – 3 to 7%
- Albuminous matter – 5 to 10%
- Water – 2 to 3%

- **Present Position of this Industry**

- Lac is produced in a number of countries including India, Thailand, Mayanmar, China, Indonesia, Vietnam and Laos.
- India and Thailand are the major producers, producing on the average 1700 tons of lac annually, followed by China.
- India alone, accounts for about 70 % of global lac production.
- Former Bihar is the most important lac producing state of India. The Indian council of Agriculture Research has established Indian Lac Research Institute at Namkum in Ranchi district of Jharkhand.

- The average of different states in the total quantity of stic lac produced in this country is given below:
- Bihar – 55.5%
- Madhya Pradesh – 22%
- West Bengal – 10%
- Maharashtra – 7.1%
- Gujrat – 2.7%
- Uttar Pradesh – 1.8%
- Assam – 0.6%
- Orissa – 0.1%

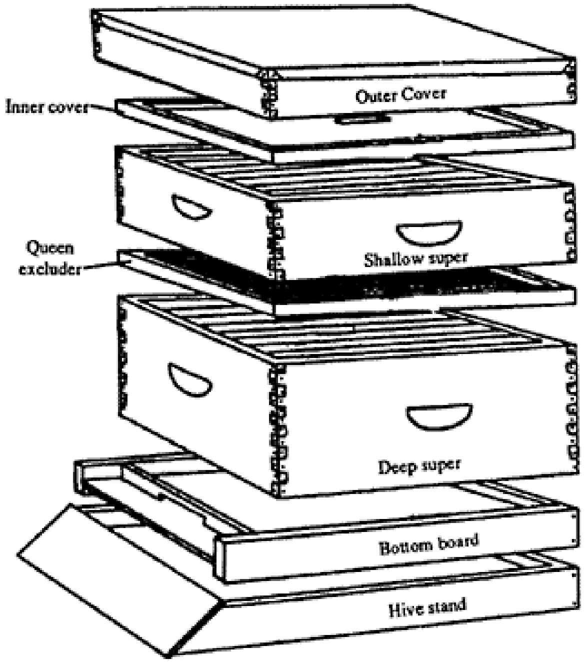
- Total annual global production of pure lac is estimated to be 20,000 tons. The average total production of stick lac in India is about 24,000 tons, while the annual average pure lac produced in the country is 11,890 tons. About 6000 tons of pure lac produced in India is exported to different countries of the world, with an average earning of Rs. 202.38 million in term of foreign exchange. It has been estimated that 3-4 million people mostly tribal are engaged in the cultivation and several thousands in addition are engaged in the trade and manufacture of lac.
- Two main competitors of Indian lac are (i) Thailac, which accounts 50% of the total lac exported, and (ii) Synthetic resin, which have replaced lac in certain field. Shellac being a versatile resin, there is immense scope of increasing its utilization in various fields and there is also scope to modify it to meet particular need.

Beekeeping

- Beekeeping is Applied Bee Biology
- Beekeeping is Anticipation not merely reaction
- Beekeeping is Colony Population Management
- Beekeeping is Science and Art

The place where a beekeeper keeps his bees is called an apiary or a bee yard.

- The bee colony is kept inside a hive that is made from a series of wooden boxes and frames that hold wax sheets for the bees to use as a starting point when building honeycomb.
- The top box contains honey, while the bottom box is used to hold the queen bee and most of the worker bees.
- In the United States, the most popular type of hive design used for beekeeping is known as a Langstroth bee hive.



Beekeeping, the practice of artificially maintaining honey bee colonies, one of the oldest forms of food production.

- Honey is a sweet yellow to rich amber colored fluid produced by bees. Other insects can also produce honey, but bee honey is the product which most people are familiar with, since it has been consumed for centuries as a sweetener.

Formally known as *apiculture*, beekeeping is thought to have been practiced as early as 13,000 BC.

- The ancient Egyptians were particularly skilled in the art of beekeeping, since they considered honey to be an important part of their diet.
- Temples kept bees in order to satisfy the desire of the gods for honey and for the production of medicines and ointments.

Tomb of Pabasa (25th dynasty)

Beekeeping History

- Human as Hunter

Beekeeping History

- Human as Primitive Beekeeper

Smoking the bees

Beekeeping History

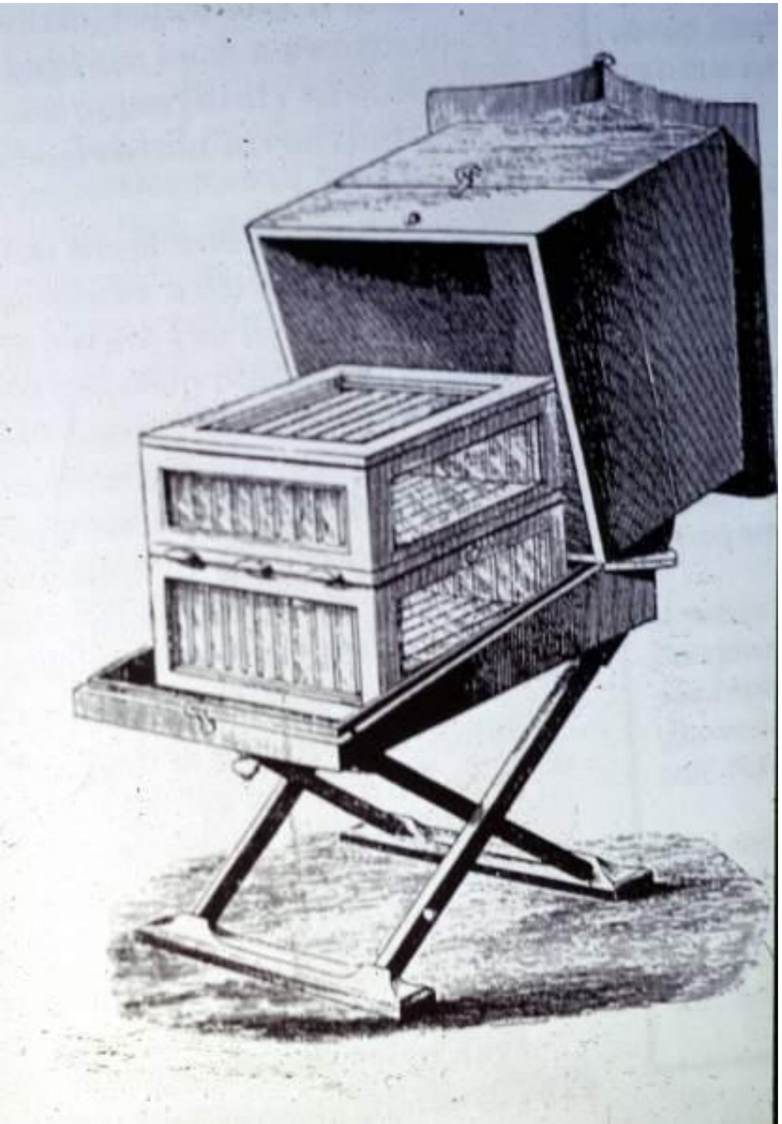
Revolutionary war-era beekeeping – 2 gums & 2 skeps

Skep beekeeping

Beekeeping History

- Human as Beekeeper

Rev L.L. Langstroth



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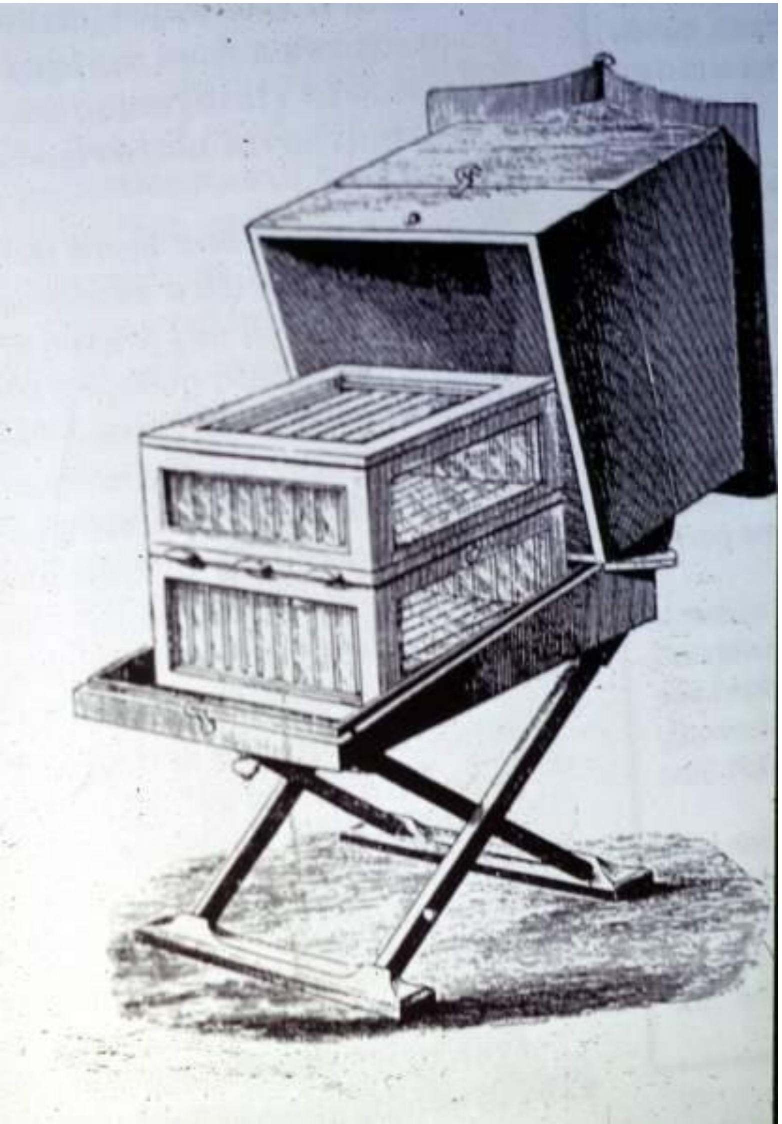
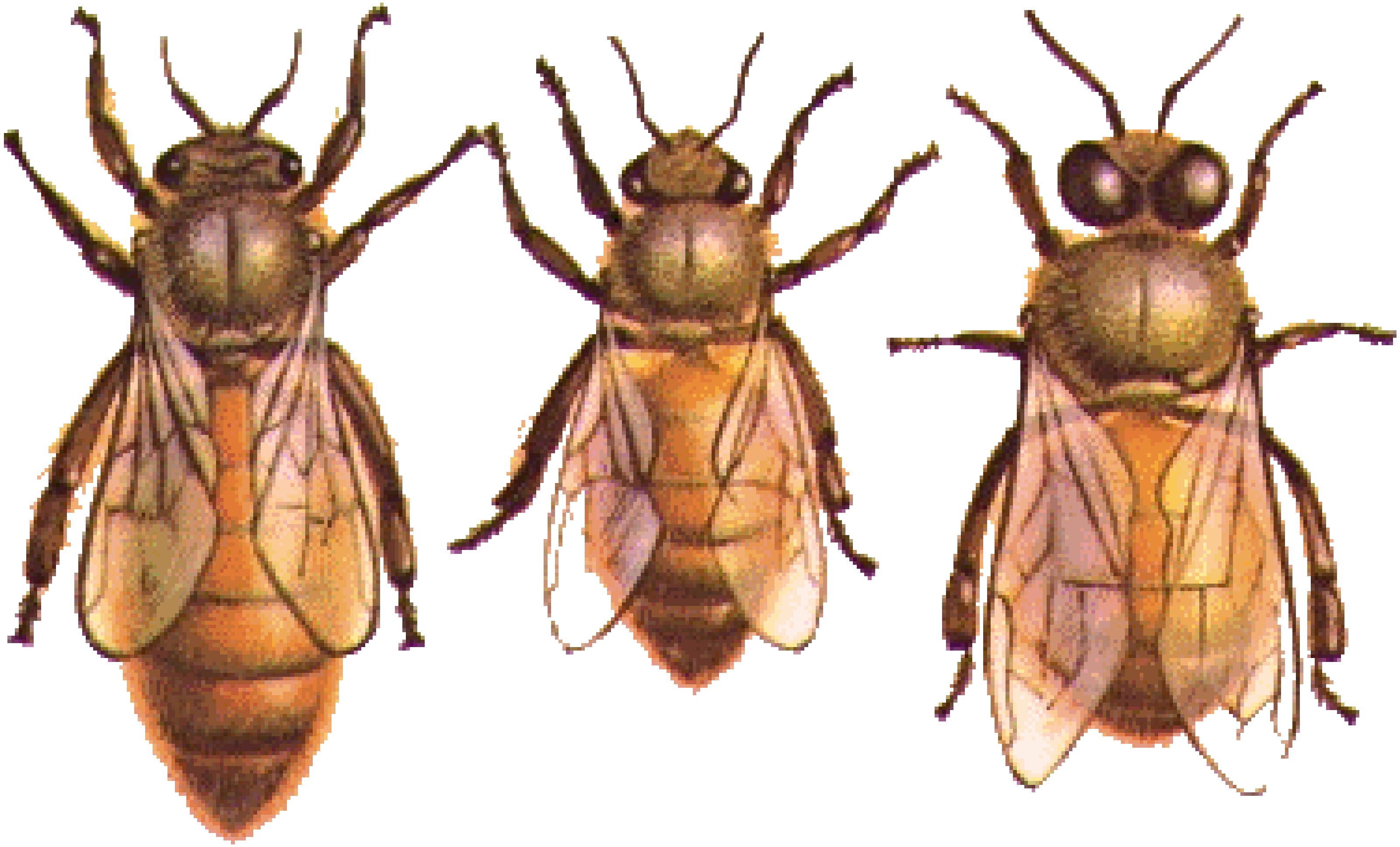
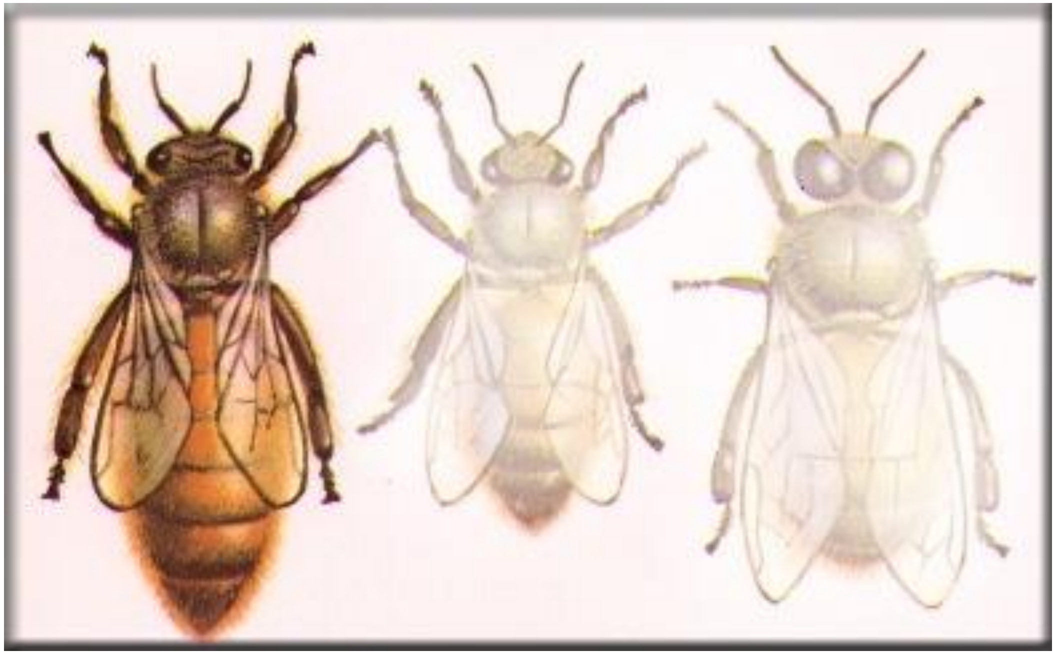


So, let’s meet these wonderful creature’s.

Queen **Worker** **Drone**



The Queen



- The queen is the only sexually developed female in the hive.
- She is the largest bee in the colony.
- A productive queen can lay 2,000 eggs in a single day.

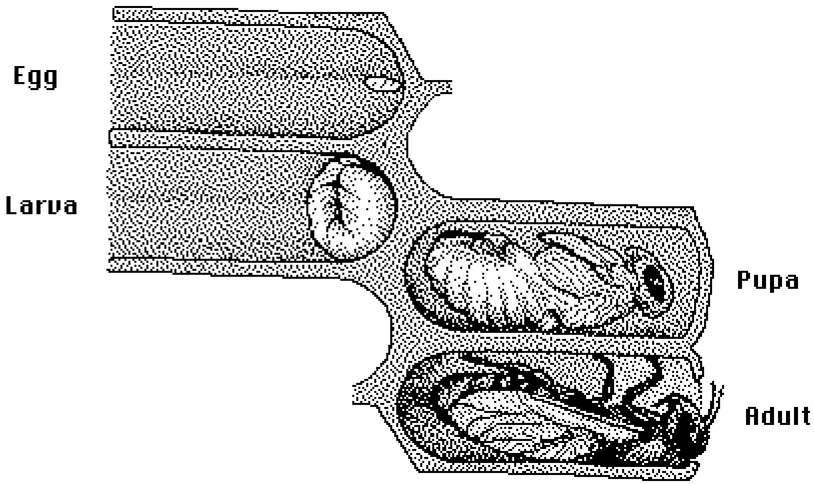
The Worker

- Workers, the smallest bees in the colony, are sexually undeveloped females.
- A colony can have 50,000 to 60,000 workers. The life span of a worker bee varies according to the time of year. Her life expectancy is approximately 28 to 35 days.
- Workers that are reared in September and October, however, can live through the winter.
- Worker bees also collect nectar to make honey.
- Bees produce honey as food stores for the hive during the long months of winter when flowers aren't blooming.

The Drone

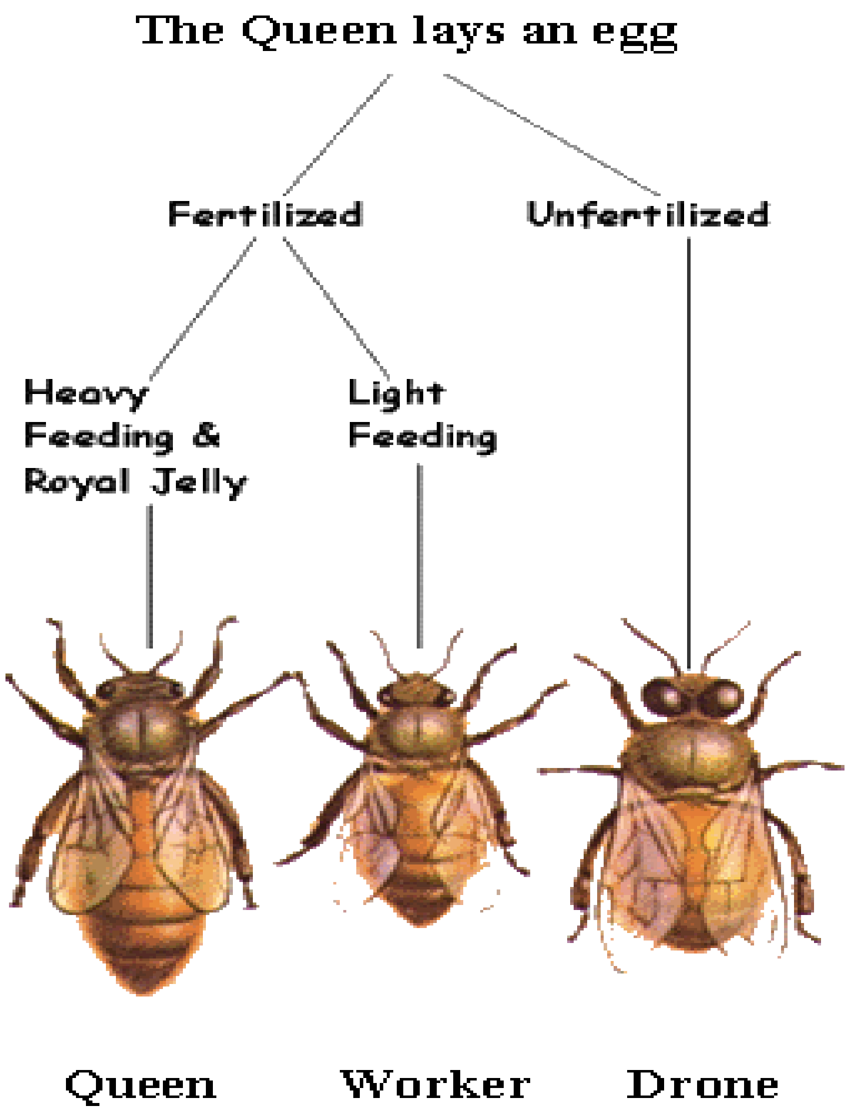
- Drones are stout male bees with large eyes and no stingers.
- Drones do not collect food or pollen from flowers.
- Their sole purpose is to mate with the queen.
- They die upon mating.
- If the colony is short on food, drones are often kicked out of the hive.

Bee Stages

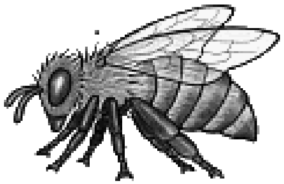


Type	Egg	Larva	Pupa	Total
Queen	3 days	5 days	9 days	17 days
Worker	3 days	6 days	12 days	21 days
Drone	3 days	7 days	14 days	24 days

Bee Development



Visit the life of the Worker Bee



(Day 1-2)

- **Cell cleaning** - Brood cells must be cleaned before the next use - cells will be inspected by the queen and if unsatisfactory will not be used. Worker bees in the cleaning phase will perform this cleaning, if not clean worker bee must do it again.

(Day 3-11)

- **Nurse bee -** Feed the worker larvae, worker jelly, secreted from the same glands that produce royal jelly.

Life of a Worker Bee

(Day 6-11)

- **Advanced Nurse -** Bees Feed royal jelly to the queen larva. Drones receive worker jelly for 1 to 3 days at which time they are moved to honey and pollen.

(Day 12-17)

- **Wax production** - Build cells from wax, repair old cells, and store nectar and pollen brought in by other workers. Early in the worker's career she will exude wax from the space between several of her abdominal segments. Four sets of wax glands, situated inside the last four ventral segments of the abdomen, produce wax for comb construction.
- **Honey sealing -** Mature honey, sufficiently dried, is sealed tightly with wax to prevent absorption of moisture from the air by workers deputized to do same.
- **Drone feeding -** Drones do not feed themselves; they are fed by workers.

Visit the life of the Worker Bee

(Day 12-17) Continued

- **Queen attendants** - Groom and feed the queen. They also collect QMP (Queen Mandibular Pheromone) from the queen and share it with the bees around them who also share it spreading its effects through the hive.
- **Honeycomb building** - Workers will take wax from wax producing workers and build the comb with it.
- **Pollen packing** - Pollen brought into the hive for feeding the brood is also stored. It must be packed firmly into comb cells and mixed with a small amount of honey so that it will not spoil. Unlike honey, which does not support bacterial life, stored pollen will become rancid without proper care and has to be kept in honey cells.

Life of Worker Bee

- **Propolizing** - The walls of the hive will be covered with a thin coating of propolis, a resinous substance obtained from plants. In combination with enzymes added by the worker this will have antibacterial and antifungal properties. Propolis is also used to close off excessive ventilation and entrances.
- **Mortuary bees** - Dead bees and failed larvae must be removed from the hive to prevent disease and allow cells to be reused. They will be carried some distance from the hive by mortuary bees.
- **Fanning bees** - Worker bees fan the hive, cooling it with evaporated water brought by water carriers. They direct airflow into the hive or out of the hive depending on need.

Visit the life of the Worker Bee

(Days 18 - 21)

- **Guard Bees** - protect the entrance of the hive from enemies.
- **Soldier bees** - Soldiers hang around near the entrance and attack invaders. They work in concert with entrance guards.
- **Entrance guard bees** - These inspect incoming bees to ensure that they are bringing in food and have the correct hive odor. Other bees will be rejected or attacked with soldier bees.

Life of Worker Bee

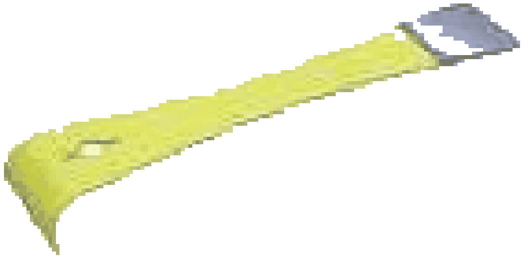
- **Outside guard bees** - Outer guards may take short flights around the outside of the hive in response to disturbances.
- **Water carriers** - When the hive is in danger of overheating, these bees will obtain water, usually from within a short distance from the hive and bring it back to spread on the backs of fanning bees.

(Days 22 - 35)

- **Foraging bees** - The forager and scout bees travel (2 to 5 miles) to a nectar source, pollen source or to collect propolis.
- **Die in field** - The life span of worker bees depend on the time of year. Most worker bees live about 28 to 35 days. However, workers that are reared in September and October can live through the winter.

What do we need to harvest honey and how do we do it?

– Each stack is a hive. Each box is called a super. The supers are full of hanging frames. The frames are full of comb. The comb is full of honey, we hope!
  The bees glue absolutely everything together with propolis, which resembles resin more than wax. You have to pry(interfere, meddle) everything apart.



So, we need bees with excess honey and a hive tool.

What do we need to harvest honey and how do we do it?

– There is only one correct way to smoke, but no two beekeepers agree what that is! My smoker is filled with pine straw. Smoke makes the bees unusually calm.

So, we need a smoker.

What do we need to harvest honey and how do we do it?

– Remove a super full of honey and get rid of the bees. I use a leaf blower without the snout. You can use a fume board and Bee-Gone but I do not use chemicals. Blow the bees out of the super in front of the hive, it's like taking them to Six Flags!

So, we need a leaf blower.

What do we need to harvest honey and how do we do it?

– Supers full of honey are heavy, shallow 37 pounds, medium 52 pounds and a deep 90 pounds so you need a device to carry from bee yard to honey house.

So, we need a wheel barrow, wagon or truck.

What do we need to harvest honey and how do we do it?

– You need a honey house (a place where the bees can not get into), a decapping tank (holds wax and a little bit of honey that dripped off the open frames).

So, we need a honey house and a decapping tank.

What do we need to harvest honey and how do we do it?

– Honey on a frame is somewhat like a bottle of soda, you can't taste it until it is open. Here we are using a decapping knife (gets hot like your mother's iron and has sharp edges on both sides).

So, we need a decapping knife.

What do we need to harvest honey and how do we do it?

– Sometime the bees do not build out the comb to where the decapping knife can cut it so we have to pick or scratch the capped comb open.

So, we need a pick.

What do we need to harvest honey and how do we do it?

- We must get the honey out of the frames of comb and we do this with the aid of an extractor. Years ago beekeepers would squeeze it out by hand.

So, we need an extractor.

What do we need to harvest honey and how do we do it?

– When the extractor gets full you need a bucket or buckets to store the honey in. This is also a good time to filter the honey and I use panty hose stretched across the top of the five gallon storage bucket.

So, we need five gallon storage bucket and a panty hose filter.

What do we need to harvest honey and how do we do it?

– Here the finished product, is a quart of honey. I usually let my honey sit for a few days so any particles that the panty hose did not filter out will rise to the top.

So, we need containers.

Bees can be dangerous, a beekeeper must take several safety precautions when working around a honey bee colony.

– A hat or veil is commonly used to keep the face and neck protected from stings.
– Gloves are another popular form of beekeeping protection, although many beekeepers complain that gloves restrict their movement.
– A hooded suit, typically made from a light colored fabric to help distinguish the beekeeper from the honey bee's natural predators, may also be used.

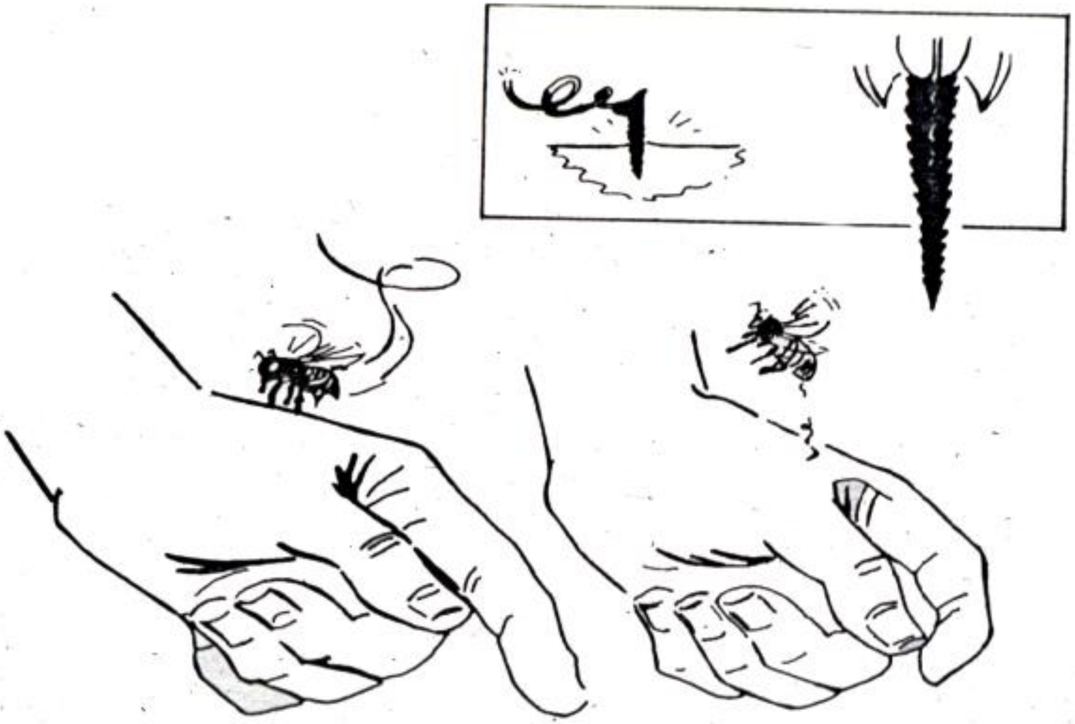


While working with a honey bee colony, a beekeeper uses a smoker to help calm the bees.

- Smoke is useful in beekeeping because it masks the guard bee's alarm pheromones and encourages the other bees to feed by tricking them into thinking they'll soon need to abandon their hive.
- The smoke gives the beekeeper enough time to inspect the colony and perform any needed maintenance.
- I use Pine needles for fuel in my bee smoker.

Bee Stings 101

- They HURT and....



we REACT

Bee Stings 201

- Normal Reaction

  ► **Pain**
  ► **Wheal(swelling) develops at puncture site**
  ► **Redness develops around wheal**
  ► **Swelling**
  - a little at site
  - a lot at site (large local)
  ► **Itching**

Normal Reaction

Bee Stings 201

- Normal Reaction
- **Allergic Reaction**
  - ▶ **widespread, rapid swelling**
  - ▶ **itching of body**
    - ▶ **disorientation feeling**
    - ▶ **stomach upset**
    - ▶ **Loss of consciousness**

Bee Stings 201

- Normal Reaction
- Allergic Reaction
- Toxic Reaction
    - Too many stings at one time

Too Many Stings!!

Bee Stings 401

- What to do to avoid being stung.....
  -
  -
  -
  -
  -
  -
  -
  -
  -

And if you receive multiple stings ?

Bee Stings 601

A bee's front end is sweet and kind,
But never trust a bee's behind.
A bee can sting if it can sit,
So always stay in front of it!

Bee Stings 401

- What to do to avoid
  being stung.....
  - proper clothing
  - smoker
  - best environmental conditions
  - scrape sting out promptly
  - slow movements- no jerking or ‘windmills’
  - extra care around hive/flowers
  - don’t remove veil too soon
  - keep gentle bee stock

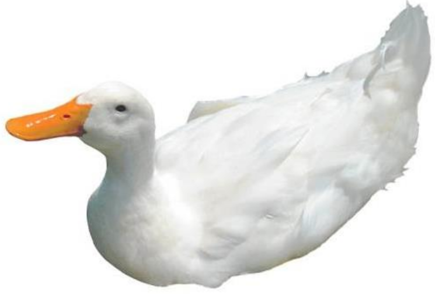
Poultry farming

Introduction

Chicken, turkey, duck and goose are all types of birds called poultry.

They are reared for meat.





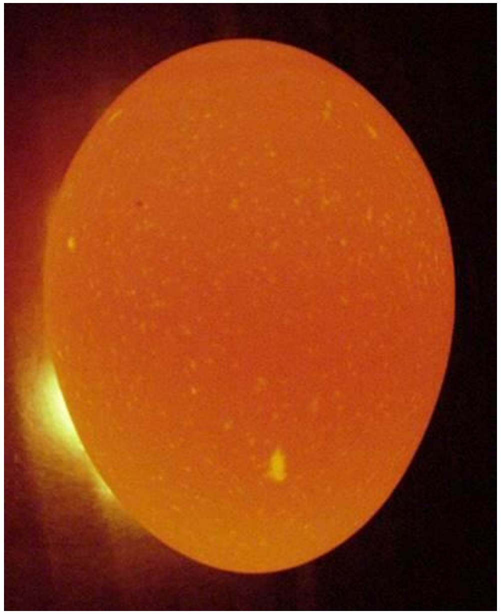

Things to Know About Poultry Farming

- Understanding poultry terms.
- Differentiate between a productive hen and a non- laying hen
- Identify parts of a chicken.
- Evaluate eggs.
- Where to get quality chicks from
- Where to sell the product
- Biosafety and
- Control of diseases

Basic Terms to Understand

- Scientific Name: Galine
- Chick: Newborn chicken
- Pullet: Young, immature female chicken less than 5-6 months of age
- Hen: Mature female chicken
- Rooster: Mature male chicken
- Roaster: male or female chicken 3-5 months of age and raised for the production of meat

More Terms



- Capon: Castrated male chicken
- Layer: Hen used for laying eggs
- Broiler/Flyer: Chickens grown for meat production
- Group Name: Flock
- Candling: examining a shell egg’s content by holding it between one’s eye and a light source
- Clutch: Nest of eggs

More Terms

- Egg: hard- shelled; reproductive body produced by a bird
- Green: description of chicks that have recently hatched
- Axial feather: short wing feather that separates primaries from secondaries
- Molt: To shed feathers periodically
- Oviposition: laying of an egg by a bird
- Plumage: Feathers of a bird

Introduction to chicken farming

Chickens farmed for meat are called broiler chickens.

A group of chickens is called a flock.

Breeder farm

Eggs are laid by broiler hens (parent flock).

Male chickens are called cockerels and female chickens are called pullets or hens.

Male turkeys are called stags and

female turkeys are called hens.

The eggs are collected

and sent to the hatchery.

Did you know?

At any one time there are approximately 7 million broiler chicken hens laying eggs for hatching in the UK.

Hatchery

The eggs are incubated at the hatchery. They are kept warm, until the chicks start to hatch out of their shells.

Chickens hatch at around 20 days and turkeys hatch at around 27 days.

Baby chickens are called chicks.

Baby turkeys are called poults.

The hatched birds are then sorted and transported to Rearing farms.

Do you know what a group of chicks is called?

A group of chicks (baby chickens) is called a clutch or peep.

About Chicks

When a chick hatches it can live healthily for up to two days without being given any food or water. This is because it still has nutrients in its stomach from when it was inside the egg.

This is why chicks do not need food or water when they are being moved to the rearing farm.

Rearing farms

- The baby birds are reared in special large houses, which provide them with water and a special diet.
- These houses are cleaned before each new arrival of baby birds.
- Trained staff look after the birds in the houses every day.
- If the birds are ill, special medicines are given in their food or water.
- The birds are reared until they reach their required weight.

Catching

- Once the birds reach their required weight they are transported to the processing plant.
- Trained staff called ‘catchers’ catch the birds and put them in special containers called modules.
- Catching is carried out quietly and with care to avoid unnecessary stress and to prevent injury to the birds.
- The modules are then loaded into lorries and taken to the processing plant.

Egg- Type Hens

- Characteristics to look for when examining hens:
  - Bleaching of yellow pigment in the shanks, feet, and beak
  - Condition and capacity of the abdomen
  - Condition of plumage and rate of molt of the wing primaries
  - Vigor and vitality
  - Head characteristics

Bleaching of Body Pigment

- Order that the body pigment fades:
  - Vent
  - Eye Ring
  - Earlobe
  - Base of Beak
  - Tip of Beak
  - Bottom of Foot
  - Shank
  - Hock and Tip of Toe

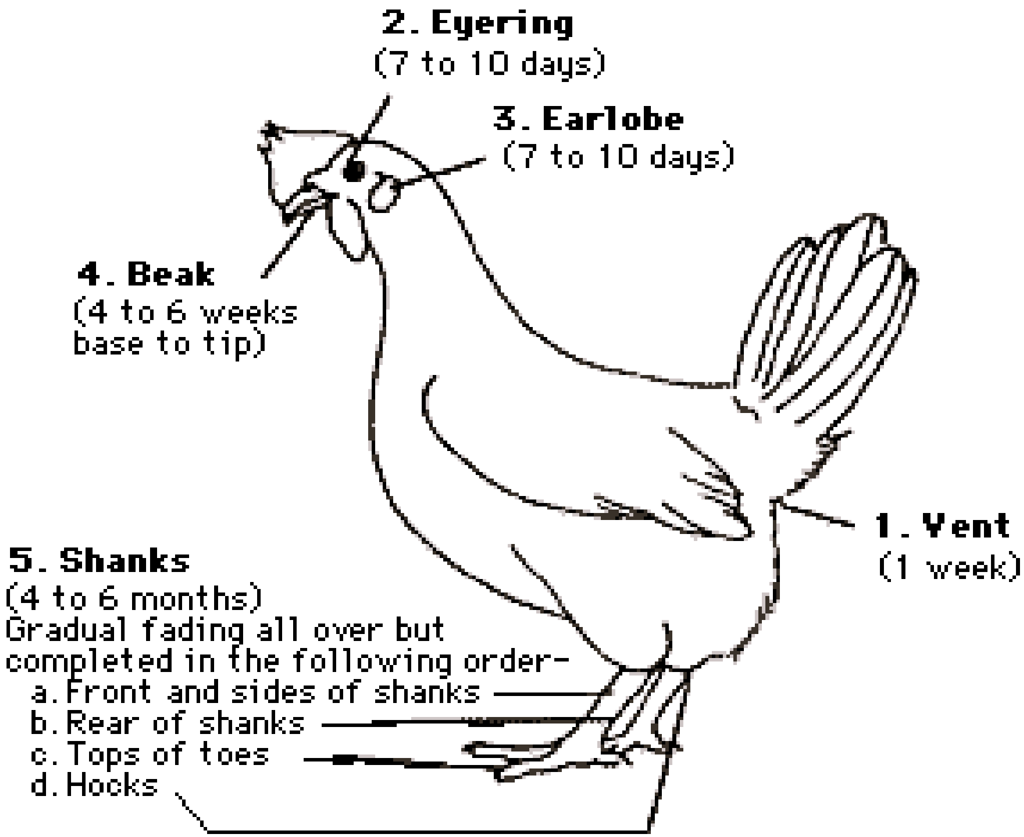


Figure 5. Photographs showing the loss of pigment from the front of the shanks and tops of toes

Hen has laid few eggs --------------------------------→ Hen has laid many eggs

Figure 4. Comparison of the yellow color in the eye ring, ear lobe and beak of a poor layer (photo on the left) and a good layer (photo on the right)

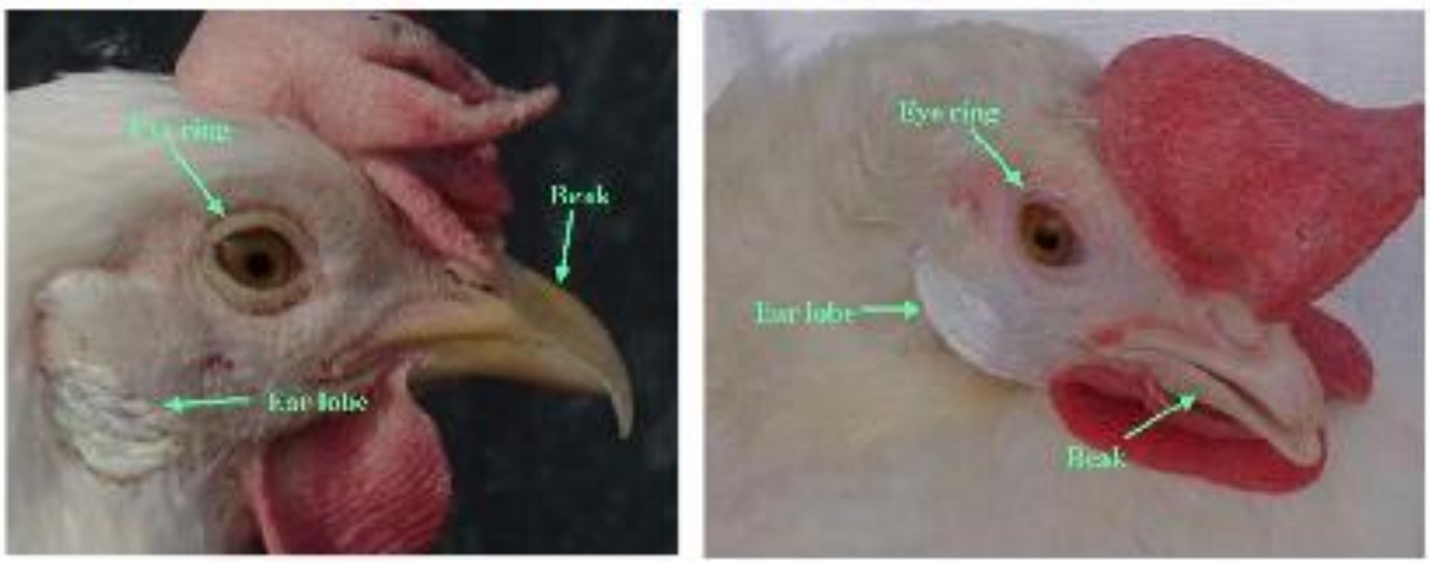
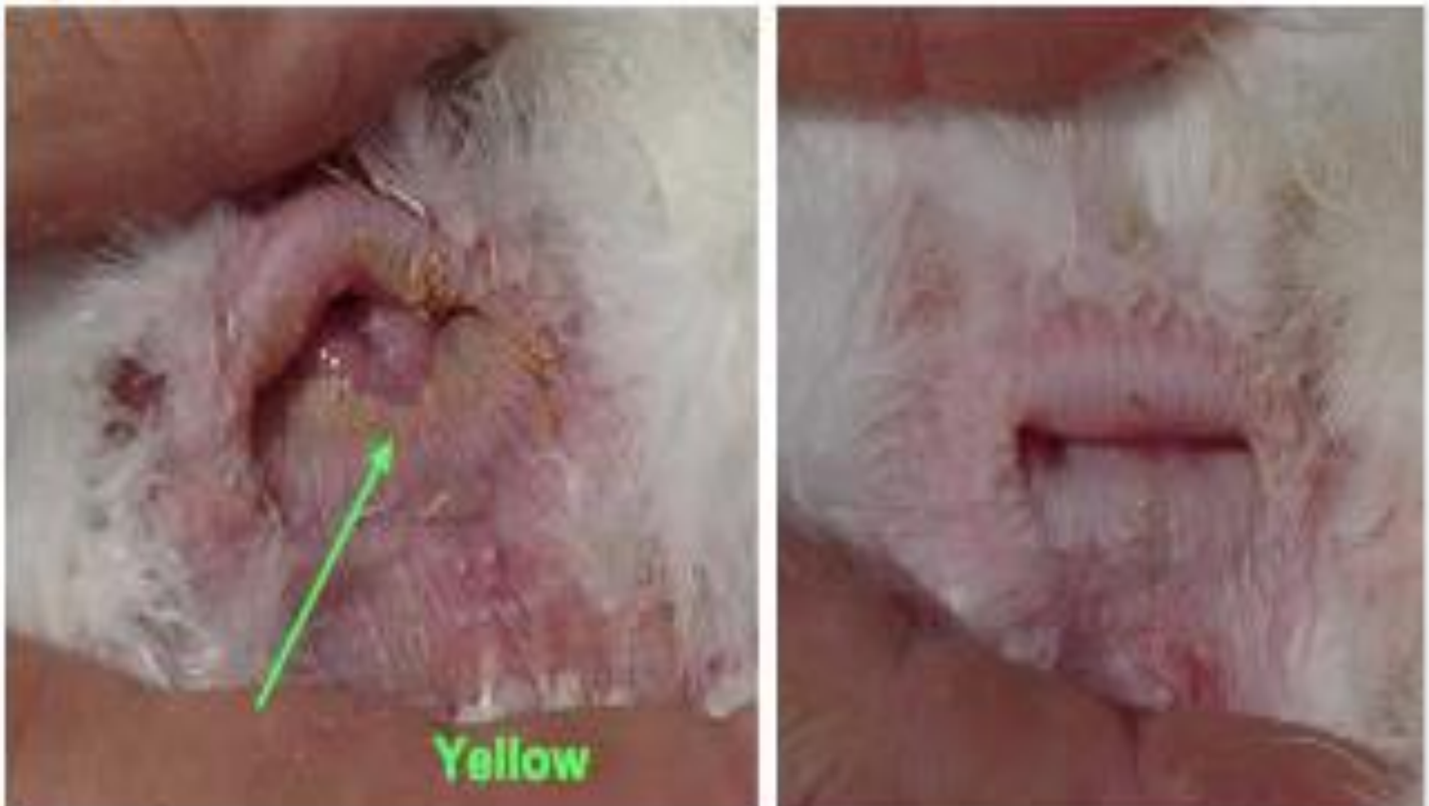


