1) Single-particle dynamics course.

2) $\Delta p / p = 0$ and $\phi = \phi_s = 0$. It is in the centre of the bucket. Its energy gain is 0.
$\Delta p / p = 0$ and $\phi = \phi_s \neq 0$, with $0 < \phi_s < \pi / 2$.

3) Matching means that the RF frequency and the RF voltage are adjusted such that the phase space trajectories are homothetic to the contour of the injected bunch.
If there is a longitudinal mismatch in phase, there will be a dipolar oscillation (the whole bunch oscillates in the RF bucket around the centre at the synchrotron oscillation frequency). If there is a longitudinal mismatch in amplitude, there will be a quadrupolar oscillation (the bunch oscillates in length and momentum spread at twice the synchrotron oscillation frequency, the centre remaining at the same place).

4) If the peak RF voltage increases, the bunch length decreases.

5) It is the longitudinal acceptance.
It is maximum for a stationary bucket => synchronous phase 0 (below transition) and π above.
It is the separatrix.
It has to do a RF phase jump, i.e. to change the phase from $\phi_s = 50^0$ to $\pi - \phi_s = 130^0$, because stable motions require $\eta \cos\phi_s > 0$.

6) In a synchrotron, R=cte => during acceleration, the magnetic field has to be increased, otherwise the radius would change as in a cyclotron.

7) Change of the harmonic number (the beam is on a magnetic flat-top with a stationary bucket): the beam is adiabatically debunched and rebunched with the new harmonic number. Or bunch splitting or merging can also be used and they require in this case a correlated variation of the RF voltages in the different RF systems.

8) The synchrotron radiation.
Yes. To compensate the energy loss due to the synchrotron radiation.
In the case of protons, this is usually (for nowadays energies) not needed, because the synchrotron radiation is negligible. However, the LHC is the first hadron collider for which synchrotron radiation plays a noticeable role.

9) Above transition, particles with higher momentum go slower, contrary to physical intuition. This is the negative mass effect (as it is as if the mass of the particle was negative).
Above.

10) This is the ratio between the peak energy gained by a particle with finite velocity to the peak energy gained by a particle with infinite velocity. In other words, it shows the missing energy gain due to the finite velocity of the particle in a sinusoidal electric field. It is a reduction factor in energy gain.

It is always smaller than 1.
The transit time factor is normally of little concern in circular accelerators. It may become critical in linacs, especially in bunches for low-velocity ion beam, where the inherent transit time factor can be as low as a few percent if no corrective action is taken.

11) In a circular machine, there can be only 1 RF cavity (for acceleration), whereas in linacs, there are almost only cavities.

12) In a synchrotron, particles perform synchrotron oscillations (i.e. oscillations in position and energy) around the synchronous particle, whereas in linacs the longitudinal positions of particles are frozen.
At transition energy in synchrotrons, there is no synchrotron oscillations anymore and the slip factor is 0, therefore the longitudinal positions of particles are frozen as in linacs.

13) The RF cavities are installed at location where $D_x \approx 0$, because (i) the voltage across the gap, and hence the energy gain per particle, is then independent of the radial position in the gap ($x = D_x \, \Delta p / p_0$). The particles pass on the same orbit, whatever is its energy and therefore receive the same energy gain, (ii) the beam dimension being equal to $x = \sqrt{\beta \varepsilon} + D_x \, \Delta p / p_0$, if $D_x \approx 0$, then the aperture of the RF cavities will be small.
Measurement on a magnetic flat-top. We change the frequency of the RF cavity. This gives a Δf. We measure the position ΔR on the beam position monitor. The dispersion function at the beam position monitor is given by $D_{monitor} = \dfrac{\Delta R}{\Delta p / p}$.