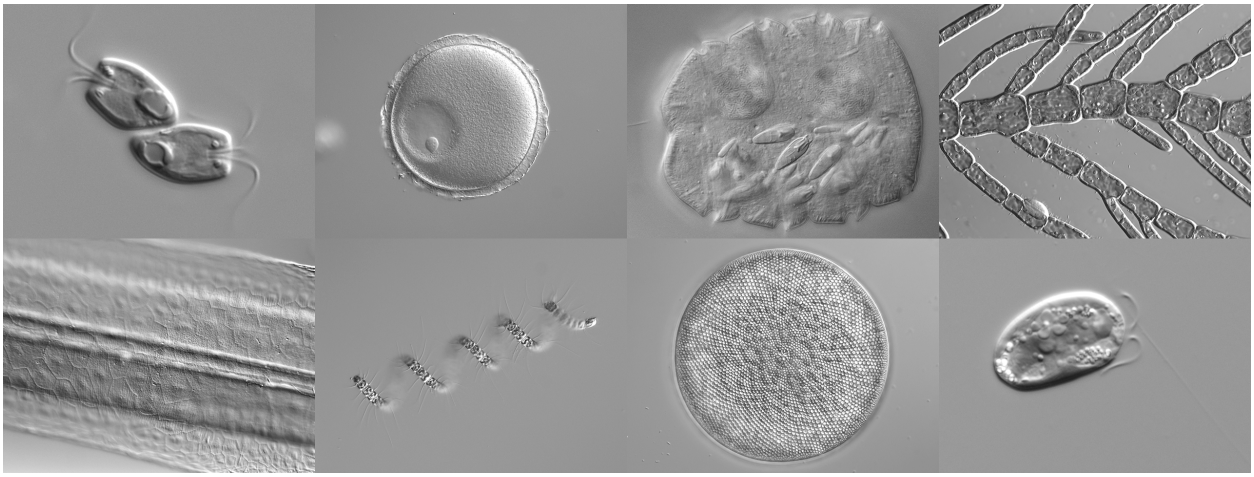
BI 457/557: Marine Biology: Cell Physiology in the Marine Realm
Instructor: George von Dassow
Meeting Thursdays 8:30 am–noon and 1:30–5 pm in the Invertebrate Zoology Lab



This course covers fundamental topics of cell biology with a focus on marine organisms in relation to their lifestyle in the natural environment. Specific topics will include cell division (mitosis, meiosis, and cytokinesis) and the cell cycle, organization and dynamics of the cytoskeleton, cell motility and related behaviors, intracellular transport, cell shape change, and multicellularity. This course will *not* directly cover gene expression, signal transduction, or prokaryotes.

Texts:

Required readings include papers for weekly discussions, complemented by a set of review articles. These will be available on Canvas one week before they are to be discussed in class. Optional readings (selections from texts, papers, as appropriate) will be available on reserve or through Canvas.

A standard text of cell biology (e.g., Alberts et al., "Molecular Biology of the Cell") in any edition published after 2000 will provide a valuable reference *but is not explicitly required*. Please note that the entire 4th edition of Alberts is available free (requires search; cannot be browsed) through the National Library of Medicine: http://www.ncbi.nlm.nih.gov/books/NBK21054/

Another very useful text is Dennis Bray's book "Cell Motility". Scanned selections will be on Canvas and there will be a hard copy for local reserve.