Figure 3. Comparison in the color of the skin around the vent of a poor layer (photo on the left) and a good layer (photo on the right)



Bleaching of Body Pigment

- Hens that show signs of returning pigment are decreasing in egg production
- Pigment returns to the body parts in the same order it faded
  - Returns 3 times quicker
  - Four factors:
    - Amount of pigment in feed
    - Health and vitality of hen
    - Whether the hen is confined or not
    - Size and coarseness of the hen

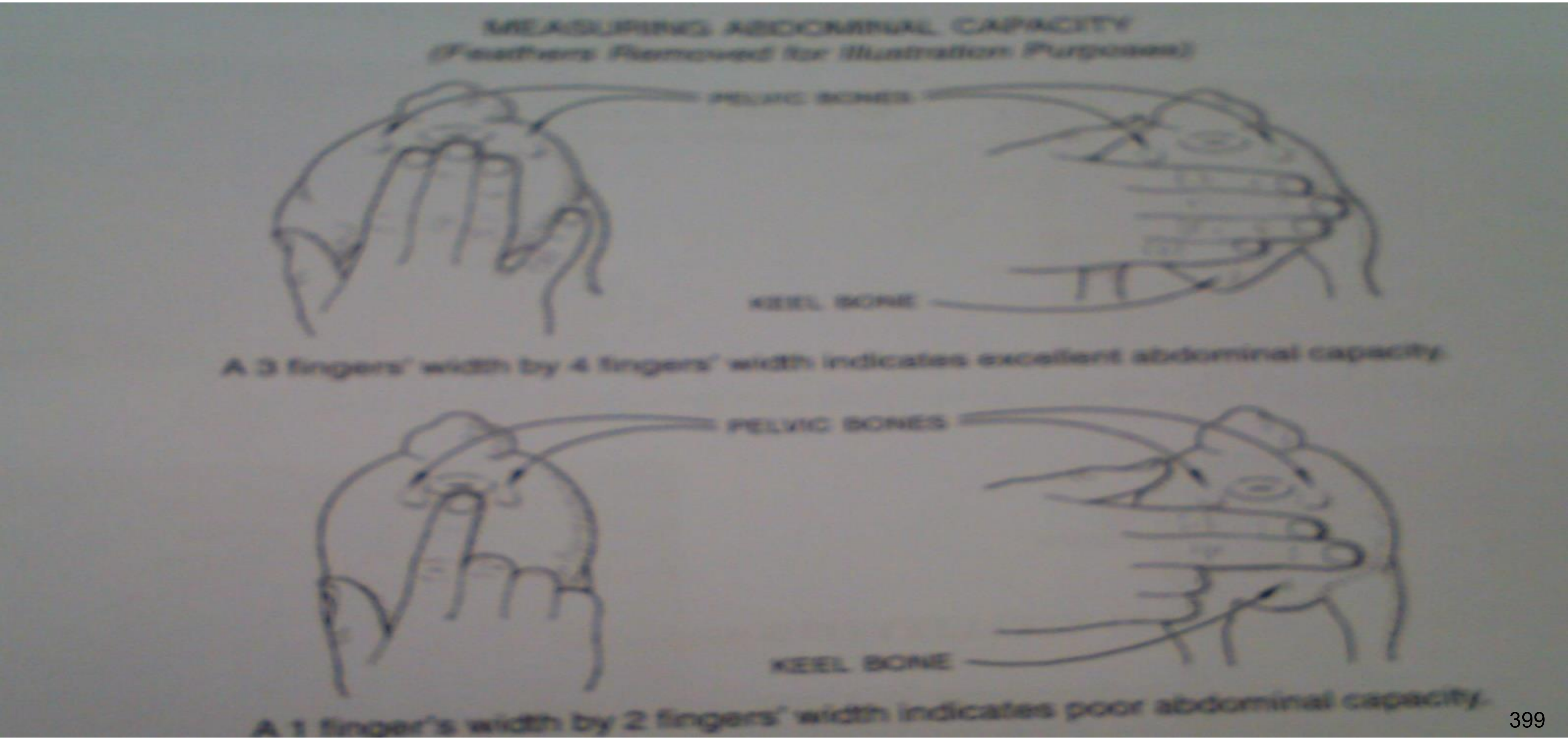
Condition and Capacity of Abdomen

- Good indicator of egg production
  - Abdomen of a layer is wide, soft (lacks fat), and expanded
  - Pelvic bones are thin and flexible
  - Vent is moist, large, and oblong in shape

- Non-layer
  - Narrow, hard (fatty), and contracted
  - Pelvic bones are thick and rigid
  - Vent has some moistness but is small and round in shape

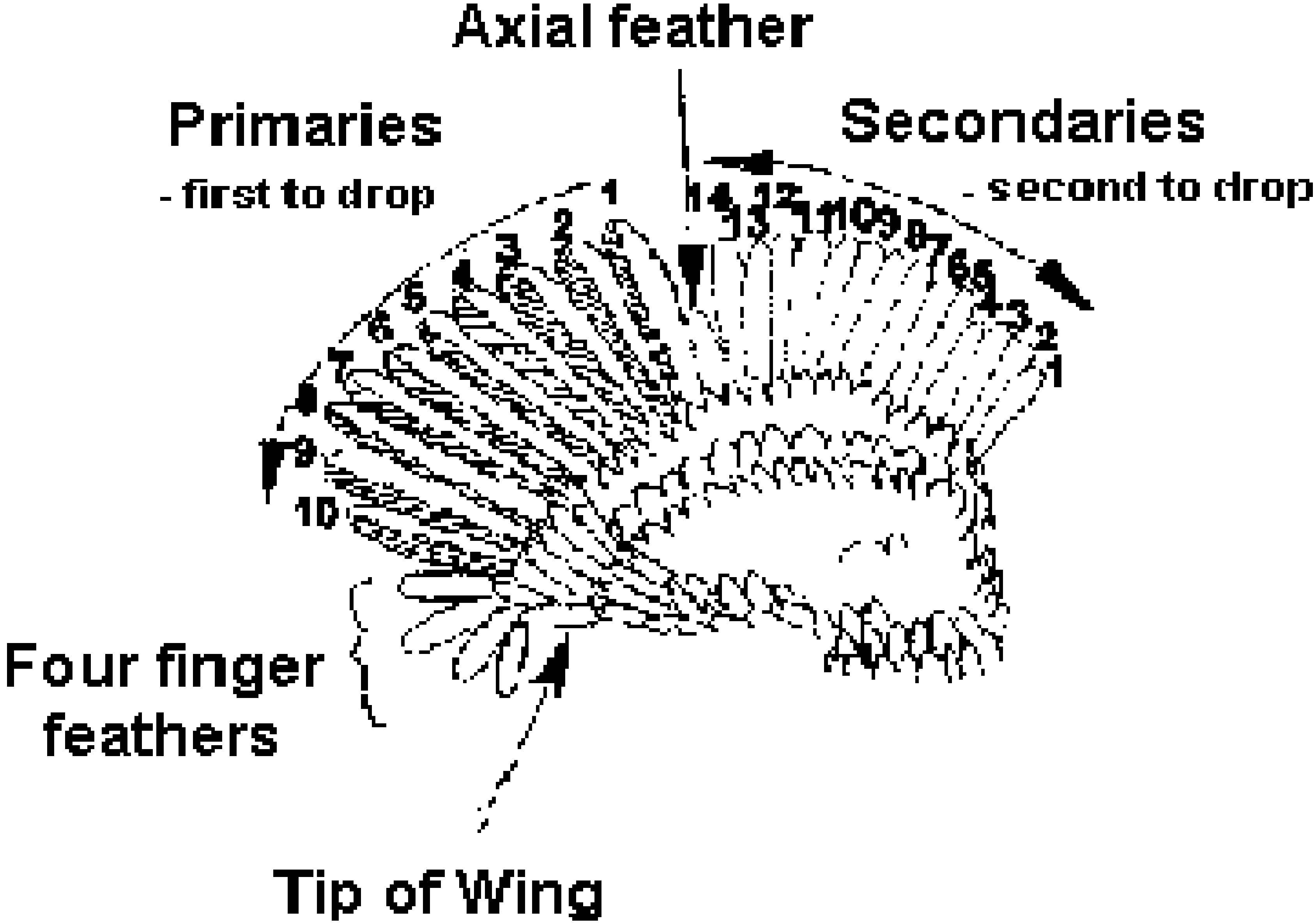
Abdominal Capacity

- Abdominal capacity of a hen is measured and expressed by ones fingers width.
  - Normal- 3 fingers width by 4 fingers width



Plumage and Rate of Molt

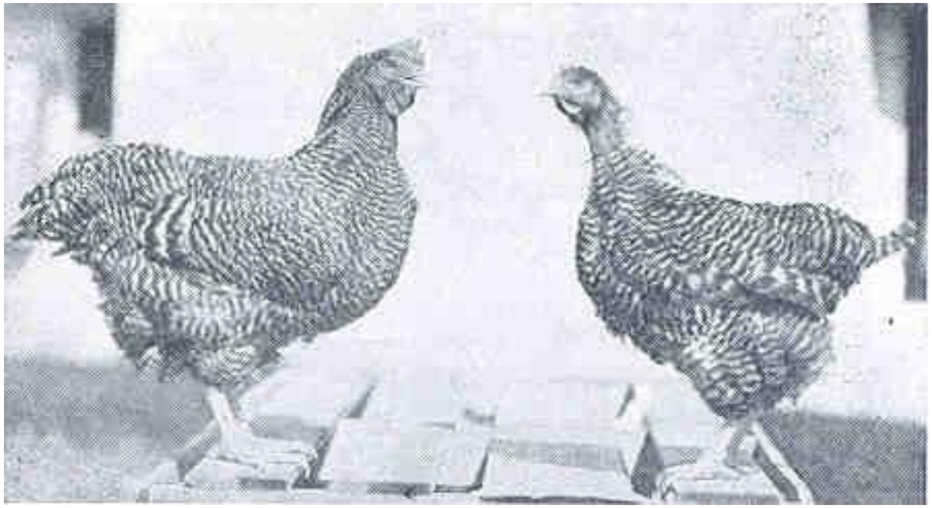
- Two factors considered in appraising the plumage of hens include condition (feather appearance) and molting rate (speed of shedding feathers)



Axial feather
Primaries
- first to drop
Secondaries
- second to drop
Four finger feathers
Tip of Wing

Vigor and Vitality

- A high producing hen appears vigorous, alert, and quick in movement
- Non-producing hen is sluggish

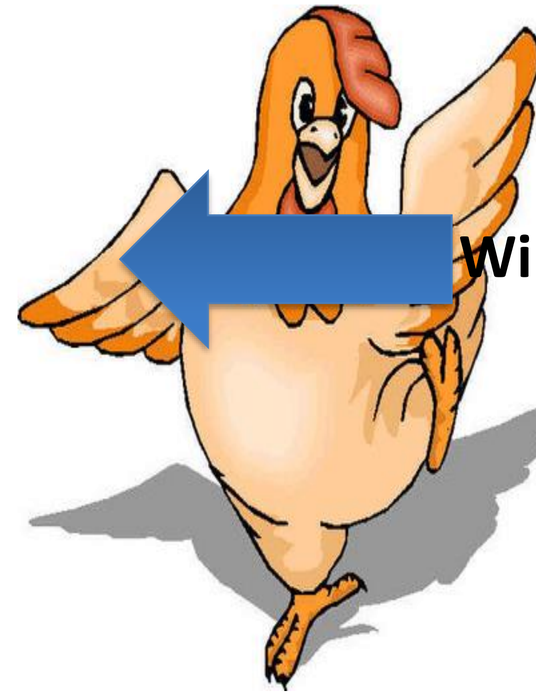


Head and Head Parts

- If not trimmed- a productive hen’s beak is short
  - The hens eyes are bright, alert and round.
  - Her skull is flat from side to side
  - Her comb and wattles are large, bright red, and glossy
  - They feel velvety soft and warm when touched.
- Non-producing hens beak is long
  - The hens eyes are dull, sleepy, and oblong.
  - Her skull is rounded from side to side
  - Her comb and wattles are shrunken and dull
  - They feel rough and cool when touched

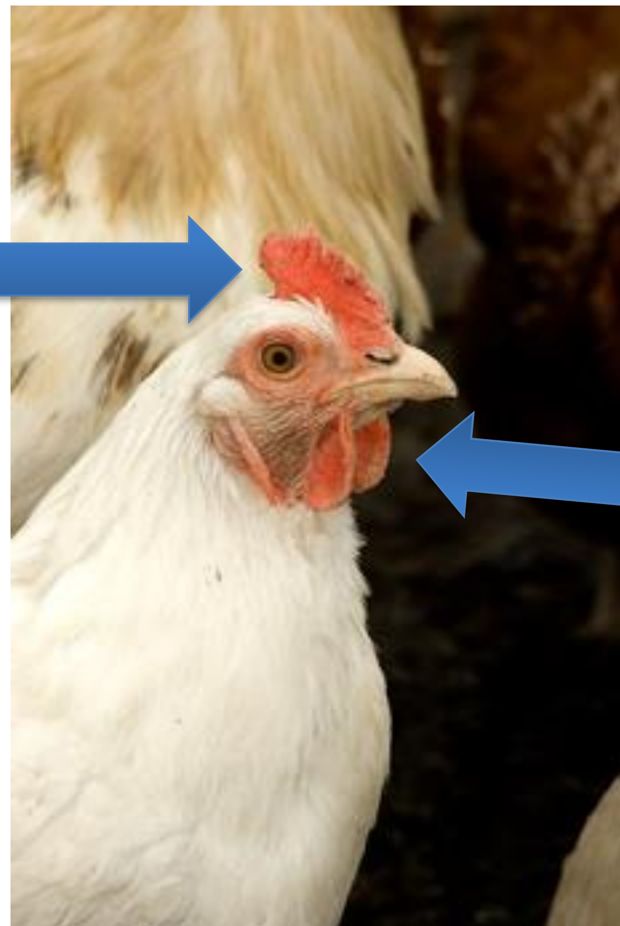
Parts of A Chicken

Comb and Wattles



Wing

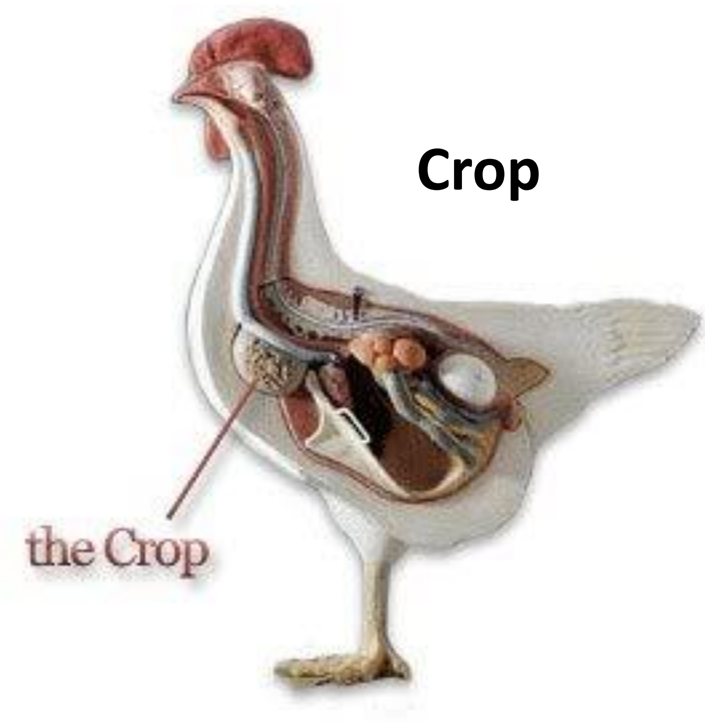
Comb



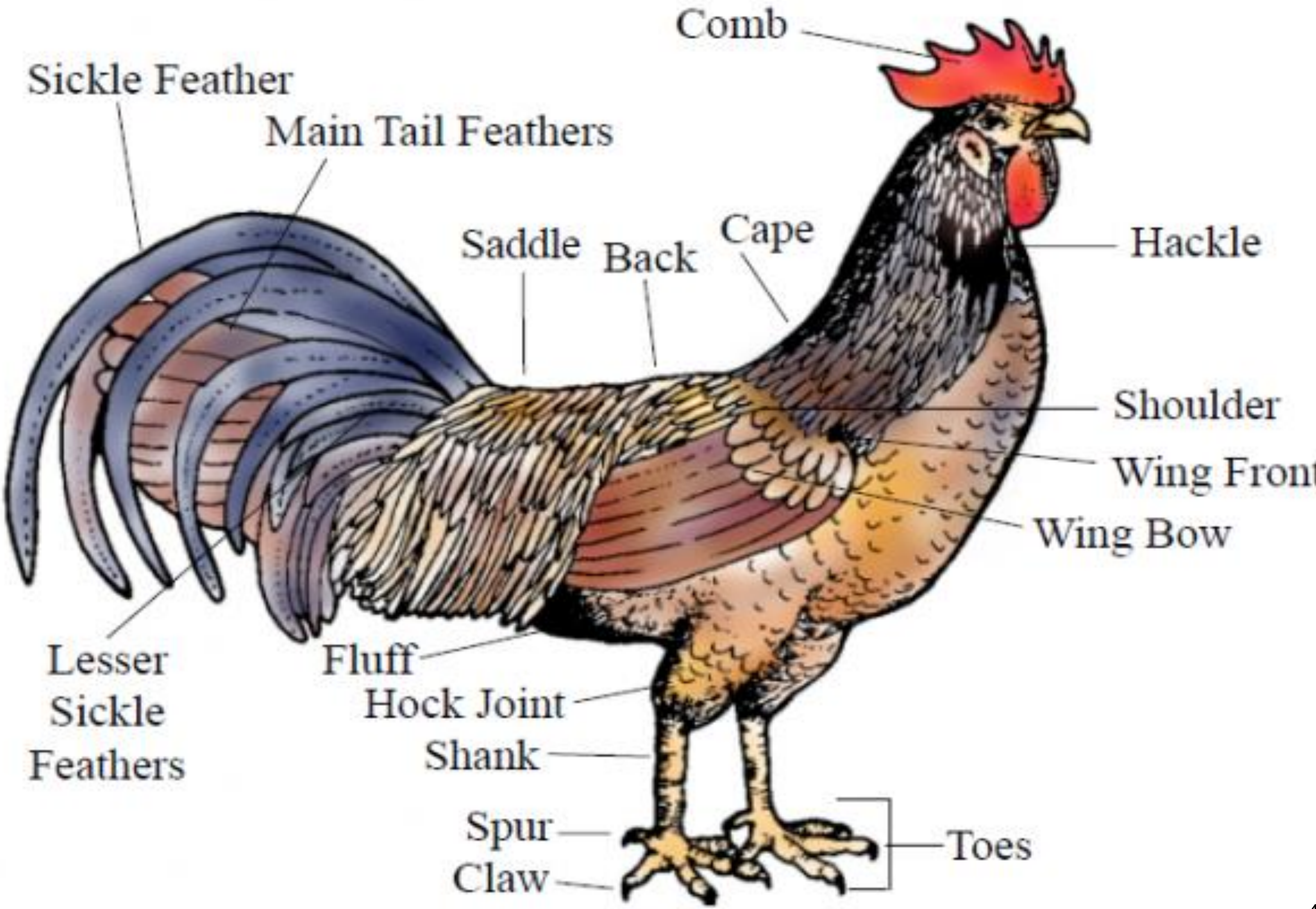
Wattles

Hock, Shank, And Feet

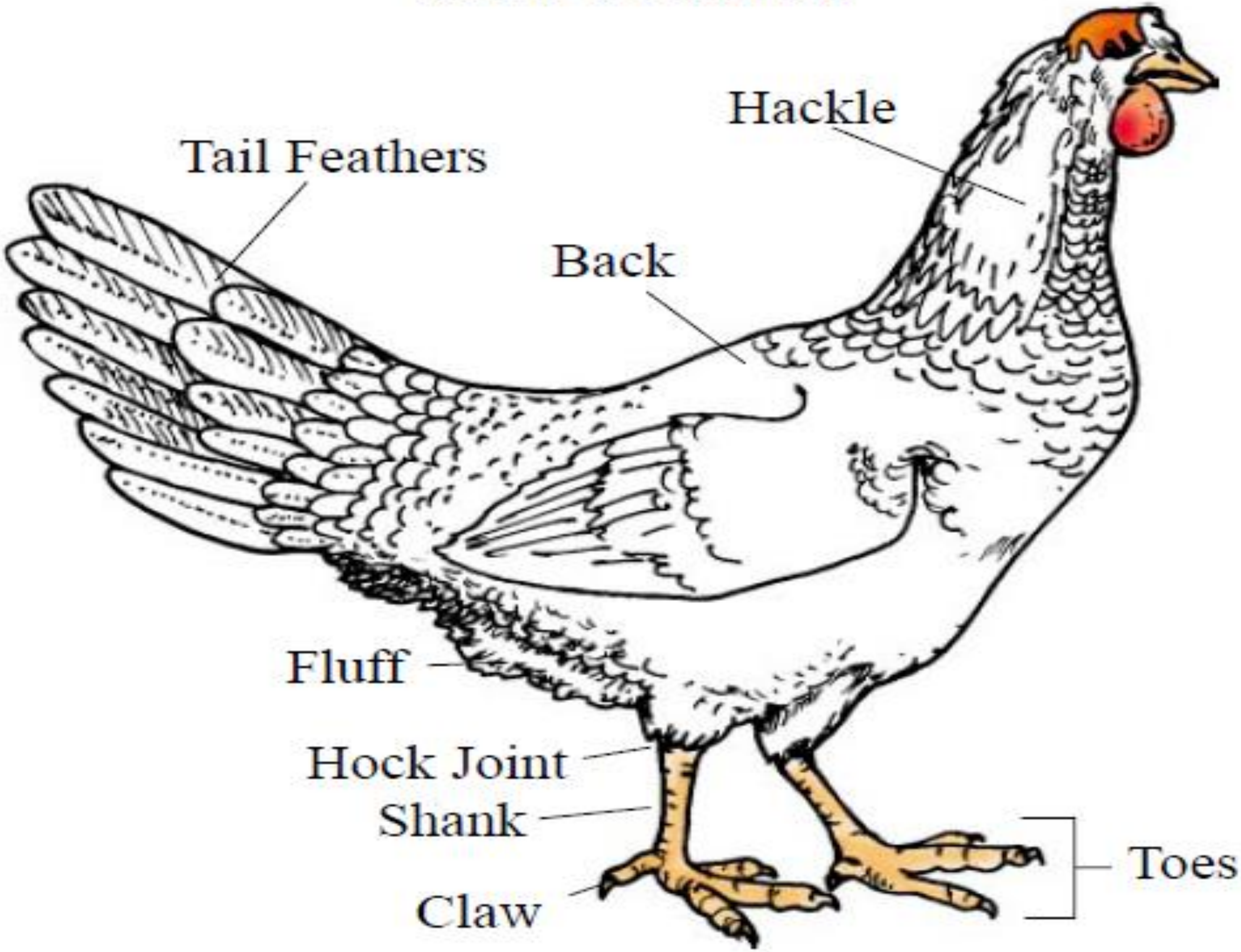
Crop and Vent



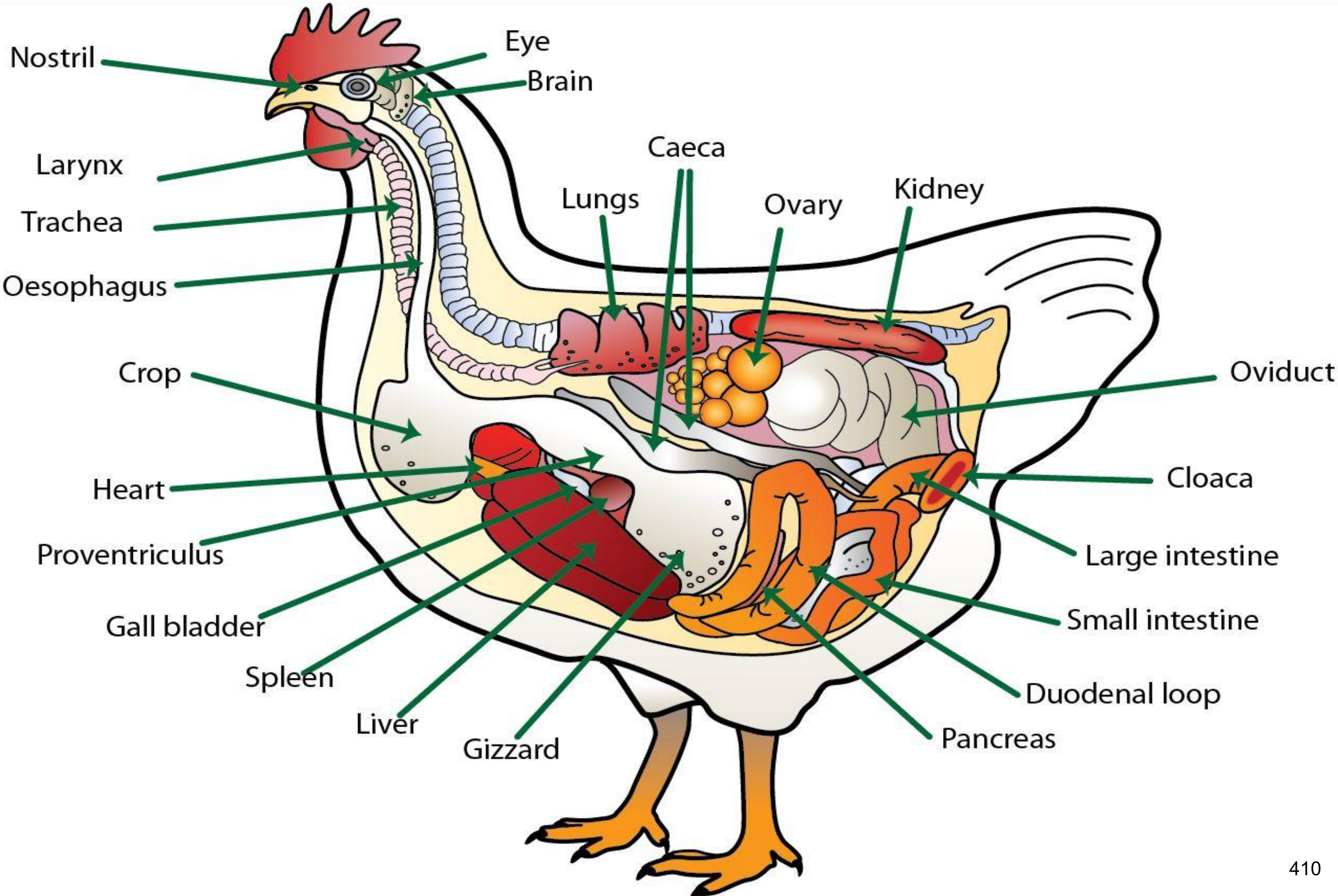
Parts of a Rooster



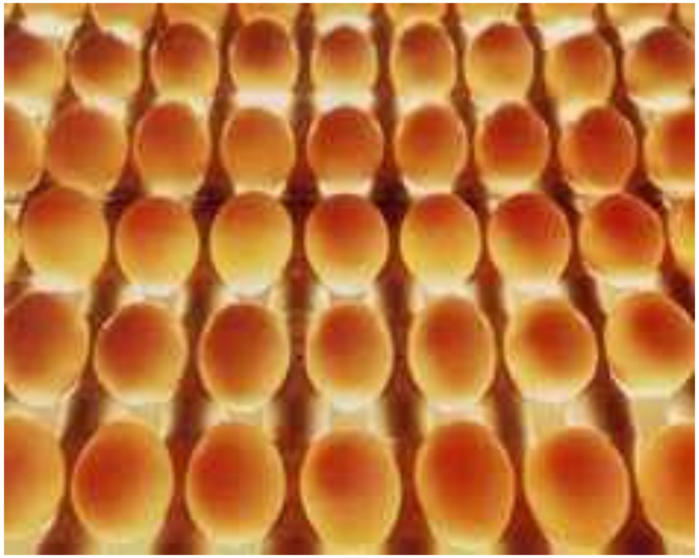
Parts of a Hen



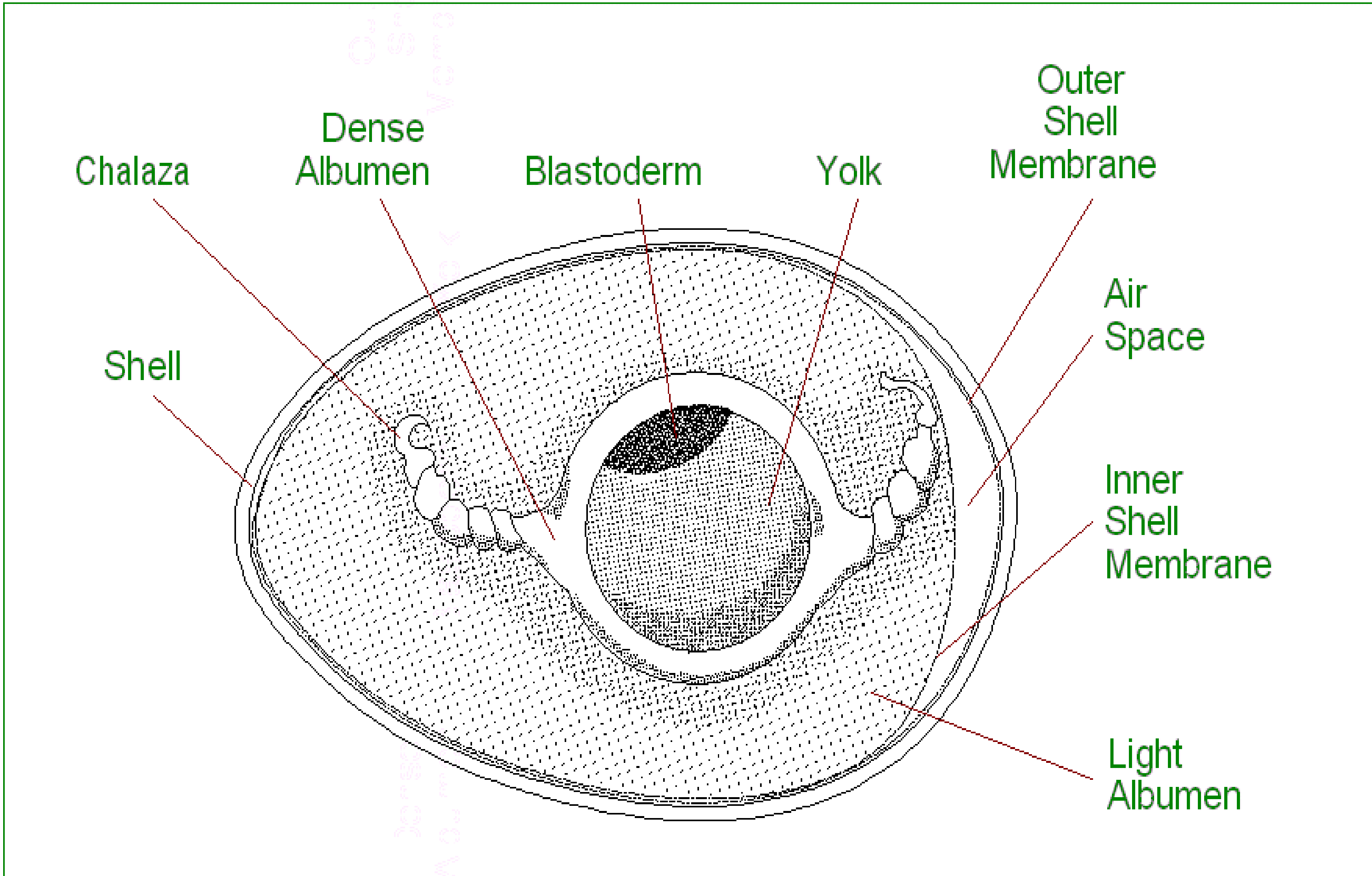
Body Parts of Chicken



Eggs



Egg and Its Parts



Candling Eggs

- Candling Demo
- What do we look for when we candle eggs?
  - Air Cell
  - Yolk
  - Cracks in shell
  - Blood spots and other foreign matter

Before We Candle Eggs

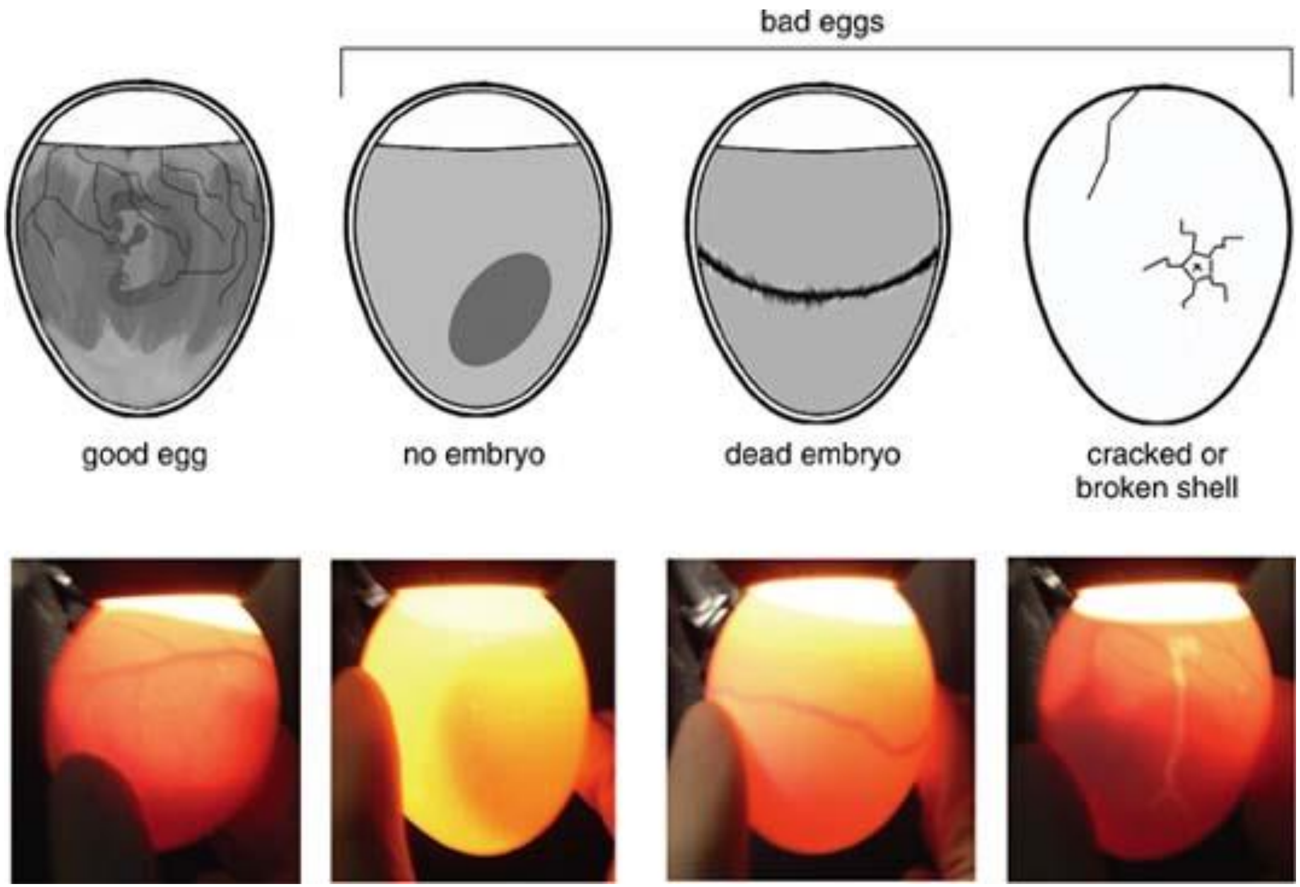
Air Cell

- Temperature- 105 degrees
- Is normally at the large end of the egg
- Quality Grades:
  - AA- up to 1/8”
  - A- 1/8”-3/16”
  - B- > 3/16”

Yolk

- Yolk size and shape
- Distinctness of yolk shadow outline
- Yolk defects and germ development

What Does Your Egg Look Like?



Processing Plant

- Here the birds are processed and packaged.
- After the birds have been processed they are weighed, and then either left whole or portioned.
- The meat is then packaged and labelled ready to be delivered to restaurants, shops and supermarkets.

POULTRY FEEDING

Following facts should be considered when computing ration for poultry:

1-Feed must contain all essential nutrients in right amounts & proportion required.

2-Different standards per age should be followed.

3-Palatability of the ingredients which used.

POULTRY FEEDING

4-Unlike ruminants, poultry completely depend upon the dietary sources for all nutrients (essential AAs., vit.B groups & vit.K).

5-Include agro-industrial by-products to minimize cost of the ration,

6-Optimum level of ingredient inclusion as many of ingredients have a deleterious effect at higher levels.

7-Optimum Ca:P ratio for different purposes.

POULTRY FEEDING

Nutrients requirements of poultry:

1-Energy requirement:

- Ration for poultry calculated on the basis of ME.
- Poultry eat to satisfy their energy needs when fed free choice, thus must control the intake of all nutrients by including them in a definite proportion to available energy level..

POULTRY FEEDING

- High energy cereal grains are the principal energy sources.
- Fat may be added at levels of 3-8% to increase dietary energy concentrations.

Factors affecting feed intake:

1-Energy levels in the ration:

$\uparrow$ energy level $\Rightarrow \downarrow$ feed intake

$\downarrow$ energy level $\Rightarrow \uparrow$ feed intake

POULTRY FEEDING

2-Environmental temperature:(SET, 16-24C)

$\uparrow$ Temp. $\Rightarrow \downarrow$ feed intake

$\downarrow$ Temp. $\Rightarrow \uparrow$ feed intake

3-Health of the bird

4-Genetics

5-Form of the feed

6-Nutritive balance of the diet

7-Stress

8-Body size

9-Rate of growth & egg production

POULTRY FEEDING

2- Protein requirement:

- The amount of protein required is proportional to the energy level in the ration.
- Poultry required the 14 essential AAs.
- $\uparrow$ Temp. $\Rightarrow \downarrow$ feed intake $\Rightarrow \uparrow$ protein req.

  $\downarrow$ Temp. $\Rightarrow \uparrow$ feed intake $\Rightarrow \downarrow$ protein req.
- Some AAs can met by other AAs:

  Cystine $\Rightarrow$ methionine, Tyrosine $\Rightarrow$ phenylalanine

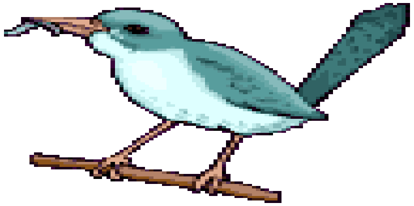
  Glysine $\Rightarrow$ Serine

POULTRY FEEDING

- Overheating or under heating during processing can affect the availability of some amino acids.

3- Mineral requirements:

- The major minerals needed in poultry diets are Ca, P, Na & Cl.
- Trace minerals may be added if feeds grown on soil deficient in them.



POULTRY FEEDING

A-Calcium & Phosphorus:

- The recommended ratio P:Ca in diet of poultry is 1:1.2 (range 1:1 to 1:1.5)

  For laying hen 1:4 (Ca important for bone & shell formation)
- $\uparrow$ Ca in diet $\Rightarrow$ $\downarrow$utilization of Mg, Mn & Zn.
- Inorganic P have a higher availability than organic P
- All P from animal origin & 40% from plant origin (wheat bran & rice bran) is available.

POULTRY FEEDING

B- Salt (NaCl):

- The amount added depend upon the feed ingredients.
- The recommended level in the ration 0.5-1% of the ration.
- Adult poultry can tolerate much higher inclusion but the water consumption increased.

POULTRY FEEDING

C- Manganese:

- Def. Of Mn cause perosis with slipped tendon.
- A free flowing Mn supplements should normally be included in all poultry feeds.
- Mn needed for egg production & hatchability.
- Mn carbonate, oxide, sulfate & commercial mineral mixture can be used.

