VAN ANDEL INSTITUTE
GRADUATE SCHOOL

Problems & Proposals in Graduate School:

A Problem-Based Learning Approach to Doctoral Education in Biomedical Research

Presentation to faculty of University of Toledo College of Medicine and Life Sciences

May 19, 2017

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VAIGS President and Dean

Objectives for today:

Successful participants will be able to:

- **Describe key features of problem-based learning (PBL)**
- **Recognize advantages of PBL approaches for PhD students in biomedical research programs**
- **Evaluate whether and how PBL fits with specific grad programs or disciplines**
- **Brainstorm specific "problems" as prompts for student learning objectives (skills or knowledge) in a given discipline**

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GRADUATE SCHOOL

Our setting:

Single small PhD program; independent charter

PhD in cellular and molecular biology

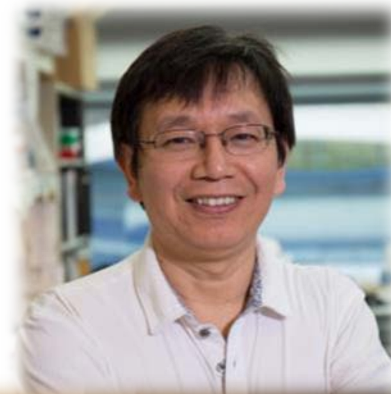
25 students / 5-7 in each cohort

Our setting:

Single small PhD program

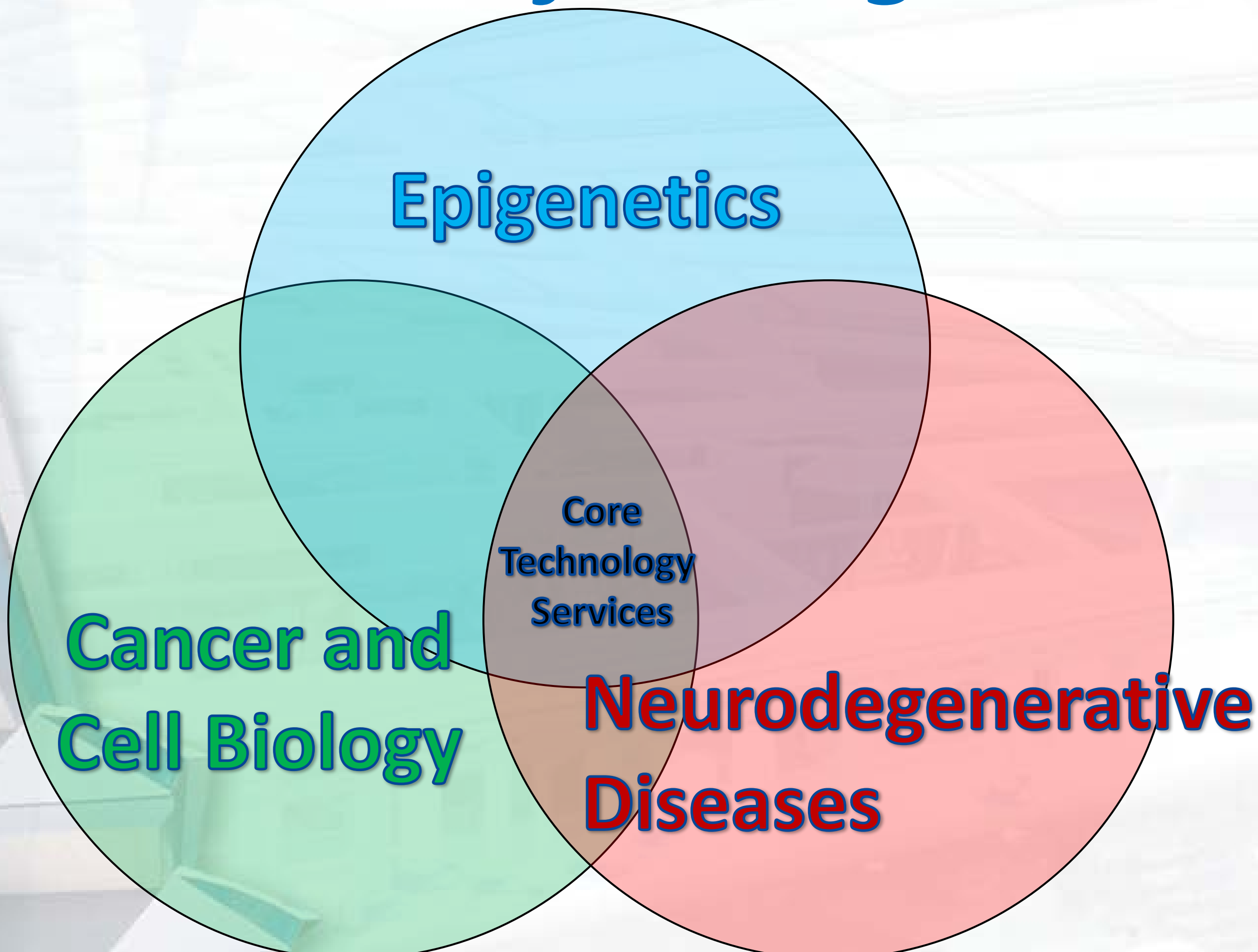
Housed within a biomedical research institute (Van Andel Research Institute)

