# Development of a curriculum map in Integrative Physiology to provide a mechanism for assessing student achievement of departmental program goals

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## Introduction

In 2016, we surveyed faculty to identify how much emphasis is and should be placed on each of three main categories (disciplinary knowledge, critical thinking & professional skills) in the Integrative Physiology (IPHY) undergraduate curriculum. We observed a mismatch between what faculty said they wanted and what they were doing, with faculty wanting more emphasis on critical thinking and professional skills than was currently occurring. Therefore, we began drafting more specific **program goals** in these areas identifying what a student *should know* (concepts and content knowledge) and *be able to do* (critical thinking and other professional skills) upon completion of the major.

We also realized the need to create a **curriculum map** that provides a visual representation of what goals are accomplished in each course and the reported level of student exposure (as indicated by faculty). The process of mapping the curriculum is the first step in ensuring that program goals are met, that courses in the curriculum combine into a cohesive whole, and that changes to the curriculum are intentionally designed to build upon and improve student learning.

## Methodology & Timeline

| Fall 2018 | Spring 2019 | Summer 2019 | Fall 2019 | Spring 2020 |
|---|---|---|---|---|
| Development of IPHY program goals | Review of goals by Curriculum Committee | Faculty surveys | Artifact collection, faculty interviews & review of taught curriculum | |
| | Review of goals by IPHY faculty | Development of IPHY curriculum map | | |

Over the past year, we created program goals informed by overarching principles from disciplinary professional societies. This involved adding two more categories (scientific method & metacognition). Once we had a draft, we solicited and received helpful feedback from faculty.

## IPHY Undergraduate Program Goals

The term "*integrative physiology*" is designed to encompass the broad fields of study within our department related to the structure and function of living organisms. This includes the study of organisms as functioning systems of molecules, cells, tissues, and organs with an emphasis on whole-body function and its applications to human health and disease.

### 1. Scientific method in IPHY (SM)

- **Ask research questions**
- **Search existing literature for relevant studies**
- **Create & test hypotheses**
- **Design experiments with appropriate controls**
- **Acquire, analyze, interpret, & present data**
- **Draw evidence-based conclusions**
- **Identify strengths & limitations of the design**
- **Place experimental results in the larger scientific context**

### 2. Critical thinking in IPHY (CT)

- **Apply knowledge within and across integrative physiology courses, and to novel and real-world contexts**
- **Analyze data (e.g., graphs, images, tables, etc.) to extract meaning and significance.**
- **Judge and critique claims in the scientific literature and popular media.**
- **Synthesize ideas and concepts from multiple sources to form new, integrated and meaningful patterns/designs/inventions.**

### 3. Professional Skills in IPHY (PS)

- **Communication** – Students demonstrate effective oral and written communication skills, and the ability to successfully communicate an understanding of integrative physiology to a wide audience.
- **Collaboration/teamwork** - Students collaborate with others towards shared goals.
- **Scientific reading comprehension** - Students demonstrate the ability to search, critically evaluate, and analyze scientific literature.
- **Disciplinary experience and awareness** – Students gain experience in disciplinary settings (e.g., research, teaching, leadership, outreach, internship, volunteering), and awareness of a variety of careers suitable for those with expertise in integrative physiology.
- **Basic skills** – Students demonstrate practical and relevant lab and technology skills.

### 4. Metacognition (MC)

- **Self-reflective learning -** *Faculty/teaching assistants promote students' periodic self-assessment of their knowledge, skills, and interests (e.g., administer post-exam reflections, one-minute papers, exit slips, portfolios, journaling)*
- **Feedback -** *Faculty/teaching assistants encourage students to be open to and act on feedback as part of the learning process (e.g., encouraging students to review graded assignments to understand what they missed and why).*
- **Seek expertise -** *Faculty/teaching assistants encourage students to seek out assistance of expert individuals (e.g., actively promoting office hour attendance, beyond listing office hours in the syllabus).*
- **Study and test-taking skills –** *Faculty/teaching assistants introduce and promote effective studying and test-taking skills (e.g., encourage students to use learning goals, self-quiz, concept-map/draw, form study groups; or discuss test-taking strategies).*
- **Time management –** *Faculty/teaching assistants introduce and promote student time management skills, including ability to plan ahead, prioritize tasks, and adapt to change (e.g., starting study early/not procrastinating, create a calendar).*

### 5. *Disciplinary knowledge in IPHY

- **Terminology** – Develop a vocabulary of appropriate terminology to effectively communicate information related to integrative physiology.
- **Levels of organization** - Develop a broad working knowledge of the different levels of organization (molecules, cells, tissues, organs, and organ systems) in health and disease.
- **Homeostasis**
  - Recognize and explain the principles of homeostasis and the use of feedback loops to control physiological systems.
  - Explain how organisms sense and control their internal environment and how they respond to external change.
- **Structure/function relationship**
  - Recognize the interrelatedness of structure and function in integrative physiology, and demonstrate an understanding of physiological function at both an anatomical and physiological level
  - Use anatomical knowledge to predict physiological consequences, and knowledge of function to predict the features of anatomical structures.
- **Mechanism & process -** Demonstrate an understanding of integrative physiology at the teleological (why) and mechanistic (how) levels.