Learning goals:

1) Acquire fluency in the basic vocabulary of mainstream cell biology, including competence at reading the primary literature from classical to current works;
2) Master the standard techniques of transmitted light microscopy to observe and document cell shape, structure, and behavior;
3) Familiarize yourself with the relative and absolute scales (in space and time) of cell physiology;
4) Become able to develop testable hypotheses, based on the standard repertoire of cell structures and behaviors, to explain kinematic observations of living cells;
5) Appreciate the many deep roots of modern cell biology and biomedical science in curiosity-driven research on wild organisms encountered in their natural habitat

Grading:

- Weekly quizzes (25%) will focus on vocabulary and foundational narratives.
- Participation (25%) includes lab attendance and completion of the week's worksheet.
- Discussion (25%) is eight weekly sessions in which groups of students read, analyze, and explain papers from the primary literature of cell biology.
- Final exam (25%) will focus on the interpretation of material from primary literature and on conceptual questions.
- Video project, presentation and essay (25%): each student is assigned to document on video a non-trivial cell behavior, present the video, and turn in a written account. This research component requires direct instructor involvement and shared instrument use; don't think about it until week 6.

These add up to more than 100%. This grading approach is based on two principles: first, if your instructor doesn't try to teach you more than you can learn, you're not getting your money's worth (a mathematical proof of this will be provided on request); second, your instructor doesn't pretend to know everything and can't expect you to either. Therefore, some not-quite-perfect score (100/125, in this case) should be "good enough" for an A. **You will not be competing: I will be thrilled if everyone gets an A**.

Quizzes will be held each week except the first and last (8 total). Most will consist of a fill-in-the-blanks text based on vocabulary study guides from the previous week.

Exercise worksheets will be handed out each week and turned in the next. Worksheets will be assessed for depth and accuracy of observation. **I don't expect anyone to fill in the entire worksheet**: in general, you are obliged to choose about half the suggested exercises, but if you do a terrific, insightful study of a single question, I will give you full credit.

Course plan:

Paper discussions will take place at 8:30 AM. They are expected to last 1-1.5 hour. We'll meet in the Dining Hall, just so we don't spend the *entire day* in the same classroom.

Lectures will follow in the classroom, starting at approximately 10 AM, with breaks. On some days, to facilitate specific lab activities, lectures will be split between morning and afternoon.

We will break for lunch at noon.

Quizzes will be available in the lab at the lunch break; turn it in by 1:30.

Labs or demos will run from 1:30 PM until 5 PM. Some lab activities may require students to acquire specimens on their own time, or examine them outside of set class times.

Week 1 (Sept. 29) – Fertilization, mitosis, and introduction to the cytoskeleton

Discussion: No discussion first week

Lecture modules:
1) MEET AT 8:30 in the classroom for an introduction to the course – cellular view of animal development
2) 10 AM: Cell biology of fertilization; acrosome reaction and cortical reaction; actin assembly
3) Pronuclear migration and intracellular microtubules
4) Mitosis: stages, spindle assembly and function
5) The Ran GTPase

Lab material: Echinoid eggs and embryos

Technical demo: Clay-feet preps; Köhler alignment; darkfield

Week 2 (Oct. 6) – Meiosis, mitosis, and cytokinesis in animal embryos

Discussion: the cytoskeleton and intracellular motion (Tilney's echinoderm acrosome; Hiramoto's pronuclear migration paper; *Beroë* fertilization; discovery of microtubule-based motors)

Lecture modules:
6) Meiosis – recombination, or sex at the cytological level
7) Oocyte maturation: GVBD, meiotic spindle assembly, polar body formation; centriole management
8) Cytokinesis: cytokinetic patterning; asymmetric cell division
9) Embryonic cell cycle and development of the blastula – basic constraints on animal life cycles

Lab material: Starfish oocytes and embryos

Technical demo: Phase contrast; taking photos and videos

4 PM: slide-show lecture on optics of the light microscope

Week 3 (Oct. 13) – Cell cycle and cilia

Discussion: adaptations of cell division in early animal development (oocyte centriole inheritance; meiotic spindle assembly; cytokinetic timing; checkpoints? what checkpoints?)