Scientists of research institute = faculty of graduate school



VARI mission:

improve health and enhance lives of current and future generations



VAN ANDEL INSTITUTE

Our setting:

Single small PhD program

Housed within a biomedical research institute

We're young!

First students 2007

First graduates 2012

Initial accreditation 2013

VAN ANDEL INSTITUTE

GRADUATE SCHOOL

Mission: To train Ph.D. scientists as biomedical research leaders in cell and molecular biology relevant to human diseases with translational emphasis.

VAIGS setting and philosophy:

Mission: Develop biomedical research leaders

Approach: "Think and act like a scientist"

(i.e., research leader)

= Combine research skills and leadership skills

The pedagogical problem:

"How do we best help

our doctoral students learn

what they really need to learn

for the work and career

that they will come to?"

Stating the pedagogical problem

"How do we best help our doctoral students learn what they really need to learn for the work and career that they will come to?"

- **Too much knowledge to know it all**
- **Access to information is very rapid**
- **Growth of knowledge is too rapid to keep up**
- **Telling them all that I know: isn't the answer.**

Not just our issue, and not an entirely new issue:

Walker, Golde, Jones, Bueschel, Hutchings

The Formation of Scholars **(2008)**

Carnegie Foundation for Advancement of Teaching

Key theme: "stewards of the discipline"

generating …

conserving …

transforming …

Reframing our problem

How do we best help our doctoral students think and act like (research leaders)?

Well … what do research leaders do?

Take 3 minutes …

list 4-5 key activities
that define or demonstrate
what research leaders do

(Yes, you may talk with your neighbor.)

What do research leaders do?

Let’s collect a few examples:

What do research leaders do?

Let's collect a few examples:

Which of those do we want our students to learn to do?

Let's collect a few examples:

THESE are now our "student learning outcomes"

Learning outcomes = *aka* core competencies

Knowledge	Research	Communication	Professional and Ethical Conduct
Describe key concepts in biomedical science	Define sound rationale / identify gap in knowledge	Speak effectively	Manage data with scientific integrity
Place core concepts in the relevant clinical context	Frame appropriate hypothesis	Write effectively	Engage in best authorship practices
Know scientific literature relevant to the research area	Apply creative and appropriate experimental design	Communicate to diverse audiences	Address ethical problems in scientific research
	Use controls appropriately		Comply with safety and regulatory standards
	Execute experiments with technical skill		Display appropriate lab citizenship
	Demonstrate critical analysis and thinking		Work collegially and effectively as a team / collaborator
	Integrate results into relevant models		

What do <u>research leaders</u> do?

AND … *how do research leaders learn*?

~~Take a semester or two of lecture courses~~ …

Read current research papers

Read key review articles

Find a gap that you can exploit

Design a project to hit that gap

Reframing our problem again …

How do we best help our doctoral students learn to do what scholars do, and learn the way that scholars learn?