POULTRY FEEDING

D- Iodine:

- Iodine included at rate of 0.5mg but when fish meal included at 5-10% no need iodine suppl.
- $\uparrow$ Ca & P in diet $\Rightarrow \uparrow$ iodine requirement

E- Magnesium:

- No Mg Suppl. Needed for poultry ration.
- $\uparrow$ Mg in diet $\Rightarrow$laxation

POULTRY FEEDING

4-Vitamin requirements:

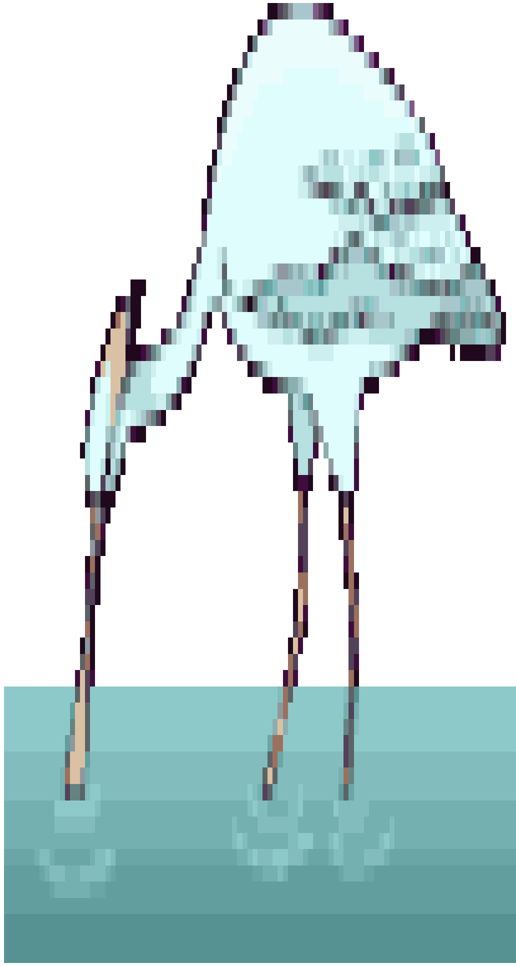
A- Vitamin A:

- Liberal supply of vit.A or carotene is needed for normal growth & health.
- Def. Symptoms: retardation of growth, emaciation, staggering gait & ruffled feathers, reduced immunity
- Sources: fish liver oils & other animal sources.

POULTRY FEEDING

B- Vitamin D:

- Vit.D required for bone formation, egg production, reproduction & prevention of rickets.
- Def. symptoms:poor growth, lameness & rickets.
- Poultry do not exposure to sunlight, ration must suppl. With vit.D.



POULTRY FEEDING

C- Vitamin E:

- Vit.E in vegetable is not readily available as in oil concentrates.
- Vit.E essential to prevent encyphalomalacia or crazy chick disease.

D- Vitamin K:

- Def. of vit. K $\Rightarrow$ delay clotting time of the blood & produce serious hemorrhage
- All mixtures should be suppl. With vit. K
- Treatment by sulfonamide $\Rightarrow \uparrow$ vit. K req.

POULTRY FEEDING

E- Riboflavin:

- Def. of vit.B2 ⇒curled-toe paralysis, dwarfism & degeneration of nerve trunks.
- Requirement: Broilers & breeder 4.4mg/kg

  Layers 2.5 mg/kg ration

F- Thiamin:

- Def. of thiamin ⇒ nerve deg., convulsion & heart abnormalities.

POULTRY FEEDING

G- Niacin:

- Def. of niacin $\Rightarrow$inflammation of tongue & mouth cavity (black tongue).
- Young chick required niacin more than adult due to less bacterial action synthesis.

H- Vit.B12:

- Animal proteins are good sources of vit.B12.
- Def. of vit.B12 $\Rightarrow$irritability, poor feathering & poor hatchability.

POULTRY FEEDING

Feeding space:

1 inch feeder space /chick for 2 weeks age & 2 inches after that.

Water:

- Bird drink about twice as much water by weight of feed consumed.
- Water consumption increase or decrease according to the environmental temperature.
- Some medications are administered in the drinking water.

FEEDING OF BROILERS

Age / Nutrients	Protein (%)	ME (Kcal/kg)
Starter ration (0-3weeks)	22-24	2800
Grower ration (3-5 weeks)	20-22	3000
Finisher ration (5-7 weeks)	18-20	3200

FEEDING OF BROILERS

$$\text{Feed conversion (FC)} = \frac{\text{Feed intake (g or kg)}}{\text{Weight gain (g or kg)}}$$

Feed conversion of broilers = 2.2

Factors affecting feed conversion:

1-Type of feed fed

2-Strain of the birds

3-Environmental temperature

FEEDING OF BROILERS

4-Age and weight of the birds

5-Diseases and condemnations

6-Rodent & flying bird control in feeding area

7-Antibiotics and medications $\Rightarrow$improve FC

8-Debeaking & size of baby chicks

9-Feed wastage

10-Form of the feed

FEEDING OF BROILERS

Broiler breeding pullets:

- Chickens bred for meat production grow rapidly & reach sexual maturity at early age $\Rightarrow$too many small egg & not good for hatching.
- Bird kept for breeding purposes, it is necessary to slow down their rate of growth & development of sexual maturity.

FEEDING OF BROILERS

Methods used:

1-Restricting feed intake to approximately 70% (when pullets at 7-9 weeks till 23 weeks),or

2-A skip –a-day program involves full feeding every other day, or

3-Feeding a diet containing 10% protein.

FEEDING OF BROILERS

Energy feeds:

- Grain, grain by-products and animal & vegetable fats and oils supply the most of energy in the poultry diets.
- Corn is the most common grain used in formulating poultry diets
- Other grains such as grain sorghum & wheat substituted part of corn
- Animal & vegetable fats added in limited amounts (5-10% of the diet)

FEEDING OF BROILERS

Protein supplements:

- Protein suppl. Added to provide the essential AAs.
- Several protein sources used to achieve a better balance of the needed AAs.
- Animal protein sources are more variable in their amino acids than plant protein
- AAs req. for poultry differ from that of other animals in that glycine & serine are dietary req. & required glycine for uric acid formation.

FEEDING OF BROILERS

A-Plant protein:

- Soybean meal is most commonly plant protein source & has a better balance of AAs than other plant protein (cottonseed meal, corn gluten meal, linseed meal).
- Cottonseed meal used in grower poultry ration to replace up to 50% of the soybean meal, while linseed meal not more than 3-5% of diet.

FEEDING OF BROILERS

B-Animal protein:

- The most commonly used are fish meal, meat by-products, milk by-products, blood meal, feather meal & poultry by-product meal.
- Fish meal have a good balance of AAs, but must not used in large amount (used at 2-5%) to avoid fishy flavor in eggs & poultry meat.

FEEDING OF BROILERS

Mineral supplements:

- Sources of Ca in poultry diets are ground oyster shell, limestone, bone meal, di-calcium phosphate.
- Inorganic P supplied by bone meal, di-calcium phosphate, rock phosphate.
- Na & Cl adding as common salt (0.5-1% of diet)
- Mn (Mn sulfate), Zn (Zn sulfate)

FEEDING OF BROILERS

Vitamin supplements:

- Natural feedstuffs provide some vitamins for poultry.
- Vitamin premixes are commonly used to provide the required vitamins in poultry.

FEEDING OF BROILERS

Feed preparation:

- Commercial feeds for poultry as mash, pellets or crumbles.
- Less wastage when using pellets or crumble and poultry grow faster and more commonly used for broilers and turkey than for laying hens (laying hen tend to become too fat unless they are on the restricted feeding program.

FEEDING OF LAYING HENS

Nutrient requirements of laying hens:

1-Energy requirement:

- For maintenance (2kg wt.) = 220 Kcal

  For 70% production = 130 Kcal

  For 1 g gain/day = 3 Kcal

- The usual energy conc. Is 2.8 Mcal ME/kg diet

↓ Energy conc. Than 2.3 Mcal ⇒↓energy intake & egg production

FEEDING OF LAYING HENS

2-Protein requirement:

- Laying hen receiving diet containing 3.1 Mcal ME/kg DM require 16.5% protein.
- To get maximum economic return from laying hen flock, a feed efficiency of 1.6-1.8 kg of feed per dozen of eggs produced is need.
- A laying ration should contain about 15% protein based on 2900 Kcal ME/kg of diet.

FEEDING OF LAYING HENS

Effect of environmental temperature:

- Small light body weight hens consumes:

  In Summer $\Rightarrow$90g feed (19% protein $\Rightarrow$

  17g protein/ hen/ day).

  In Winter $\Rightarrow$ 110g feed (15.5% protein $\Rightarrow$ 17g protein / hen / day)

FEEDING OF LAYING HENS

Essential AAs for laying hens:

- Leucine, isoleucine, lysine, methionine, tryptophan and arginine.
- Methionine is first limiting AAs for egg production.
- Mash for laying hens should contain not less than 3-4% animal protein supplement.
- Feather are high in sulfur amino acids (required methionine).

FEEDING OF LAYING HENS

Fat supplement:

- Fat addition $\Rightarrow \uparrow$ egg yield in winter
- Fat addition $\Rightarrow \downarrow$ amount of feed required / dozen eggs.

FEEDING OF LAYING HENS

3-Mineral requirements:

A-Calcium:

- Laying birds need large amounts of Ca because egg shells composed entirely of $CaCo3$

$\downarrow$ Ca in laying ration $\Rightarrow \downarrow$ egg production & egg shell weak.

- Bird stored Ca for about 10-14 days before the first egg was laid in the marrow of long bone.

FEEDING OF LAYING HENS

B-Phosphorus:

- Protein supplement used in poultry rations (mat meal, tankage, fish meal & dairy by-products) usually be sufficient in phosphorus.
- Plant protein supplement (SBOM) should supplement with P & Ca.
- Inorganic P is more available than phytate P.

FEEDING OF LAYING HENS

C-Manganese:

$\downarrow$ Ca in laying ration $\Rightarrow \downarrow$ egg production & egg shell weak & $\downarrow$ hatchability.

- ¼ lb Mn sulphate added to ton of mash fed without grain & ½ lb to mash fed with grain

D- Iodine:

$\downarrow$ Iodine in laying ration $\Rightarrow$ goiter

- Iodized salt must be used instead of common salt in the ration of poultry.

FEEDING OF LAYING HENS

E- Selenium:

$\downarrow$ Se in laying ration $\Rightarrow$Exudative diathesis

F- Zinc:

$\downarrow$ Zn in laying ration $\Rightarrow$skeletal abnormalities, ataxia, necrotic dermatitis & thin shell & hyperkeratinization of epidermis.

G- Salt:

- 0.5-1% of the total ration salt

FEEDING OF LAYING HENS

4-Vitamin requirements:

A-Vitamin A :

- Laying hens require higher content of vit.A in their feed in very hot weather than cold because they consume less feed.
- $\downarrow$ vit.A in laying ration $\Rightarrow$Nutritional roup (sticky materials from eye & nostrils)

FEEDING OF LAYING HENS

4-Vitamin requirements:

A-Vitamin A :

- Laying hens require higher content of vit.A in their feed in very hot weather than cold because they consume less feed.
- $\downarrow$ vit.A in laying ration $\Rightarrow$Nutritional roup (sticky materials from eye & nostrils)

FEEDING OF LAYING HENS

B-Vitamin D :

$\downarrow$ vit.D in laying ration $\Rightarrow$thin shell eggs, $\downarrow$ egg production & hatchability, breast bone become soft & bones of legs & wings become fragile.

C-Riboflavin & vit.E :

$\downarrow$ Riboflavin & vit.E in laying ration $\Rightarrow$low hatchability

FEEDING OF LAYING HENS

Phase-feeding of laying hens:

To adjust nutrient intake in accordance with the rate of egg production

A-Phase I (most critical period):

During 20 W period (22-42 W of age) pullet :

1-↑ egg production from zero to peak (85-90% production).

2- ↑ body weight from 1300 to 1900g.

3- ↑ egg size from 40g/egg at 22W to over 56g/egg at 42W of age

FEEDING OF LAYING HENS

B-Phase II :

- Period after 42W of age when the hens attained mature body weight
- The period ranged from 42-72W of age.

Effect of temp. on egg shell:

- Hot weather $\Rightarrow \uparrow$ respiration rate $\Rightarrow \uparrow$ Co2 loss $\Rightarrow \downarrow$ blood bicarbonate level $\Rightarrow \downarrow$ egg shell formation

FEEDING OF LAYING HENS

Stage of egg production:

- Egg production hen usually cover a period of 15 months
- Commences at 22W of age $\Rightarrow$ peak at 28-30W of age $\Rightarrow$gradually decline to 65% after 15 months of lay.
- $\uparrow$ lighted period $\Rightarrow$ $\uparrow$ feed intake & $\uparrow$ stimulation of pituitary gland $\Rightarrow$ $\uparrow$ egg laid

FEEDING OF LAYING HENS

Feeding systems:

1-Whole grain method

2-Grain & mash

3-All mash: fed at first 8W

4-Wet mash feeding (more palatable)

5-Pellets

- With grain fed must used insoluble grit
- Also fresh green feed is fed to poultry.

FEEDING OF LAYING HENS

Nutrition and egg quality:

A-Egg size (egg weight):

Factors affecting egg size:

1-Level of protein in diet:

- 14-20% CP rations ⇒balanced AAs ⇒heavier eggs
- The choice of protein level in layer diet depend on accurate evaluation of extra-cost for the additional protein compare with the income from larger eggs obtained.

FEEDING OF LAYING HENS

2-Energy intake

3-Mineral & vitamin levels:

- $\uparrow$ Ca & $\downarrow$ vit.D $\Rightarrow$ $\downarrow$ egg weight

4-Level of linoleic acid:

- Linoleic acid $\Rightarrow$ formation lipoprotein in liver $\Rightarrow$ ovary uptake by ova $\Rightarrow$ higher egg weight

5-Strain

FEEDING OF LAYING HENS

B-Shell quality:

- The quality of egg shells depend on the presence of adequate levels of vit.D_3 & certain minerals including Ca, P & Zn.
- Def. or imbalance of vit,D_3 , Ca & P $\Rightarrow \downarrow$ shell thickness & misshapen eggs $\Rightarrow \downarrow$ egg production
- $\downarrow$ Mn $\Rightarrow$ thin & brittle-shelled eggs
- The blood carbonate is the source of carbonate in the shell formation

FEEDING OF LAYING HENS

- Very hot weather $\Rightarrow$ poor quality egg shells
- End of laying period $\Rightarrow$falls egg shell quality due to failure in Ca metabolism & $\downarrow$ Ca of ration
- Sulphonamide drugs $\Rightarrow$thin shelled eggs
- Insecticides & fungicides in grains $\Rightarrow$malformed eggs
- Rancid cod liver oil in diet $\Rightarrow$rough shells
- Diseases $\Rightarrow$poor shell quality

FEEDING OF LAYING HENS

C-Internal egg quality:

- The nutritive content of the egg depends upon the level of these nutrients in the diet of laying hen
- Suitable iodine in diet $\Rightarrow \uparrow$ I content of eggs
- Def. of vit.B2 $\Rightarrow$slight yellowish-green tinge in albumin

FEEDING OF LAYING HENS

D-Yolk color:

- The color of egg yolk depend upon the presence of carotenoid pigment (xanthophylls) in the ration

(fresh & good dried green feeds & feed additives)

- When 30% yellow maize or 5% good quality alfalfa or up to 22mg xanthophyll/kg $\Rightarrow$ deep-yellow yolks
- Highly pigmented plants $\Rightarrow$undesirable colored yolks
- Large amount of untreated CSM $\Rightarrow$brown mottled yolk & pinkish tint of albumin
- Pimento pepper in diet $\Rightarrow$ orange-red yolks

FEEDING OF TURKEYS

- The general principles of feeding turkeys are similar to those for feeding broilers. Major differences are in the protein levels required and the importance of the vitamins biotin & pyridoxine in turkey diets
- Poults must be fed & watered as soon as possible after hatching & if feeding delayed beyond 36h after hatching ⇒difficulty learning to eat & drink.
- Vits. & minerals suppl. of the diet essential for good hatchability of turkey eggs.
- At 10-12W of age separate hens from toms

Period	Protein (%)	ME (Kcal/kg)
First 3 weeks	30-33	2930-3000
0-4 W	28	2930-3000
4-8W	26	2900
8-12W	20-22	3100
13-16W	19	3200
17-20 W	16	3275
21 W-market	13-14	3350
Laying hen	15-18	2925
Peak production	19	2755

FEEDING OF TURKEYS

Nutritional disorders of turkey:

1-Leg weakness disorders:

Cause: def. of Ca, P, vit.D, choline, biotine, folic acid, Mn & zinc.

2-Enlargment of hock joint:

Cause: def. Of niacin, biotin, vit.E & zinc.

3-Footpad dermatitis:

Cause: biotin deficiency

Symptoms: sticky droppings adhere to the feet & cause dermatitis

FEEDING OF TURKEYS

4-Pendulous crop:

Cause:yeast proliferation in crop

Symptoms:gas production from fermentation of carbohydrate $\Rightarrow$interfere with passage of ingesta from crops to proventriculus $\Rightarrow$pendulous crop

Treatment: fungal inhibiting antibiotics

5-Ascitis:

Cause: high salt intake $\Rightarrow$fluid accumulation in body cavities

FEEDING OF TURKEYS

6-Exudative diathesis:

Cause: Selenium deficiency

7-Aflatoxicosis:

- Aflatoxin affect the immune system $\Rightarrow$increase susceptibility to disease
- Mycotoxin $\Rightarrow$hemorrhage may bluish the carcass

FEEDING OF DUCKS & GEESE

- Commercial feeds in mash, pelleted or crumbles form available for ducks & geese
- If a commercial feed for ducks & geese is not available, chicken feed may be used (not contain coccidiostat)
- Geese will start to eat pasture when they are only few days old & feed additional grain if pasture is not of good quality.

FEEDING OF GEESE

Period	Protein (%)	ME (Kcal/Kg diet)
0-4 W (starter)	20	2900
After 4 W (grower)	15	3000
Breeding	15	2900

FEEDING OF DUCKS

Period	Protein (%)	ME (Kcal/Kg diet)
0-2 W (starter)	22	2900
2-7 W (grower)	16	3000
Breeding	15-18	2900

Biosecurity for poultry

Disease Prevention

- There are basically 2 types of diseases that must be considered in poultry production:
  - diseases of detriment to bird health
  - diseases of potential human health concerns

Causes of Health Issues

- Pathogens
  - bacteria, viruses, parasites, protozoa, fungi
- Nutritional deficiencies
- Chemical poisons
- Overmedication
- Poor management

Biosecurity

What is "Biosecurity"?

- Protecting your birds from disease
- Preventing or controlling disease transmission by vectors

What is a vector?

- Something that may transmit a disease
- Rodents, birds, insects, shoes, car tires, shared equipment, best friend, pet, feed, water, dust, air….

Biosecurity

- Preventative strategies to control disease causing organisms and their carriers (vectors).
- Protection of poultry flocks from any type of infectious agent.
- Control transmission of disease from flock to flock.

Biosecurity is the cheapest, most effective means of disease control available.

Who should practice good biosecurity?

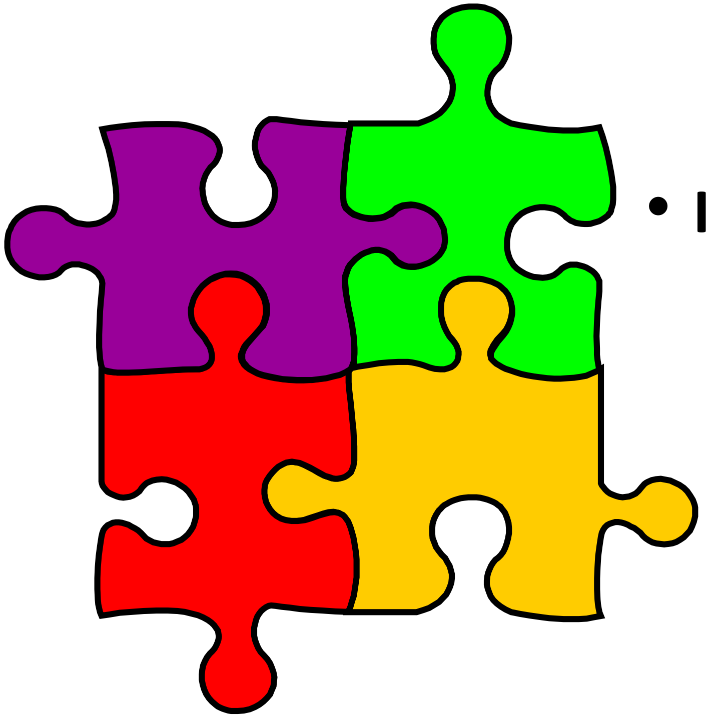
- Everyone!
  - Commercial producers
  - Small flock/backyard poultry owners
  - Hobbyists/breeders
  - Youth poultry project owners for livestock shows (4-H and FFA members)

Why should I be concerned about biosecurity?

- Because of what might happen:
  - Disease and high mortality in flocks
  - Infected flocks euthanized
  - Loss of income for producers
  - Higher prices of poultry meat and eggs
  - Quarantines and restricted movement/sale of birds
  - Cancellation of poultry shows

Major Components OF Biosecurity

- **Flock Management**
- **Isolation**
- **Traffic Control**
- **Cleaning/ Sanitation**



Biosecurity Monitoring Points

- Humans
- Equipment
- Environment
- Animals
- Contaminated eggs and chicks
- Contaminated feed

Environmental Routes of Disease Transmission

- Environmental contaminants:
  – wind
  – water
  – dust
  – feathers
  – manure
- Drying and sunlight are very effective at killing many disease causing organisms.

Good Biosecurity Practices

- Keep pets, wild birds and animals and other livestock away from the flock
- No trading or purchase of untested birds – quarantine new birds
- Use dedicated footwear/clothing or disposable coveralls and boot covers when checking your birds
- Hand washing before and after handling birds, manure, coops, eggs, etc.

Isolation Measures

- Confine flocks to controlled environment
- Screen houses to protect flock from wild birds
- Avoid contact with migratory waterfowl and other birds
- Restrict visitors
- Do not share equipment, coops or leftover feed

Reduce exposure Risks

- Control vector habitat and attractants
  - birds
  - rodents
  - varmints
  - insects

- Make sure pen is animal and bird proof

Maintenance Flock health

- Minimize stressors to prevent increased susceptibility to disease
  - Fresh feed
  - Clean water
  - Clean, dry litter
  - Good ventilation
  - Provide an overall comfortable environment

Cleaning and Sanitation

Five steps to cleaning and disinfection (C&D)

1. Dry Clean (remove all organic matter)
2. Soap
3. Rinse
4. Dry
5. Disinfect

Disease/Health Checks

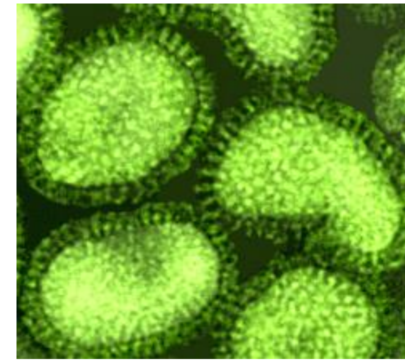
- Watch for symptoms such as:
  - Coughing, sneezing, watery eyes, ruffled feathers, loss of feathers, excessive picking, labored breathing and sudden drops in production and feed or water consumption
- Eliminate unhealthy or nonproductive birds
- Check birds periodically for lice, mites, and worms

COMMON DISEASE IN POULTRY FARMING

What is disease

Any condition that results in deviation from normal function

AGENT



How do diseases occur?

HOST

ENVIRONMENT

ETIOLOGY

Infectious Agents

- Bacteria
- Viruses
- Parasites
- Fungi

Non-infectious agents

- Chemical
- Physical
- Lack or excess of certain vitamins and minerals
- Toxins

General Signs of Disease

- Poor appetite
- Huddling
- Depression
- Runting/stunting
- poor uniformity
- Ruffled feathers
- Coughing, sneezing,
- oculo-nasal discharge,
- difficult breathing
- Bloody or wet litter
- Increased mortality

VIRAL DISEASES

FOWL POX

- Viral disease of domestic fowl
- development of nodular proliferative Skin lesions on the featherless parts of the body.
- fibrino necrotic and proliferative lesions in the mucous membranes

- Family: Pox viridae
- Genus: avipoxvirus
- Double stranded DNA

CLINICAL SIGNS

- Appearance of nodular lesions
- combs
- wattles
- eyelids
- other unfeathered areas of the body.

PREVENTION AND CONTROL

- Prophylactic vaccination
- Fowl pox vaccine at 4-6 weeks of age
- Second dose at 12-14 weeks of age.

RANIKHET DISEASE

- New castle disease
- Viral disease of domestic fowl is characterized by
- respiratory signs
- often associated with nervous and digestive disorders
- high mortality.

ETIOLOGY

- Paramyxoviridae
- Paromyxovirus-1

CLINICAL SIGNS

Opisthotonus

- Listlessness
- Increased respiration
- Weakness
- Edema around the eyes
- Torticolis
- Paralysis of legs

Prevention and control

- Prophylactic vaccination
- Lentogenic strain (F or B1)
- day old chicks
- intranasal
- intraocular route
- drinking water.
- Mesogenic strain (R2B)
- 6-8 weeks of age
- intramuscular
- Subcutaneous route.

BACTERIAL DISEASES

INFECTIOUS CORYZA

- FOWL CORYZA
- Highly contagious
- acute disease of upper respiratory tract of chickens,
- turns into a chronic respiratory disease.

ETIOLOGY

- *Haemophilus paragallinarum*
- Small cocoid or gram negative rod
- Non motile
- Exhibits bipolar staining

CLINICAL SIGNS

- Serous to mucoid nasal discharges with foul smelling
- Facial edema
- Conjunctivitis
- Swollen wattles
- Diarrhea
- Reduced feed and water consumption.

Treatment and control

- Gentamicin
- Penicillin
- streptomycin
- delivered in feed or drinking water.
- Proper Disinfection

BACILLARY WHITE DIARRHEA

- PULLORUM DISEASE
- Fatal septicemia of young chicks .
- *Salmonella pullorum*

CLINICAL SIGNS

- Somnolecence
- Weakness
- Loss of appetite
- Chalky white diarrhea
- Stained greenish brown(sometimes) in and around vent

TREATMENT

- Enrofloxacin
- Parenteral injections
- Oral liquids
- Supportive therapy

BUMBLE FOOT

PODODERMATITIS

Injury to the lower

surface of the foot and

subsequent infection with

Staphylococcus bacteria

Common causes of injury:

- Rough perches
- Splinters
- Wire floors
- Poor litter or bedding
- quality

CLINICAL SIGNS

- Lameness
- Swelling of the foot pad
- Hard, pus-filled abscess on foot pad

TREATMENT

- Soak foot in warm water and Epsom salts.
- disinfect with alcohol.
- If skin is open, drain pus from abscess.
- Flush abscess cavity with hydrogen peroxide to cleanout pus and debris.
- Pack the cavity with antibiotic ointment .
- wrap the foot with gauze and elastic bandage.
- Repeat daily until foot heals.

PREVENTION AND CONTROL

- Provide good quality litter or bedding.
- Keep bedding clean, dry, and deep.
- Keep perches less than 18 inches from the floor to prevent foot damage due to impact from jumping.
- Remove potential sources of injury such as sharp objects and/or surfaces.

DEFECIENCY DISEASES

CURLED TOE PARALYSIS

- Deficiency of Riboflavin
- Poor growth
- Weakness
- Emaciation and diarrhea
- unable to walk as their toes are turned inwards
- Drooping of wings

TREATMENT

- Riboflavin @3.6 mg/kg of feed in chicks
- Riboflavin @ 1.8 mg/kg of feed in growers
- Riboflavin @ 2.2mg/kg of feed in layers

Animal Science and Livestock Production

What is Animal Science?

- Refers to the total store of knowledge relative to the breeding, feeding, care and management of animals and the marketing and processing of animals and their products as gained through practical experience and research methods.

Animal Use as Food

- Meat – Beef, Pork, Lamb, Goat Poultry
- Milk – Cheese, Ice Cream, Yogurt
- Eggs – Pastries, Mayonnaise, Custards

Animal By-Products

- Bones – Button, glue, mineral supplement for livestock feed (Ca)
- Fat – Chemicals, salves, creams, dressings, lubricants, soaps, food
- Glands – Medicines, food additives
- Collagen – Glue, Gelatin
- Intestinal & Stomach tissue – lunch meats, surgical sutures, strings for musical and sports instruments
- Fertilizer

Animal Use as Work

- Cultivate land
- Transportation
- Control other animals (herding)
- Assist physically & Medically handicapped
  - Blind
  - Epileptic & Diabetic

Other Animal Uses

- Hides – Leather
- Hair – Wool, mohair, fiber
- Lab Animals – Mice, rats, guinea pigs etc.
- Pets

Livestock Enterprises and Management

- Numerous livestock enterprises
  - Traditional
  - Exotic
  - Purebred/Crossbred
  - Recreational

Species

- Cattle, Horses
- Sheep, Goats, Swine
- Poultry, Rabbits

- Different Space Requirements
- Different Nutrition and Management
- Many co-exist well

Dairy Farming

Basic Principles of Dairy Farming

Birth and Puberty

- A female calve (destined for dairying) weigh approx 40kg at birth.
- If reared correctly, she should reach puberty at 1 year, weighing 250kg.

Oestrous Cycle

- The length of the oestrous cycle of a cow is 21 days and it lasts an average of 18 hours.
- The gestation period of the dairy cow is 283 days (approx 9.5 months)

Basic Principles of Dairy Farming

- Lactation
- A cow commences producing milk as soon as she has a calf.
- If the cow is used to suckle calves, then she may continue to produce milk for up to 2 years.
- If she becomes pregnant (in-calf) she will go dry two months before calving.
- In commercial milk production, the aim is have the cow calve once a year, around the same time each year.
- This means that she will me milking 10 months of the year or approx 305 days.

Basic Principles of Dairy Farming

- Lactation Yields
- The milk yield of the cow depends on the breed.
- Holstein: 5800kg per year
- Jersey: 3400kg per year
- Ayreshire: 4000kg per year
- Friesian: 5000kg per year.
- Dairy Shorthorn: 4000kg per year.
- These vary significantly even amongst individual cows – A Friesian may vary from 2000kg a year to 12000kg of milk a year.
- These yields have also increases over the last number of years due to better selection of breeds.

Basic Principles of Dairy Farming

- Lactation Yields also vary with a cows age:

Age	Lactation No	% Of Max Yield
2	1	75
3	2	85
4	3	90
5	4	95
6	5	100

- **The yield of the average dairy cow decreases after the 5th Lactation.**

Basic Principles of Dairy Farming

Frequency of Milking

- Milking empties the udder of the cow, which stimulates milk-secreting alveoli to commence producing milk.
- Frequently milked cows produce more milk than those milked irregularly.
- Therefore a cow milked four times a day will produce more milk than a cow milked twice – it will work to demand.

Basic Principles of Dairy Farming

- BUT milking more than twice a day is uneconomical and leaves cows more prone to disease such as mastitis.
- With milking twice daily, the ideal milking interval is 12 hours. This gives the cow less stress and will get the highest yields.
- But this gives the farmer a very long working day and is uncommon. The most common intervals are 14/10 or 13/11 hour intervals.

Basic Principles of Dairy Farming

- The average milk **composition** is as follows:

Milk

- Total Milk Solids 12.5%
  - Fat 3.8%
  - Solids Non Fat (SNF) 8.7%
    - Lactose 4.6%
    - Protein (Casien) 3.1%
    - N Protein 0.2%
    - Vitamins & Minerals 0.8%
- Water 87.5%

Basic Principles of Dairy Farming

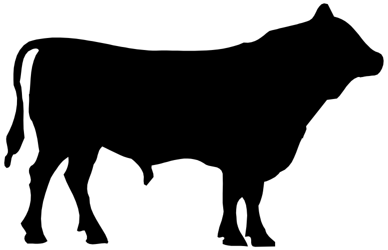
- Milk used for bottling or drinking must by law contain 3.6% fat and 8.5% SNF.
- Creameries buy milk in many different ways – sometimes at a flat rate per kg.
- Sometimes, however, it may be by percentage butterfat or protein.
- Milk composition varies also amongst different breeds.
- The milk of the Jersey cow has the highest butterfat and SNF content of any cow.
- Also the composition of milk varies during milking.
- The milk at the start may only contain 1% fat, while the milk at the end (“The Stripping”) may contain 10% fat.

Basic Principles of Dairy Farming

- Hygiene and Milk Quality
- Dirty milk (containing dirt, bacteria or antibiotics) can cause serious problems when processing.
- Dirty milk is caused by unhygienic milking machines or poor milk filters.
- Antibiotics are found in milk as residues from treatments to cows for mastitis.
- When milk is found to be not up to standard, it may be rejected by the creamery or bought at a lower price.

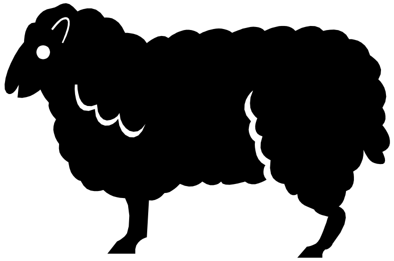
Beef Farming

- Great for the Part-time
- Labor and facilities can be low cost
- Land is required 1-5 acres per animal
- Returns can be low and seasonal
- Enterprises
  - Freezer beef, feeders, purebred, contract heifers



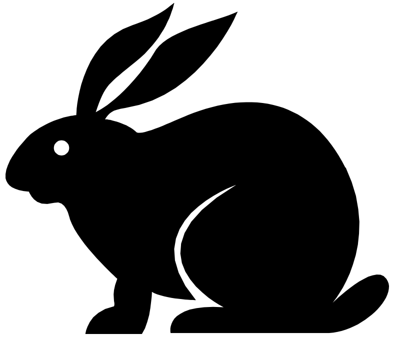
Sheep Farming

- Low initial investment
- Low labor – expect when lambing
- Little investment
- Meat/Wool
- Not a huge market



Rabbit Farming

- Small acreage requirements
- Minimal cash outlay
- Small market – mostly pets and show



Livestock Selection

- Profitability of any individual animal or of a herd or flock of animals is determined by
  - Type or individuality based on the ability to produce high-quality products for a tough market
  - Performance or efficiency of production which is the ability to utilize feed efficiently, in producing meat, milk, wool or power.

Bases of Selection

- Selection based on
  - Type and individuality
  - Pedigree
  - Show-ring winnings
  - Production testing

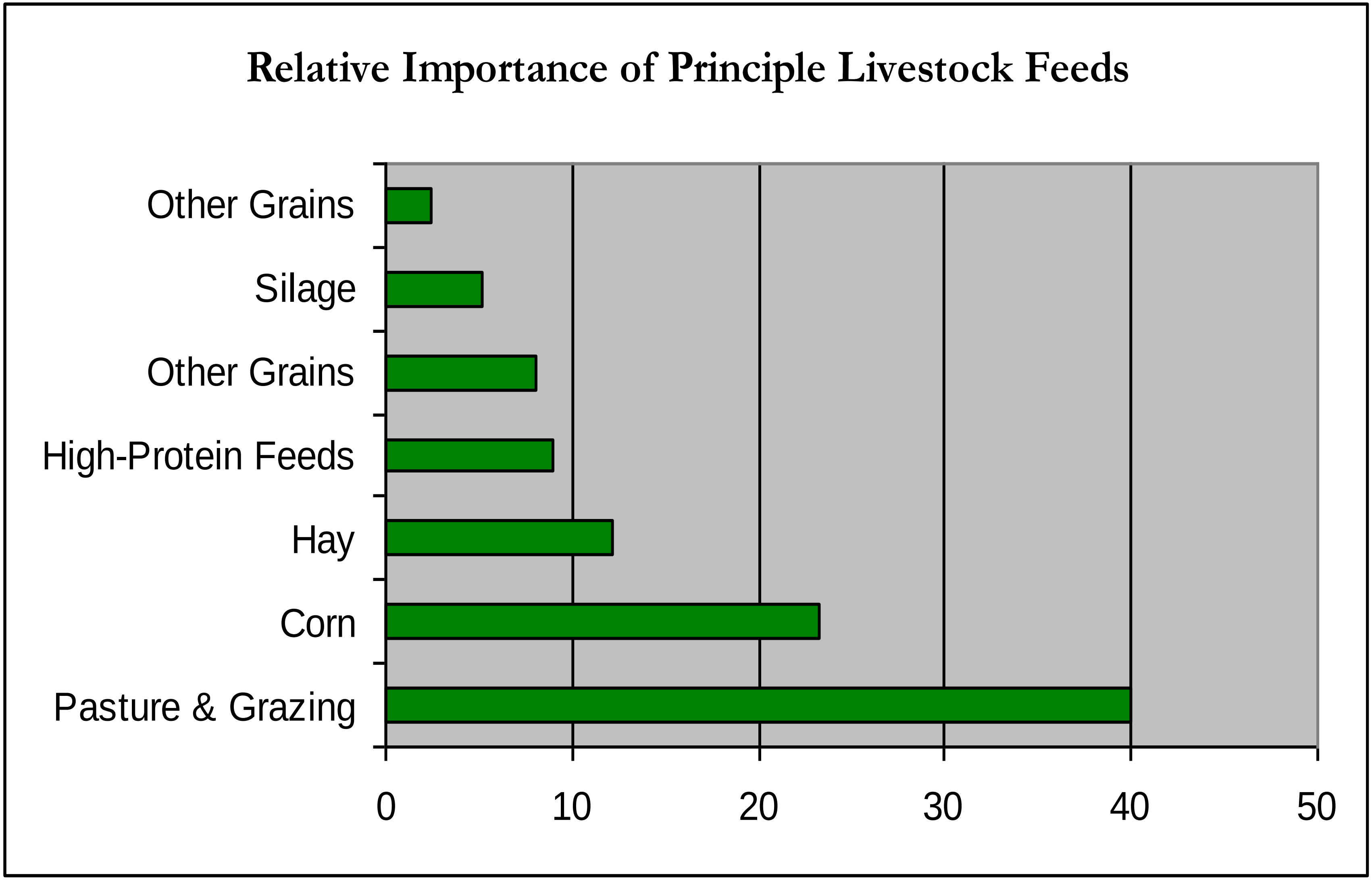
Bases of Selection

- Type or individuality
  - Selecting those animals that most closely approach an ideal or standard of perfection and culling out those that fall short.
- Pedigree
  - Used in most purebred operations
  - Based on performance of ancestors

Bases of Selection

- Show ring winnings
  - Implies the animals that have placed well in one or more shows are superior.
- Production
  - Generally look at economics such as body type and feed utilization
  - Performance testing, progeny testing

Feeding Livestock



Feed Quality

- Quality of feed affects its value for animal nutrition.
- Quality factors include palatability and nutrient content.
- Palatability refers to how well the animal will accept feed.
- Improper harvesting or handling will reduce quality.

Feed Quality

- If an animal does not find a feed palatable it will not eat enough, make good gains, grow properly or produce meat, milk or eggs.
- Feeds on produced on well fertilized soils will produce feed, especially roughages, that is of a higher quality.
- Vitamins, amino acid content and minerals will also be affected by soil type.

Digestion

- Monogastric (simple stomach)
  - Pig, Dog, Human
- Avain (poultry) – Gizard
  - Chicken, Turkey, Duck
- Polygastric (ruminants)
  - Cow, Sheep, Goat
- Pseudo-ruminants (cecum)
  - Horse, Rabbits, Hamster

Feeding Goals

- Maintenance
- Growth
- Finishing
- Reproduction
- Work
- Age

What is Proper Animal Nutrition?

- The process by which animals eat and use food.

- Proper animal Nutrition

  1. Increases feed efficiency

  2. Increase Rate of Gain

A Nutrient is:

- A substance that is necessary for an organism to live and grow
- Nutrients make it possible for animals to carry out life processes.

- Nutrients are provided to animals through?

  1. Feed Stuff

     (Feed & Water)

Nutrient Needs of Animals

- 6 Essential Nutrients

  1. Water
  2. Carbohydrates
  3. Fats
  4. Proteins
  5. Minerals
  6. Vitamins

Nutritive Needs

- Energy
  - Carbohydrates, Fats
- Protein
- Mineral
  - Macro
    - Salt, Calcium, Phosphorous, Magnesium, Potassium, Sulfur
  - Micro
    - Chromium, Cobalt, Copper, Fluorine, Iodine, Iron, Manganese etc.
- Vitamin

Nutritive Needs

- Most Important
  - WATER
- Roughages (Forages)
  - Bulk feeds that are low in weight per unit of volume, >18% curde fiber, low energy
  - Hay
  - Pasture
  - Silage
  - Crop Residues

Why are some animals fed roughages and others concentrates?

- Types of digestive systems

  I. Non- Ruminants

  1. Mono-gastric – has one stomach
  2. Avian – has a crop & gizzard
  3. Pseudo–Ruminants

Ruminants

- Have 4 compartments or stomachs

  Ex Sheep, Cattle

Digestion -the mechanical and chemical breakdown of feed into a form which can be absorbed into the blood.

Ration

- The total amount of feed an animal has in a 24 hr period

- Balanced Ration

  \- Contains all the nutrients that the animal needs in the *correct proportions*

Water

- Necessary for an animal to live
- Animal can liver longer without food than water
- Water makes up 75% of the weight of an animals body.
- Basic functions of water

1. Regulate body functions
2. Promoting biochemical process

Carbohydrates

- They provide Energy
- Should make up 75% of an animals diet
- Types of Carbohydrates
  1. Sugars
  2. Starches
  3. Fiber

Sources of Carbohydrates

- Cereal Grains

1. Corn
2. Wheat
3. Barley
4. Oats
5. Hay
4. Rye

Lipids

- Fat is a good source of energy
- Fats have 2.25 times more energy than carbohydrates

Protein

- Needed for

  Grow new tissue and repair old tissue.

