IN THE HEADHOUSE

1. Identify the growth cycle of the tomato plant
   
   **Seedling phase:** from planting the seed to transplanting onto the bags = 4-6 weeks
   
   **Vegetative phase:** from transplanting on to the bags until the 1st flower = 2-3 more weeks
   
   **Early fruiting phase:** from 1st flowers opening to 1st pick = another 6-8 weeks
   
   So, 10-17 weeks after planting the seeds, you can start harvesting
   
   **Mature fruiting phase:** from 1st pick until the termination of the crop = as long as possible
   
   This will depend on the time available (i.e., length of school year, etc.)
   
   **Post-growing point removal phase:** one month prior to termination of the crop the plants can be topped (the growing point/apical meristem removed). The fruit will continue to ripen but new fruit will not form = less small green fruit to get rid of

2. Identify the environmental conditions necessary for optimum growth/production
   
   **Greenhouse vs outside:** advantages:
   
   - Indifference to the seasons – can grow year around
   - Control over the aerial (upper) portions of the plant including T, CO2, RH, light
   - Suitable for mechanization
   
   **Temp:** Inc. T - heaters (also heat blanket). Dec. T - fan/pad cooling (also vents, shade)
   
   - Germ/post emergence = 74-77F (23-25C)
   - Prod opt (depends on variety) = 70-77F (21-25C) day and 64-68F (18-20C) night
   
   **RH:** Can red. by venting, leaf pruning, heating. Can inc. by running pads, more leaves
   
   - Opt = 55-95%
   
   **Carbon Dioxide:** needed for photosynthesis. Can be drawn down in closed GH morning/winter
   
   - Use CO2 generator to maintain ambient of 330 ppm up to 800-1000 ppm CO2
   
   **Light:** needed for photosynthesis. Make sure the glazing allows good light transmission
   
   - Proper quality - PAR 400-700 nm
   - Proper quantity – in summer light may be hi (burning, hi T) – shade, 4-5 fruit/cluster
   - in winter light may be low - no shade, 3 – 4 fruit/cluster

3. Demonstrate the steps in propagation from seeds
   
   **Appropriate varieties = indeterminant, bred for greenhouse**
   
   **Quality seed = reputable companies – Cropking, Burpee, Stokes**
   
   **Quantity of seed = check % germination on the package, usually overplant by 10-20 %**
   
   **Storage of seed = refrigerate in a sealed container**
   
   **Rule of thumb: RH + T should not go over 100**
   
   **Selection/prep of growing media [hand out samples and discuss samples on desks]**
   
   - Rockwool in bags, perlite in bags or fill empty bags
   - Bags that can be filled with other media (all give about the same growth/yield)
   - Bags need to be positioned, slit on the top for cubes, slit on the sides for drainage
T/light/moisture for germ: 74-77 F, light is not nec, high RH (moist but not submerged)
Timeline: Plant seeds into 1” RW cubes – 2 weeks – transplant into 3 or 4” cubes
Nutritional needs: Until germination (green showing) = water only
   After germ = ½ strength NS every watering
   OR 20-20-20 2 Tbs/gal 1 X per week – rinse leaves w/ plain water
Teachers plant a few seeds – sprinkle vermiculite: seeds, 1” cubes
   Can plant directly into the 3 or 4” blocks or place 1” cubes directly onto bags
DISPLAY Henry’s germination bench. Can also use a mist bed or flood & drain system.
Cull weak seedlings: toss ungerminated seed. Choose best looking, strongest, most uniform seedlings for the GH

4. Demonstrate care of seedlings in Rockwool cubes
Appropriate seedling size for transplant into 3 or 4” cubes – 2 wks or when roots emerge
Teachers transplant seedlings into 3” blocks – have seedlings in 1” cubes, 3” blocks
Space blocks so that leaves do not overlap to avoid stretching (etiolation)
Nutrition = full strength NS with every watering (1-2 X per day – keep hydrated)
   OR water 1-2 X per day with water and water 1 X per week 20-20-20 2 Tbs/gal rinse with plain water
T/light/moisture needs: 74-77 F, good light, water to the root zone 1-2 X per day as above