*Faculty review of this category will occur AY19-20.

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## Faculty Survey Results & Curriculum Mapping

We then used an online survey to ask faculty about the level of exposure students had to each of the goals in the course(s) they teach (n=31 courses; response rate of >90%). Exposures were based on a scale from 0 to 3. Survey results were used to create a map of the curriculum to more easily identify gaps in coverage and reported level of exposure to the program goals.

| | INTEGRATIVE PHYSIOLOGY | COURSES REQUIRED FOR THE MAJOR | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Course number | IPHY 2800 | IPHY 3410 | IPHY 3435 | IPHY 3470 | IPHY 3480 | IPHY 4060 | IPHY 4440 | IPHY 4540 | IPHY 4580 | IPHY 4600 | IPHY 4650 | IPHY 4720 |
| | Course name | *Introduction to Statistics | *Introduction to Human Anatomy | Physiology Labs | *Human Physiology 1 | *Human Physiology 2 | Cell Physiology | *Endocrinology | Biomechanics | Sleep Physiology | *Immunology | *Exercise Physiology | *Neurophysiology |
| *Scientific method* | Ask research questions | 2.5 | 0.3 | 3 | 0.5 | 1.5 | 2 | 1 | 3 | 3 | 1.0 | 2.5 | 1.5 |
| | Search existing literature for relevant studies | 0.8 | 0.0 | 1 | 0 | 1.5 | 1 | 0 | 3 | 1 | 0.7 | 2 | 1 |
| | Create & test hypotheses | 1.8 | 0.0 | 3 | 0 | 1 | 1 | 1 | 3 | 2 | 0.7 | 1.5 | 0.5 |
| | Design experiments with appropriate controls | 1.3 | 0.0 | 3 | 0 | 1 | 2 | 1.5 | 3 | 2 | 0.7 | 1 | 0 |
| | Acquire, analyze, interpret, & present data | 2.5 | 0.0 | 3 | 0.5 | 1.5 | 3 | 2 | 3 | 1 | 0.3 | 3 | 2.5 |
| | Draw evidence-based conclusions | 3.0 | 1.3 | 3 | 0.5 | 2 | 2 | 2 | 3 | 3 | 2.0 | 3 | 2.5 |
| | Identify strengths & limitations of the design | 3.0 | 0.0 | 3 | 0.5 | 1 | 1 | 1.5 | 3 | 3 | 1.3 | 2 | 0.5 |
| | Place experimental results in the larger scientific context | 2.5 | 0.0 | 1 | 1 | 1.5 | 1 | 2.5 | 3 | 3 | 1.0 | 2.5 | 2 |
| *Critical thinking* | Apply knowledge | 2.8 | 2.7 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 2.7 | 3 | 3 |
| | Analyze data | 3.0 | 0.7 | 3 | 3 | 3 | 2 | 2.5 | 3 | 3 | 2.0 | 3 | 3 |
| | Judge and critique claims | 1.8 | 1.0 | 0 | 1.5 | 1.5 | 0 | 1.5 | 3 | 1 | 2.3 | 2 | 1.5 |
| | Synthesize ideas and concepts | 1.0 | 1.0 | 0 | 1 | 2 | 0 | 2 | 3 | 2 | 2.0 | 2.5 | 1.5 |
| *Professional skills* | Communication | 1.0 | 1.7 | 1 | 0 | 1.5 | 1 | 1 | 3 | 1 | 0.0 | 2 | 3 |
| | Collaboration/teamwork | 1.8 | 2.3 | 3 | 1.5 | 3 | 3 | 2.5 | 3 | 1 | 1.3 | 3 | 3 |
| | Scientific reading comprehension | 1.0 | 0.0 | 1 | 0 | 1 | 1 | 0.5 | 3 | 3 | 0.3 | 2.5 | 1 |
| | Disciplinary experience and awareness | 0.8 | 0.3 | 1 | 1.5 | 0.5 | 0 | 1.5 | 3 | 1 | 1.0 | 2.5 | 0 |
| | Basic skills | 3.0 | 0.7 | 3 | 0 | 0 | 1 | 3 | 3 | 1 | 0.0 | 3 | 2.5 |
| *Metacognition* | Self-reflective learning | 0.8 | 0.7 | 0 | 2 | 1 | 0 | 1 | 3 | 0 | 0.0 | 2.5 | 1.5 |
| | Feedback | 2.8 | 2.7 | 2 | 2 | 3 | 1 | 3 | 2 | 2 | 2.3 | 2.5 | 3 |
| | Seek expertise | 2.8 | 3.0 | 2 | 2.5 | 3 | 0 | 2 | 3 | 2 | 2.0 | 2 | 2.5 |
| | Study and test-taking skills | 3.0 | 3.0 | 0 | 2 | 3 | 0 | 2.5 | 3 | 3 | 1.7 | 2 | 2.5 |
| | Time management | 2.3 | 2.7 | 1 | 1.5 | 2.5 | 0 | 0.5 | 2 | 1 | 0.7 | 1 | 1.5 |