- Highest amount found it muscles

Proteins contain

A. Amino Acids

Building blocks of proteins

B. 23 Amino Acids (10 are essential)

Sources of Protein

- 6 common sources

  1. Soybean Meal
  2. Cotton Seed Meal
  3. Fish Meal
  4. Tankage
  5. Skim Milk
  6. Alfalfa

- Protein is the most common **Nutrient Deficiency**

Minerals

- Macro-minerals-Calcium, phosphorous
- Micro-minerals
- Essential for

  1.Skeletal growth

  2. Body systems to function properly

Common sources

Alfalfa Hay, Cereal Gains, Bone Meal, Molasses, Salt

Vitamins

- Functions

  1. Help regulate body functions
  2. Keep body health
  3. Develop resistance to Disease

Types of Vitamins

1. Fat Soluble

    - Vitamin A, D, E, K

2. Water Soluble

    - Vitamin C & B

Feedstuffs Used in Livestock Diets

- Feed Classes
  - 8 classes grouped by origin and like characteristics
  - Dry Forages & Roughages
    - All feeds that are cut and cured
    - All feeds w/ CF>18%
    - Usually low in NE
    - Carbonaceous Roughages
      - Generally low in protein
      - Straw

Feedstuffs Used in Livestock Diets

    - Stalks
    - Weathered grass
  - Proteinaceous Roughages
    - Legume hays
    - Some grass hays
    - Legume/grass mixtures
- Pasture, Range Plants, & Fresh Fed Forages
  - Pasture grass
  - Anything that is not allowed to ferment before feeding

Feedstuffs Used in Livestock Diets

– Silages
  - Ensiled forages
  - Carbonaceous
    - Corn silage
    - Grass silage
  - Proteinaceous
    - Alfalfa silage
    - Clover silage

Feedstuffs Used in Livestock Diets

- Energy Feeds
  - <20% CP, <18% CF
  - May be ensiled
  - Carbonaceous Concentrates
    - All cereal grains & sorghums
    - Byproduct feeds
      - Bran
      - Middlings
      - Cobs
      - Molasses

Feedstuffs Used in Livestock Diets

- Protein Supplements
  - >20% CP
  - Vegetable Origin
    - Soybean Meal
    - Cottonseed Meal
    - Corn Gluten Meal
    - Brewer's Dried Grains
  - Animal Origin
    - Animal tissues
      - » Meat & Bone Meal
      - » Blood Meal
      - » Most are banned/restricted from livestock diets

Feedstuffs Used in Livestock Diets

  - Fish Products
    - » Fish Meal
  - Milk Products
    - » Whey protein
  - Feather Meal
- Mineral Supplements
  - Calcium Carbonate
  - Limestone
  - Others

Feedstuffs Used in Livestock Diets

- Vitamin Supplements
  - Fish Oil
  - Others
- Additives
  - Propylene Glycol
  - Titanium Dioxide (coloring agent)

Feedstuffs Used in Livestock Diets

- International Feed Names
  - Used to create a “common language” among the feed industry
  - 6 Facets are included in the naming process
    - Original Material
    - Parts of Material used as feed (may be affected by processing)
      - Bran
    - Processing and Treatments
      - Dry-rendered
      - Hydrolized
      - Extracted

Feedstuffs Used in Livestock Diets

    - Stage of Maturity (plants & animals)
    - Cutting
    - Grade
- Characteristics of Concentrate Feedstuffs
  - Carbonaceous Concentrates
    - <20% CP, <18% fiber
    - Generally, high energy feeds

Feedstuffs Used in Livestock Diets

- General Nutritive Characteristics
  - High in energy
  - Low in fiber
  - Low in protein
  - Low protein quality and high variability
  - Minerals
    - » Low Ca
    - » Med P

Feedstuffs Used in Livestock Diets

- Examples
  - Corn
    - » 80% TDN
    - » 8-9% CP
    - » Med P, low Ca
    - » Recent technologies – high lysine corn, waxy corn, high-oil corn
    - » Alternative feeding forms
  - Oats
    - » 65-70% TDN
    - » 12% CP
    - » Very palatable, more expensive to feed

Feedstuffs Used in Livestock Diets

  - » Where is it most commonly used?
- – Dried Beet Pulp
  - » 65-70% TDN
  - » 8-10% CP
  - » Byproduct of sugar beet processing
  - » ~18% CF
- – Molasses
  - » 55-75% TDN
  - » 3-7% CP (mostly NPN)
  - » Byproduct from same industry as above
  - » Usually fed in what form?
  - » What are the advantages to feeding?

Feedstuffs Used in Livestock Diets

- Animal Fat
  - » Byproduct of rendering
  - » Treated w/ antioxidant to prevent rancidity
  - » Why do we feed it?
  - » 5% max in ruminant diets, 10% in non-ruminants
- Dried Bakery Product
  - » What might this include?
  - » Similar to corn in energy, higher in fat, and salt?

Feedstuffs Used in Livestock Diets

- Proteinaceous Concentrates
  - Quality
    - Kinds, amounts, ratios of amino acids
    - Essential Amino Acids
      - » Must be supplemented
      - » PVT TIM HALL
      - » Phenylalanine, Valine, Threonine, Tryptophan, Isoleucine, Methionine, Histidine, Arginine, Leucine, Lysine
    - NPN may be used as a protein source (only in ruminants)

Feedstuffs Used in Livestock Diets

- Examples
  - Urea
    - » 281% CP
    - » Use only in very small amounts
    - » Very effective for feeding rumen bacteria
  - Soybean Meal
    - » Most commonly used plant protein supplement
    - » 44% or 48% CP available (depends on how much its diluted w/ soyhulls)
    - » 71-80% TDN
    - » Very low in fiber
    - » Very broad amino acid profile

Feedstuffs Used in Livestock Diets

        - » What other forms are used?
- Animal/Marine protein supplements
  - – Derived from meat/poultry packing/rendering, or from the marine industry, or surplus milk
  - – Used only to improve the CP of basal feeds and improve amino acid profile
  - – Balances protein sources (plant vs. animal)
  - – Blood Meal
    - » 80+% CP
    - » Highly unpalatable
    - » High rumen undegradable protein for ruminants

Feedstuffs Used in Livestock Diets

- Fish Meal
  - » 35-70% CP
  - » Excellent protein quality and good source of B vits
- Whey protein
  - » 11% CP, 61% lactose
  - » Used in milk replacers or pig starter diets
  - » Highly palatable, excellent source of protein
- Animal Waste
  - » Nutrient content varies
  - » Used primarily in ruminant diets
  - » Usually high in NPN
  - » Has proven to be fairly effective, in certain diets

Feedstuffs Used in Livestock Diets

- Feed Grain Byproducts
  - Corn byproducts
    - Corn Gluten Meal
      - Dried residue remaining after removal of most of the starch, germ, and bran
      - 46-60% CP
    - Corn Gluten Feed
      - Dried residue remaining after removal of most of the starch, germ, gluten, but contains bran
      - 20-25% CP

Feedstuffs Used in Livestock Diets

- Distiller's Dried Grains
  - Byproduct of the alcohol brewing industry
  - 25-27% CP, 9-11% CF
- Distiller's Wet Grains
  - Byproduct of ethanol production
  - Use usually restricted to geographical area close to the distiller
  - Will ferment if not used quickly

– Wheat byproducts
- Wheat middlings
  - Fine particles of bran, germ, shorts, tailings

Feedstuffs Used in Livestock Diets

  - 16-18% CP
  - More commonly fed in swine diets, unpalatability makes its use limited in ruminants
- Soybean Hulls
  - 12% CP, 78% TDN
  - Very good for replacing other high fiber feeds, without losing too much fiber
  - Very palatable

Feedstuffs Used in Livestock Diets

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  - >20% CP
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      - 46-60% CP
    - Corn Gluten Feed
      - Dried residue remaining after removal of most of the starch, germ, gluten, but contains bran
      - 20-25% CP

Feedstuffs Used in Livestock Diets

- Distiller's Dried Grains
  - Byproduct of the alcohol brewing industry
  - 25-27% CP, 9-11% CF
- Distiller's Wet Grains
  - Byproduct of ethanol production
  - Use usually restricted to geographical area close to the distiller
  - Will ferment if not used quickly

– Wheat byproducts

- Wheat middlings
  - Fine particles of bran, germ, shorts, tailings

Feedstuffs Used in Livestock Diets

    - 16-18% CP
    - More commonly fed in swine diets, unpalatability makes its use limited in ruminants
- Soybean Hulls
    - 12% CP, 78% TDN
    - Very good for replacing other high fiber feeds, without losing too much fiber
    - Very palatable

Feedstuffs Used in Livestock Diets

- Characteristics of Roughage Feedstuffs
  - Generally low in energy
  - Higher in fiber
  - Higher mineral content
  - Extremely palatable to ruminants
  - Nutritive value can be extremely variable
  - Limited inclusion in beef finishing diets, excluded from swine rations

Feedstuffs Used in Livestock Diets

- Must be present in dairy rations to maintain health rumen and milk fat content
- Proteinaceous Roughages
  - Alfalfa
    - Hearty, w/ extensive root system
    - May be pastured, baled, mealed, or ensiled
    - 15-25% CP, >50% TDN
    - High in Ca, fair P
    - 2-5 cuttings/yr.

Feedstuffs Used in Livestock Diets

- Carbonaceous Roughages
  - <10% CP
  - Nonlegume forages, low quality roughages
  - Ex. Switchgrass
- Cool-season Perennial Grass Forages
  - Particularly productive during spring – early summer, and fall
  - Orchardgrass
    - Grows in clumps
    - May grow to 2-4’

Feedstuffs Used in Livestock Diets

  - Grows early in the spring
  - Rapid developer
  - Highly palatable
  - 8-18% CP
  - Good partner w/ alfalfa for hay or pasture grass
- Timothy
  - 8-12% CP
  - Not great for pasturing alone, but good in a mixture
  - Cut no later than early bloom for maximum nutritive value

Feedstuffs Used in Livestock Diets

- Small Grains (wheat, oats, etc.)
  - Generally same seeding rate as for grain, may increase if going to cut for silage
  - Effective in the pasture
  - Harvesting for silage should occur around boot stage
  - 10-22% CP, 62-72% TDN
  - If harvested early, can mimic corn silage
  - Be cautious of low Mg levels, may see grass tetany

Feedstuffs Used in Livestock Diets

- Corn Silage
  - Most popular silage
  - Extremely palatable
  - Moderate to high energy, low in protein
  - May not be most efficient in a finishing diet
  - Many varieties available
  - High grain content is desirable
- Corn Stover (Stalklage)
  - Harvested at or just after grain harvest
  - Ensiled
  - Should be fairly fine-chopped to ensure packing
  - Good for wintering cattle, somewhat high in energy

Feedstuffs Used in Livestock Diets

- Methods of Utilizing Forages
  - Pasture
    - Major feed for dairy, beef, and horses
    - For certain situations, the most profitable option
    - Essential Pasture Qualities
      - Durable both for longevity, and to stand up against the foot traffic
      - Growth start early in spring continue late through fall
      - Plant variety
        - » Greater yields
        - » Better nutritional value

Feedstuffs Used in Livestock Diets

      - » More complete nutritional balance
  - – Monitor quality/growth
  - – Use paddocks
      - » Reduces under or overgrazing
      - » Increases carrying capacity of the pasture
      - » Costs more to maintain
  - – Manage w/ mowing, fertilization, or herbicides (if necessary)
  - – Avoid grazing in wet conditions
  - – Proper stocking rate
      - » Varies w/ pasture crops
      - » Some 1-2 acres/cow, others 10-20 acres/cow

Feedstuffs Used in Livestock Diets

- Special concerns
  - Poisonous plants
    - » Highest risk w/ poorly maintained pastures or poor cattle management
  - Bloat
    - » Risk on legume pastures due to amount of lush plant material
    - » Can reduce risk by adding other grasses into the alfalfa
  - Nitrate Poisoning
    - » Accumulation after drought, or cultivated forages
    - » Seldom occurs in other types of pastures
    - » Causes abortion or death

Feedstuffs Used in Livestock Diets

- Green Chop
  - What is it? Is it still being used?
  - Advantages
    - Maximizes yield/ac.
    - Less nutrient loss
    - Less fencing
    - May reduce bloat
  - Disadvantages
    - No uniform quality
    - Weather
    - Cannot be fed year round

Feedstuffs Used in Livestock Diets

- Hays
  - Should be 15% moisture or less
    - Why?
    - What are the risks?
  - Keys to haymaking
    - Know when you want to mow
      - » Stage of maturity directly correlated to nutritional value
      - » Nutritional value decreases quickly
      - » What kind of yield to you want?
      - » How does it fit into your feeding program?

Feedstuffs Used in Livestock Diets

- Allow for sufficient curing
  - » Conditioning can reduce curing time by 50%
  - » Maximum moisture 18-22%
- Raking
  - » Should be done prior to the end of curing to minimize leaf shatter losses
  - » May be necessary to facilitate drying
- Baling
  - » Squares – should be stored and stacked ASAP out of the weather
  - » Round Bales – will survive outside storage if stacked in a pyramid shape (sheds water), grass hays last longer than legumes

- Common Losses in Haymaking
  - Leaf Shatter
    - » Leaves have 2-3x more protein than stems
    - » Higher in most other nutrients, except fiber
    - » ~20% loss is normal, losses can be as much as 40-75%
  - Heat Damage
    - » >25-30% moisture may lead to mold and excess heating
    - » During its sweating phase, hay should be not warmer than 84°, above 120° nutrient loss occurs
    - » Spontaneous combustion risk is high is hay reaches 160°

Feedstuffs Used in Livestock Diets

- Fermentation losses
  - Should account for only 5-7% loss in total DM
  - Converts sugars and starches to carbon dioxide and water
  - Reduced energy content
- Bleaching
  - Loss of color
  - Some vitamin losses

- Losses under normal conditions
  - 20-30% DM
  - 27-30% CP
  - 25-28% TDN

Feedstuffs Used in Livestock Diets

- Additives in Haymaking
  - Preservatives
    - » Propionic acid, acetic acid, etc.
    - » Allow storage at higher moisture
    - » Should be applied at the bale chamber
    - » ~20#/t
  - Drying agents
  - Anhydrous ammonia
    - » Treatment for low quality hay to improve protein and energy content
    - » Must seal and gas for 20-30 min
    - » Can increase CP by 3-6%
    - » Difficult to handle

Feedstuffs Used in Livestock Diets

- Silages
  - Goes through acid fermentation under anaerobic conditions
  - Types of silos
    - Upright
      - » Semiairtight
      - » Airtight
    - Horizontal
      - » Trench/pit
      - » Bunker
      - » Piles
      - » Temporary
      - » Bags

Feedstuffs Used in Livestock Diets

- Silage activity in the silo
  - Plant cells continue to respire
    - » Consume oxygen
    - » Produce carbon dioxide
    - » Mold inhibited due to lack of oxygen
  - Temperature increases
    - » Should increase to 80-100°
    - » Temperatures >100-120° result in carmelization
  - Fermentation
    - » Acetic acid – first acid, reduces pH from 6-4.2, in the first 4 days

Feedstuffs Used in Livestock Diets

  - » Lactic Acid – begins on d 3 and lasts 2 wks., most abundant acid, stops around pH 4.0
  - » Butyric Acid – forms if an insufficient amount of lactic acid is present, or a result of excess moisture—leads to a putrid smell
  - » Propionic Acid – very little present
- – Lowered pH prevents bacterial growth and further fermentation as long as it is w/out oxygen
  - » Takes ~21d, but many say 2-3 months is best
  - » Corn silage can keep for several years, if stored well

Feedstuffs Used in Livestock Diets

- Crops used for Silage
  - Corn
  - Legumes
    - » Haylage is most common, very difficult to make well
- Using silages
  - Advantages
    - » More feed/ac. Land
    - » High quality feed
    - » Harvest is mechanized, range of harvest dates are wider?

Feedstuffs Used in Livestock Diets

- Disadvantages
  - » Once you have it, you got to feed it
  - » May slow ADG
  - » Considerable cost
  - » Water is a factor?
- Making good Silage
  - 50-70% moisture range target
    - » Too wet – sour smell, nutrient loss by seepage
    - » Too dry – improper fermentation, difficult to pack
    - » May add water during ensiling process

Feedstuffs Used in Livestock Diets

- Proper stage of maturity
  - » When should we chop corn?
  - » When should we chop alfalfa?
- Proper packing
  - » Cut at proper length to ensure packability, but maintain good fiber
  - » Distribute evenly in the silo
  - » Uprights pack themselves
  - » As much weight and time as possible on a bunker
- Proper drainage
  - » Slope
  - » Base of the silo

Feedstuffs Used in Livestock Diets

- Losses from Ensiling
  - Field losses
  - Gas/fermentation losses
  - Surface spoilage
    - » Can be as much as 25% on a bunker silo
  - Seepage
- Silage Additives
  - Nutrient Additives
    - » Urea/ammonia – increase CP concentration
  - Preservatives
    - » Acids, Bacteria, Enzymes, cultures, etc. – all to promote proper fermentation

Feedstuffs Used in Livestock Diets

- General idea is do add/subtract DM, aid in fermentation, or increase nutrient content

- Ensiling vs. Hay making
  - Advantages
    - » Wider harvest windows
    - » More nutrients are accessible/maximized
    - » Weeds are prevented more effectively
    - » More yield/ac.
  - Disadvantages
    - » More and more expensive machinery?
    - » More variability in quality
    - » Fermentation problems may destroy good feed

Feedstuffs Used in Livestock Diets

- Characteristics on Common Nutrient Additive Feedstuffs
  - Macro-minerals
    - What are the major macro-mineral ingredients that will be used?
  - Trace Minerals
    - Cu – copper sulfate
    - Zn – zinc oxide
    - Se – sodium selenite

Feedstuffs Used in Livestock Diets

    - Chelates may increase the amount absorbed in the SI
- Vitamins
    - Fat soluble
        - A
            - Found in all green plants
            - Usually don’t need to supplement much
        - D
            - Can be synthesized by sunlight on the skin
            - Fed through fish oil

Feedstuffs Used in Livestock Diets

- E
  - » Found in germ of grains
  - » Green plants
- K
  - » Also found in green plants
- May all be generated and fed synthetically
  - » E is the most supplemented and has the most health implications attached to it (especially in cattle)

• Water soluble

- Riboflavin
  - » Milk products, yeast, hay, etc.

Feedstuffs Used in Livestock Diets

- Niacin
  - Some present in all feedstuffs
  - Much is not available for digestion (especially swine)
- Choline
  - Present in most feeds of animal origin
- Most all are synthetically made also
- Supplemented at extremely low rates
- Very expensive

Feedstuffs Used in Livestock Diets

- **Extrusion Pelleting**
  - » Heat and pressure forcing feed through a small spiral hole
  - » Produces a flaked feed
  - » Similar to pelleting

- High Moisture Grains
  - Harvested at 20-35% moisture (usually corn)
  - Coarsely ground and stored in a silo
  - Does goes through fermentation
  - Highly palatable
  - Can improve feed efficiency up to 8%

Feedstuffs Used in Livestock Diets

- Feed Mixing Methods
  - Must have accurate scales
  - Types of mixers
    - Vertical
      - Cylindrical with vertical auger(s)
      - Cannot handle much molasses
    - Horizontal
      - Rolling mixer w/ an auger and paddles inside
      - Handles higher molasses feeds better

Feedstuffs Used in Livestock Diets

  - Sequencing of feeds is important
    - Why?
- Feed Storage
  - Moisture level is key
    - What problems can be encountered?
  - Must be void of insect problems and rodents

Feedstuffs Used in Livestock Diets

- Factors Affecting Feed Intake
  - Water Availability
  - Palatability
  - Dietary energy level
    - Animals will generally eat to their caloric intake needs
  - Age and Size of animal
  - Temperature
  - Health

Feedstuffs Used in Livestock Diets

- Expected Intake guidelines (% of BW)
  - Swine 4-5%
  - Cattle 2-3%
  - Horses 1.5-2.5%
  - Dogs 2-3%

What is forage?

- Vegetable matter in a fresh, dried, or ensiled state.
- What can you do with forage?
  - graze it
  - machine harvest and store it
  - it's animal feed
- Forage allows you to raise an agricultural crop on land where other crops cannot be produced.

Grasses

- Timothy
- Orchard Grass
- Kentucky Blue
- Fescue (endophyte free)

Legumes

- White Clover
- Alfalfa
- Ladino Clover
- Red Clover

Mixing Forage Species

Consider the traits of each species.

Aggressive vs Passive

Maturity dates: early vs late

Other traits that can be utilized:

-N fixation	-heat tolerance
-fast germination	-wet tolerance
-sod(turf/grass) formation	- palatability
-summer dormancy	- hay or grazing
-life span	-fertility needs

Forage Establishment

- Plan at least 1-year ahead.
- Planning includes soil testing.
- Don’t be cheap with fertilizer, limestone, and seed.
- Do proper field preparation.
- Select the right forage species and best available varieties of forage.
- Need good seed/soil contact.
- Don’t bury seed too deep.

Harvesting Forages

- Making quality forage is an art.
  - need to know your forage species
  - keep on top of the weather
  - have flexible production options
  - have timely access to equipment
  - have equipment in good working order
  - have healthy forage and few weeds
  - have some luck!

Forage Storage Losses

- Uncovered bales stored outside
- Hay baled too wet
- Bales stacked in contact with the ground
- Holes in plastic bags and tubes, or leaky silos
- Poorly packed and uncovered trenches

Evaluating Hay Quality

- Leafiness
- Color
- Foreign Material
- Odor and Condition

- ACTIVITY

Why Manage Pastures?

- Pastures are profitable
  - grazed forage is good, cheap feed
  - pastures are inexpensive to develop and maintain
  - animals do the harvesting, therefore there is a reduction in the need for machine harvesting and forage handling
  - while on pasture, animals spread manure in the field, reducing hauling

Why Manage Pastures?

- Protects surface and groundwater from nutrient pollution
  – acts as a filler to screen out and traps soil particles which contain nutrients such as N and P
  – the nutrients are then utilized by the pasture plants once these nutrients have moved into the root zone of the soil

Why Manage Pastures?

- Reduces soil erosion
  - the top growth of pasture plants lessons the impact of rain drops on the soil surface and also slows down the surface runoff of water across the field
  - pasture plant root systems bind the soil together, thereby holding it in place
  - most pastures keep the soil covered year around, unlike annual crops

Why Manage Pastures?

- Improves forage yield and quality
  - plants that are maintained at the optimum fertility level and are not stressed by pests or by poor grazing management will be more productive
  - healthy, productive plants will provide a quality product
  - healthy plants will have a higher nutritional value

Why Manage Pastures?

- Reduces weeds and improves esthetics
  - weeds are opportunistic; they will move rapidly into an open area or an area occupied by a weak plant
  - weeds cannot gain a foothold in a field with vigorously growing plants
  - a clean, weed free pasture reflects well on your farm manage and how people passing by view your farm

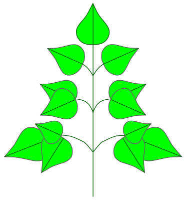
Maintaining Pastures

- Rotate
- Clip
- Irrigate
- Drag Manure

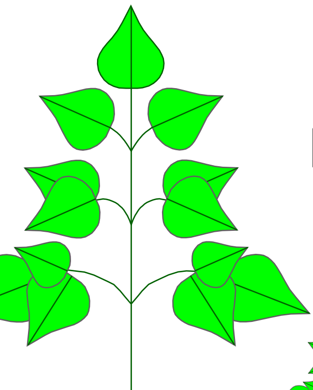
Grazing Management

- Protecting pasture plant root reserves and maintaining plants in a vegetative state are keys to a good pasture.
- Overgrazing reduces root reserves which shrinks the root system and leads to fewer leaves being produced; plants also take longer to recover from grazing.
- Under grazing reduces quality and yield as over-mature plants become less vigorous and more fibrous.

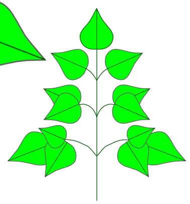
Forage Re-Growth



Slow to recover at first



Rapid growth after recovery



Slow after rapid growth period

How Grazing Affects Root Growth

% Leaf Vol. Removed	% Root Growth Stoppage
10%	0%
20%	0%
30%	0%
40%	0%
50%	2-4%
60%	50%
70%	78%
80%	80%
90%	100%

All root growth stops for 12 days with 80% removal & 18 days with 90% removal. When 60 % is removed, only half of the roots stop growing.

A Good Grazing Rule of Thumb

Take half ----------------------------Leave half

- In the long run, the animals will have more forage to graze.

Why Timely Mowing?

- Mowing prevents plants from becoming over mature.
- Vegetative plants are more palatable and more nutritious.
- Mowing helps to control weeds.
- Flash grazing can work in place of mowing to help reduce excess forage in paddocks.
- Harvesting excess forage for hay is a good way to fully utilize forage resources.

Why Control Weeds?

- Some weeds have been declared illegal noxious weeds by the State.
- Weeds look bad, they reflect poorly on your management.

Weeds will:

- Reduce the stand of desirable plants.
- Reduce overall quality and yield.
- Reduce overall animal yield.
- Some are poisonous, or can affect the animal product.
- Seeds are spread through manure.

Weed Management

- Cultural Control
  - mowing
  - grazing
  - over seeding
  - improved fertility

Chemical Weed Control
Grazing Restrictions

- Ally…………………..none
- 2,4-D………………..milk cows, 7 days+
- Crossbow……………milk cows, 14 days+
- Banvel……………….milk cows, 7 days+
- Roundup…………….livestock, 8 weeks
- Spike…………………none
- Stinger……………….none


We all want to have lush, green pastures.

Planning A Pasture System
Sources of Info and Help

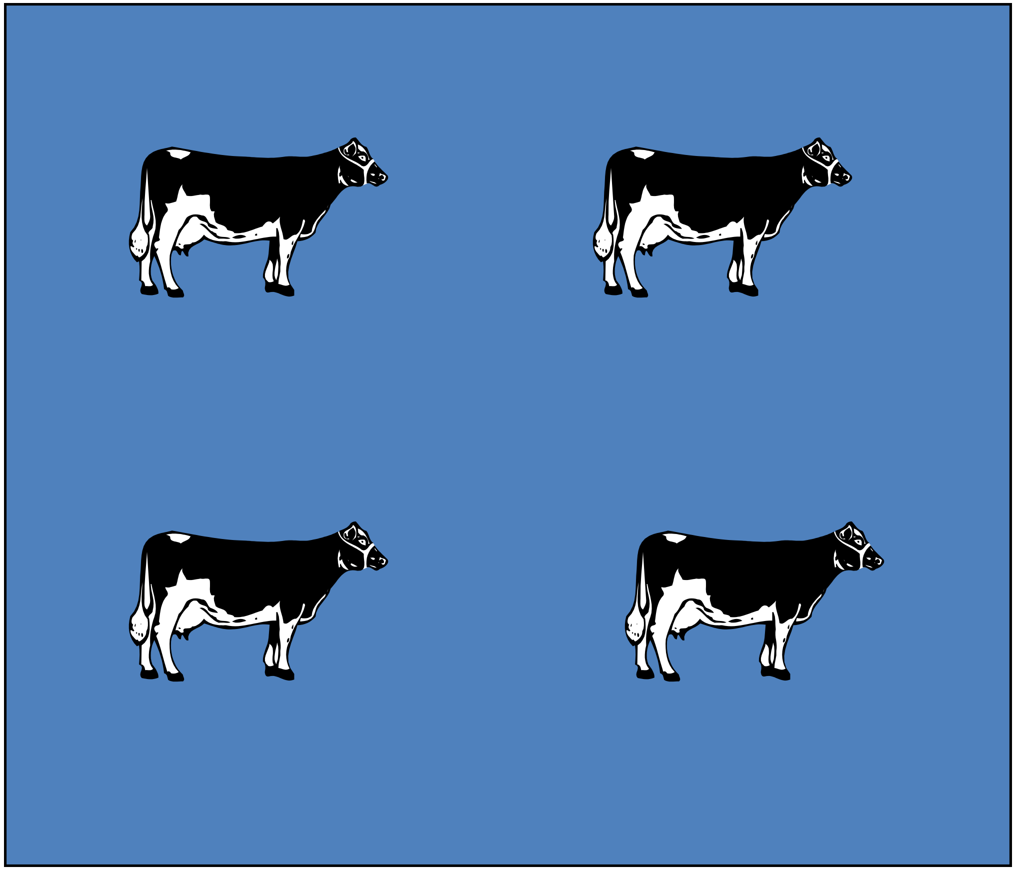
- Resources
  - soil survey map
  - soil capability assessment
  - aerial farm map
  - walking the farm

- Assistance
  - Cooperative Extension
  - N.R.C.S
  - F.S.A.
  - Farming Supply Companies

Basic Types of Pastures

- Continuous
  - animals are allowed to graze in the pasture for extended periods of time
  - animals often do well in this system since they are allowed to choose the plants they eat
  - plants are often overgrazed and under-grazed in this system

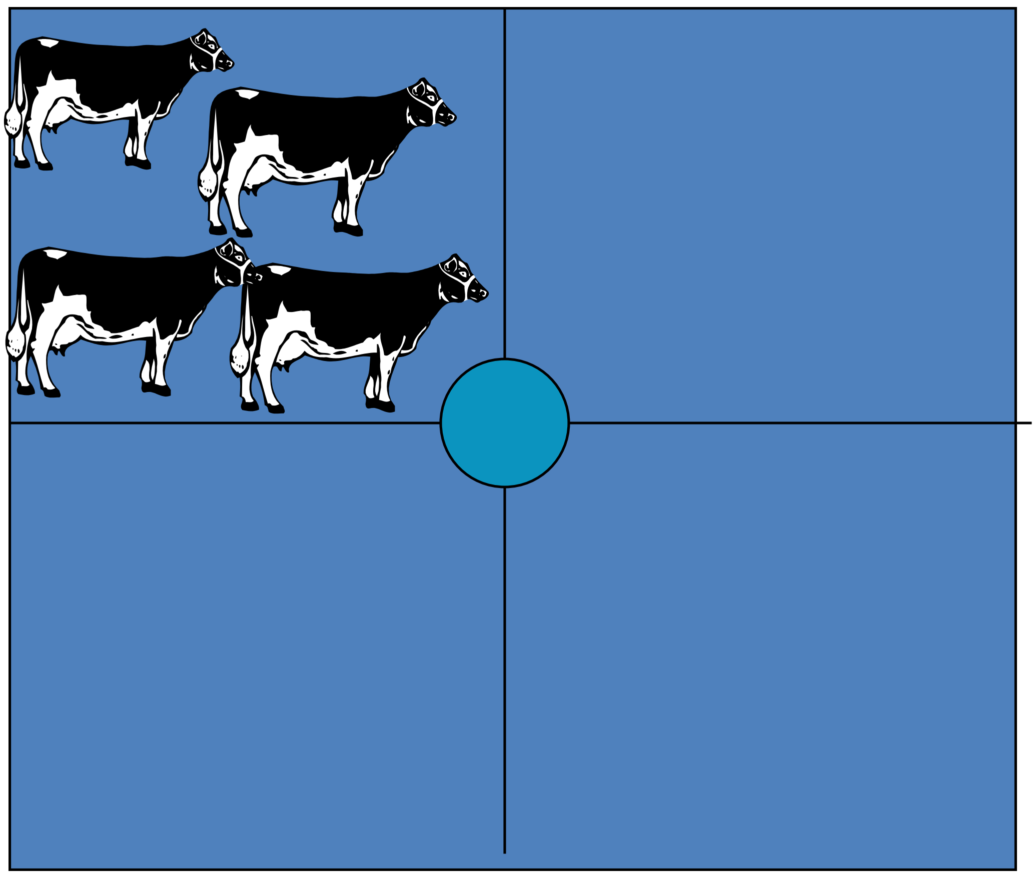
Continuous Grazing



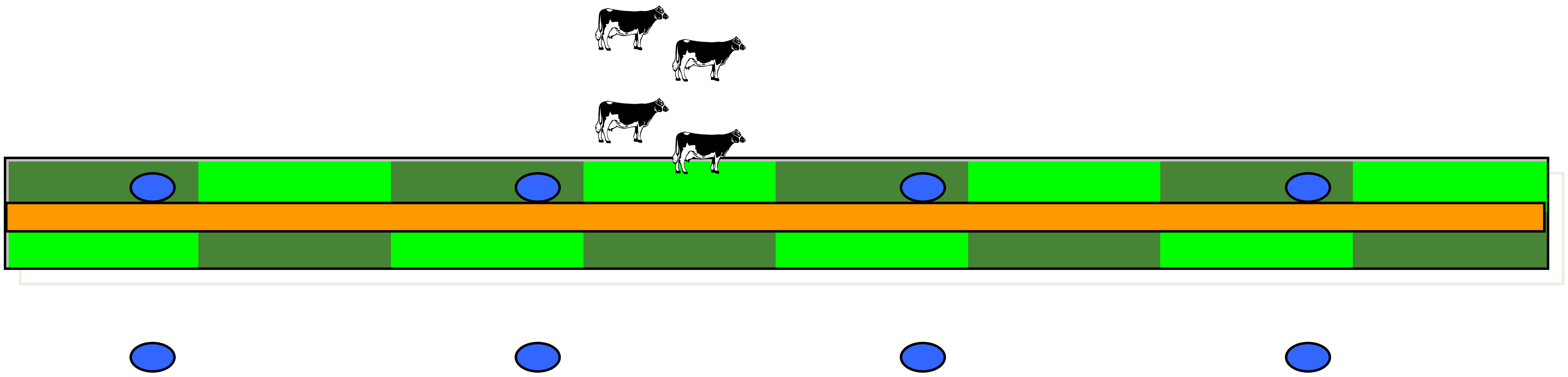
Basic Types of Pastures

- **Rotational**
  - animals are allowed to graze for only a limited period of time and animals are moved when existing forage has been removed
  - intensive rotational grazing systems subdivide pastures into paddocks and use high stocking rates where animals are forced to eat all forages
  - this system is most efficient

Rotational Grazing



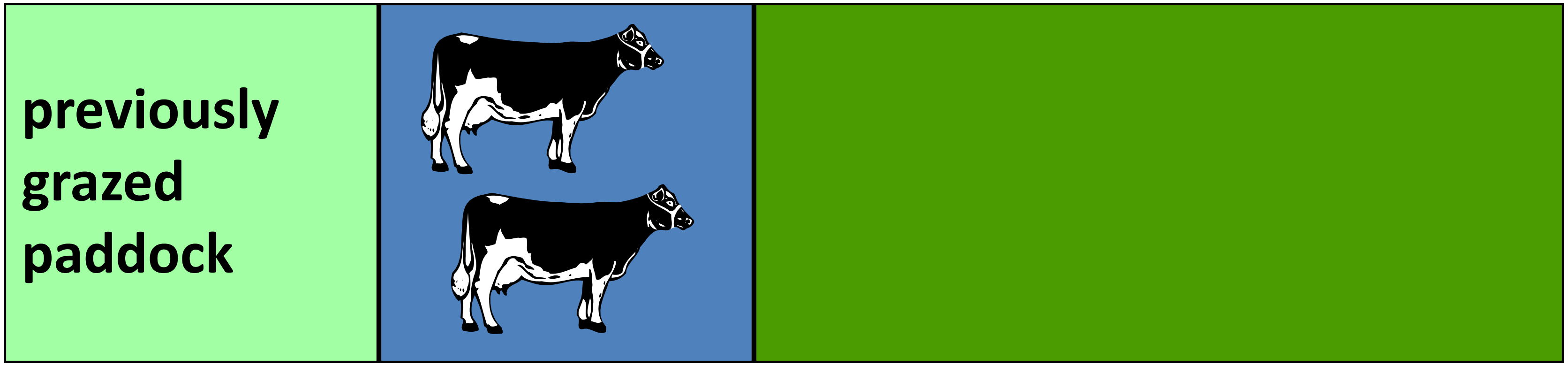
Intensive Rotational Grazing



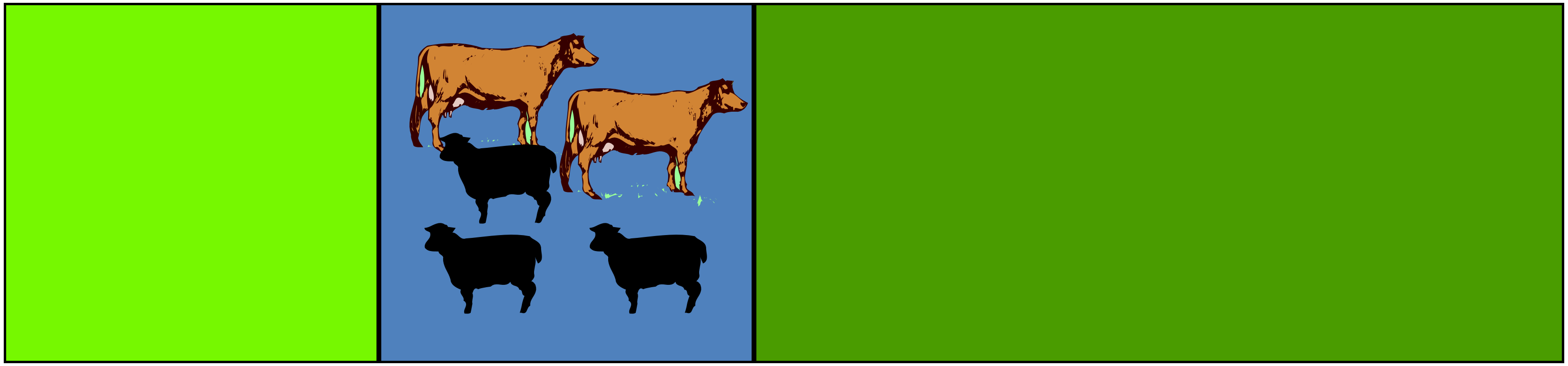
Basic Types of Pastures

- Deferred Grazing
  - forage is allowed to accumulate in a pasture for grazing at a later date
    - stockpiled tall fescue is an example
- Strip Grazing
  - high stocking rate of animals are put into a pasture for a limited period
  - usually involves a specially planted crop typically an annual species i.e. rape, turnips, or summer grasses

Strip Grazing



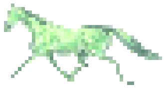
Co-grazing



Rotating Pastures

- Benefits
  - Feeding less grain and hay
  - Reduce pest populations
  - Slow soil erosion
  - Allow daily exercise

BE OBSERVANT and watch your pastures



Setting Up A Pasture System Recommendations

- Develop a 5 year farm/business plan
- You need to plan ahead
  - plan for when fields need to be renovated
- Use existing resources whenever possible (fences, water, forage crops)
- Establish crops according to your plan
- Existing pastures can be renovated later if needed now for grazing

Setting Up A Pasture System Recommendations

- Put your money into good perimeter fence.
  - this will help to keep predators out and your animals in.
- Map out farm, give each field own identity
- Soil test fields individually
  - each has its own personality, so treat it accordingly
- Develop a practical watering system
  - common problem for many
  - there are many factors to consider (costs, environmental, system)

Setting Up A Pasture System Recommendations

- Create a sacrificial area
  - this will protect your pastures
- Estimate the carrying capacity of your pastures
  - impacts on the number of animals and paddocks (rotational)
- Calculate number of paddocks(enclosures) needed and days/paddock (rotational)
- Temporary fence works well to form paddocks

Sacrifice Area

- This is a part of your pasture system that, just as it sounds, is permitted to become trashed.
- What is important here is that the trashing is confined to one small area where the mess can be controlled.
- Animals are kept in here during periods (i.e. wet) when it is not fit to put animals in the pasture.

Paddocks

- Sacrifice area
- Turn out lots

Paddocks

- In a rotational grazing system pastures are divided up into smaller units within the pasture
  - these smaller units are called paddocks.

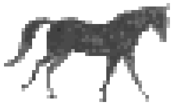
- In some smaller operations, permanent fencing is used to divide up the pasture.

- Temporary electric fence is a low cost, effective method of creating paddocks.

Fencing

- Considerations
  - Safety
  - Efficiency
  - Cost
  - Aesthetics

Fence height should be a minimum of 5 feet.



Fencing Materials

- Wood Fencing
  - Different types (3 rail, spilt rail)
  - Low Maintenance
  - Expensive
  - 20-25 years life expectancy

Fencing Materials

- Other
  - PVC
  - Plastic grid/mesh
  - Electric Tape

Fencing Materials

- Wire Fencing
  - Different Types (board and wire, high tensile, electric, V-mesh)
  - Less expensive
  - Maintenance is low to medium
  - Extended life expectancy

Facility Requirements

- Things to think about
  - Water
  - Air/Ventilation
  - Space Requirements
  - Shelter

Animal Behavior

- Causes
  - Genetic
  - Simple learning (training or experience)
    - Habituation
    - Conditioning
    - Reasoning, Insight
    - Imprinting, Socialization
  - Complex learning (intelligence)

Pest Management

Pest Control Is An Everlasting Problem

- How does an organism become labeled as a pest species?
- Pest control: winning the battles but losing the war.
- Designing better mouse traps.

What is a Pest?