5. Transplant seedlings into perlite bags or rockwool slabs
ID pros/cons of Rockwool: costs more, irritant - wear gloves, no dust
   Perlite: costs less, non-irritating, dust problem – wear mask
DEMO filling of a perlite bag DEMO bag sealer and stapler
Prepare rockwool slabs for planting
   Teachers… cut plant openings
   DEMO… wet the rockwool
DESCRIBE… spacing/layout… 2 parallel rows of bags or 6” slabs with 3 plants/bag
   OR 1 row of bags or 8” slabs with 6 plants/bag
   Bag rows 5 feet apart with 2 overhead support cables each 1’ off center
Teachers… ONE SLAB PER TABLE: plant a 3” block with seedlings
DEMO… slit the slabs for drainage

WALK TO THE PEPPER GREENHOUSE – Take folders, pen, etc. (chairs?)
   Point out… layout of the rockwool slabs
   Point out… positioning of the poly tubing
   Point out… tanks and injectors (Dosmatic)

WALK TO THE TOMATO GREENHOUSE

6. Deliver nutrients to the plant
Demo ½” poly tubing, feeder (spaghetti) tubing, emitter (dripper), poly punch
   Need pressure compensating emitter (delivers rated flow under variable pressure)
   Need 5-10 psi of water pressure
Teachers…punch and place a dripper [punch in and pull out straight]
Show teachers how/where to place the stabilizer peg (“C” and “V” types) and drip tube.
Pegs should be jammed into block
End of drip tube should be over block, not touching block or plant stem (adv root)
Water should drip onto block not plastic, or be diverted onto floor, etc.

7. Develop a custom nutrient mix
Plants need 13 mineral nutrients, 6 in large amounts (macro), 7 in small amounts (micro).
CAN TEACHERS NAME THEM?: N, P, K, Ca, Mg, S… B, Cl, Cu, Fe, Mn, Mo, Z
Most water supplies have some amounts of many of these already in the water.
Ex: UA tap Calcium = 100 ppm, only need about 200 ppm, and we can add TOO MUCH
Cropking has a service: Can send a source water sample to the lab, the lab sends the results back
to Jim Brown at Cropking who then develops a custom nutrient mix taking into account any
nutrients already in your source water.

8. Identify 3 options for nutrient mixes
Pre-made – generic hobbyist mix (Pat-solid Veggie mix) (Chris-liquid concentrate)
Custom recipe – Cropking (Curt will furnish)
Mix your own – DEMO bags, scale, micros

9. Mix nutrients
Safety measures: Safety glasses, gloves
Problems mixing: if Ca is mixed with PO4’s or SO4’s in hi conc = ppt = unavailable to plants
DEMO: Weigh out nutrients following recipe
DEMO: agitation pump
DEMO: pH/EC meters (Myron and electrode type)
  Teachers… test nutrient solution with electrode type meter

10. Determine water/nutrient schedule
ID factors which determine water/nutrient needs
  Water needs: size of plant, temp and solar radiation load, RH
  Nutrient needs: size of plant, stage of development,
Signs of inadequate watering = wilt
Water needs vary throughout the day => am/late pm = cool, low light means less water
  mid-day = warm, hi light, hi transp means more
  Teachers… GRAPH typical water need for plant during 12 hr daylight
DEMO: feed monitoring jug (to collect input nutrient for amount, pH and EC)
  Leaching tray (to collect output nutrient for amount, pH, and EC)
Adequate watering? Output amount/# Plants / Input amount X 100 = %output of in
  Want 15-30% coming out to make sure salts are leached from bags.
  Teachers… calculate % output if have 6 plants, 12000 ml out and 8000 in (25%)
Types of controllers: Several types from simple to complex. Type will depend. Ask CK