**KEY for Scientific Method, Critical Thinking, Professional Skills**
0 Students are ***not exposed*** to concept/skill (not included in my course)
1 Students are ***minimally exposed*** to concept/skill (once or twice a semester)
2 Students are ***moderately exposed*** to concept/skill (monthly or bi-weekly)
3 Students are ***significantly exposed*** to concept/skill (weekly)

**KEY for Metacognition**
0 Teaching faculty ***never*** address this goal with students (not included in my course)
1 Teaching faculty ***seldom*** address *this goal with students* (once or twice a semester)
2 Teaching faculty ***sometimes*** address this goal with students (monthly or after each exam)
3 Teaching faculty ***often*** address this goal with students (weekly)

*Data was averaged for courses with multiple instructors.

Next, we averaged faculty ratings of each goal for required and elective courses, respectively, and ranked the order by average rating.

**Required courses**

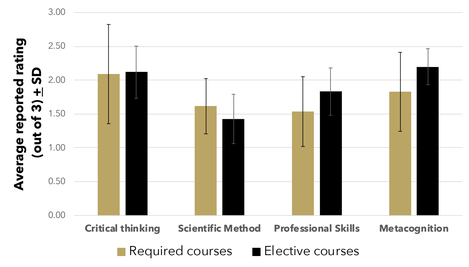
| | Category | Average faculty rating per goal (out of 3) | S.D. | Rank Count (based on avg. rating) |
|---|---|---|---|---|
| CT | Apply knowledge | 2.84 | 0.30 | 1 |
| CT | Analyze data | 2.60 | 0.72 | 2 |
| PS | Collaboration/teamwork | 2.37 | 0.77 | 3 |
| MC | Feedback | 2.35 | 0.59 | 4 |
| SM | Draw evidence-based conclusions | 2.28 | 0.80 | 5 |
| MC | Seek expertise | 2.23 | 0.82 | 6 |
| MC | Study and test-taking skills | 2.14 | 1.10 | 7 |
| SM | Acquire, analyze, interpret, & present data | 1.86 | 1.15 | 8 |
| SM | Ask research questions | 1.82 | 0.98 | 9 |
| SM | Place experimental results in the larger scientific context | 1.75 | 0.97 | 10 |
| PS | Basic skills | 1.68 | 1.34 | 11 |
| SM | Identify strengths & limitations of the design | 1.65 | 1.12 | 12 |
| CT | Synthesize ideas and concepts | 1.50 | 0.93 | 13 |
| CT | Judge and critique claims | 1.42 | 0.86 | 14 |
| MC | Time management | 1.38 | 0.84 | 15 |
| PS | Communication | 1.35 | 0.97 | 16 |
| SM | Create & test hypotheses | 1.28 | 1.01 | 17 |
| SM | Design experiments with appropriate controls | 1.28 | 1.06 | 17 |
| PS | Scientific reading comprehension | 1.19 | 1.07 | 19 |
| PS | Disciplinary experience and awareness | 1.09 | 0.92 | 20 |
| MC | Self-reflective learning | 1.03 | 1.03 | 21 |
| SM | Search existing literature | 0.99 | 0.88 | 22 |