- Technically, any organism (bacteria, fungi, plant, animal) that has a negative effect on human health or economics (food).
- Realistically, any organism we don’t want around (factors in convenience and esthetics).
- So generally speaking any organism that is detrimental to humans
  - destroys crops & structures
  - poses threats to human health and livestock
  - reduces aesthetic and recreational value

- Pests include insects, mites, plant pathogens, weeds, mollusks, fish, birds, and mammals

History Lesson: Bubonic Plague

- 14^{th} Century Europe: mysterious scourge kills millions
- Centuries later it was found that rat fleas became infected with disease-causing bacteria
- Fleas sought other warm-blooded hosts (humans) when rat numbers declined
- Plague is currently managed monitoring for plague and reducing the number of rodent-hosts for fleas

History Lesson: Potato Famine

- Late blight, a fungal disease, decimated Ireland's potato crops
- Thousands starved; over a million migrated to U.S.
- Today, late blight is still a major problem, but is managed by:
  - resistant cultivars
  - proper sanitation
  - fungicide applications

History Lesson: Pest Control

- Primitive: pulling weeds, clubbing rats, plucking insects from foliage
- Sulfur burning for mites/insects: 2500 B.C.
- Lead arsenate in orchards - 1892
- Lime and copper sulfate – Bordeaux mixture
- Early pesticides – plant extracts or inorganics
- World War II: DDT
  and low cost
  synthetic chemistry

Concerns with Pesticide Dependence

- Pest resistance
- Environmental persistence
- Bioaccumulation: when a chemical accumulates in animal fat (historical fact)
- Bio-magnification: when an organism accumulates residues at higher concentrations than the organisms they consume

Pest Management

- Is the pest really causing the problem?
- 1st Step: Always identify the pest before taking any action!
- Become familiar with its life cycle and habits
- Use the information
  to design a pest
  management plan
- Misidentification results in lack of knowledge = ineffective control of the real pest

Philosophies of Pest Control

- **Chemical technology**
  - **Use of chemicals to kill large numbers of the pest**
  - **Short-term protection**
  - **Environmental and health consequences**

- **Ecological pest management**
  - **Control based on pest life cycle and ecology**
  - **Control agent may be an organism or chemical**
  - **Specific to pest and/or manipulate a part of the ecosystem**
  - **Emphasizes protection from pest**

Four Major Pest Categories

#1 - Weeds: undesirable plants

Four Major Pest Categories

- #2 - Invertebrates, such as:
  - Insects
  - Spiders and mites
  - Sowbugs, pillbugs
  - Snails, slugs, and mussels



Four Major Pest Categories

- #3 – Vertebrates, such as:
  - Birds
  - Snakes
  - Fish
  - Rodents and other mammals

Four Major Pest Categories

- #4 - Plant Diseases
- Pathogens – living agents
  - Fungi
  - Bacteria
  - Viruses
  - Nematodes
  - Phytoplasmas
- Non-living agents: cold, heat, pollutants, dog urine

Pest Identification is Critical

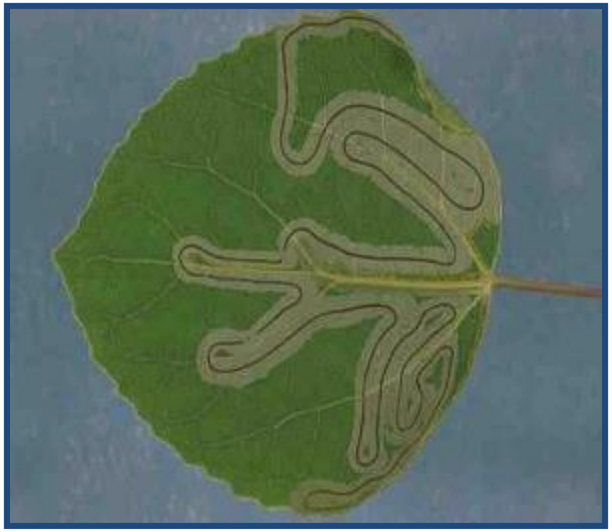
- Understand that all stages of a pest do not look the same
- Know the host of the pest
- Use books, extension bulletins, field guides, Web, etc.
- Have pests examined by specialists
  - Handle samples carefully

Look for Characteristic Signs

- Birds and rodents: unique nests
- Insects: feeding damage
- Fecal materials are distinctive – insect frass or bat guano
- Weeds: particular flowers, seeds, or unusual growth habits
- Pathogens: unique patterns or growths on plant tissue

Natural Pest Controls

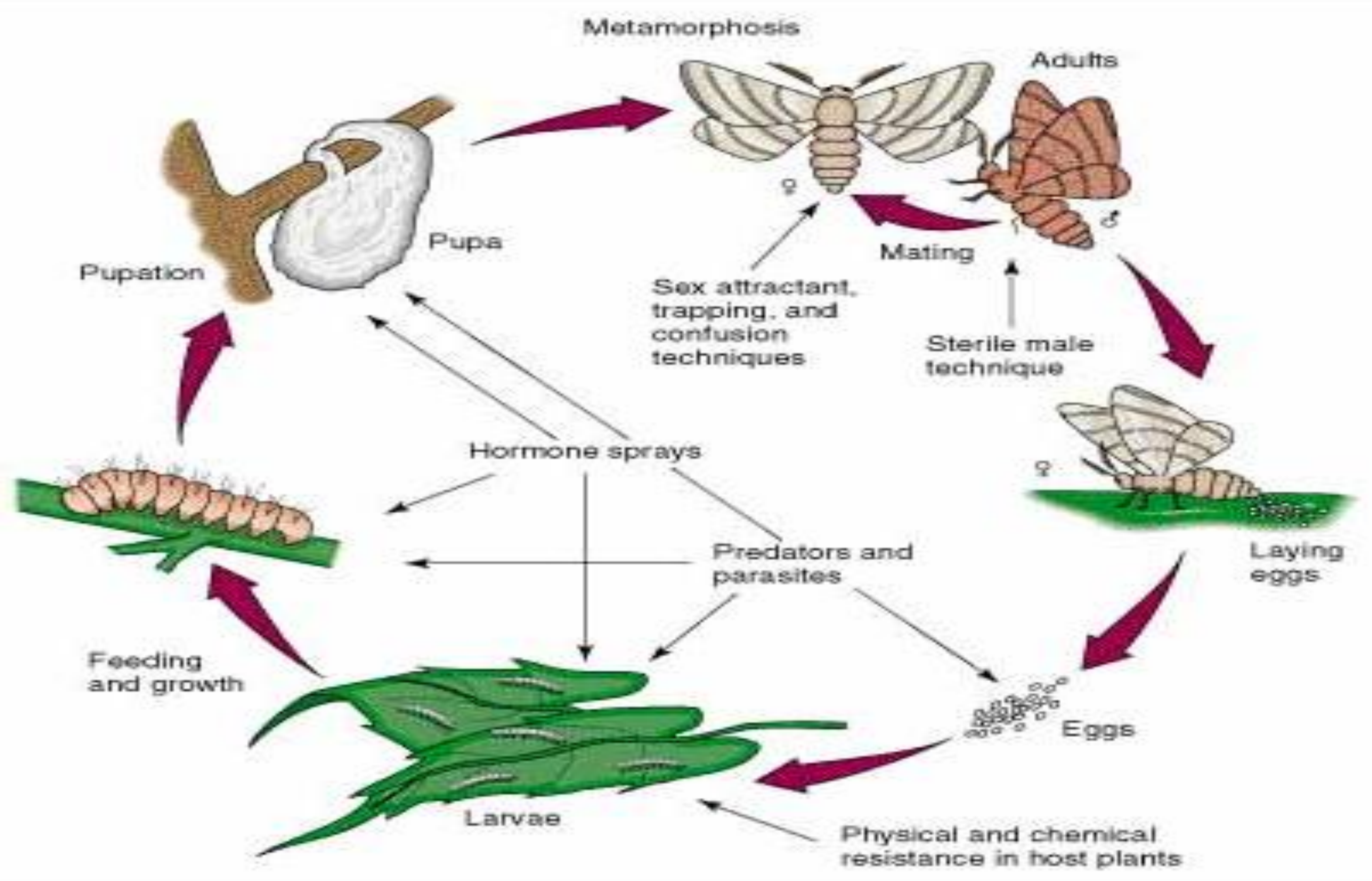
- Wind
- Temperature
- Humidity, rain
- Rivers, lakes, mountains
- Pathogens, predators
- Food supply of the pest



Natural Pest Control

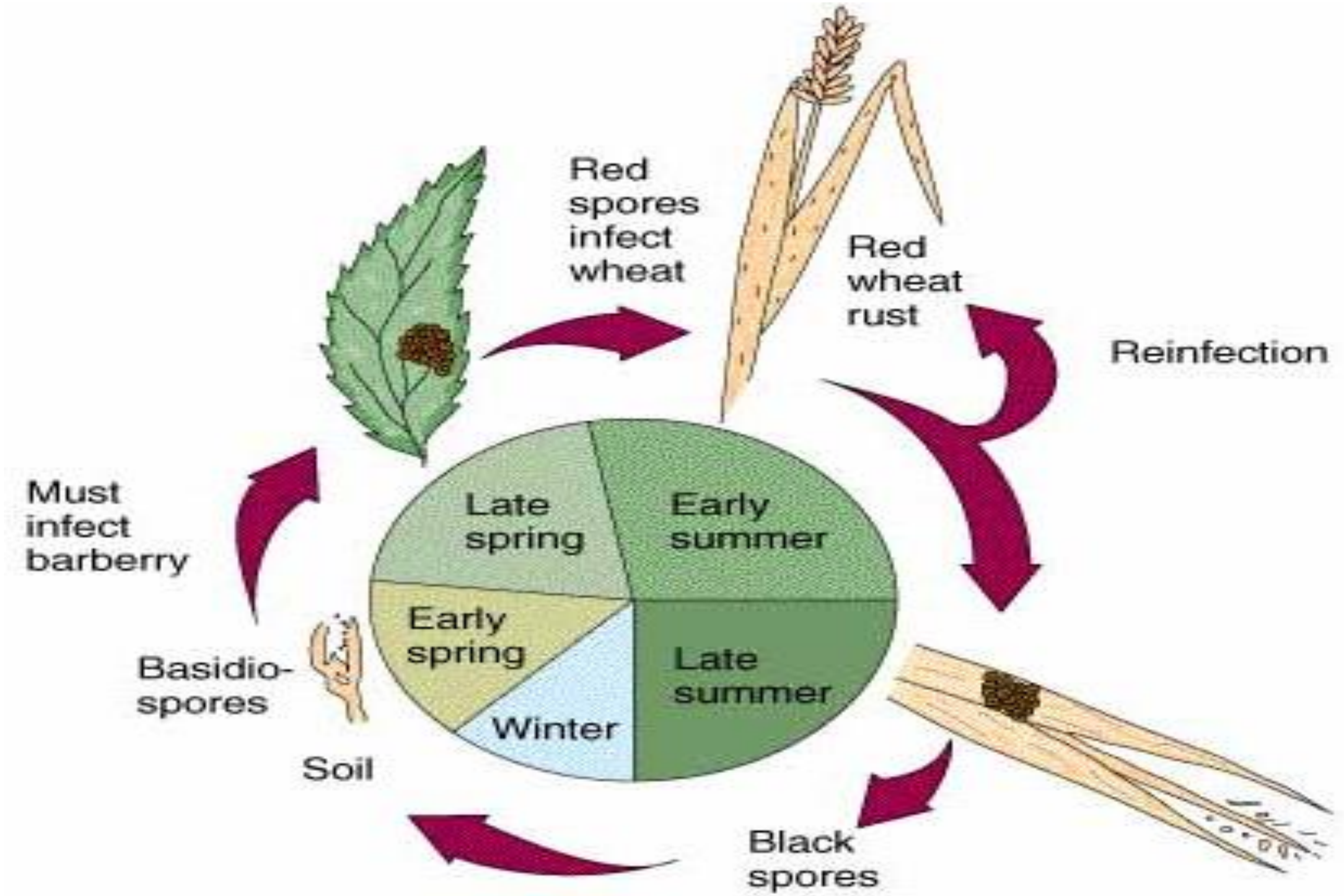
- Cultural control
- Control by natural enemies
- Genetic control
- Natural chemical control

Insect Life Cycle

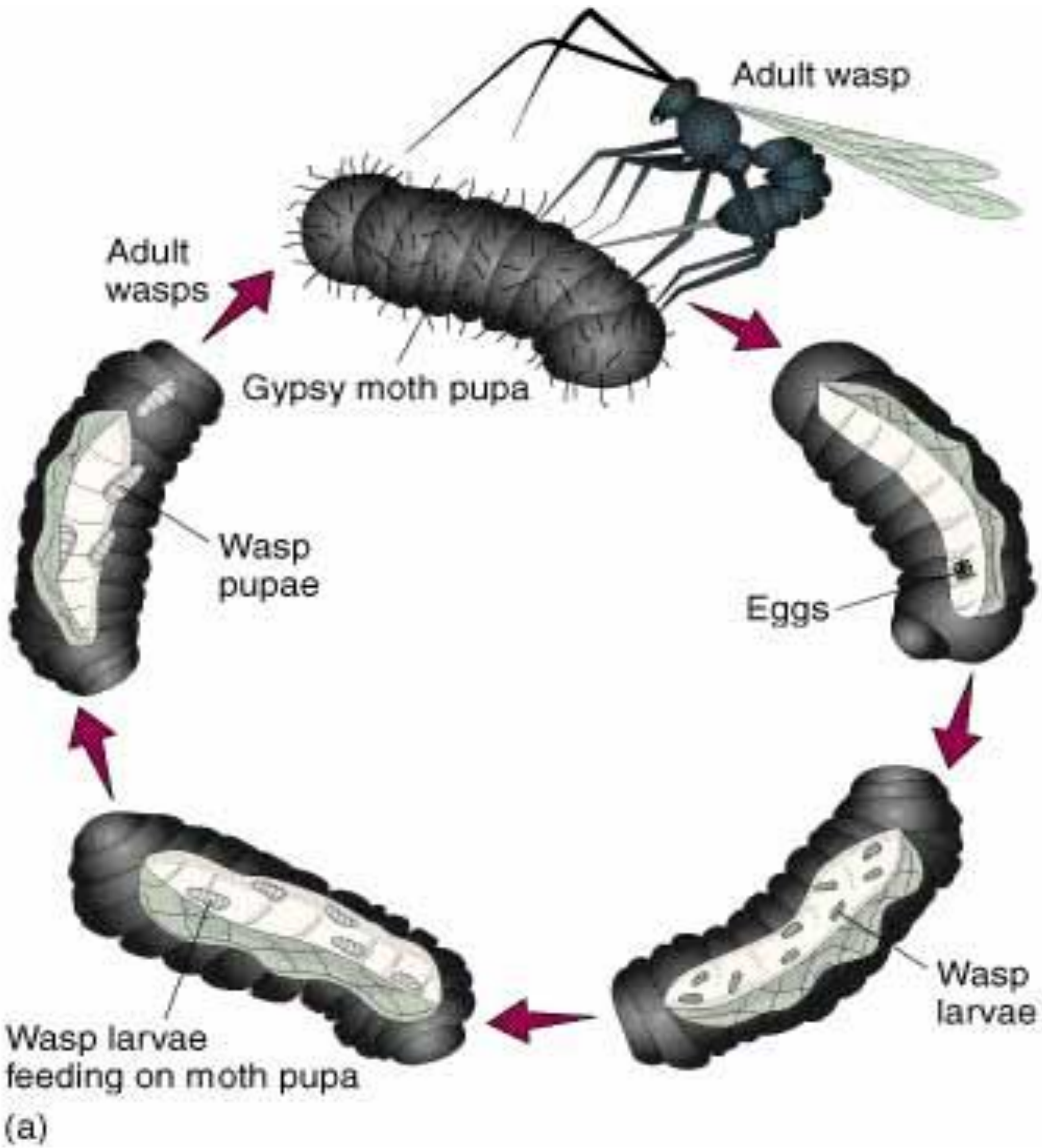


Cultural Control

Get rid of the alternative host!



Control by Natural Enemies



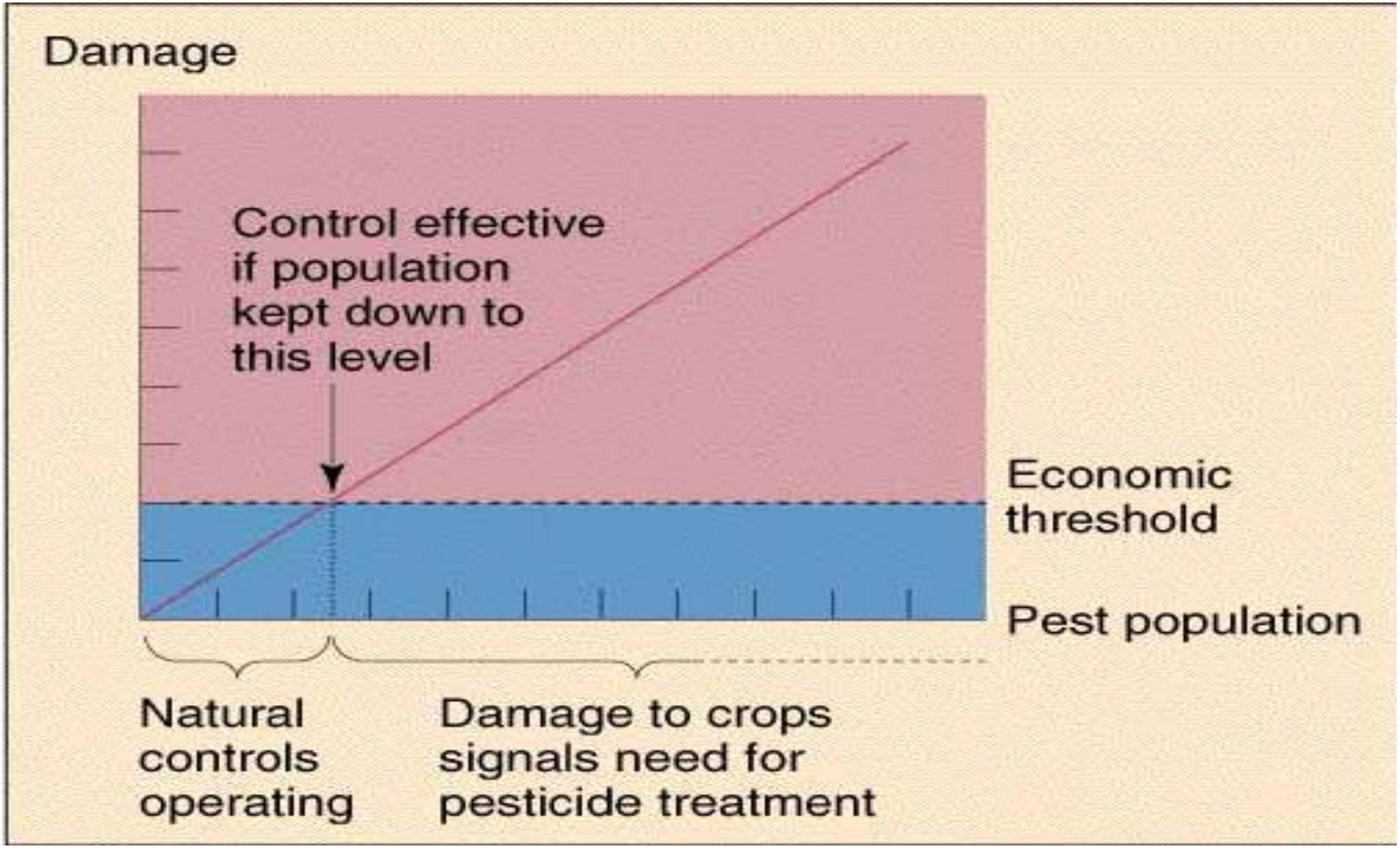
Genetic Control

- Plants or animals are bred to be resistant to the attack of pests.
  - Chemical barriers.
  - Physical barriers.
- Introduction of genes into crops from other species: transgenic crops
- Sterile males are released into pest population.

Natural Chemical Control

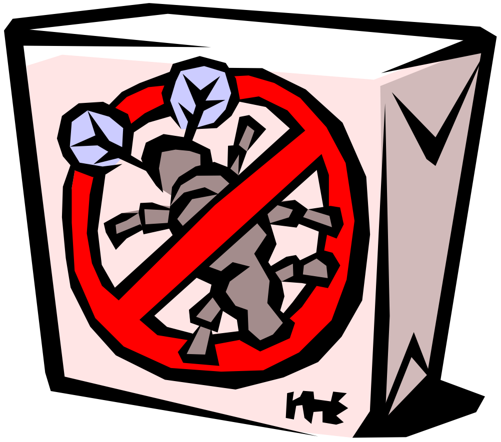
- Manipulation of pests' hormones or pheromones to disrupt the life cycle.
- Japanese beetle trap.

Economic Threshold of Pest Control



Human-applied Controls

- Biological
- Mechanical
- Cultural
- Physical
- Genetic
- Chemical
- Regulatory

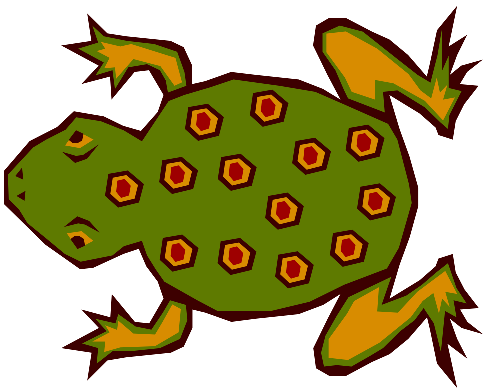


What is Biological Control?

- Usually, pests are not native to area
- Locate pest’s native homeland and find natural enemies
- Before releasing natural enemy, evaluate if suitable
- Rear, release, redistribute

Biological Control Results

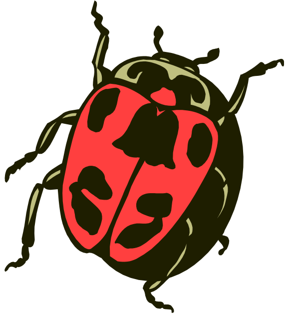
- Release natural enemies may become established and reduce infestation levels
- May not require any additional releases



BEWARE:

The cane toad was introduced in Australia in 1935 to control two pests of sugar cane, but later emerged as an invasive species itself!

Using Biological Control



- Periodic mass release from cultures
  - Natural areas, greenhouses, orchards
- Recognize naturally-occurring organisms
- Manage to conserve native beneficials
- Avoid broad-spectrum insecticides
- Use non-chemical strategies

Nabid eating a lygus bug.

Applied Control: Mechanical

Use of devices, machines, and other physical methods to reduce pest populations or to alter the environment

Mechanical: Cultivation

- Disrupt soil conditions for weeds and insects
  - Hoes
  - Plows
  - Disks
- Control growth or destroy plants
  - Mowers

Mechanical: Exclusion

- Prevent pests from entering or traveling
  - Nets, screens, air curtains
  - Caulking, steel wool
  - Metal tree collars
  - Sticky materials
  - Sharp objects

Mechanical: Trapping

- Use of mechanical or sticky device
- Captures pests in a holding device
  - Restrains the pest
  - Kills the pest

Applied Control: Cultural

Alter conditions or pest behaviors

- Mowing
- Irrigation
- Aeration
- Fertilization
- Mulching

- **Tolerant crop varieties**
- **Planting timing**
- **Crop rotation**
- **Trap crops**

Applied Control: Cultural

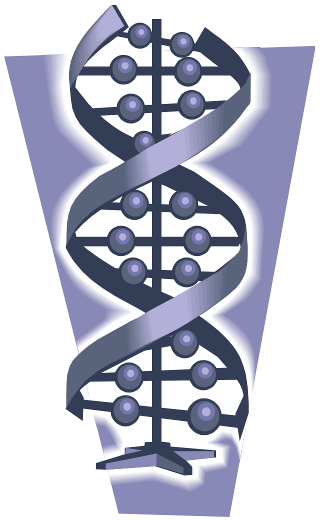
- Sanitation: eliminate food, water, and shelter
  - destroy infected crop residues or infected ornamental plant materials
  - weed to reduce pest harborage
  - manage manure
  - seal garbage cans
  - remove soil near siding

Applied Control: Physical

- Alter physical environment
  - humidity
  - temperature
  - air movement
  - water
  - light

Refresh birdbath water weekly to manage for mosquitoes

Applied Control: Genetics or Host Resistance



- Add or modify genetic material in crops and ornamental plants

❖ **Breed or select plants for resistance**

Resistance to Pesticides

Diamondback moth - first reported *Bt* resistance Source: USDA

- Chemical pesticides lose effectiveness
- Resistant pest populations produce next generations

Genetics of Pest Resistance

- There are two copies of each gene. Each gene may have several variations (called alleles).Some alleles are more dominant than others.

- Consider a gene for an insect's reaction to a pesticide. See how the alleles are distributed among offspring if susceptible bugs (RR) mates with a resistant bug (RR)

RR x rr Susceptible x Resistant	R Susceptible allele	R
r resistant allele	Rr Mildly resistant offspring	Rr
r	Rr	Rr

Populations will have different proportions of dominant and recessive traits depending on selective pressures in the environment.

Consider what happens if mildly resistant bugs (Rr) mate with each other; and then offspring are exposed to a dose of pesticide.

Rr x Rr Heterozygous mildly resistant	R	r
R	RR dies	Rr May survive
r	Rr May survive	rr **SURVIVES!**

How many exposures does it take to make your population resistant?

- Expose a population to a pesticide several times with mating in between exposures and see how many exposures it takes for resistant bugs to become the majority.
- Rules of the Game:
  - Toss your population (pennies) on the ground, and consider all with painted sides showing as exposed to pesticide
  - All exposed yellow (RR = susceptible) die so remove these pennies.
  - All exposed red (rr = resistant) survive and double; add a red penny for each exposed red penny.
  - For every <u>three</u> exposed blue (mild resistance) add one of each color. (Keep track of any remaining blues (<3) to ad to those on the next throw)
  - Keep track of the exposure count and repeat until most pennies are red.

Applied Control: Chemical

- Pesticide: any material that is applied to kill, attract, repel, or regulate pests
  - Disinfectants, fungicides, herbicides, insecticides, repellents, defoliants, piscicides, etc.
- Advantages: effective, fast, easy

Pesticides (Biocides)

- Insecticides (insects)
- Herbicides (not just the weedy plants)
- Rodenticides (mammalicides)
- Fungicides (mildews and rusts)
- Acaricides (ticks and mites)
- Bacteriocide (e.g. antibiotic)

The Early Years of Chemical Pest Control

- First-generation pesticides (inorganic)
  - First attempt at chemical technology
  - Included heavy metals such as arsenic, copper and lead.
  - Toxic to humans and agricultural plants.
  - Pests developed resistance.

Pesticide “Improvements” (?)

- Second-generation pesticides
  - Organic chemical (organochlorines).
  - Used after WWII (presently in developing countries)
  - Synthesis begins with petroleum (“oil”)
  - Mechanism of actions often unknown.
  - Bioaccumulation & Biomagnification.
  - Toxic to animals (humans) and agricultural plants.
  - Pests developed resistance.

Smarter Pesticides (?)

- Third-generation Pesticides
  - Organophosphates and carbamates
  - Less persistent in environment (good deal)
  - Acutely potent nerve toxins
  - More lethal in low dose than organochlorines

- Fourth-generation Pesticides
  - Endocrine disruptors (hormonal chaos)
  - Target a critical life cycle stage of insects.
  - Not direct killers per say.
  - Reduce reproduction (fertility) of population.

Chemical Technology Problems

- Development of resistance by pests
- Resurgences (pest comes back stronger)
- Secondary pest outbreaks (different pest)
- Adverse human health effects
- Adverse environmental health effects

Human Health Effects

- Acute: high dose, short-term response, rapid onset (headache, nausea, vomiting, respiratory failure, death). Agricultural workers suffer acute poisoning during pesticide application.

- Chronic: low-dose, long-term exposure, outcome takes many years before noticed (cancer, dermatitis, neurological disorder, birth defects, sterility, endocrine system disruption, immune system depression). Neighborhoods downwind of agricultural use; farm families; the innocent.

Environmental Effects

- Bio-concentration:
  - Movement against a concentration gradient; typically fat soluble.
- Bio-magnification:
  - Movement through the food chain to higher trophic levels; typically persistent.
- Bioaccumulation:
  - Combined effect of both; chemicals are typically fat soluble and persistent.

Chemical Technology Problems

- Resurgences: after “eliminating” a pest, its population rebounds in even higher numbers than previous levels. Why?

- Secondary outbreaks: outbreaks of species’ populations that were not previously at pest levels. Why?

Think about mechanisms of environmental resistance on any one population.

Pesticides vary by…

- Mode of action: how they work to control the pest
  - Systemic pesticides are absorbed through tissues and transported elsewhere where the pest encounters it through feeding
    - Used on plants or livestock
  - Contact pesticides must come in direct contact with the target pest

Pesticides vary by…

- Selectivity: what range of pests they affect
  - Non-selective – kills all related pests – for example some herbicides kill all green plant that gets a sufficient dose
  - Selective – kills only certain weeds, insects, plant pathogens – for example other herbicides only kill broadleaf weeds not grasses

Pesticides vary by…

- Persistence: how long they remain active in the environment
  - Residual pesticides – remain active for weeks, months, years – for example herbicides used around road guard rails
  - Non-residual – inactivated immediately or within a few days – for example – some herbicides do not remain active in the soil once applied

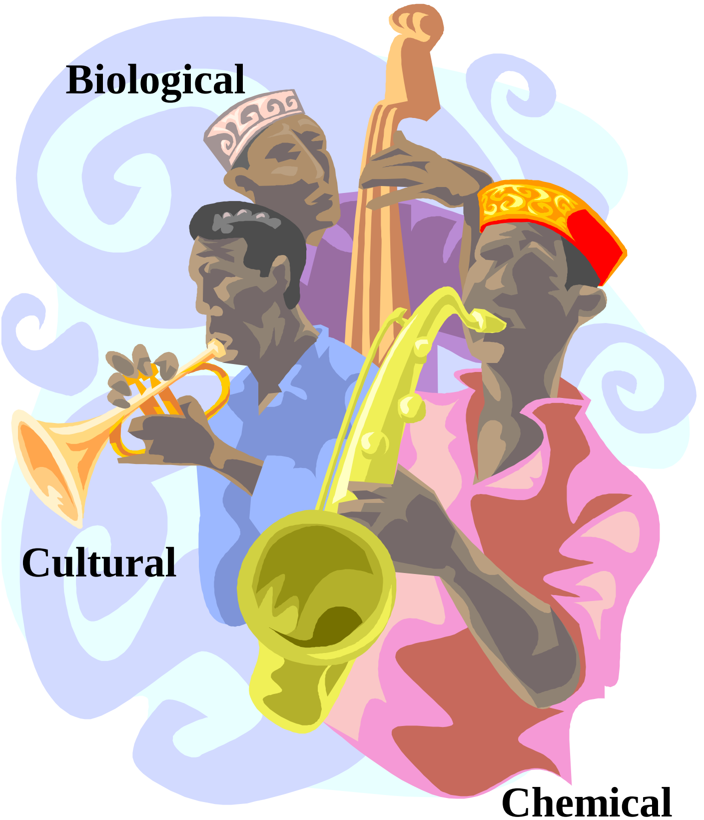
Regulatory Pest Control

- Quarantine prevents pests from entry to an area or movement from infested areas.
  - Monitor airports, ocean ports, borders
  - Nursery stocks and other plant materials

- Eradication programs eliminate a pest from a defined area
- Mosquito Abatement used for public health

Integrated Pest Management
IPM: a balanced, tactical approach

- Anticipates and prevents damage
- Uses several tactics
  in combination
- Improves effectiveness,
  reduces side effects
- Relies on identification, measurement,
  assessment,
  and knowledge



Why Practice IPM?

- Maintains balanced ecosystems
- Pesticides alone may be ineffective
- Promotes a healthy environment
- Saves money
- Maintains a good public image

Considerations for Choosing Control Methods

- Determine damage level you can withstand
- Determine desired control outcomes
  - Prevention of pest outbreaks
  - Suppression to acceptable level
  - Eradication of all pest organisms
- Manage for pesticide resistance
- Estimate costs
  - Monetary
  - Environmental impacts

Integrated Pest Management is Driven by Decisions

1. Identify the pest and know its biology
2. Monitor and survey for pests
3. Set IPM goal: prevent, suppress, eradicate
4. Implement
    1. Select control strategies
    2. Timing
    3. Economics
    4. Environmental impacts
    5. Regulatory restrictions
5. Evaluate

Components of IPM
1. Identify and Understand

- Is it a pest, beneficial, or just there?
- Study pest biology
  - Pest classification
  - Life cycle
  - Over-wintering stage
  - Damage impacts
  - Environmental needs
  - Vulnerable control stages/timing

Components of IPM
1. Identify and Understand

- Key pests
  - Prior knowledge of which common pests may pose a problem
  - Recognition of damage symptoms
  - Recognition of diseases
  - Recognition of beneficial insects
  - Frequent monitoring

Components of IPM
1. Identify and Understand

- Occasional pests may become troublesc
  from time to time
- Secondary pests become problems whe
  pests
  are controlled or eliminated
  - such as spider mites

Components of IPM
2. Monitor the Pest

- Use scouting, trapping, weather data, models
- Economics or aesthetics trigger need for action
  - Pest population
  - Beneficial population
  - Geographic location
  - Plant variety
  - Plant type & stage of growth
  - Cost of control measure(s)
  - Value of plant or crop

How many pests need to be present before action is taken?

Components of IPM
2. Monitor the Pest

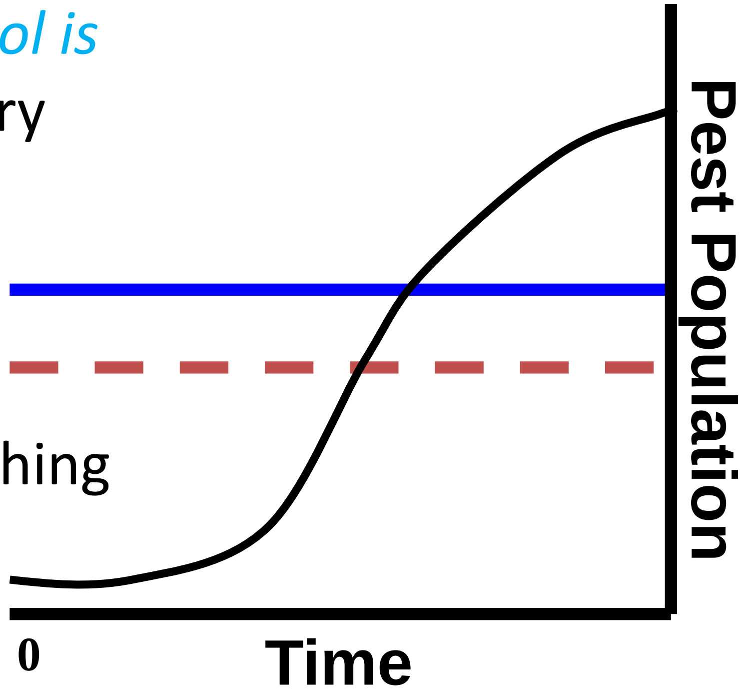
- Action threshold: unacceptable pest level – do something
- Sometimes the action threshold may be zero!
- Action thresholds vary by pest, site, and season

6 aphids per wheat plant = no problem - no action

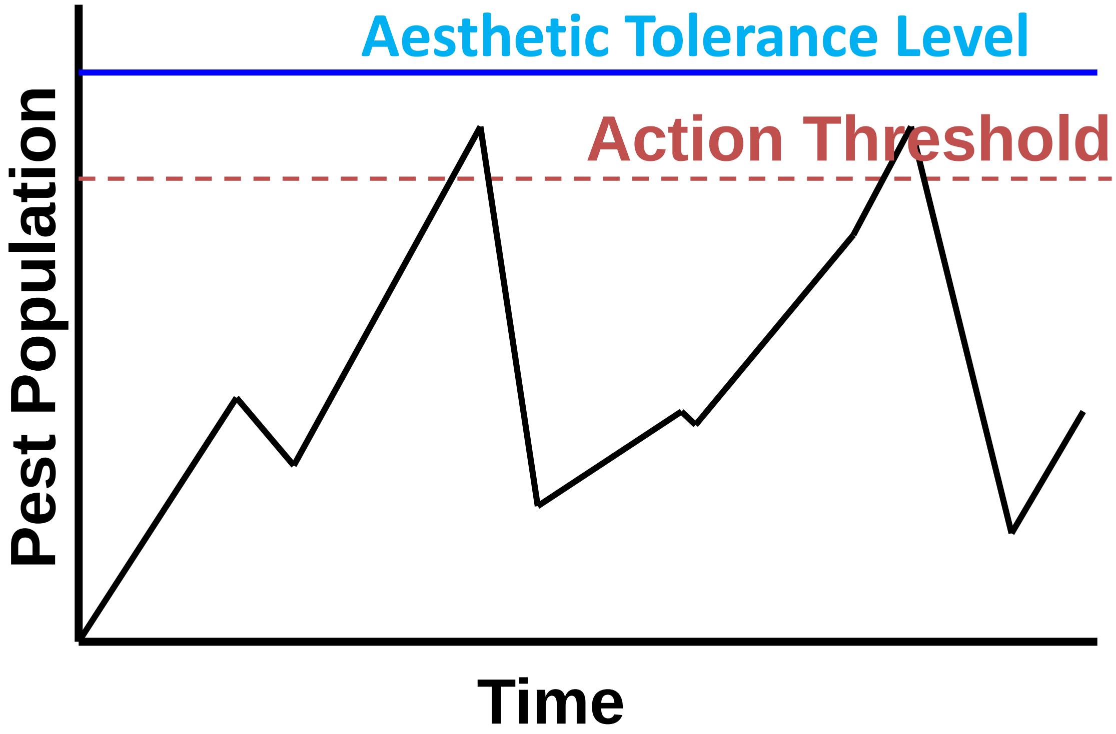
15 aphids per wheat plant = hits the pocketbook - take action

Treatment or Action Threshold

- Economic Threshold
  - pest population density when *control is necessary* to prevent economic injury
- Economic Injury Level
  - when the cost of losses equals the cost of control measures
  - Apply control measure prior to reaching economic injury level



Components of IPM
2. Monitor the Pest



Action Threshold is also based on aesthetics or public health issues

At what point does the cost of control ward off future expenses

Components of IPM
3. Develop the IPM Goal

- Prevention: weed-free seed, resistant plants, sanitation, exclusion, pesticide treatments
- Suppression=reduction cultivation, biological control, pesticides
- Eradication=elimination small, confined areas, or government programs

Components of IPM
4. Implement the IPM Program

- Make sure you have taken initial steps
  - Identification and monitoring
  - Set action thresholds
  - Know what control strategies will work
- Select effective and least harmful methods!
- Observe all local, state, federal regulations!

Components of IPM
5. Record and Evaluate Results

- Know what worked and what did not
- Some aspects may be slow to yield results
- Might be ineffective or damaging to the target crop, beneficial insects, etc.
- Use gained knowledge in future planning efforts

Considerations for Pesticide Use

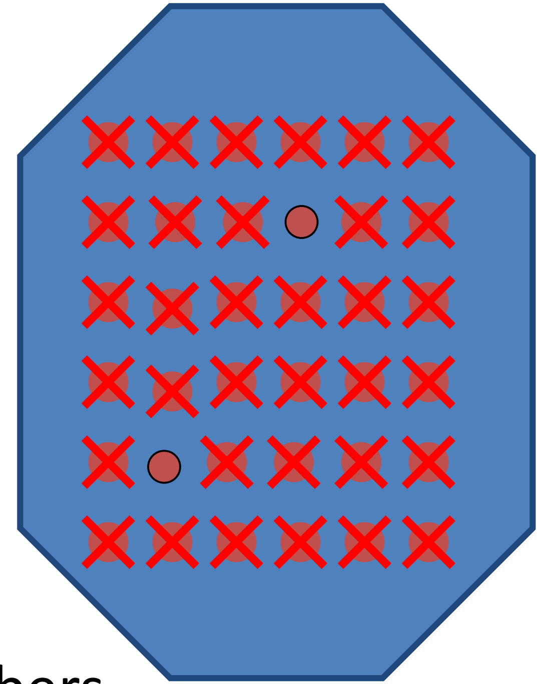
- Identify the pest and select the appropriate product
  - old or new infestation
- Avoid developing resistant pest populations
- If using pesticides, use the correct application rate (dose) and timing

Be A Professional
IPM Practitioner

- Careful observation
- Knowledge of the pest, control options
- Professional attitude

Pesticide Resistance:
the ability of a pest to tolerate a pesticide that once controlled it

- Intensive pesticide use kills susceptible pests in a population, leaving some resistant ones to reproduce
  - Use of similar modes of action
  - Frequency of applications
  - Persistence of the chemical
  - Pest rate of reproduction & offspring numbers



Resistance Management

- Do not use products repeatedly that have similar modes of action
- Allow some pests to survive
  - Limit treatment areas
  - Consider using lower dosages
- Use caution: new compounds having very specific actions - may develop resistance more quickly
- Use non-chemical means to control resistant pest populations

MEDICAL ENTOMOLOGY

- the study of diseases caused by arthropods

- Public health entomology - arthropods and human health
- Veterinary entomology - arthropods and pets, livestock and wildlife
- These fields of study are linked by the ecology of most arthropod transmitted pathogens and parasites.

Arthropods affect the health and well-being of humans and animals in several ways:

- Direct Causes of Disease or Distress
- Vectors or Hosts of Pathogenic Organisms
- Natural Enemies of other medically harmful insects

Direct Causes of Disease or Distress:

- Ectoparasites - ticks, fleas, mites
- Endoparasites - chigoe flea, myiasis
- Envenomization - wasps, bees, spiders
- Allergic Reactions - dust mites
- Annoyance - mosquitoes, black flies
- Delusory parasitosis (DP) - psychosis

Vectors or Hosts of Pathogenic Organisms:

- Arthropod serves as intermediate host and vector of pathogenic microorganisms
- Vectors and hosts – blood feeding
- Hosts only - no blood feeding

Natural Enemies of other medically harmful insects:

- Mites parasitic on mosquitoes
- Fire ants consume tick eggs

History of Medical Entomology:

- References to associations between humans and arthropods – historical

(Homer and Aristotle, among others, wrote about the nuisance caused by flies, mosquitoes, lice and/or bedbugs.)

- Important discoveries:
    - Microscope - Leeuwenhoek 1700’s
    - Infectious Disease - Koch et al. 1800’s

History of Medical Entomology - 2:

- Mosquitoes (*Culex pipiens*) and filarial worms (*Wuchereria bancrofti*) - Manson, 1877
- Tick (*Boophilus annulatus*) and Texas cattle fever (piroplasmosis) transmission - Smith & Kilborne, 1891
- Mosquito (*Aedes aegypti*) and yellow fever virus - Finlay, Reed, Carroll, Agramonte and Lazear, 1900
- Trypanosomes in cattle blood - Bruce, 1895
- Tsetse fly (*Glossina sp.*) transmission of trypanosomes - Bruce, 1896
- Tsetse fly transmission of trypanosomes to humans (African Sleeping Sickness) - Bruce, 1903

History of Medical Entomology - 3:

- Malaria parasites in human blood - Laveran, 1894
- *Anopheles* mosquitoes with malaria parasites - Ross, 1897
- Transmission of bird malaria by *Culex* mosquitoes - Ross, 1898
- Complete development of human malaria parasite in mosquitoes - Grassi, 1898
- Transmission of human malarial parasite by mosquitoes - Sambon and Low, 1899
- Only *Anopheles* mosquitoes transmit human malarial parasites - Watson and Christophers, 1899

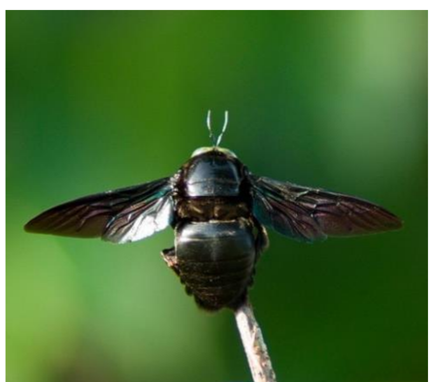
History of Medical Entomology - 4:

- Mosquito transmission of dengue virus - Graham, 1902
- Fleas and plague - Liston, Verjbitski et al., 1895 - 1910
- Triatomine bugs and trypanosomes (Chagas disease) - Chagas, 1908
- Black flies and onchocerciasis (river blindness) - Blalock, 1926
- Mosquitoes and viral encephalitides - Hammon and Reeves, early 1940's
- Ticks and Lyme disease - Spielman, early 1960's

Arthropods and Insects

Taxonomy and Characteristics

Arthropod Vectors



Kingdom: Animalia

Subkingdom: Eumetazoa

(unranked): Spiralia

(unranked): Eucoelomata

(unranked): Protostomia

Superphylum: Ecdysozoa

Phylum: Arthropoda

Subphylum: **Chelicerata** | Myriapoda | **Hexapoda** | Crustacea

Arachnida

Insecta

Arthropods

General Characteristics:

1) highly successful (⅔ of all known organisms are Arthropods)

2) segmented Eucoelomata with exoskeleton (Arthropod Metamerism)

2) Tagmata/Tagmatization (segments grouped into body regions)

3) Molting, Ecdysis (Ecdysozoa)

4) Hemimetabolous (gradual) / holometabolous (complete)

5) Cephalization (highly developed sensory organs)

6) Open circulatory system (hemolymph / hemocoel)

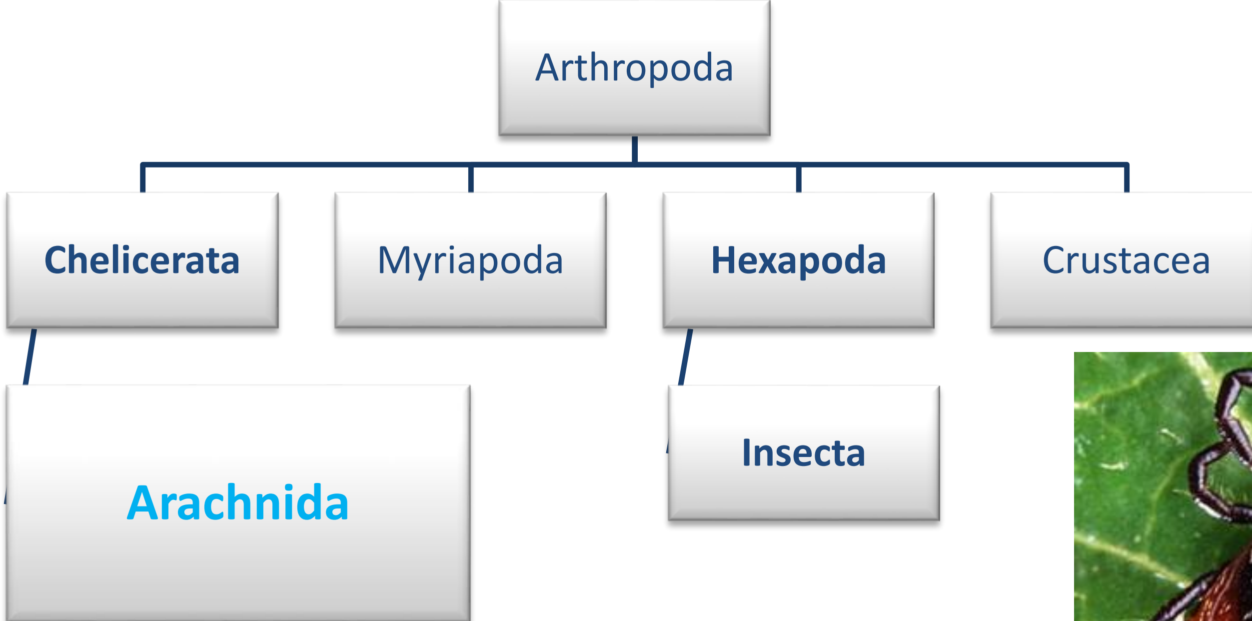
7) Respiratory system (trachea / book lungs)

8) Malpighian tubules / Coxal glands

9) Involved in virtually every kind of parasitic relationship

- definitive and intermediate hosts for protozoans, flatworms, nematodes,arthropods

- function as vectors (blood-feeding / need for protein for development)



- Class Arachnida:
    - Prosoma (Cephalothroax) – Opisthosoma (Abdomen)

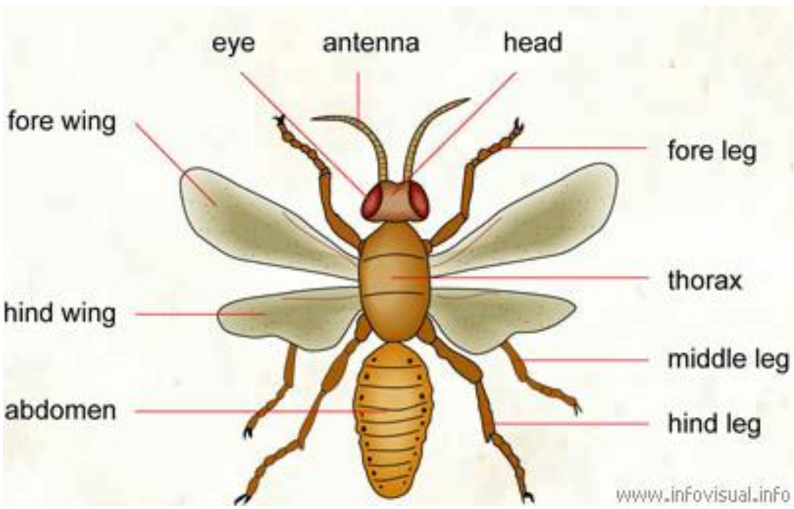
- Subclass Acari: Capitulum (head) – Idiosoma; transmit a large number of disease agents (viruses, rickettsia, apicomplexa, nemotodes)

- Ticks are pool feeders (once attached to the host, the tick will inject saliva into the wound, which liquidizes the tissues and allows them to suck up the fluid)

- Ticks sense CO_2, warmth and movement from animals

- Ticks are divided into two families: Ixodidae (hard ticks) and Argasidae (soft ticks).