GREENHOUSE – BREAK INTO 4 GROUPS
11. Support plants
ID tomahooks (best choice) and Reelenz (another design – not as good)
ID qualities of good vine twine: Rated for at least 20-50 pounds, UV resistant, not used
Length of vine twine needed: depends on plant, training technique, duration of crop = Ex. Tomato, single stem, 9-10 months = should have at least 30-40 feet of twine
PASS OUT… 1 tomahook and 1-10’ length of vine twine and 5-6 clips to each teacher.
Teachers… tie 10’ length of twine on tomahook
ID correct spacing of clips: 1 vine clip about every 1 foot, under a sturdy leaf (crutch).
NOTE: hinge of clips must clamp around twine to be effective!
Teachers… practice putting clips on twine under sturdy leaf AND remove clips.

12. Sucker the plant to maintain single leader
Suckers are side shoots arising from the axil of the leaves (connect point of leaf and stem)
Suckers “suck” nutrients away from the main stem, the growing point and the fruit.
Suckers must be removed (several buds per axil so suckers can be found low/mid/upper)
DEMO: difference between a sucker and growing tip.
Break out suckers, DO NOT CUT (unless very large–then sterilize razor blade)
Teachers… remove suckers from lower, middle and upper stem

13. Pollinate flowers for optimum yield
Benefits of proper pollination/fertilization:
Proper pollination (transfer of pollen from the male anthers to the female stigma and growth of the pollen tube down the female style to the ovary) and fertilization (joining of the male and female gametes) is imperative for proper fruit development.
DEMO: Properly pollinated fruit (#1) vs poorly pollinated fruit (cat faced)
Several methods of pollination:
Shake plants or use a blower: works fairly well as long as all plants are shaken and there are not many plants.
Use fine paint brush: works well but very labor intensive.
Use vibrating tooth brush or hand pollinator: works well but very labor intensive.
Use bumble bees: works very well, but must monitor bee visitation activity.
DEMO: inspect flower for visual sign of bee visitation (brown bruises)
Teachers… Inspect closed flowers AND hand pollinate a flower cluster.
Bumble bees: Benefits = efficiently “buzz” pollinate the flowers
DEMO bee hive = different parts (lids, doors, inside, bee happy bag)
Coverage of a hive = Class A (15K sq ft – ½ acre), Class B (5K-15K sq ft)
Cost of a hive (CK) = Class A ($265 – 10-12 wks), Class B ($175 – 8-10 wks)
Research hive (from Koppert $100 – 4-10 weeks)
Placement of hive = sturdy base, away from traffic, doors, fans, CO2 gen
Protect from ants,
Correct release procedures = instructions come with each hive
Have to enable the “bee happy” bag, then open the flight door
Hive longevity = 1-3 months depending on time of year, type of hive, etc.
Vendors: Cropking, ARBICO (can order large amounts from Koppert)

14. Cluster prune fruits for maximum yield and quality
ID benefits of cluster pruning:
To maintain constant average # of fruit on plant
To remove damaged or defective fruit (not #1) (boats, cat faced, BER, splits, etc.)
ID ideal stage of fruit development for cluster pruning: As soon as possible (golf ball)
ID correct # of fruit = 3 fruit per cluster in Winter (low light), 4-5 during times of hi light
Procedure: Pop fruit off at “knuckle” Teachers: prune a cluster.

15. Install cluster support
Need support: tomatoes could get heavy enough (1/2-1 pound each) to break cluster stem
ID J-hook and truss supports
Teachers… install J-hooks at the proper location to support the entire truss
… remove/reuse J-hooks (can sterilize with a 10% chlorox solution between uses)

