Chiang & Goldreich (1997)

* derive hydrostatic, radiative equilibrium models for passive disks around T Tauri stars
* assume flared disk rather than flat
* calculate the SED for the passive disk self consistently
* first assume blackbody disk
* for flat disk T\_e ~ a^(-3/4)
* hydrostatic equilibrium => flared disk
* then, drop blackbody assumption and determine the SED through radiative transfer
* assume that gas and dust temperatures are equal in the interior
* first consider flat disk, then flared
* compare with observations => the SED of GM Aur is consistent with a passive reprocessing disk

D’Alessio et al. (1998)

* accretion disk around T Tauri star taking into account accretional heating
* assume gas and dust in disk are well mixed and thermally coupled; disk receives radiation from the central star and through viscous dissipation, cosmic rays and radioactive decay
* energy transport through turbulent flux, radiation, convection
* steady state, disk geometrically thin, hydrostatic balance
* results for their fiducial model:
  + disk is optically thick to stellar radiation, but may be optically thin to its own radiation
  + temperature: for a < 5 AU, flaring not important => T ~ a^(-3/4) as in an irradiated flat disk
  + viscous dissipation is the main energy source for a < 2 AU
  + there is a disk atmosphere; there is also a temperature inversion due to stellar radiation
  + main improvement of this model is that they calculate the optical depth self-consistently rather than assume that the disk interior is optically thick
  + surface density consistent with analytic predictions
  + disk mass, timescales calculation
  + energy transport: convection only important in the midplane at a < 0.01 AU
  + gravitational stability: nonirradiated disk more likely to become gravitationally unstable at large a than irradiated disk

D’Alessio et al. (1999)

* use the disk model of D’Alessio et al. (1998) to explore how disk structure varies with alpha and Mdot
* compare with observations => models can explain near IR fluxed of T Tauri stars for disk accretion rates consistent with mean value estimates
* however, models seem to be too geometrically thick at large radii => dust settling could substantially reduce the geometric thickness of the disk => explore this in subsequent paper

D’Alessio et al. (2001)

* disk structure including dust grain growth
* still assume complete mixing between dust and gas
* find that the resulting disk models are less geometrically thick than in the case where ISM opacities are used, and they agree better with observed SED distributions

**CHEMISTRY** Visser et al. (2009)

* aim: understand how material changes chemically as it is transported from the molecular cloud to the star and the disk
* model the chemical evolution from the pre-stellar core to the disk phase in 2 D using a simplified semi-analytic model
* gas and dust are expected to be well-coupled => gas and dust temperatures are set to be equal
* the only chemical reactions they include are H20 and CO adsorption and desorption => total abundance of CO and H2O remains constant in each parcel
* CO and H2O begin entirely in gas phase
* Model does not include radial and vertical mixing

Disk chemistry background for thesis proposal

* from Henning & Semenov (2013):
  + mention that complex disk chemistry models have been developed by several groups and cite some literature from Table 3
  + perhaps mention that these models have shown that chemistry in disks is mostly regulated by T, rho structure, stellar / interstellar radiation fields, cosmic rays
  + some background parts from the intro can be useful for my own intro
  + disk emission from CO in its rotational transitions can be often measured due to its relatively high abundance and permament dipole moment
  + time scales of key chemical processes have to be shorter than ~1Myr => reference to Semenov & Wiebe (2011)
  + see if there’s anything relevant to mention from Table 1 (i.e. about the observed emissions from any particular molecule, perhaps from CO would be relevant)
  + abundances of discovered molecules range between ~10^-10 – 10^-4 relative to H2
  + observations find depletion of molecules relative to molecular abundances in the ISM -> caused by freeze-out or photodissociation in the disk atmosphere
  + detection of molecular ices => look at Aikawa et al. (2012, A&A 538, A57)
  + PPD’s have strong vertical and radial T and rho gradients + different radiation fields at various disk locations => diverse disk chemistry -> see summary of reactions in Table 2
    - inner disk <~ 20 AU: observed through IR spectroscopy
    - outer disk >~ 20 AU: observed through (sub)millimiter observations
  + chemistry approaches quasiequilibrium in inner disk due to high T and rho
  + for outer disk regions, high-energy radiation and cosmic rays are key drivers of chemistry; production of various ions
  + freeze-out of molecules at low T in the outer disk
  + chemical models:
    - early models: usually restricted to inner disk regions, 10-30 AU, thermodynamic equilibrium was usually assumed
  + chemical models of PPDs are based on detailed chemical kinetics models with hundreds or thousands chemical reactions => computationally intensive => decoupled from disk dynamics
  + more modern studies include various heating and cooling processes, plus grain evolution (refs 71, 98, 216, 260): 1D (ref 266), 2D approximation (ref42), X-ray radiative transport (refs 47, 52, 267, 268)
  + chemo-dynamical models: refs 207, 210, 273, 274, 275
  + more about chemistry coupled with dynamics models: Aikawa et al. (1999)… see if some references on page 9030 are worth mentioning
  + giant planets are believed to be formed outside the snowline, Kennedy & Kenyon (2008)
  + origin of water from Earth: delivered from comets, Morbidelli et al. (2010)

Semenov & Wiebe (2011)

* 2D model using the mixing-length approximation + time-dependent chemistry; for turbulent disk
* volatiles are preserved in comets
* paper about comets: Bradley (2005)
* when does turbulence affect chemistry?
  + Consider two timescales, t\_phys and t\_chem. If t\_phys < t\_chem, chemical evolution of a molecule is slow and thus sensitive to changes in the physical conditions; if t\_phys > t\_chem, chemical evolution and thus not affected by transport processes
  + Ion-molecule chemistry is very rapid, t <~ 10-1000 yr
  + Surface chemistry has a long timescale around midplane and in the outer cold regions, ~10^6 yr, larger than the turbulent mixing timescale

Cleeves et al. (2011)

* chemical model of a PPD with a large inner gap similar to those seen in classical transition disks
* radiation field: UV and X-rays; treatment of the radiative transfer in the disk
* reaction network: following Fogel et al. (2011); reaction types include photodesorption, photodissociation, freeze-out, grain surface reactions, ion and electron reactions, cosmic-ray and stellar X-ray ionization, radiative reactions

Bruderer et al. (2009), ApJS

* presents a method for the chemical modeling of young stellar objects, i.e. the chemistry changes / networks in between the cloud collapse phase and the formation of the protoplanetary disk
* consider heating due to FUV radiation and X-rays
* chemical reaction network; they interpolate abundances from a grid of physical parameters relevant for the chemical composition
* calculate reaction rates for photodissociation and ionization due to FUV radiation analytically (“classic” formulae)
* similarly for X-rays
* results for CO, CO2, H2O, etc. abundances in Fig. 4 (still for the collapse phase(?))
* main point: the grid of chemical models is publicly accessible (see website link at the beginning of section 5)
* look also at follow-up papers from 2009/2010