- Arthropoda
  - **Chelicerata**
    - **Arachnida**
  - Myriapoda
  - **Hexapoda**
    - **Insecta**
  - Crustacea



- **outnumber all other known animals put together (almost 1million species described)**
- **Head – Thorax – Abdomen**
- **eyes, antennae, sucking , chewing mouthparts, 2 pairs of wings, 3 pairs of legs**
- **can vector many diseases (mechanical / biological)**
- **Blood-feeding (need for protein), Flexibility in development, Response to host**

Insecta

Diptera

Mosquitoes, Anophelinae, Sandflies, Blackflies

Hemiptera

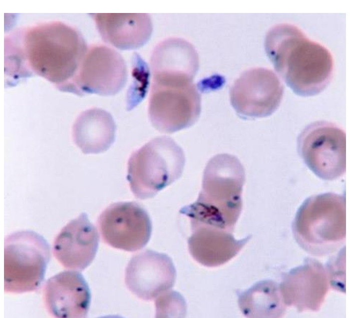
Reduvid bugs or kissing bugs

Siphonaptera

(Fleas)

Mallophaga, Anoplura

(Lice)



Phylum Arthropoda (classes and their Representative in Brief)

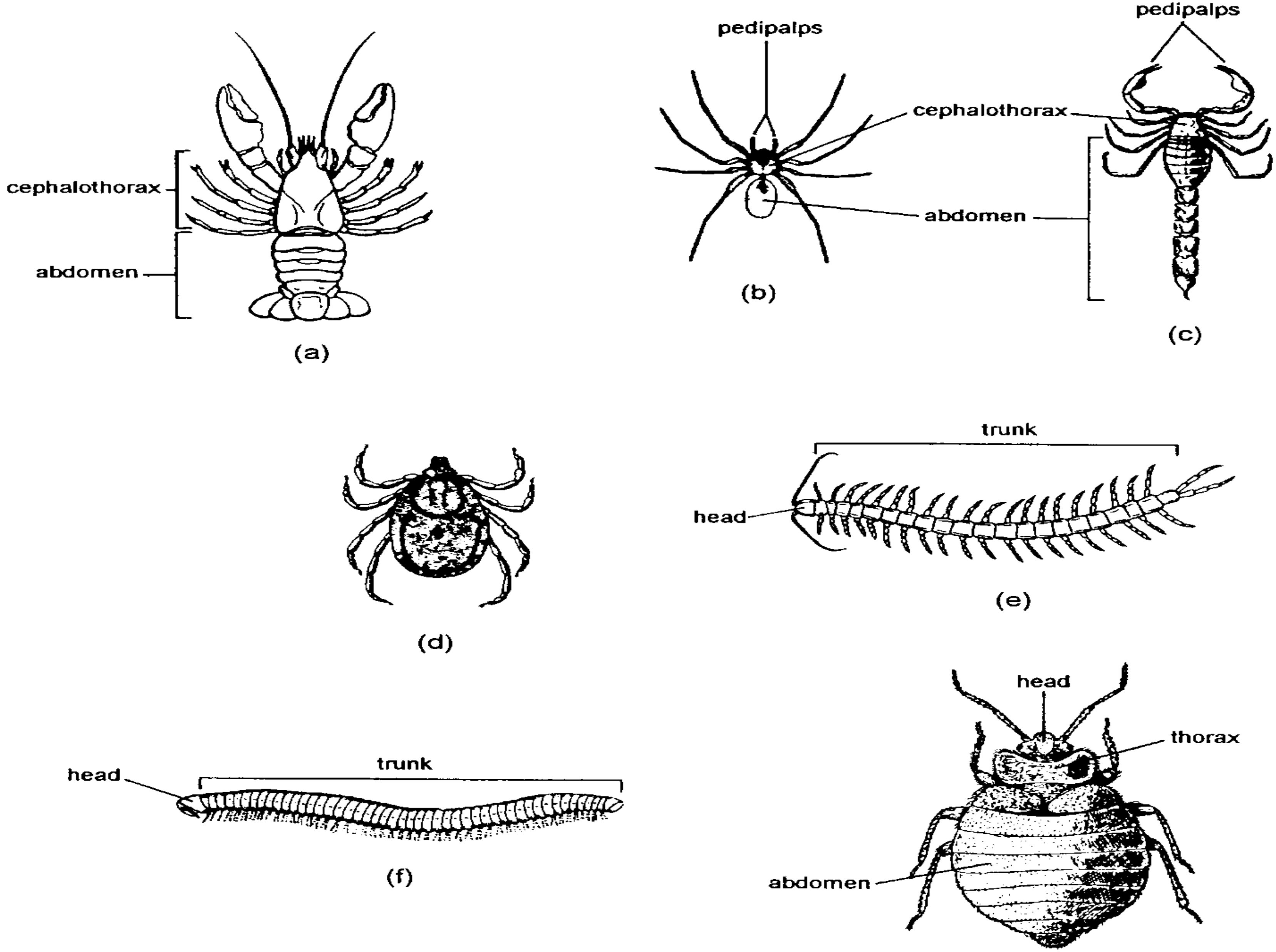
Class Crustacea - lobsters, crabs, etc.

Class Chelicerata - spiders, mites, ticks, scorpions, etc.

Class Diplopoda - millipedes

Class Chilopoda - centipedes

Class Insecta - beetles, flies, moths, etc.


cephalothorax
abdomen
(a)
pedipalps
cephalothorax
abdomen
(b)
pedipalps
(c)
(d)
trunk
head
(e)
head
trunk
(f)
head
thorax
abdomen

Phylum Arthropoda: Salient Features

- The phylum is probably monophyletic, but with 4 distinct groups.
- It includes lobsters, crabs, shrimp, centipedes, millipedes, daddy longlegs, insects, ticks, and mites, and spiders.
- There are over 1 million species of arthropods, making up the largest phylum in the animal kingdom.

Phylum Arthropoda - 2:

- Metameric - (body exhibits true segmentation - replication of muscles and nerves)

- Tagmatosis - (segments of the body are modified and grouped together to form mouthparts and body regions such as the thorax)

- Chitinous exoskeleton – nitrogenous polysaccharide

Phylum Arthropoda - 3:

- Bilaterally symmetrical
- Jointed legs
- Dorsal heart – open circulatory system
- CNS (organized central nervous system)
- Striated muscle

Hypothetical Insect Evolution

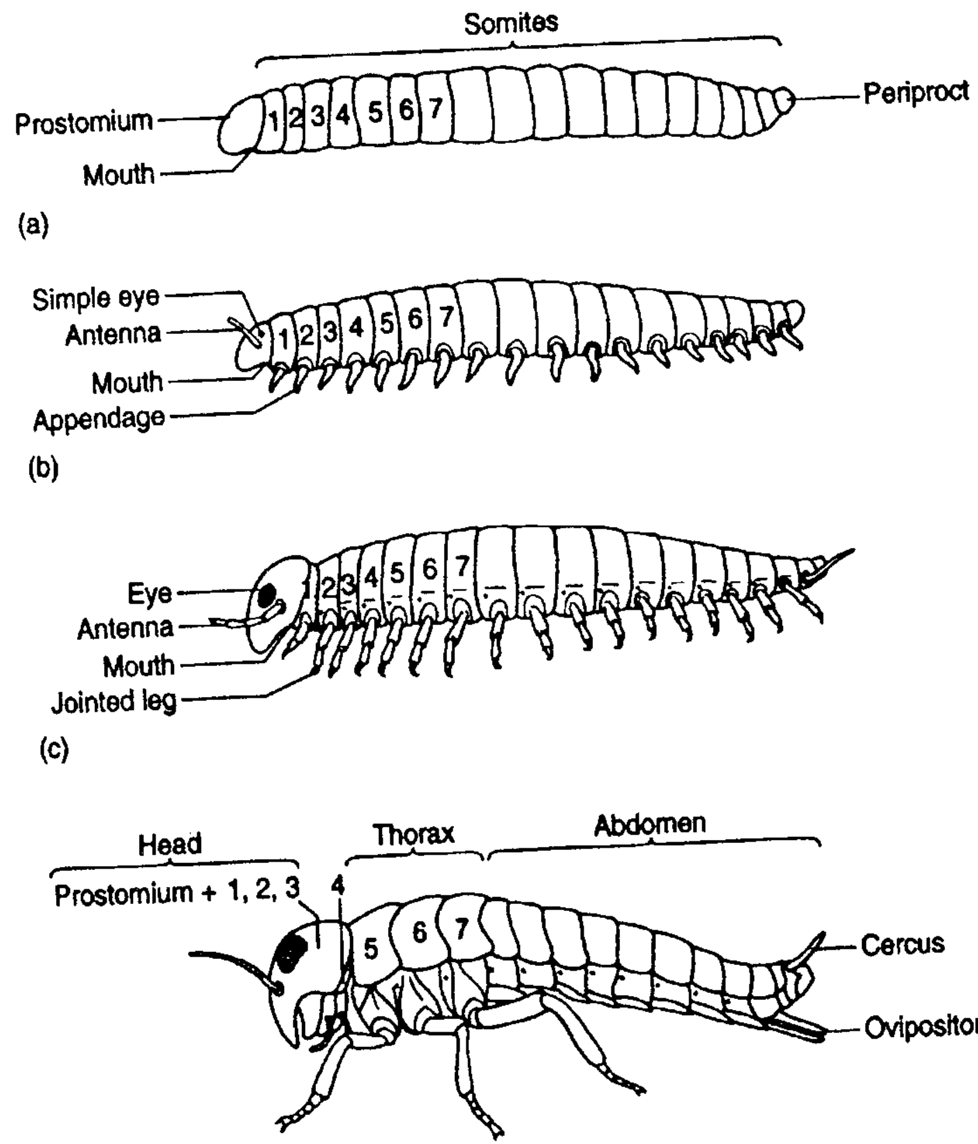
"Worm-like" ancestor

<u>Metamerism</u>

(true segmentation)

<u>Tagmatosis</u>

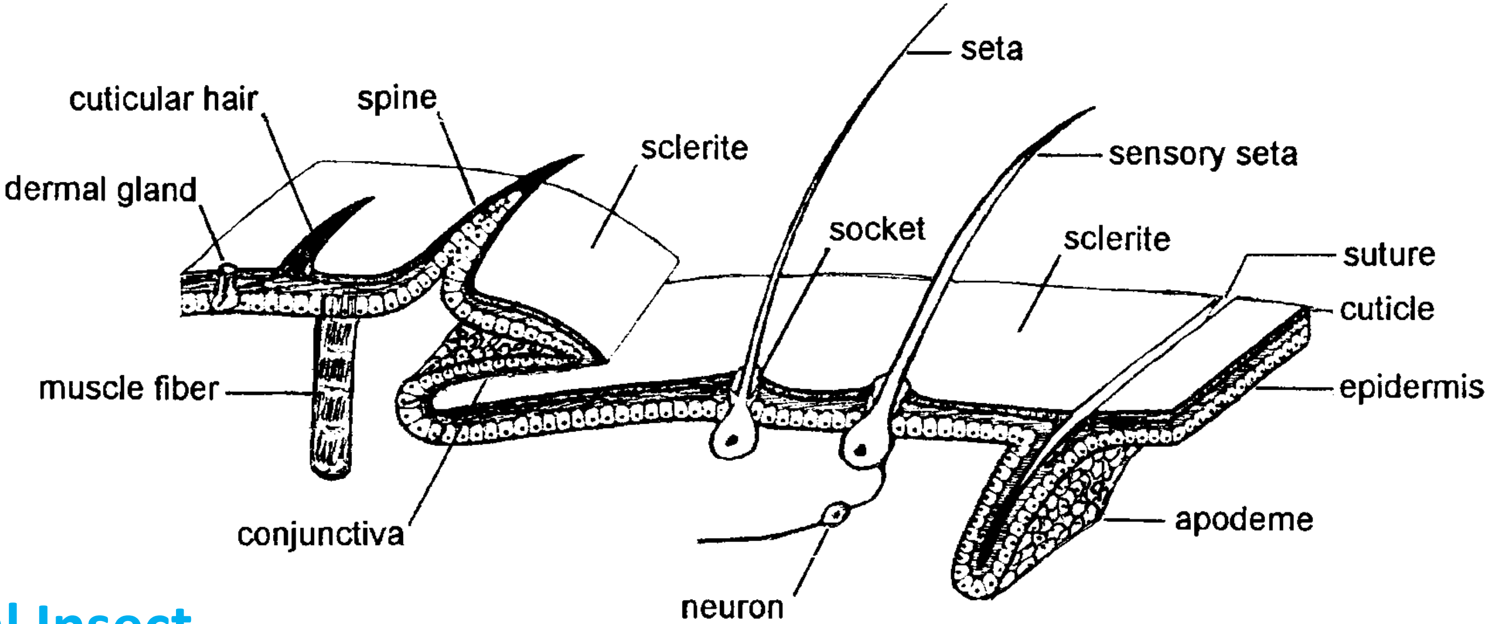
(segments modified
and grouped
together to form
larger body parts)



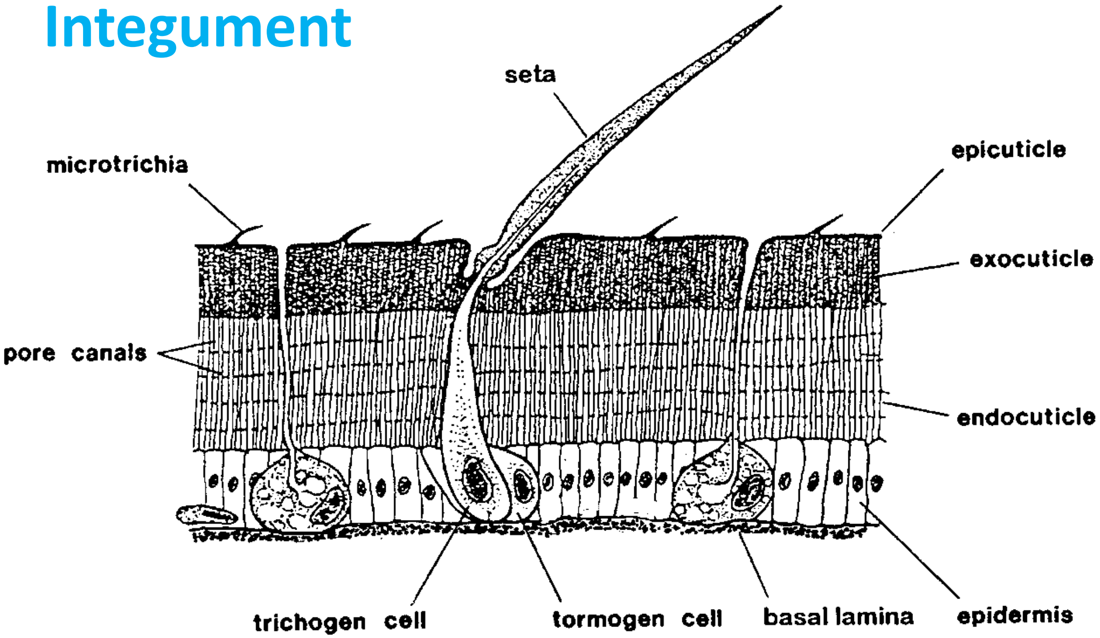
Insect Anatomical Characteristics

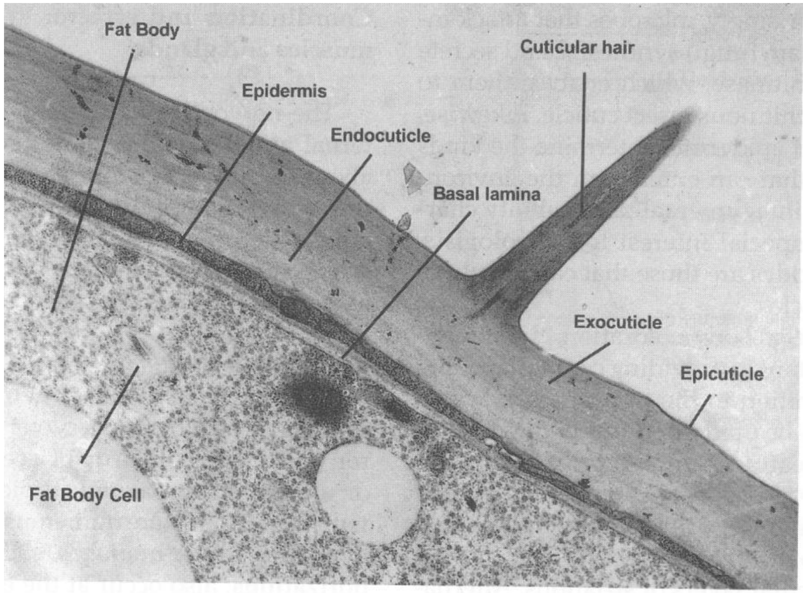
THREE distinct body regions:

- Head (feeding, sensory, CNS)
- Thorax (locomotion, respiration)
- Abdomen (feeding, reproduction)

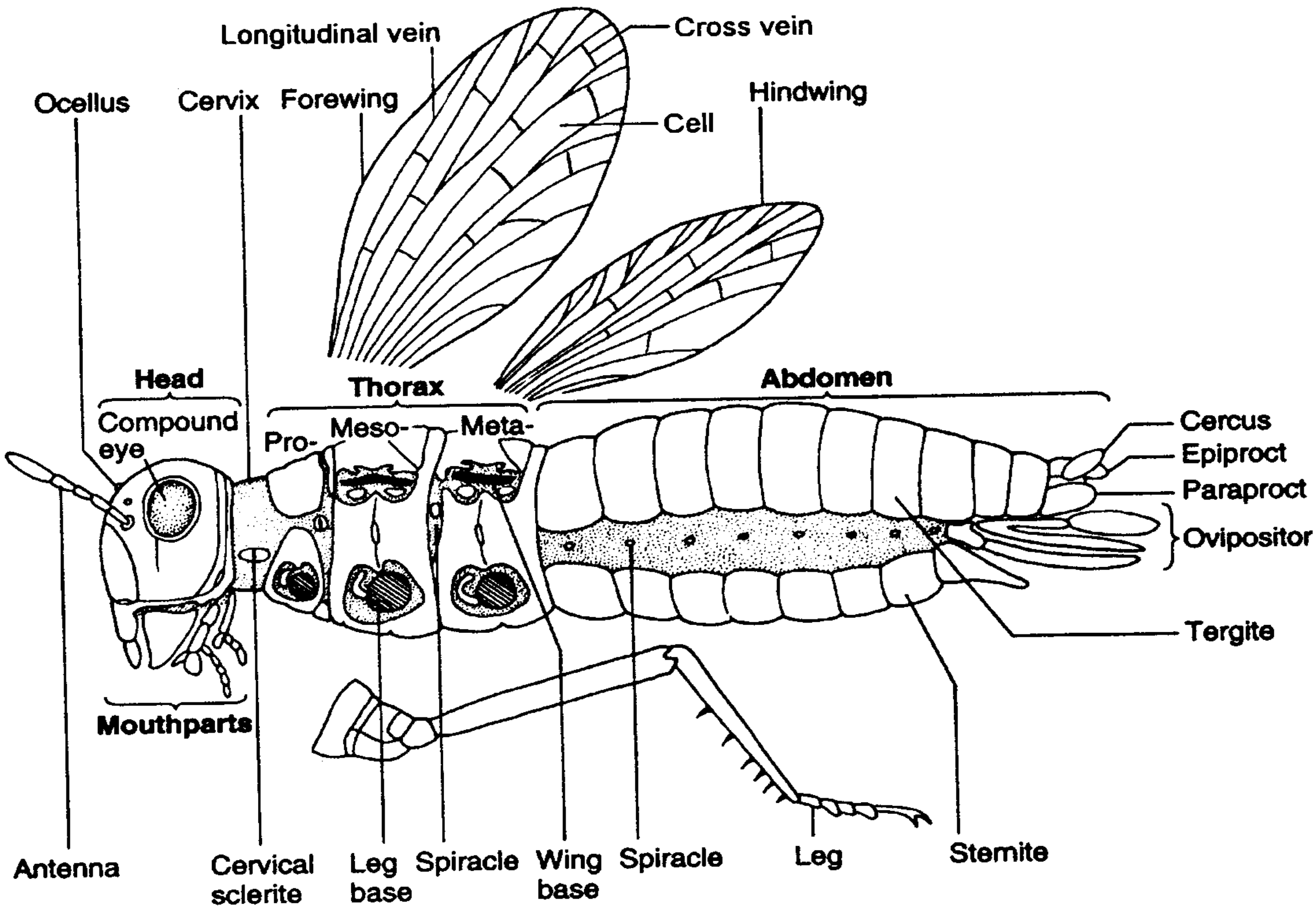


Typical Insect Integument

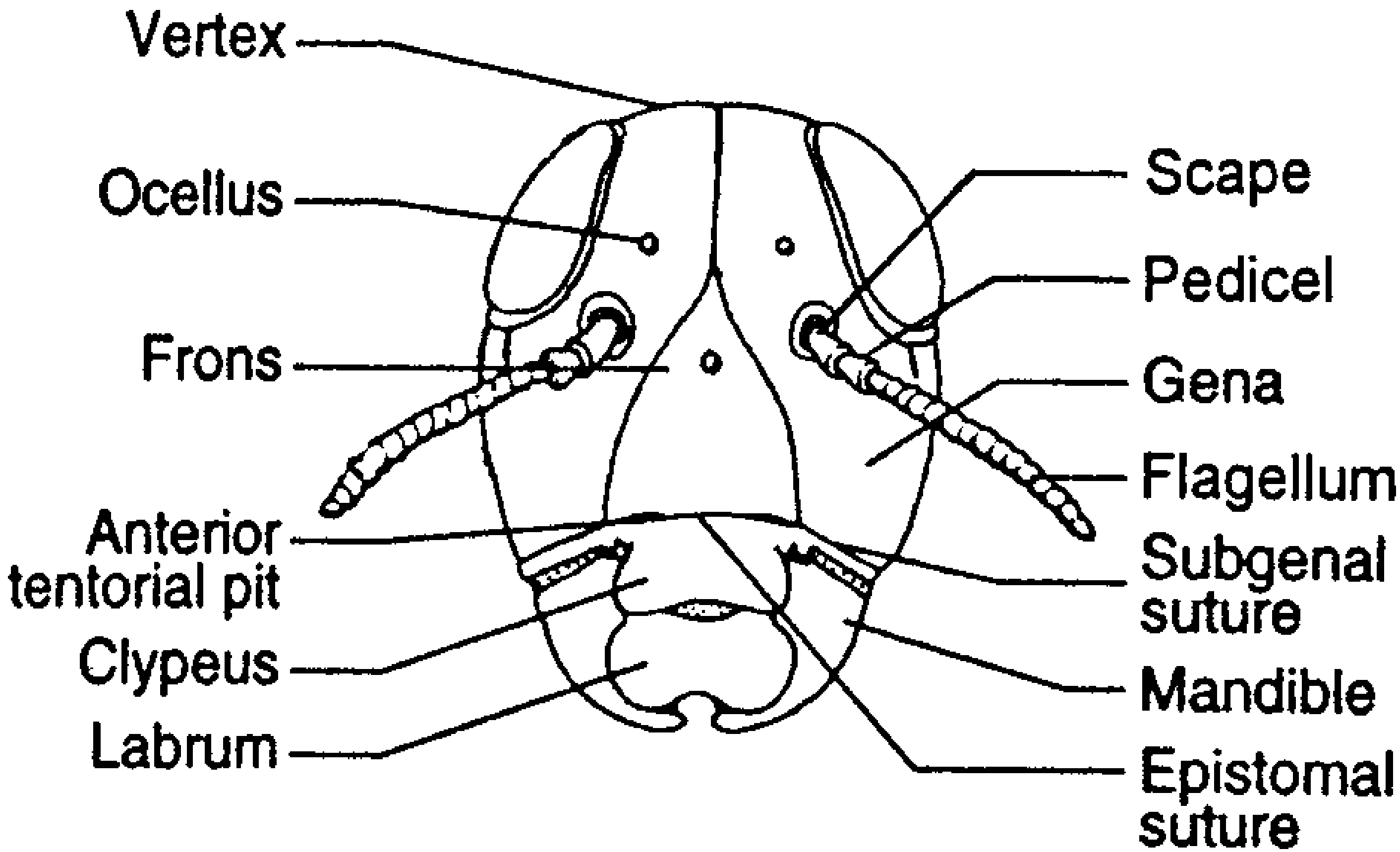




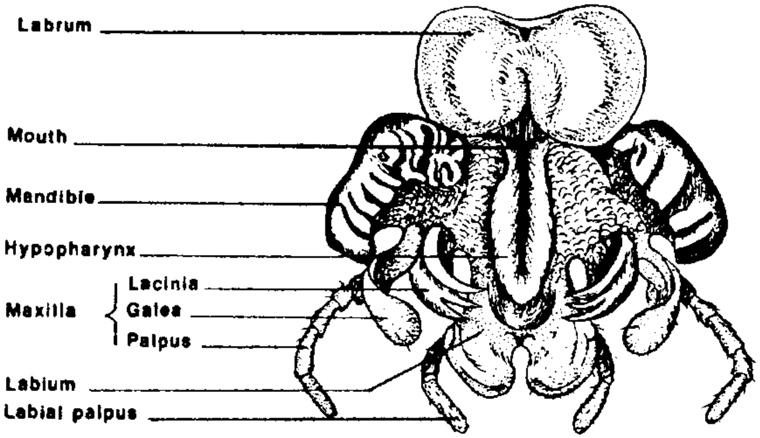
General Insect structure



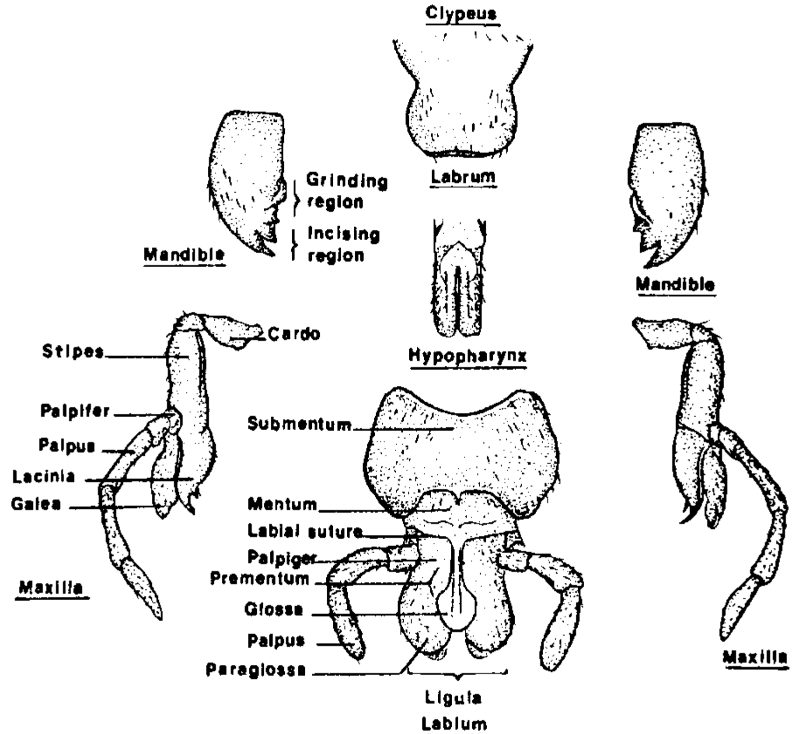
General Insect Head



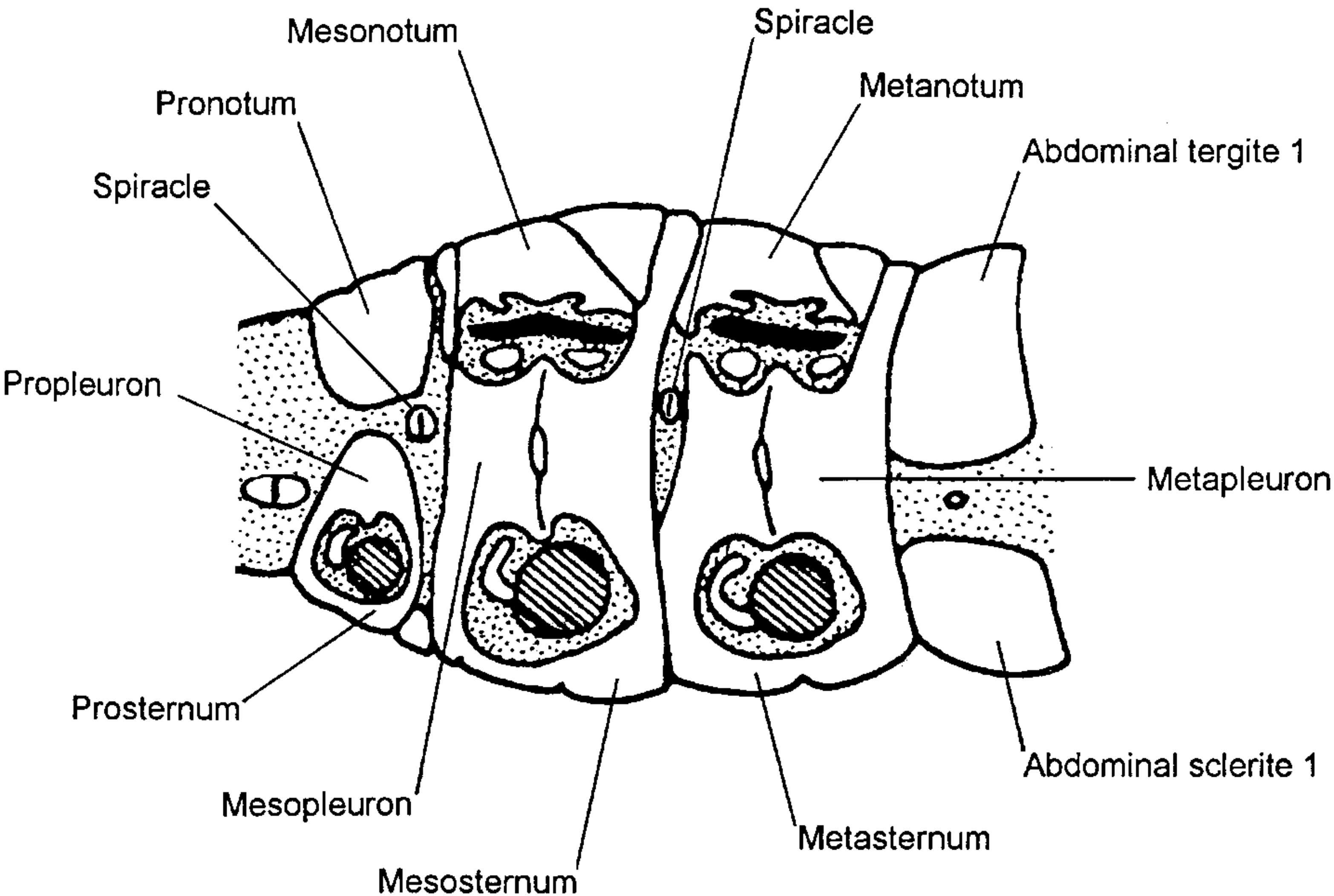
Grasshopper Mouthparts



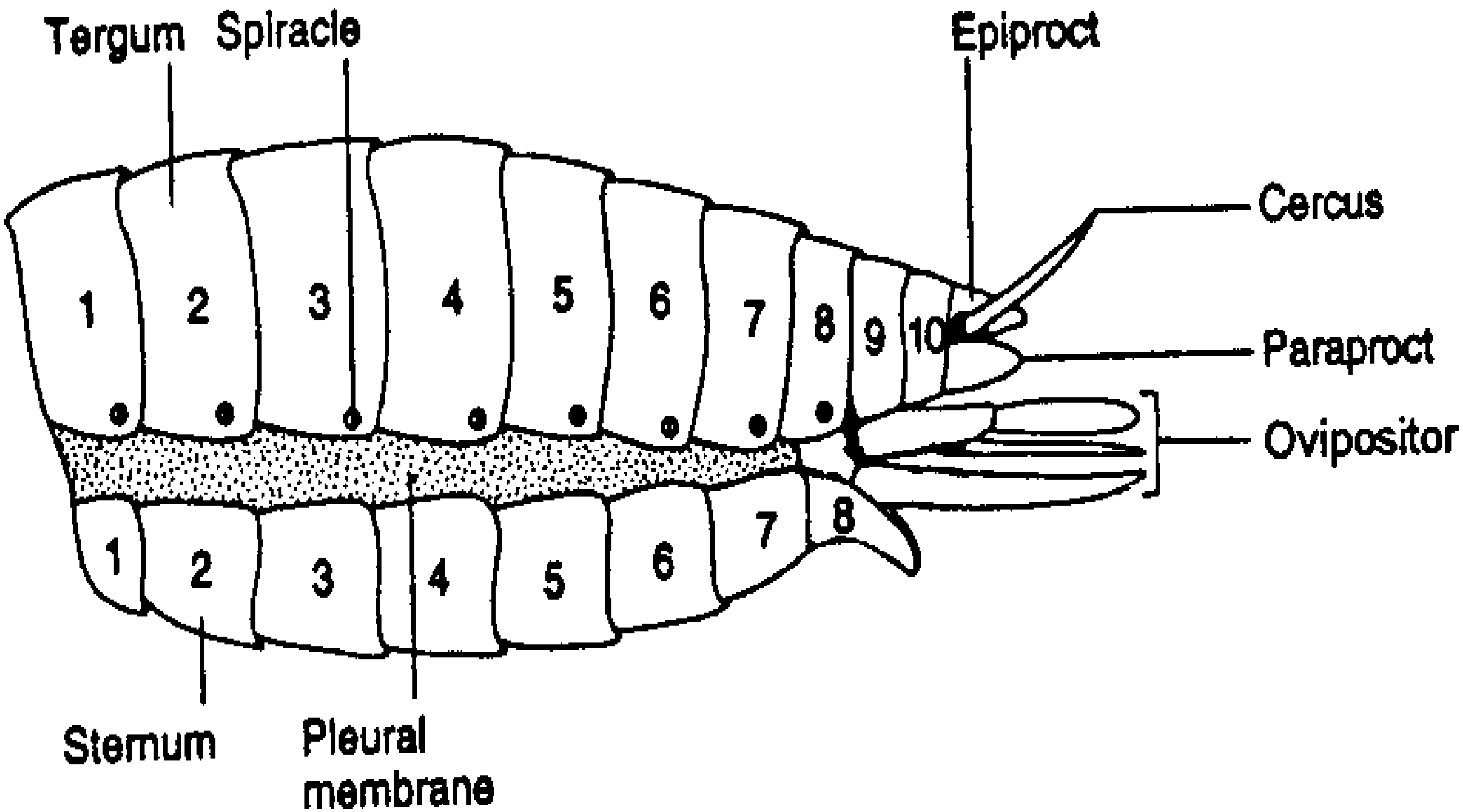
Cricket Mouthparts Dissected



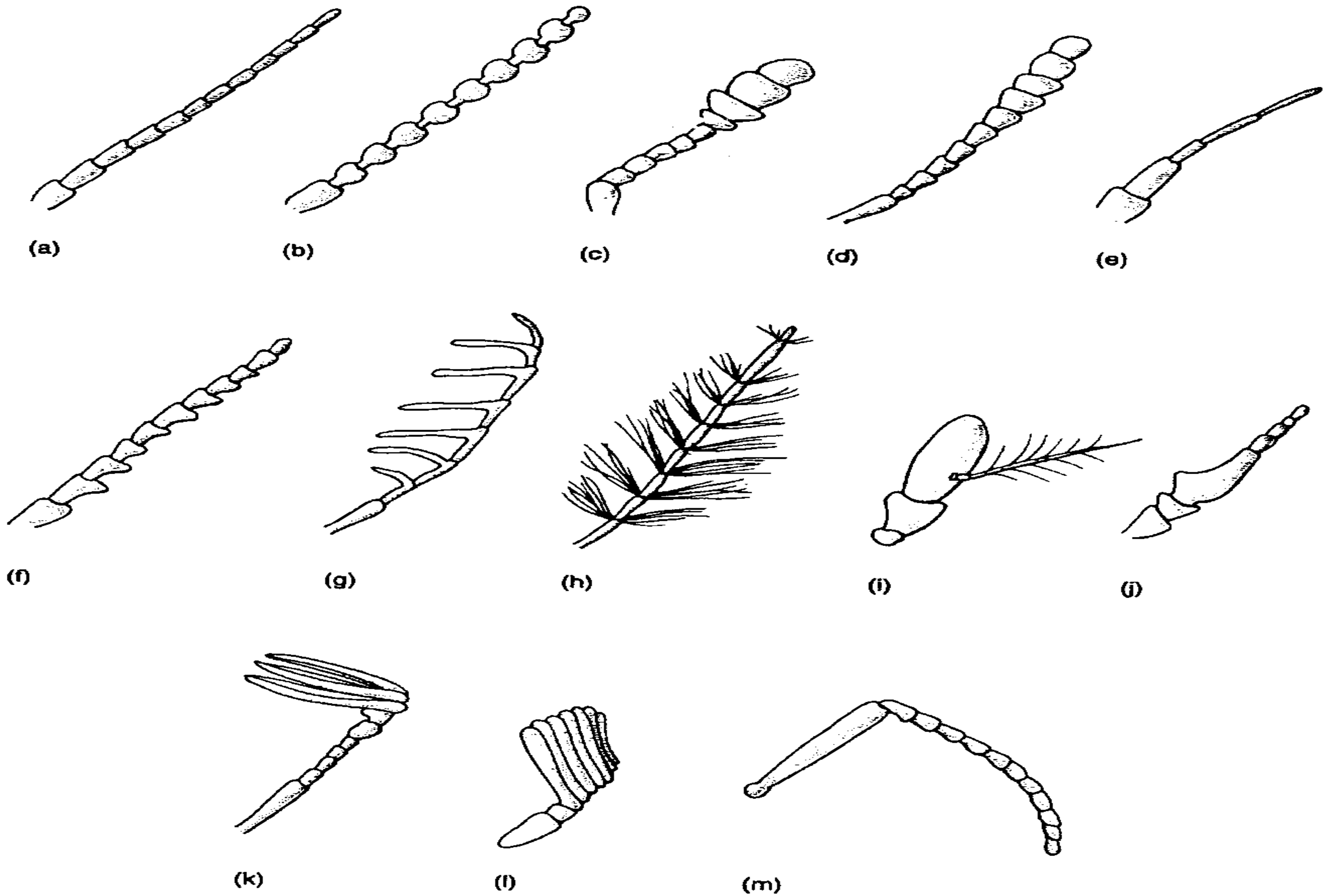
Insect Thorax



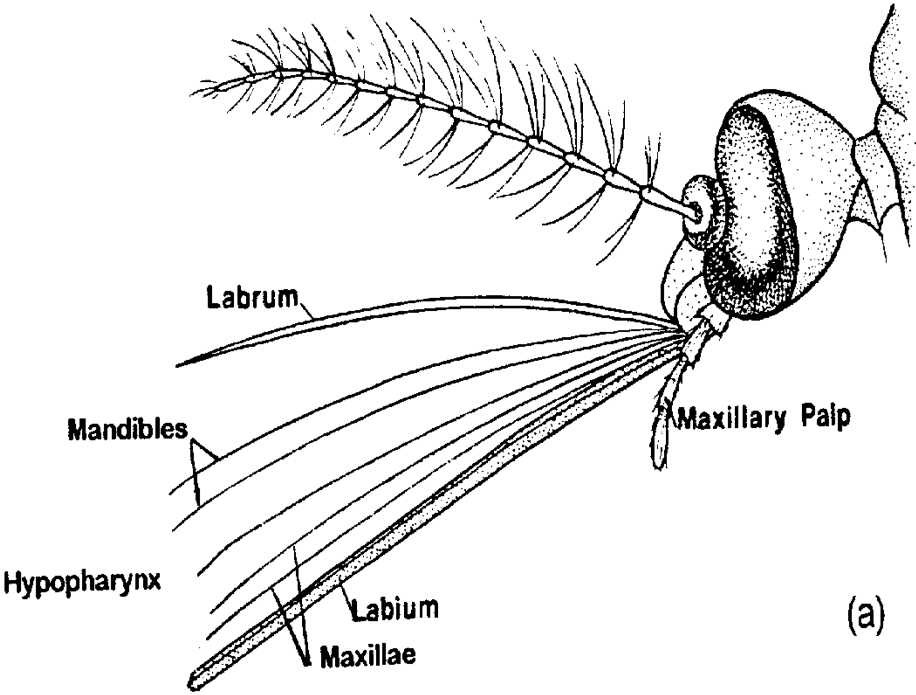
Insect Abdomen



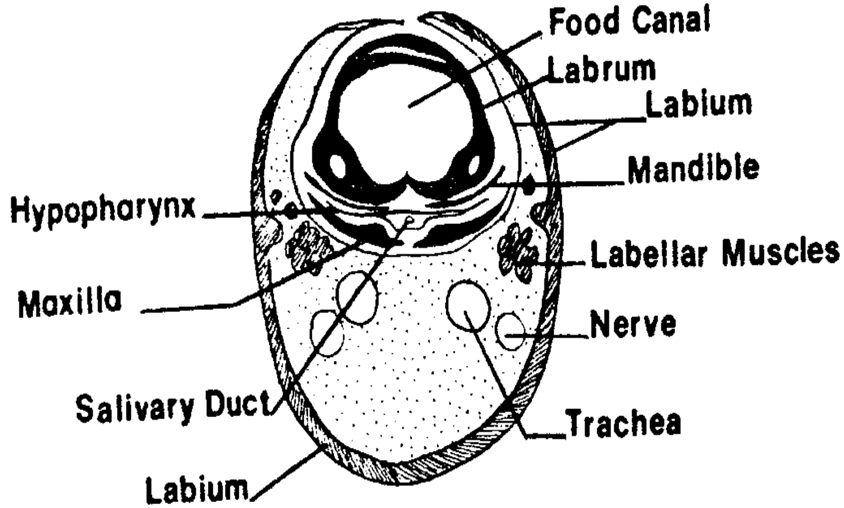
Insect Antennae



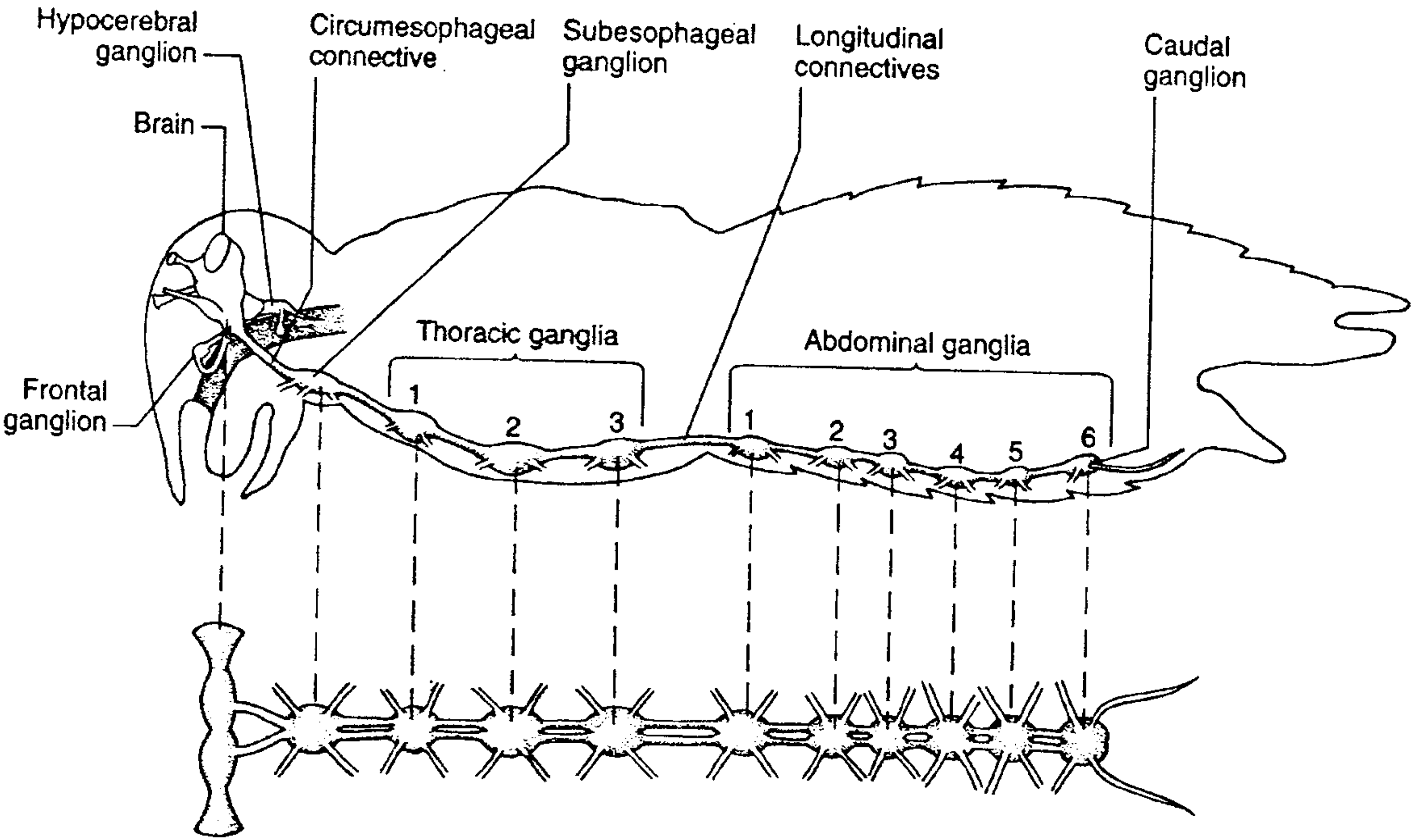
Piercing/sucking Mouthparts



(a)