16. Lean and lower plants to maintain appropriate height
Determine opt range of height:
Since tomato “vines” continue to grow up and can reach 30-40 feet after 9-10 months
AND since greenhouses are usually only 8-16 feet tall… need to lean and lower
Don’t just lower – can crack the stem. Need to lean as well.
Plants should be kept within 2 feet of the support cable: grow up to cable, L/L down
Usually, L/L is done every 2 weeks (ex. Mariachi = faster, Quest = slower)
Establish direction for leaning/lowering:
Usually counterclockwise around the double row: Looking from the side – L/L to right
L/L first plant into an open space, then work backwards, L/L next plant into 1st’s place
ID precautions:
Do not lower too far – stem should arch upward from base (no 90 degree angles)
Go around the ends slowly: out – over – back perhaps in 3 weeks
Make sure fruit on stem of one plant does not get tangled with fruit/stem of another
DEMO… leaning and lowering technique
Teachers… lean and lower 2-3 plants each.
ID method of stem repair – if stem is not completely broken through, wrap tightly with electrical tape. Can also splint with 2 cluster clips, or other sturdy brace – apply over seal.

17. Leaf prune plants
ID reasons for leaf pruning:
Lower leaves senesce (show yellowing, start to die) over time, are not contributing
Leaving too many leaves (vegetation) can force plants toward veg growth & less fruit
Lots of leaves means lots of transpirational leaf surface AND high relative humidity
High RH means greater likelihood of diseases (ex. Botrytis)
ID when to leaf prune:
Will depend on variety: Quest has long leaves, can take off more
Trust has shorter leaves, can leave more on
The point is to maintain a similar leaf surface area.
Will depend on season: Winter – remove more leaves to reduce humidity
Other seasons – can leave more leaves on
Usually remove 3 leaves per week (each week plant usually grows 3 leaves & 1 cluster)
ID correct procedure and precautions:
Better to do it in the morning when plants are turgid.
Snap leaf off at abscission zone with one hand while stabilizing the stem with the other.
Do not rip off or cut – the resulting wound won’t heal as fast. Entry point for disease. Disposal of prunings:
- Can be tossed immediately – can be put into a compost pile for use elsewhere
- Can be left in the GH in back under pads, especially if using beneficial insects. Beneficials will be hatching from the lower leaves

18. Harvest fruits
Visual signs of ripening: blossom end develops a “star” pattern, then starts to turn color. Factors to determine optimum level of ripeness:
- Where/who is your market? If shipping, harvest when fruit is less ripe.
- If selling to locals for immediate use, can harvest when fruit is more ripe.

DEMO harvesting fruit at the “knuckle”. NOTE: do not pile fruit on top of one another (pokes)
Teachers... harvest the ripe fruit from one rep.

NOTE: current variety trial experiment and need to keep the reps separated
DEMO sorting and weighing of fruit for one rep.

19. Control insects
List 3 common problem insects. (white fly, thrips, aphids, spider mites, caterpillars, leaf miners) Use yellow (and blue – for thrips esp) sticky traps to monitor insects in the GH.

Teachers... inspect a yellow sticky trap
ID beneficial insects appropriate for control of pests insects –
use Koppert poster, show “Knowing and Recognizing” Insect ID book
List factors to be considered when choosing control methods
DEMO: Ordering beneficial insects (Cropking, ARBICO, Koppert) – HAVE CK catalogue
DEMO: release of beneficial insects – HAVE box for wasps
Discuss: effectiveness of control

20. Control diseases
Define disease = a problem in the plant usually caused by bacteria, fungi or viruses.
List 5 most common diseases and their controls
- Fungi: Botrytis: reducing RH, cut out infection and treat with hi salt solution
  Fusarium: use resistant varieties
  Pythium and Phytophthora (zoosporic): sanitation, surfactants
- Bacteria: Bacterial canker and Bacterial wilt: use disease-free plants
- Viruses: TMV: use resistant varieties, exclude all tobacco products/wash hand/tools
  Geminivirus: transmitted by white fly, therefore, exclude or control white fly
ID good housekeeping measures that will minimize diseases
- Sanitation, plant pruning removal, clean tools, wash hands, do not go from infested houses or a dirt garden to a clean greenhouse without washing/changing clothes
ID resources to ID diseases –
  Tomato Diseases book from Koppert

Paper #E-125933-02-02. Supported by CEAC, the Controlled Environment Agricultural Center, College of Agriculture and Life Sciences, University of Arizona. (Seed to Harvest Sci Alive 2002.doc)