Lecture modules:
10) Cell cycle: complete somatic cell cycle
11) Cell growth control; endoreplication, cell size, etc.; comparative sketch of the cell cycle in relation to eukaryotic life cycles
12) Structure and motility of cilia
13) Ciliary assembly and intraflagellar transport

Lab material: More echinoderms, including larvae; observe simple ciliary behavior, organization, and development; ciliates (cultured *Paramecium* and *Tetrahymena*; also wild-caught tintinnids, peritrichs)

Technical demo: Differential interference contrast; practice taking photos and videos

Week 4 (Oct. 20) – Alternative lifestyles: meet the diatoms!

Discussion: classics on ciliary motility (sliding filament model; *Chlamydomonas* ciliary reversal; ctenophore ciliary reversal; intraflagellar transport)

Lecture modules:
14) Biology of diatoms: mitosis, cell division, motility
15) Biology of diatoms: the diatom shell and its biological consequences

Lab material: diatoms, cultured and wild-collected; examine and identify various diatoms from plankton and other habitats

Technical demo: fluorescence and confocal microscopy; photo exercise for extra credit

Week 5 (Oct. 27) – Unicellular diversity

Discussion: cell biology of diatoms (cytokinesis; morphogenesis; sexuality; mitotic recombination)

Lecture modules:
16) Survey of phytoflagellates: green algae, cryptophytes, haptophytes
17) Survey of phytoflagellates: euglenids, dinoflagellates

Lab material: phytoflagellates; examine various cultured phytoflagellates; look for wild phytoflagellates in water samples

Technical demo: high-speed video

Week 6 (Nov. 3) – Actin-based cytoskeleton and cell crawling

Discussion: phytoflagellates as compound cells (Maruyama and Kim phagotrophy; plastid/host-cell division; cryptophyte genome; dinoflagellate eyes)

Choose a topic this week for an end-of-term presentation

Lectures:
18) Actin dynamics: *Listeria* and the Brownian ratchet; protrusions and cell crawling
19) Muscle and myosin, versus non-muscle contractility
20) Dynamic control of actin by Rho-family GTPases; wound healing and cytokinesis (revisited)

Lab material: *Amoeba*; *Physarum*; crustaceans, ascidian tadpoles, and other muscular creatures

Technical demo: polarized light; microinjection

Week 7 (Nov. 10) – Living together as multicellular organisms

Discussion: dynamic behaviors of the actin cytokseleton (wound healing; ascidian tail resorption; keratocyte lamellipodia; *Aplysia* growth cones)

Lectures:
21) Animals: epithelia, tissue polarity, and cell shape change
22) Survey of multicellularity in the rest of the eukaryotic world: Volvocales, *Dictyostelium*, green and brown seaweeds, and the complex trade-offs of multicellularity
23) Red algae: a very different approach

Lab material: cultured and collected macrophytes; examine tissue organization, reproductive structures, growth patterns

Technical demo: project work; examine macrophytes and larvae with the confocal

Week 8 (Nov. 17) – Making things outside of cells

Discussion: morphogenesis in animals (epithelium of larvaceans; pilidium growth; anemone tentacles; pluteus ciliated band)

Lecture modules:
24) The secretory pathway: organization of endomembrane compartments
25) Vesicle trafficking and its regulation by small GTPases
26) Building extracellular structures; biomineralization

Lab material: more multicellularity – *Volvox*, *Dictyostelium*, etc. – and others.

Technical demo: project work

Week 9 (Nov. 24) – Thanksgiving holiday

Week 10 (Dec. 1) – Making things with cilia

Discussion: papers on eukaryotic symbiosis (green hydra; coral-dinoflagellate symbiosis; *Mesodinium*-cryptophyte relationship; *Dinophysis*-*Mesodinium* kleptoplasty)

Lecture modules:
27) Back to cilia: compound cilia; macrociliary development in ctenophores; ciliary coordination; ciliary sense organs
28) Collective behavior in cells and cellular communities

Lab material: project work

Finals week:

- The final exam will be a take-home assignment, due on the scheduled Finals day, Dec. 8.
- On finals day we will meet for student presentations. This is expected to last 2-3 hours with breaks.