Insect Nervous System



Insect Endocrine Regulated Process

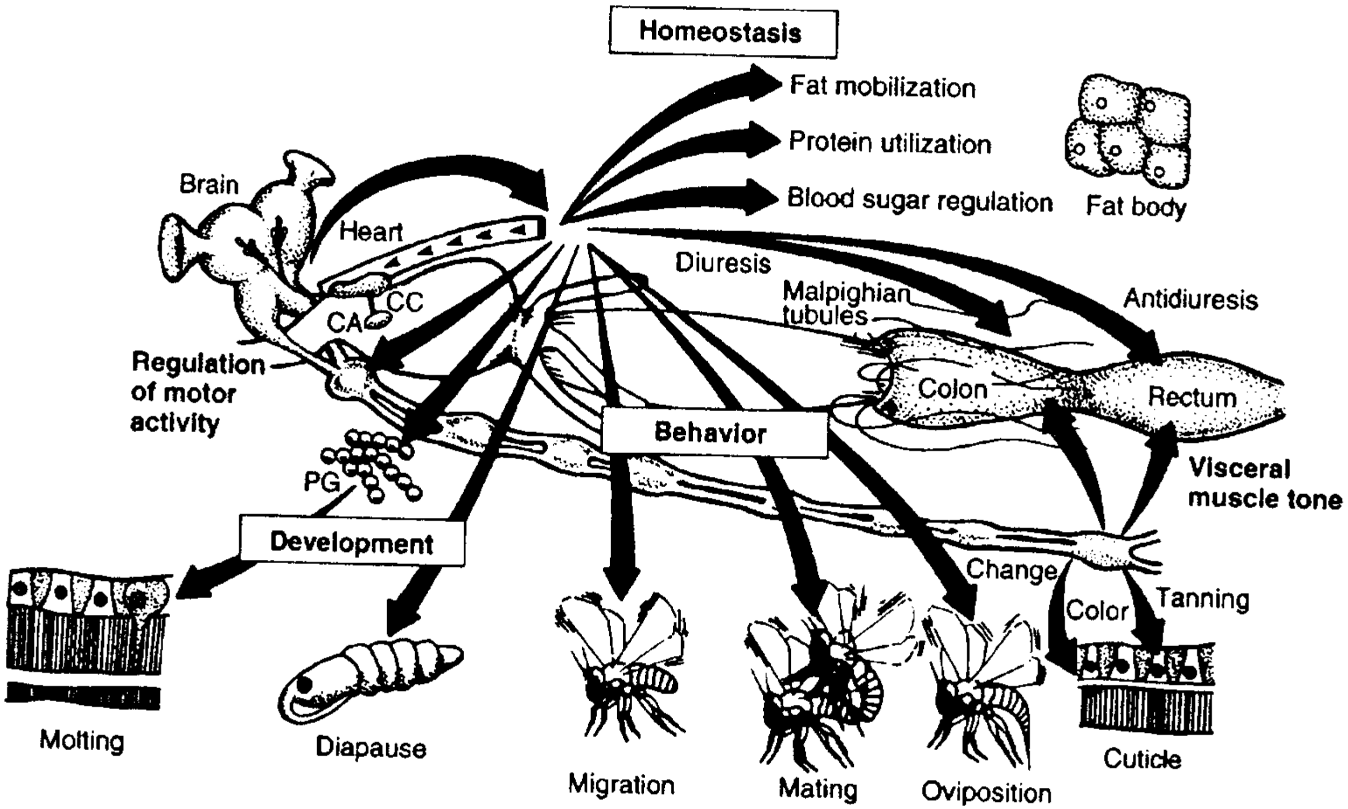
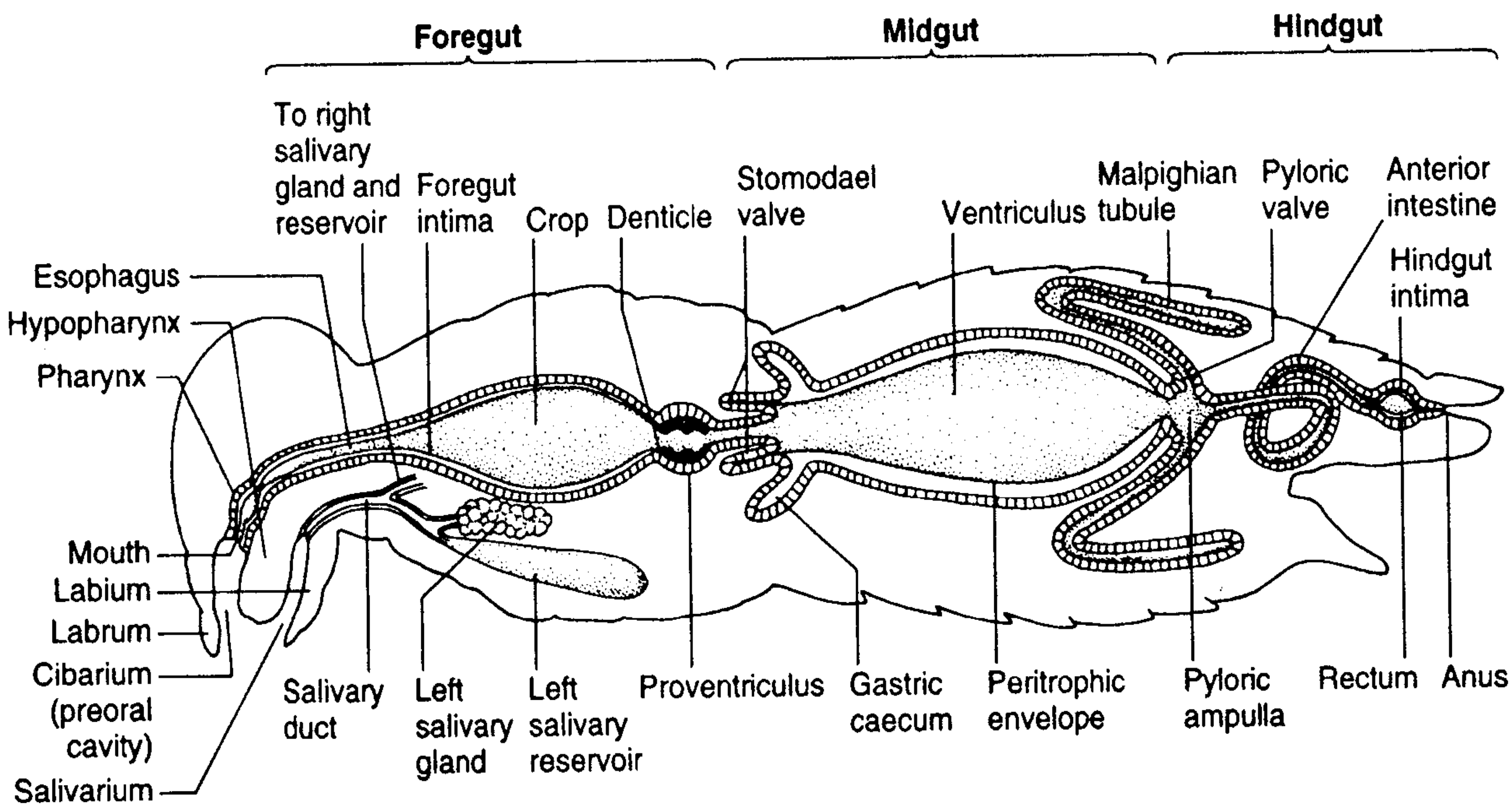
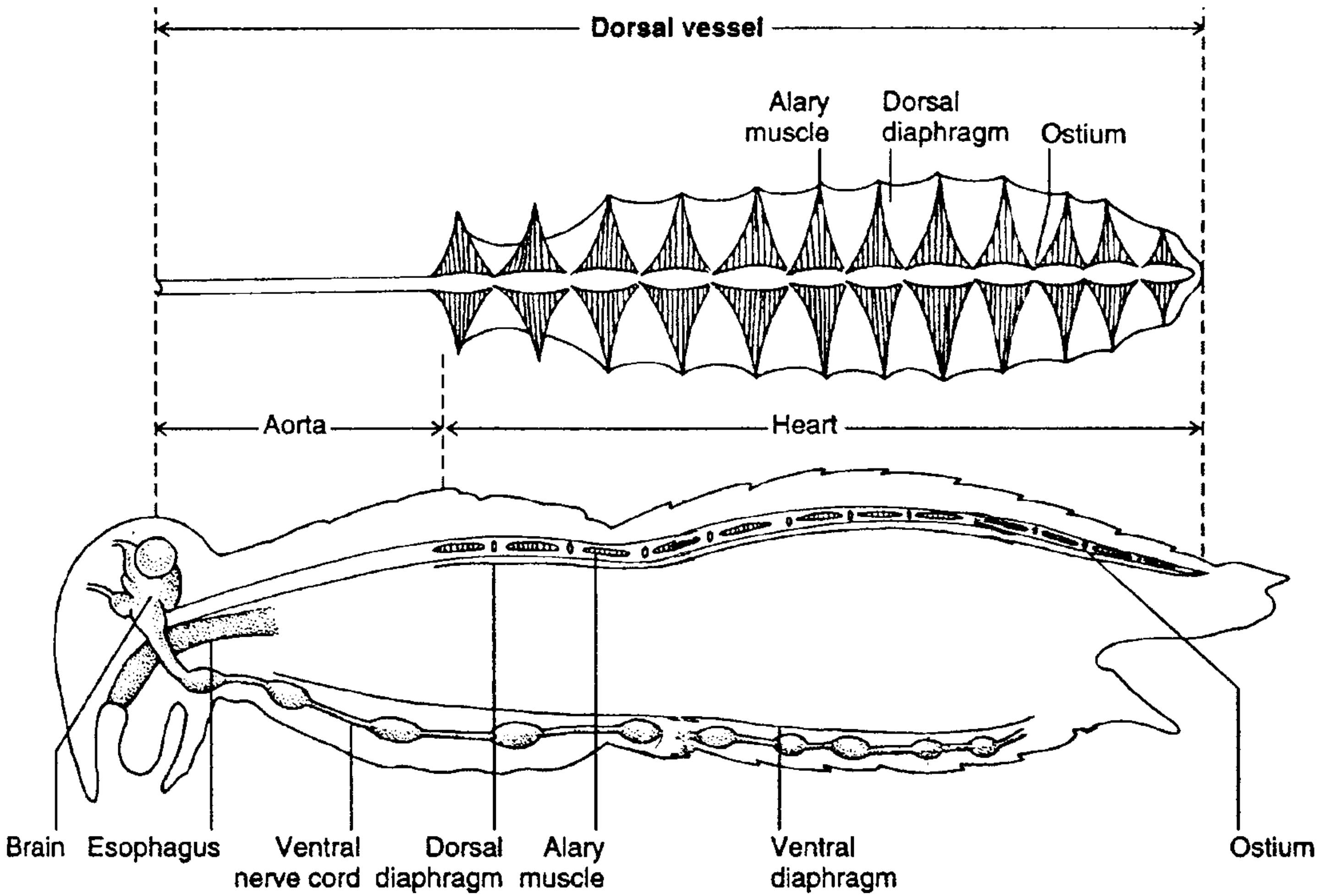


Figure 2.15. Endocrine regulated processes in insects (from Cook and Holman 1985, with permission from Pergamon Press Ltd., Headington Hill, Oxford, UK).

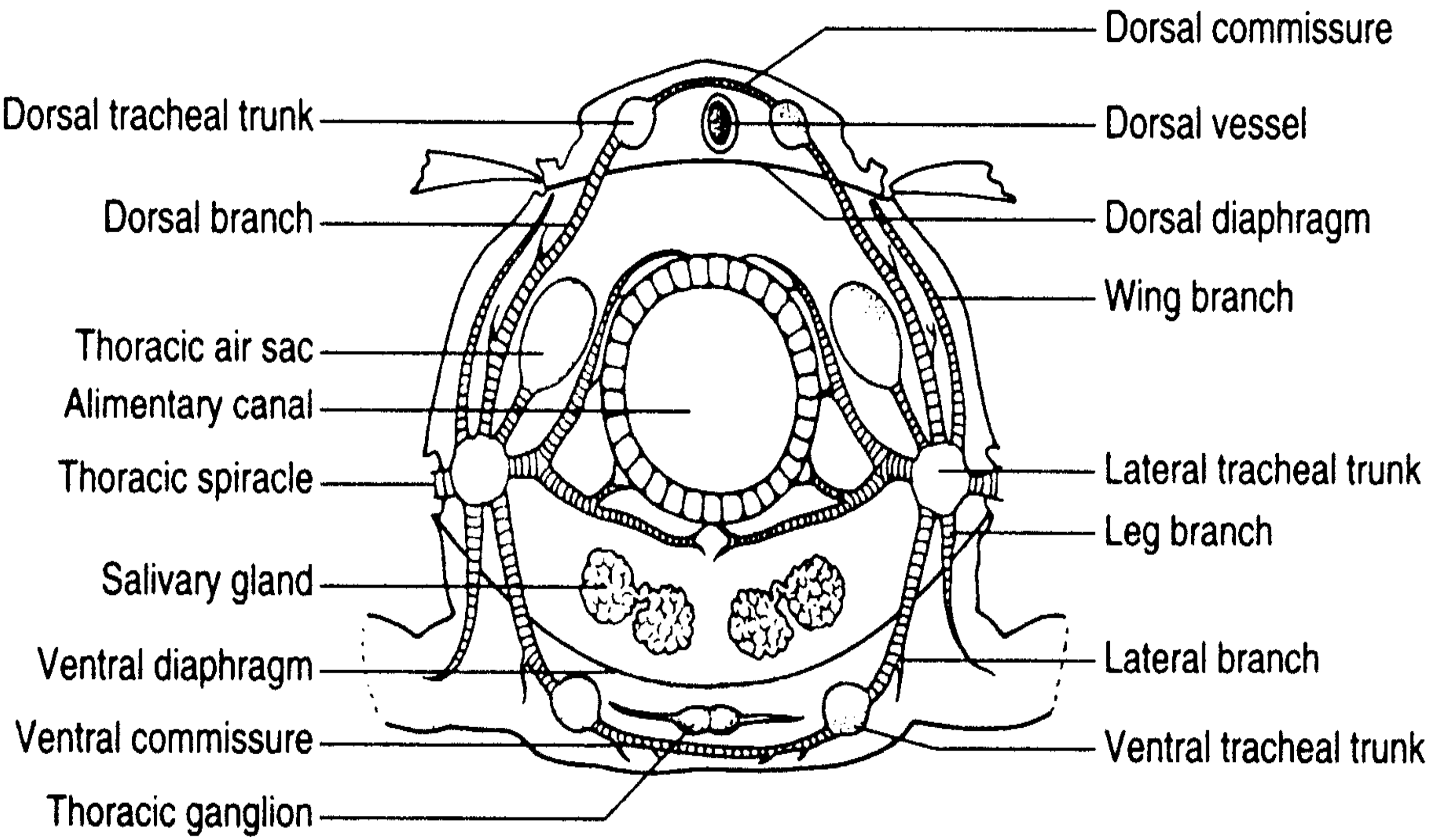
Insect Alimentary Canal



Insect Circulatory System

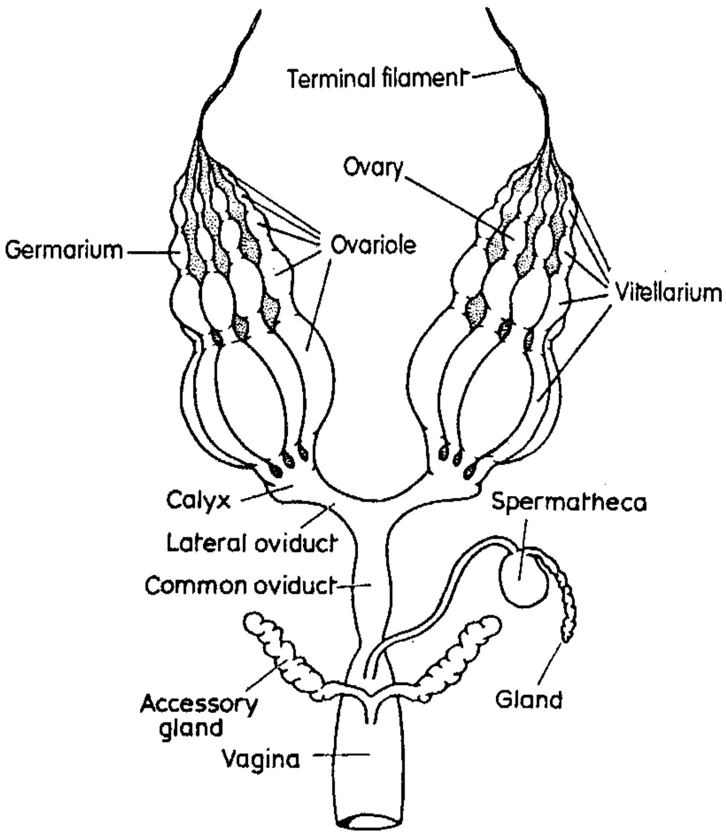


Insect thorax showing tracheal branches

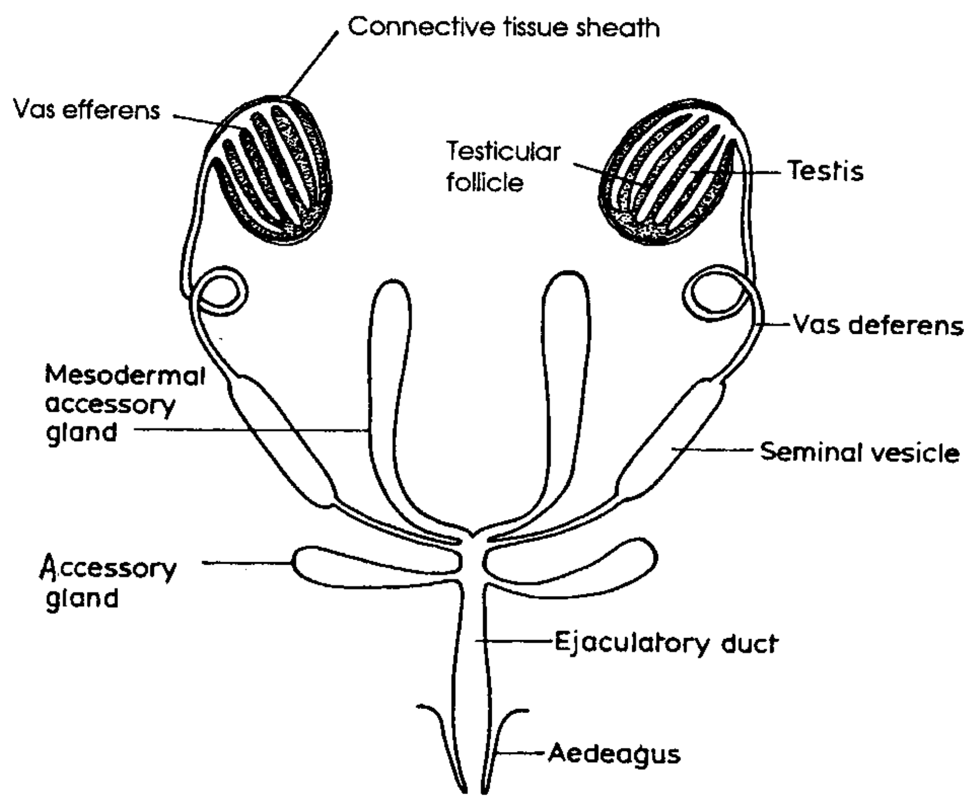


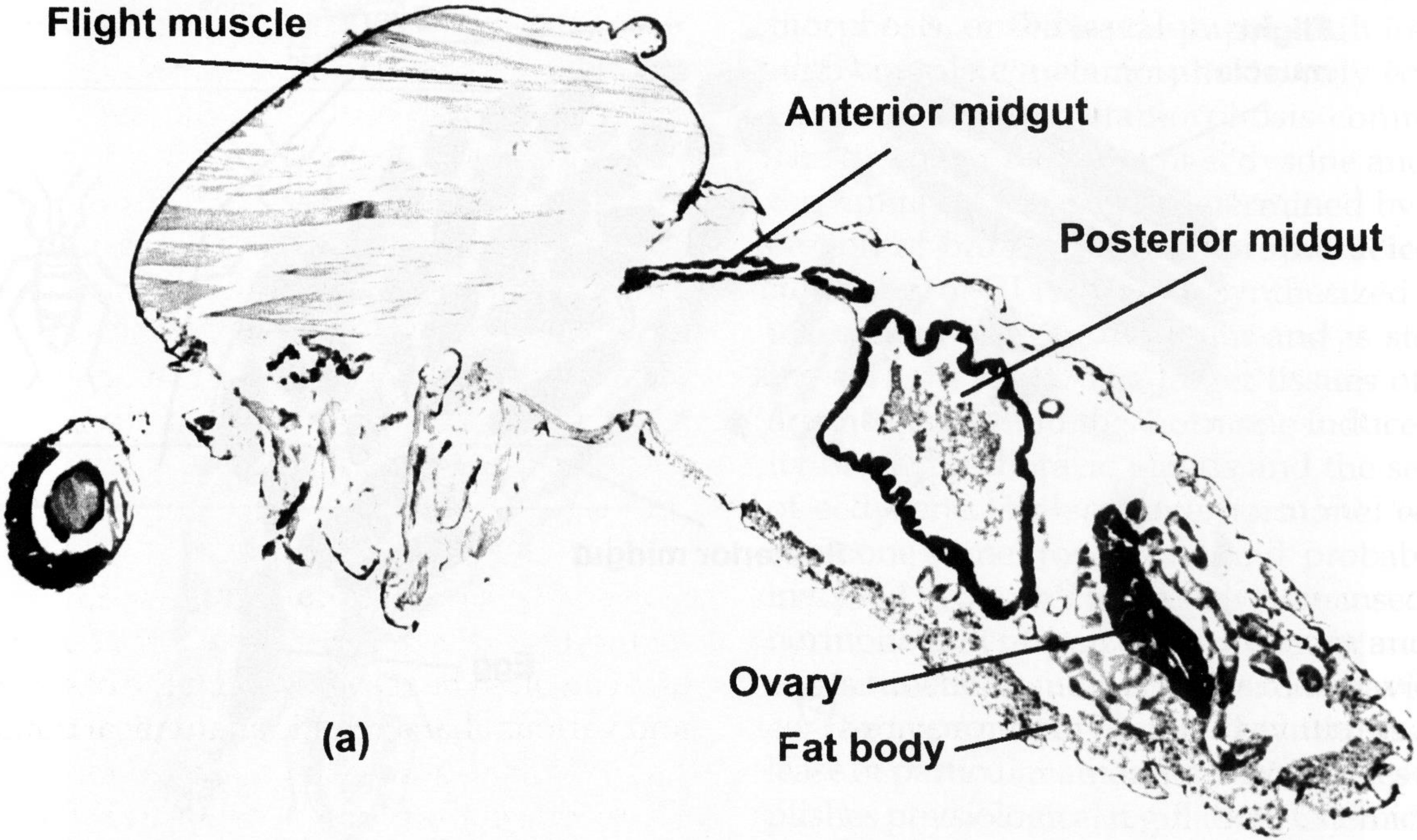
Insect Reproductive System

Female

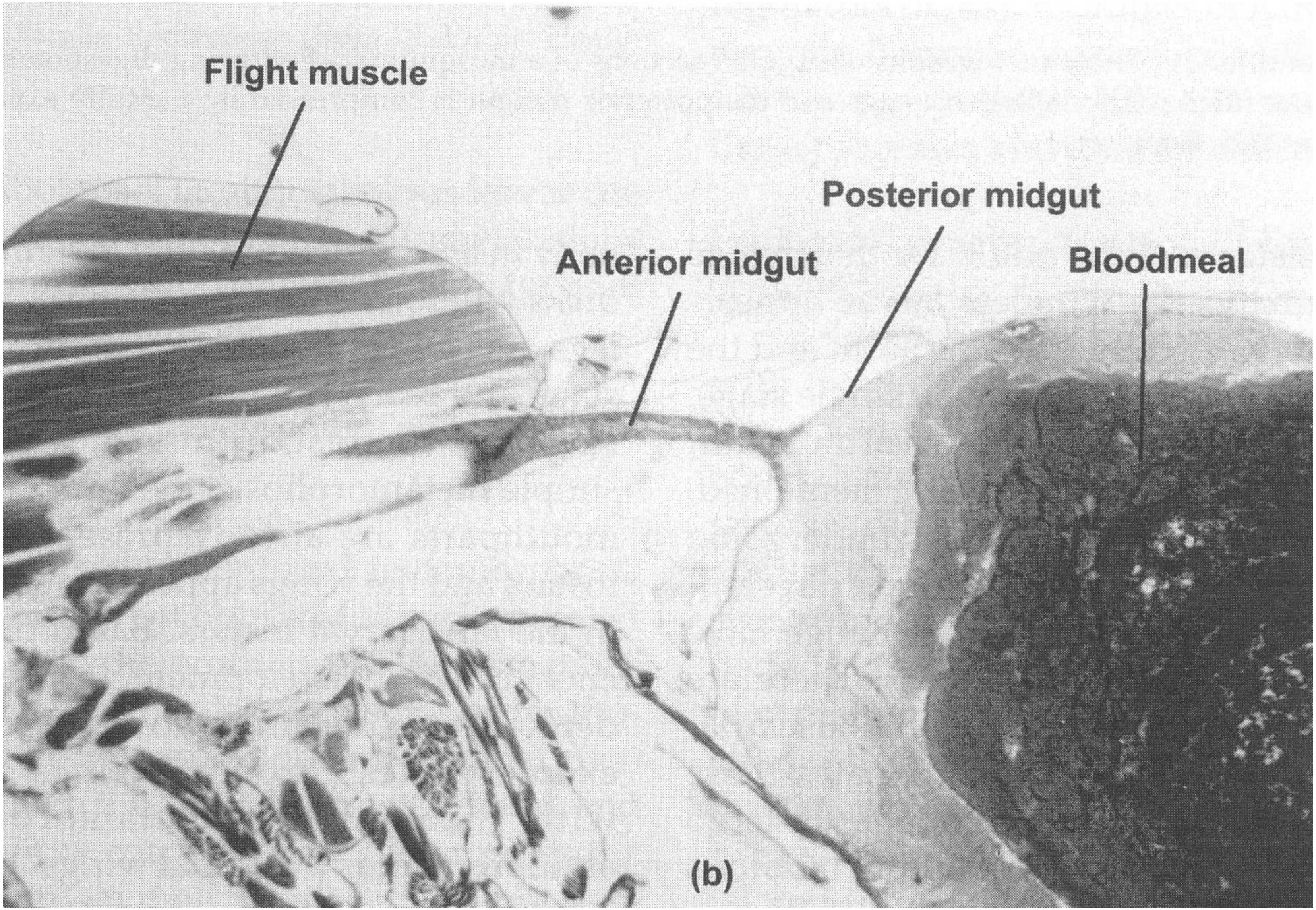


Male

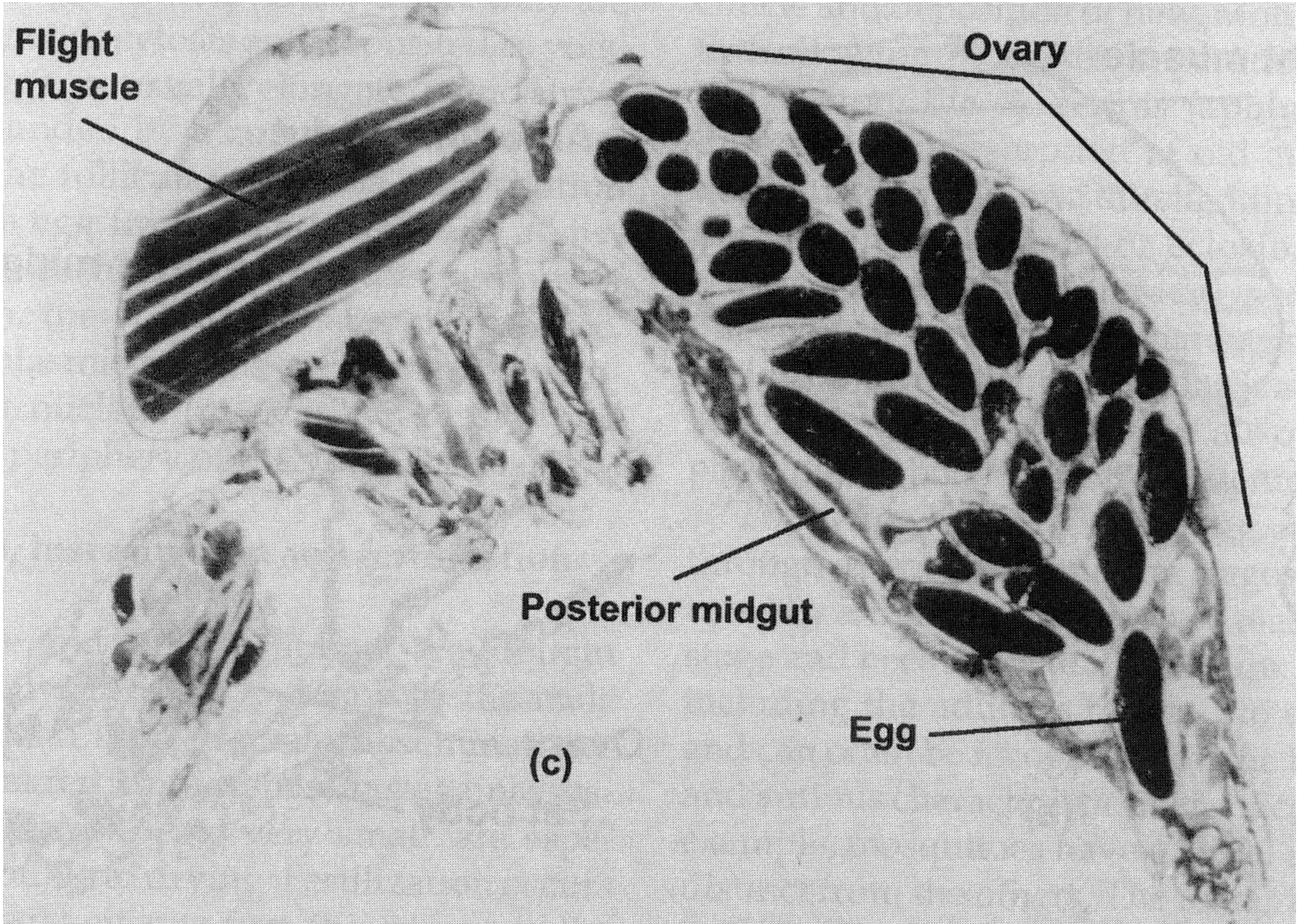




Cross Section of Unfed Mosquito



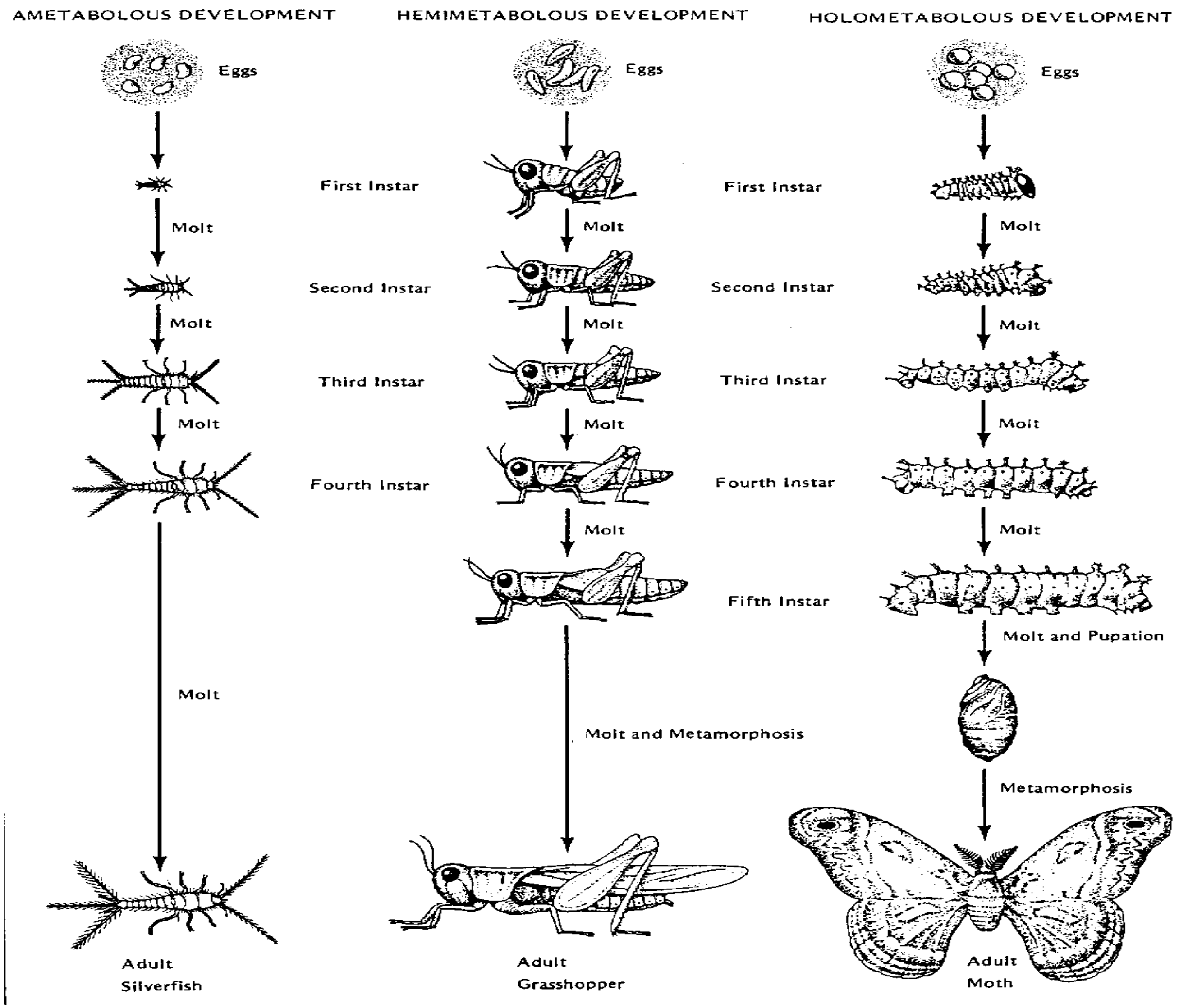
Blood fed Mosquito



Gravid Mosquito

Types of Insect Development

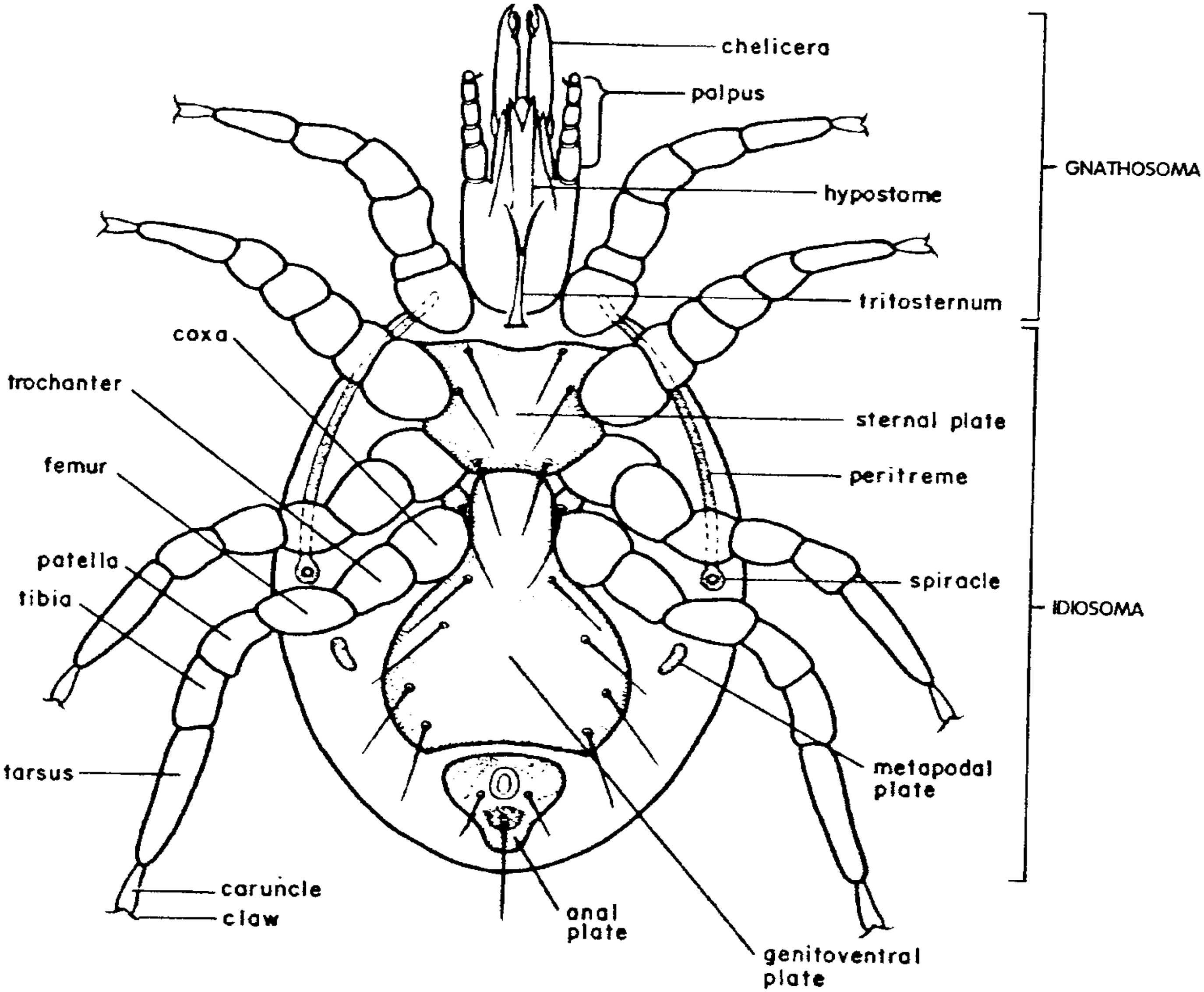
"A" – (lacking) "Hemi" -(incomplete) "Holo" -(complete)