**Elective courses**

| | Category | Average faculty rating per goal (out of 3) | S.D. | Rank Count (based on avg. rating) |
|---|---|---|---|---|
| CT | Apply knowledge | 2.67 | 0.49 | 1 |
| MC | Seek expertise | 2.54 | 0.84 | 2 |
| MC | Feedback | 2.39 | 0.63 | 3 |
| PS | Communication | 2.16 | 1.03 | 4 |
| MC | Time management | 2.07 | 0.92 | 5 |
| CT | Judge and critique claims | 2.04 | 1.16 | 6 |
| MC | Study and test-taking skills | 2.04 | 0.97 | 7 |
| PS | Collaboration/teamwork | 2.03 | 1.15 | 8 |
| CT | Analyze data | 2.00 | 0.98 | 9 |
| MC | Self-reflective learning | 1.96 | 1.20 | 10 |
| PS | Scientific reading comprehension | 1.90 | 1.07 | 11 |
| PS | Disciplinary experience and awareness | 1.82 | 1.19 | 12 |
| SM | Ask research questions | 1.77 | 1.21 | 13 |
| CT | Synthesize ideas and concepts | 1.77 | 1.16 | 13 |
| SM | Draw evidence-based conclusions | 1.73 | 1.22 | 15 |
| SM | Search existing literature for relevant studies | 1.63 | 0.90 | 16 |
| SM | Place experimental results in the larger scientific context | 1.62 | 1.19 | 17 |
| SM | Identify strengths & limitations of the design | 1.50 | 1.21 | 18 |
| SM | Acquire, analyze, interpret, & present data | 1.43 | 1.25 | 19 |
| PS | Basic skills | 1.25 | 1.24 | 20 |
| SM | Create & test hypotheses | 0.93 | 0.96 | 21 |
| SM | Design experiments with appropriate controls | 0.80 | 1.08 | 22 |

- **Required courses** are lecture courses, many with lab or recitation (n=12)
  - Goals averaging a 2+ (***moderately exposed*** – monthly or bi-weekly)
    - Top two are **Critical Thinking**
    - **Metacognition** (3/5 = 60%), **Critical Thinking** (2/4 = 50%), **Professional Skills** (1/5 = 20%), **Scientific Method** (1/8 = 12.5%)
  - Bottom goals:
    - None are **Critical Thinking**
- **Elective courses** include lectures, seminars, internships, independent studies, undergraduate teaching assistantships, honors thesis (n=19)
  - Goals averaging a 2+ (***moderately exposed*** – monthly or bi-weekly)
    - No **Scientific Method**
    - A lot of **Metacognition** (4/5 = 80%) and **Critical Thinking** (3/4 = 75%), some **Professional Skills** (2/5 = 40%)
  - Bottom goals: mostly **Scientific Method**

We then analyzed the overall ranking of the categories in required and elective courses.




**Required courses**

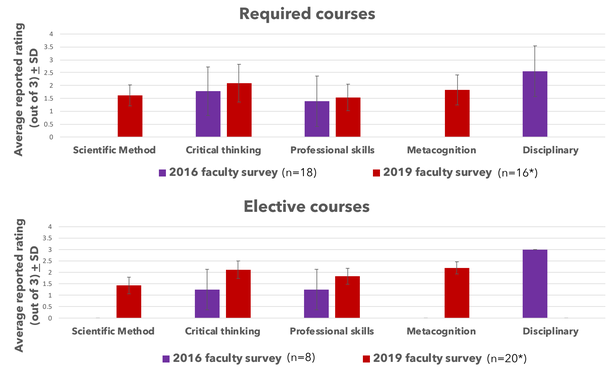
| Category | Average rating per category | Standard deviation |
|---|---|---|
| Critical thinking | 2.09 | 0.73 |
| Scientific Method | 1.62 | 0.41 |
| Problem Solving Skills | 1.54 | 0.52 |
| Metacognition | 1.83 | 0.58 |

**Elective courses**

| Category | Average rating per category | Standard deviation |
|---|---|---|
| Critical thinking | 2.12 | 0.39 |
| Scientific Method | 1.43 | 0.36 |
| Problem Solving Skills | 1.83 | 0.35 |
| Metacognition | 2.20 | 0.27 |

- **Critical thinking** highest ranked for **required** courses; overall rating similar to elective courses.
- **Scientific method** higher rank and rating in **required** courses.
- **Professional skills** higher rank and rating in **elective** courses.
- **Metacognition** higher rank and rating in **elective** courses.

Finally, we compared the 2019 faculty survey results to those from 2016. We observed consistency in faculty reporting of what they say they're doing in their classes (especially for required courses) – despite some changes in faculty (retirements, new hires).




*Some faculty completed multiple surveys in 2019.

## Future Directions

- Consult with faculty on appropriate disciplinary knowledge goals for our students.
- Compare the **operational curriculum** (what is intended to be taught) to the **taught curriculum** (what is delivered) by reviewing course artifacts and interviewing faculty.
- Once the goals and map are established, we will post them on the department website to inform prospective students, post-bac programs, and future employers of the specific knowledge and skills gained by undergraduate students through the IPHY curriculum.