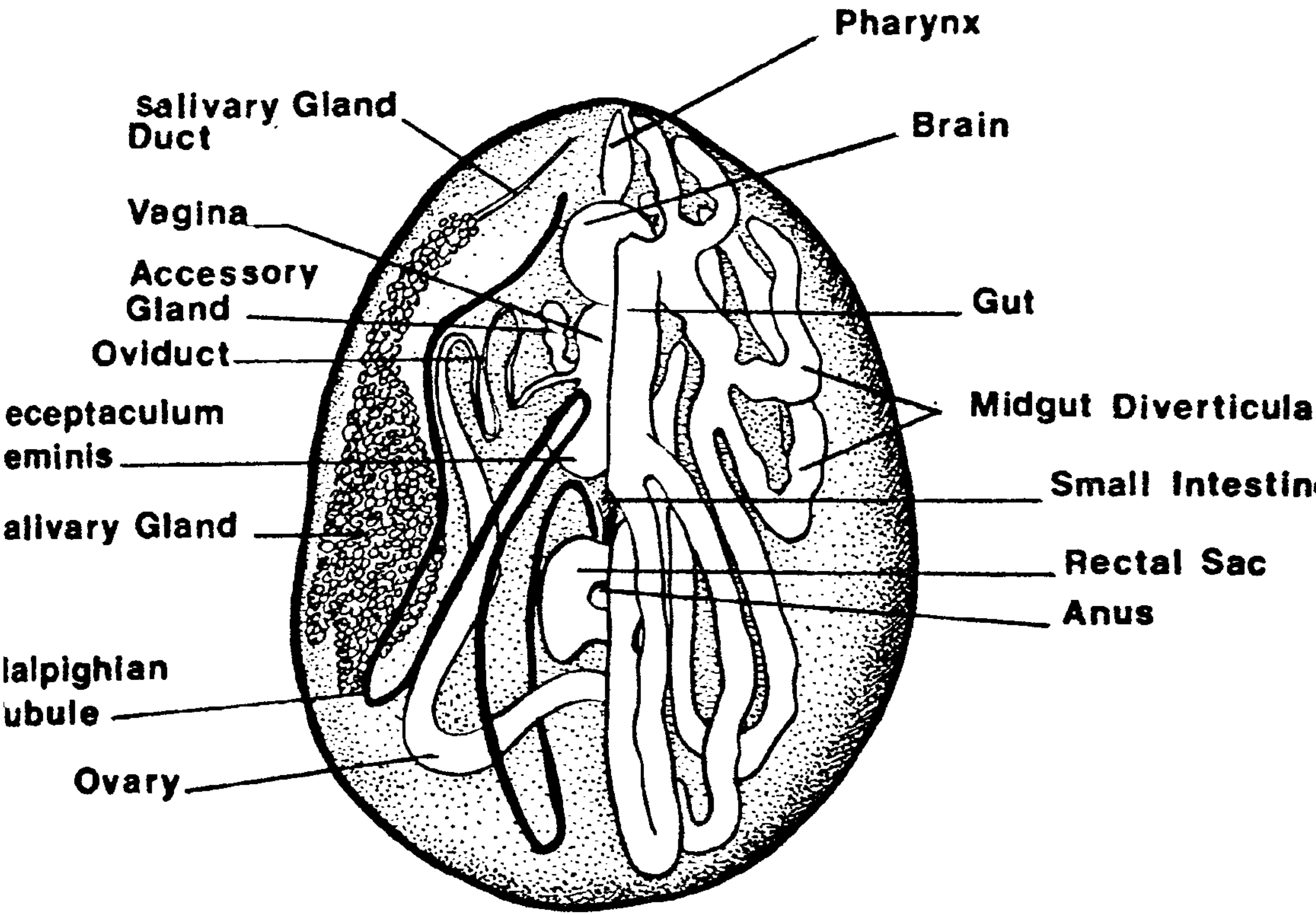


Other Medically Important Arthropods (non-insects)

Mite

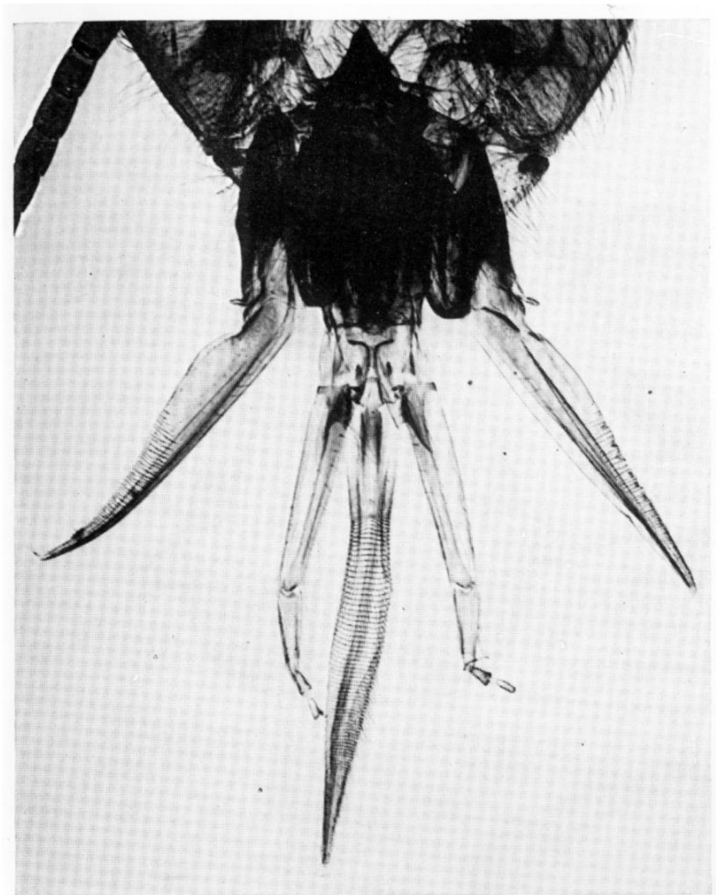
External Anatomy



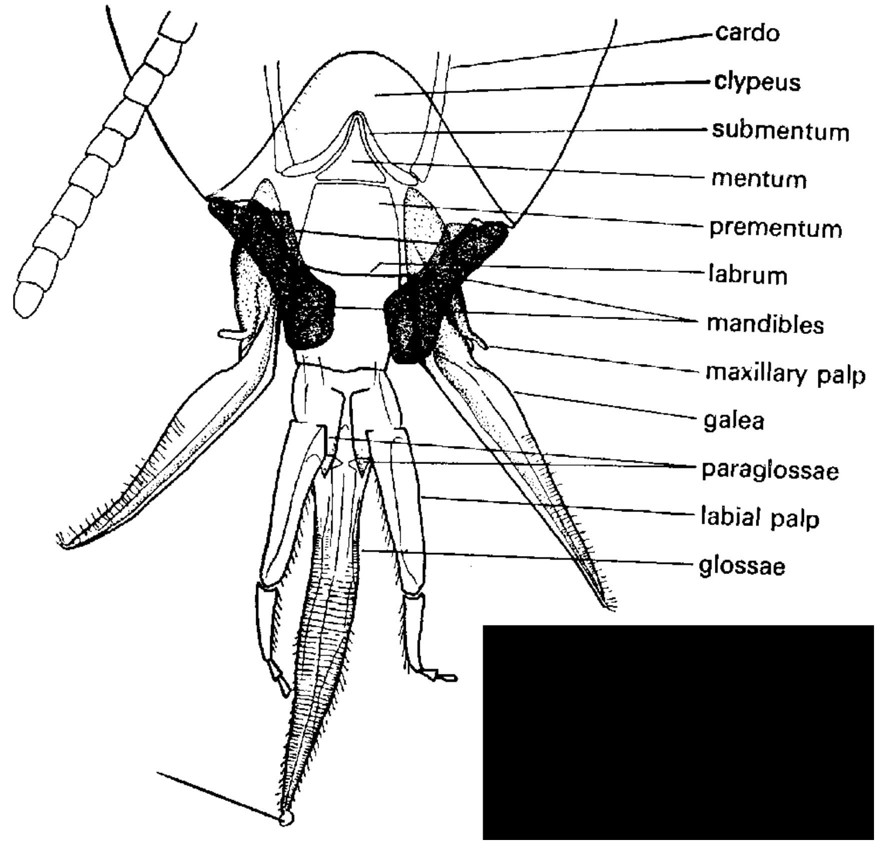


Tick Internal Anatomy

Insect Mouthparts and their Importance

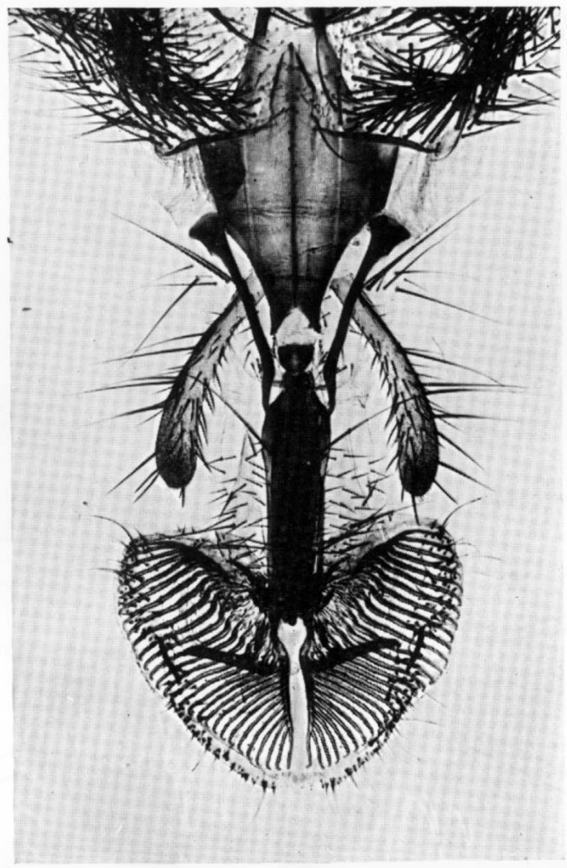


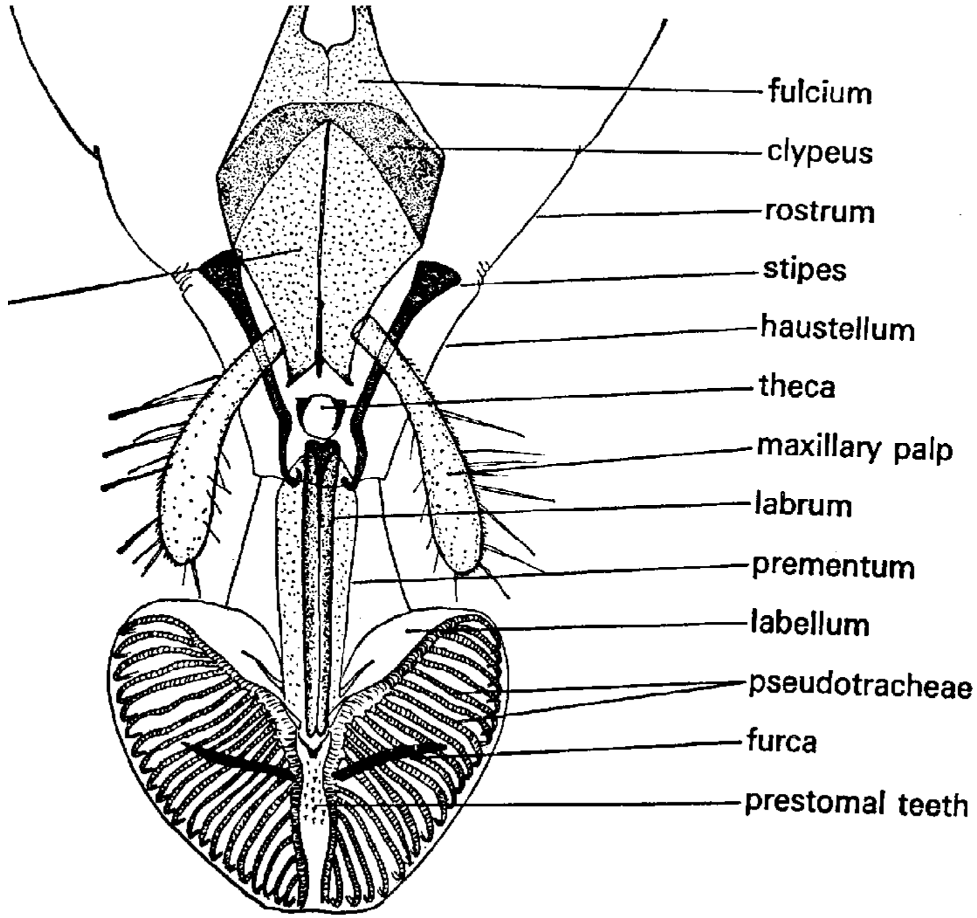
112. *Apis*, worker, mouthparts E. Mag. ×10



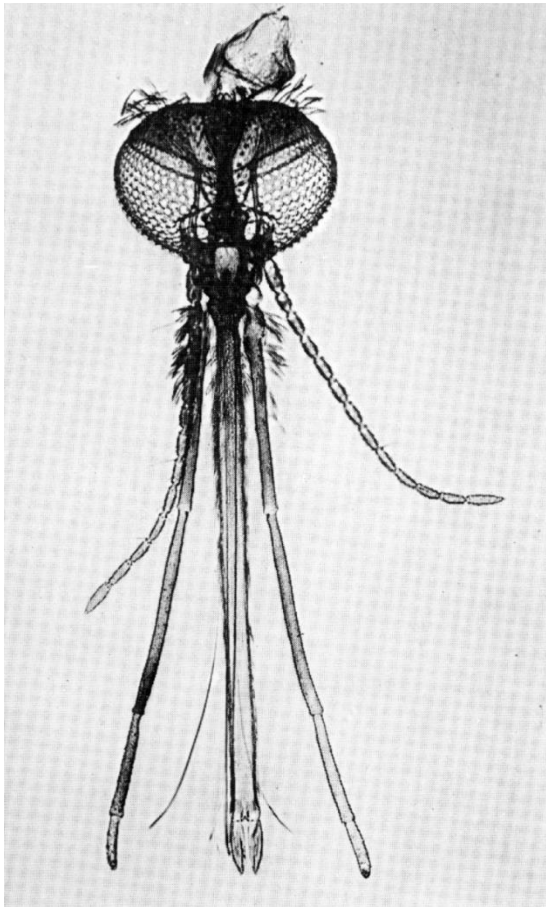
Apis (honeybee) mouthparts

114. **Housefly,** mouthparts E. Mag. ×18

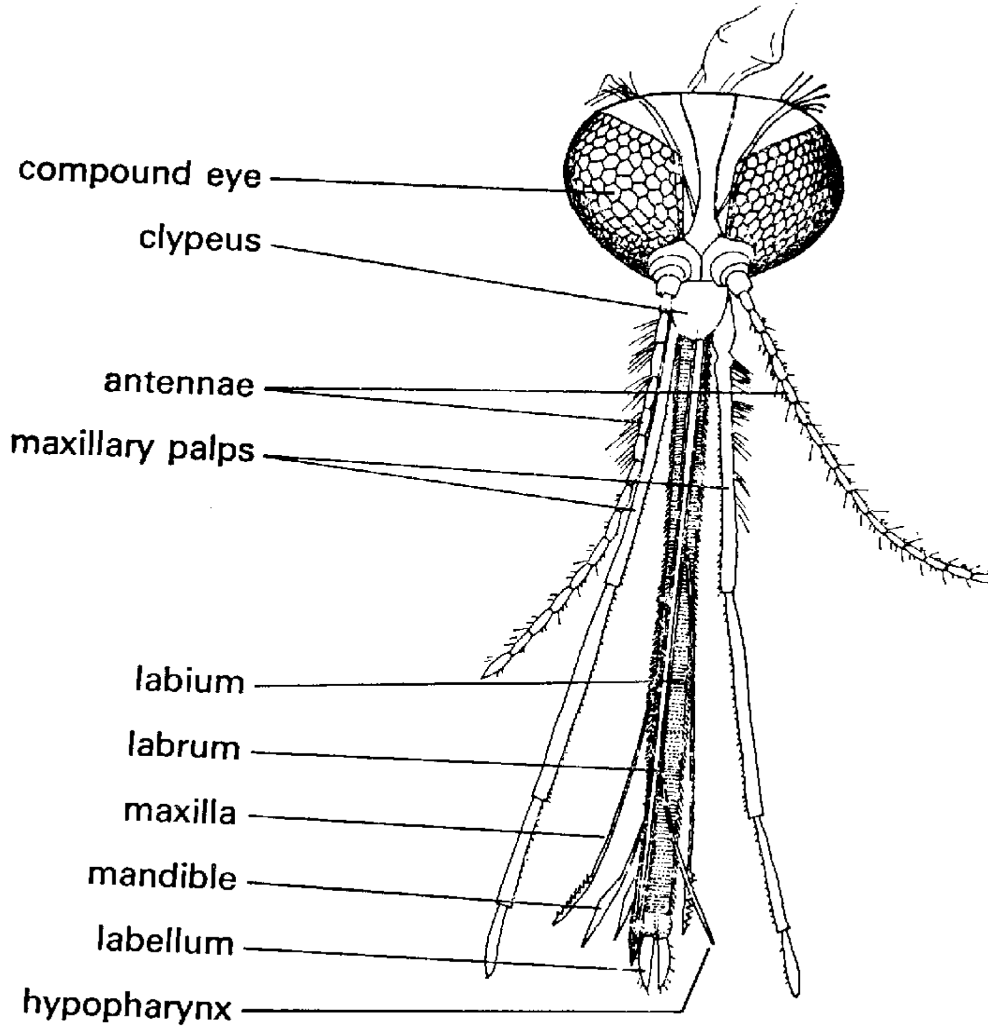




Housefly mouthparts



113. ***Anopheles,*** mouthparts E. Mag. ×12



Anopheles (mosquito) mouthparts

- Concepts in Vector-Borne Diseases

Transmission efficiency:

- Geographic or host distribution of the parasite
- Incidence of any given parasite and associated host
- Parasite enhancement of transmission

Transmission frequency:

- Shorter life cycle of parasite = more frequent and more efficient transfer to be successful
- Both transmission efficiency and frequency related to blood feeding frequency and efficiency of the vector. These are important factors in vector capacity.

Host

- reservoir host
- disseminating host
- dead-end (aberrant) host

Vector:

- primary vector
- secondary vector
- maintenance vector

Vector Biting Activity:

- nocturnal
- diurnal
- crepuscular

Host specificity (blood meal source):

- anthropophilic
- anthropophagous
- ornithophilic
- ornithophagous
- zoophilic

Feeding location:

- exophilic
- endophilic

Incubation periods:

- extrinsic incubation period (in arthropod vector)
- intrinsic incubation period (in vertebrate host)

Autogeny vs. Anautogeny

Number of blood meals:
- ovarian scar/blood meal
- parity status

Determines:
- age of vector
- blood feeding aggressiveness
- vector importance

Types of pathogen transmission:

- mechanical
- biological

Biological:

- propagative
- cyclopropagative
- cyclodevelopmental

Pathways of biological pathogen transmission:

Vertical transmission:

- transovarial transmission

Horizontal transmission:

- venereal transmission
- transstadial transmission

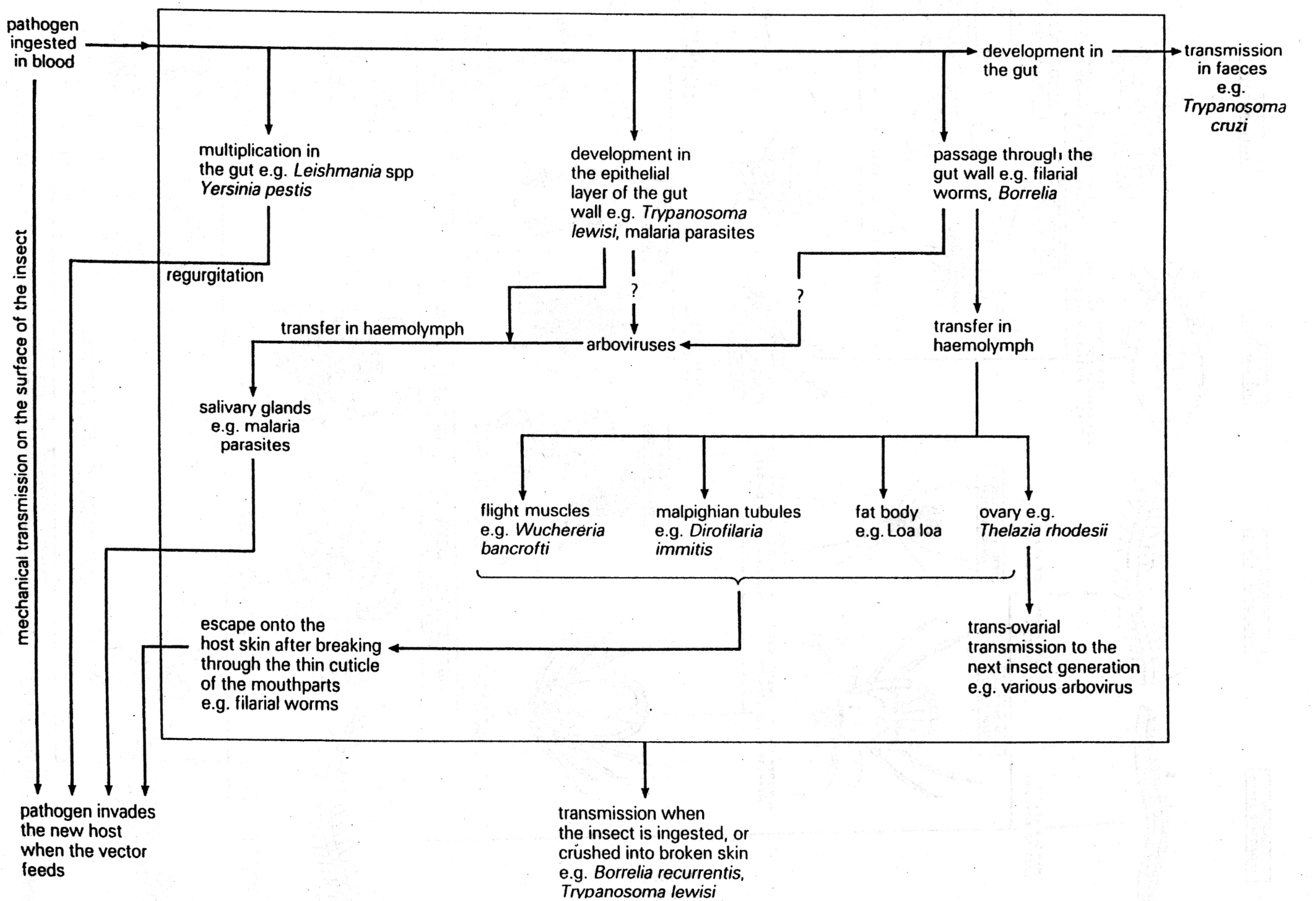
Intrinsic barriers to transmission in the vector - (genetically and environmentally controlled)

- midgut infection, midgut escape
- salivary gland infection, salivary gland escape
- insect immune response, parasite encapsulation

Vector competence vs. vector capacity

Capacity can be measured in the field using components of number of vectors per human, number of human blood meals per day per vector, daily survival rate, and the extrinsic incubation rate of pathogen; vector efficiency is expressed in terms of low - high capacity

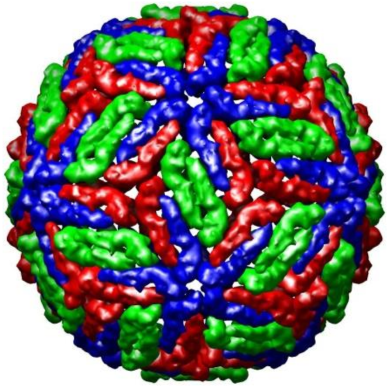
Competence can be expressed in the laboratory, but a competent lab vector is not necessarily important in disease transmission in the field.

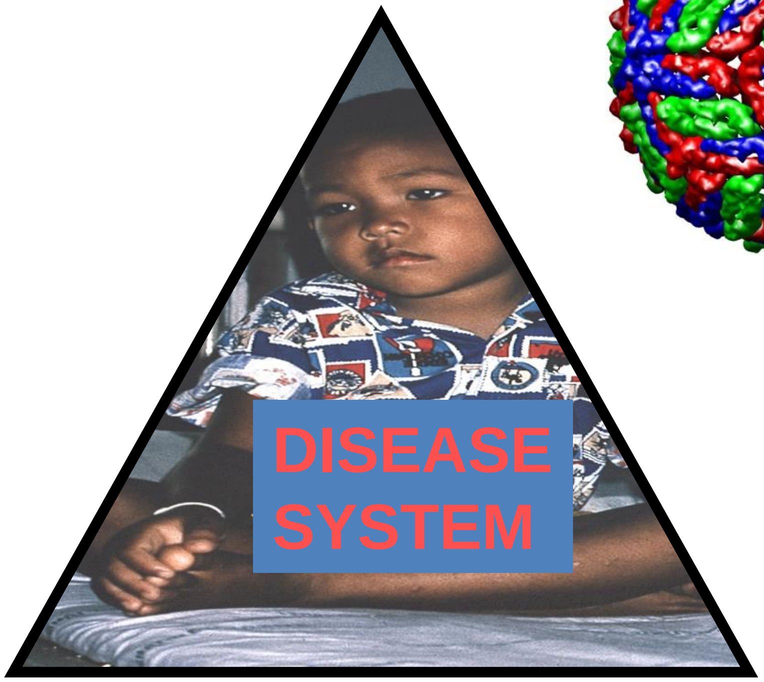


pathogen ingested in blood
development in the gut
transmission in faeces e.g. *Trypanosoma cruzi*
multiplication in the gut e.g. *Leishmania* spp *Yersinia pestis*
development in the epithelial layer of the gut wall e.g. *Trypanosoma lewisi*, malaria parasites
passage through the gut wall e.g. filarial worms, *Borrelia*
regurgitation
?
?
transfer in haemolymph
arboviruses
transfer in haemolymph
salivary glands e.g. malaria parasites
flight muscles e.g. *Wuchereria bancrofti*
malpighian tubules e.g. *Dirofilaria immitis*
fat body e.g. Loa loa
ovary e.g. *Thelazia rhodesii*
escape onto the host skin after breaking through the thin cuticle of the mouthparts e.g. filarial worms
trans-ovarial transmission to the next insect generation e.g. various arbovirus
mechanical transmission on the surface of the insect
pathogen invades the new host when the vector feeds
transmission when the insect is ingested, or crushed into broken skin e.g. *Borrelia recurrentis*, *Trypanosoma lewisi*

Disease System

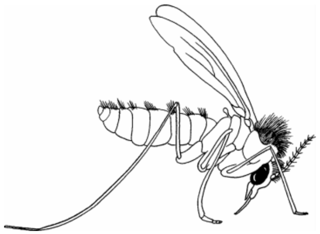
PATHOGEN

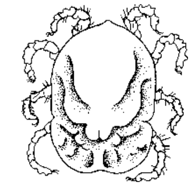


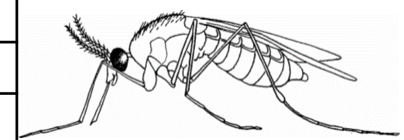


VECTOR

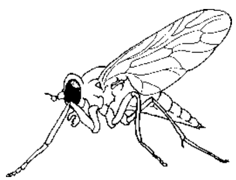
HUMAN

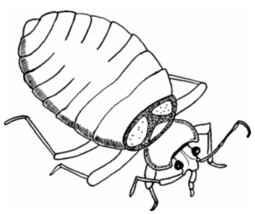


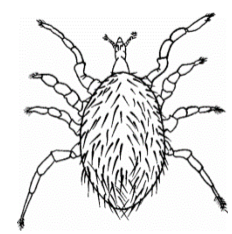


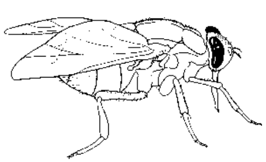


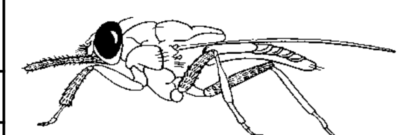
COMMON NAMES	SCIENTIFIC CLASSIFICATION	
	Order	Family
	Arachnids	
Mite	Prostigmata and Mesostigmata	many
Chigger	Prostigmata	Trombiculidae
Tick	Ixodida	Ixodidae and Argasidae
	Insects	
Bed bug	Hemiptera	Cimicidae
Kissing bug, vinchuca	Hemiptera	Reduviidae (subfamily Triatominae)
Fly	Diptera	many
Mosquito	Diptera	Culicidae
Black fly	Diptera	Simuliidae
Sand fly	Diptera	Psychodidae (subfamily Phlebotominae)
Biting midge, sand flea, sand fly, flying teeth, black gnat	Diptera	Ceratopogonidae
Snipe fly	Diptera	Rhagionidae
Horse fly, deer fly, cleg	Diptera	Tabanidae
Stable fly, dog fly	Diptera	Muscidae (species *Stomoxys calcitrans*)
Tsetse fly	Diptera	Glossinidae
Flea	Siphonaptera	many

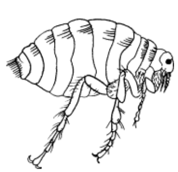


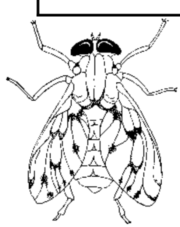


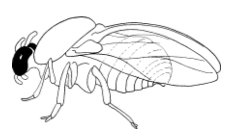


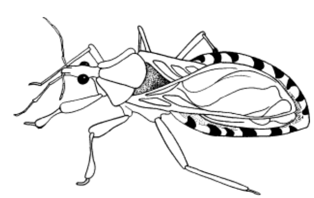


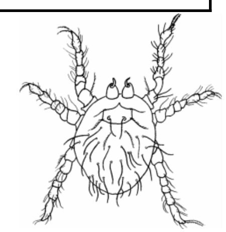


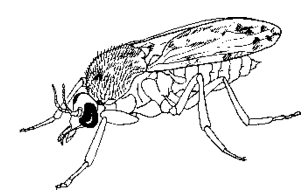


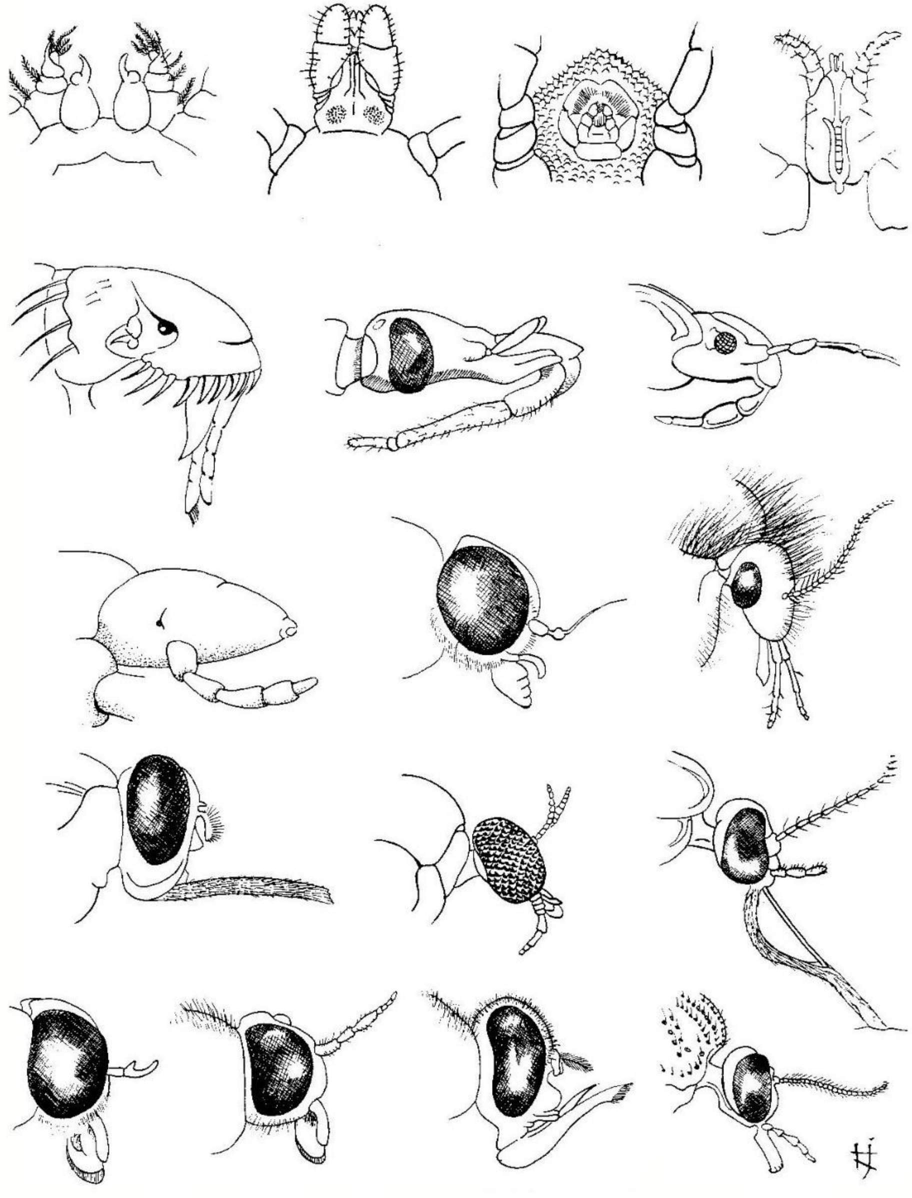












Risk from Insect Vectors

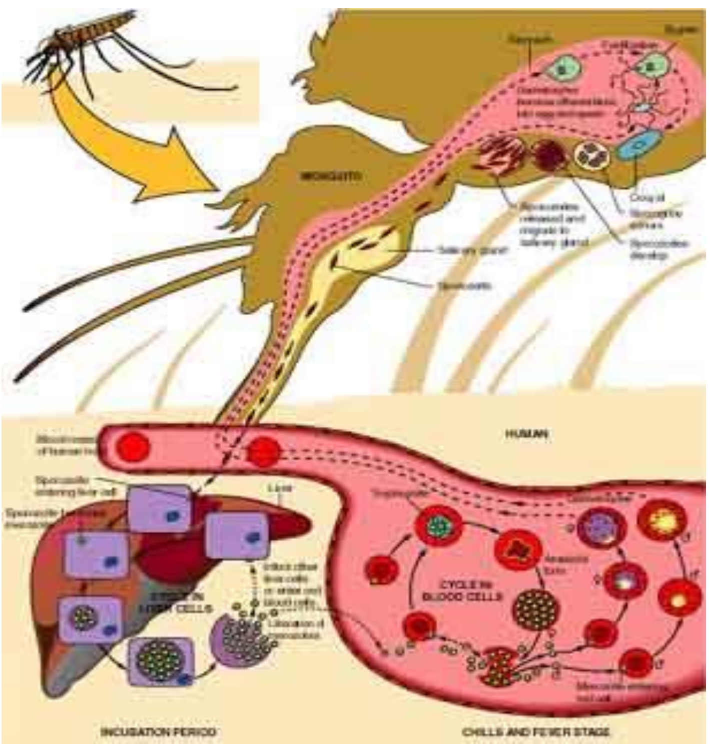
- Background
  - Overall death rate
  - Influenza in U.S. commonly 8.5% *per week*
  - Tuberculosis cases in U.S. 4.6 cases/100K
  - Traffic fatalities in U.S. 14.7/100K

Vector-Borne Pathogens

- Typhus
  - 1996 Burundi 24K cases
  - 1945-6 Japan and Korea 30K cases
  - Historical outbreaks with millions
- Scrub typhus – Up to 20% of fever
- Chagas' Disease
  - 18M cases of 100M in endemic areas
  - Incurable chronic form
- Dengue
  - 2000 cases/100K, reported cases lower
  - 4 x increase 1975-1995
- Leishmaniasis – 57 cases/100K (350M at risk)
- Lyme disease – 31.6 cases/100K in 10 states
- WNV in US – 0.33 cases/100K in 2003

Malaria is King

- Endemic areas (41% of world population)
  - >14,228 cases/100K (350-500M/yr)
  - >4.1 deaths/100K
  - Accounts for 10.7% of childhood deaths
  - Malawi: 28% of hospital deaths



Who is Responsible?

- The individual
- The local community
- Local government
- State government
- National government
- International organizations

Integrated Pest Management

- Risk assessment
  - What you do to find out about the problem without on-the-ground measurements
- Surveillance
  - Direct measurements to find the target
- Control
  - The suite of techniques used to render the population harmless
  - Hopefully integrated
- Monitoring and Sustainability
  - After success, then what?
  - Our most common source of failure

Risk Assessment

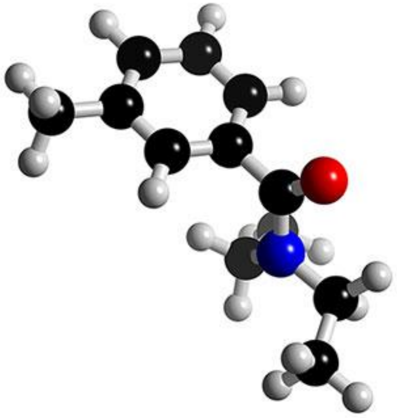
- Much basic work can fit into this slot
  - Population biology
  - Genetics
  - Transmission biology
- Global Information Systems
  - What is adequately fine scale?
  - Integrate spatial analysis and modeling
- Products are localization, prioritization, and organization

Surveillance

- Sensitivity vs specificity
- Multiple methods often necessary
- How to handle dirty data
- Archival vs operational surveillance
- Models
  - Scale of inputs and outputs
  - Consideration of communication (=politics)

Control

- Stop them at their source
- Kill the population that remains
- Erect barriers against the ones you miss
- Advocate personal protection as the final layer of protection



Stop Them at Their Source

- Household
  - Water sources
  - Rodent harborage
  - Access into the house
  - Harborage in the house, animals
- Community
  - Civil engineering, particularly drainage
  - Zoning
  - Economics

Wanted Dead or Dead

- Household
  - Outdoors
    - Larvicides
    - Barrier sprays, residuals
    - Traps?
  - Indoors
    - Residuals
    - Aerosols
- Community
  - Organized mosquito abatement
  - Organized campaigns against other vectors
    - Triatomines
    - Black flies

Good Fences Make Good Neighbors

- Household
  - Structure of walls, roof
  - Screens
  - Doors, interior and exterior
- Community
  - Screens (sand flies)
  - Barrier fogging
  - Barrier spray

Last Resort or First Line of Defense

- Personal
  - Topical repellents
  - Clothing
    - Textile
    - Conformation
    - Chemical treatment
- Household
  - Area repellent systems
    - Passive chemical dispersion
    - Active chemical dispersion
  - Excitorepellency

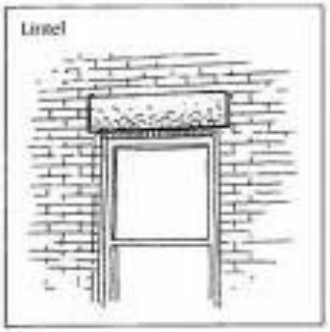
Monitoring and Sustainability

- Detect re-emergence of the problem
  - Early detection
  - Cheap to run
    - Associated with other activities
    - Inexpensive apparatus
    - Clear interpretation
- Resources and methods for response
  - Mobile response team
  - Avoid need for new decision process
  - Informed public
- Political motivation in absence of active damage

Integrated Disease Management

- Objective is reduction or elimination of disease
- Considers medical interventions
- Intelligently applied, actions chosen to leverage IPM and medical
- Challenges
  - Public Health vs. Environmental Health
  - Practical application of theoretical knowledge
  - Communication and good will between action agencies

Additive Measures vs. Integration



- Lintel vs. Arch
  - Role of each piece
  - Strength of whole
- Maintenance focus vs. expansion focus
- Prioritization of targets
- Attacking the life stages that matter most to transmission
- Using most economical control of each element of disease system to achieve IDM
- Breaking the chain of transmission

The Scale of the Problems

- Macro: What's the point?
  - Interventions limited (e.g., economics)
- Meso: Getting to the point.
  - Potentially powerful if cooperative forces unleashed
- Micro: The point of the spear.
  - Where interventions take place
  - Where all the action happens

Where Does Research Fit In?

- Tends to form leadership positions
  - Most evidence based knowledge
  - Most scholarly knowledge
- Inherent communication gap between research and operations
- Problems solved through experience or experiments?
- Imagination and logic are rusty keys

Some Successes

- 1890-1920: Transmission studies, mosquito abatement
- 1942-1955: Antibiotics and pesticides
- 1940s: Eradication of *Anopheles gambiae* 1940-1955: Elimination of malaria in US
- 1950-present: Eradication of screwworm
- 1940-1960s: Eradication of *Aedes aegypti*
- 1950-1970: Reduction in malaria
- 1980s-present: Reduction in *Onchocerca*
- 2000s: Roll Back Malaria and PMI

Some Failures

- 1980s-present: Resurgence of malaria
- 1978-present: Expansion of dengue
- 1980s-present: Reintroduction of *Aedes aegypti*
- 1980s-present: Expansion of Lyme disease, ehrlichioses
- 1986-present: Introduction and expansion of *Aedes albopictus, japonicus*
- 1999-present: West Nile virus

What Does the Future Hold?

- Negatives
  - Global climate change
  - Exponential increases in introductions
  - Energy and nutritional impoverishment(failure)
- Positives
  - Continuing discovery of interventions
  - Management of wild habitats
  - Intensification of agriculture
  - Intensification of community effort