Carnegie Hall:
Practice, practice, practice …

One approach:
Problem-based learning

Common in medical training (nursing, law, business):

"Learn to think like a doctor"

<u>Use a relevant problem to drive learning</u>:

Create the "reason to learn" / "need to know"

Use that context to get to <u>underlying concepts</u>

One approach: Problem-based learning

Common in medical training (nursing, law, business)

<u>**Use an ill-structured (but well-planned) problem to drive learning**</u>**:**

- **Create a authentic "need to know" / "reason to do"**
- **Set the context for conceptual framework**
- **Students express what they do (<u>and don't) know</u>**
- **Students drive the "learning"; teachers support**

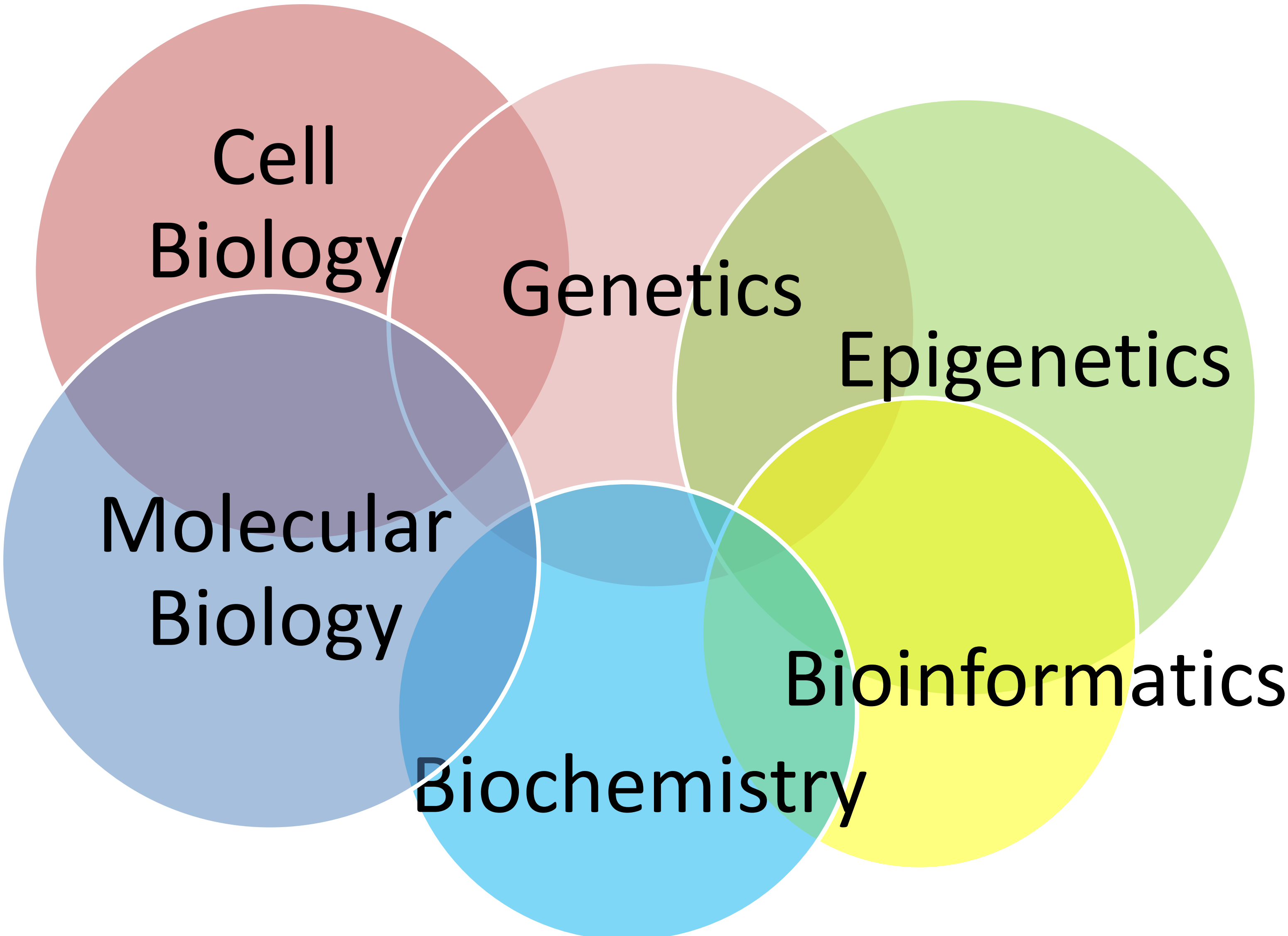
Today's Workshop:

Case study:

Using PBL at
Van Andel Institute Grad School

What can YOU learn / apply?

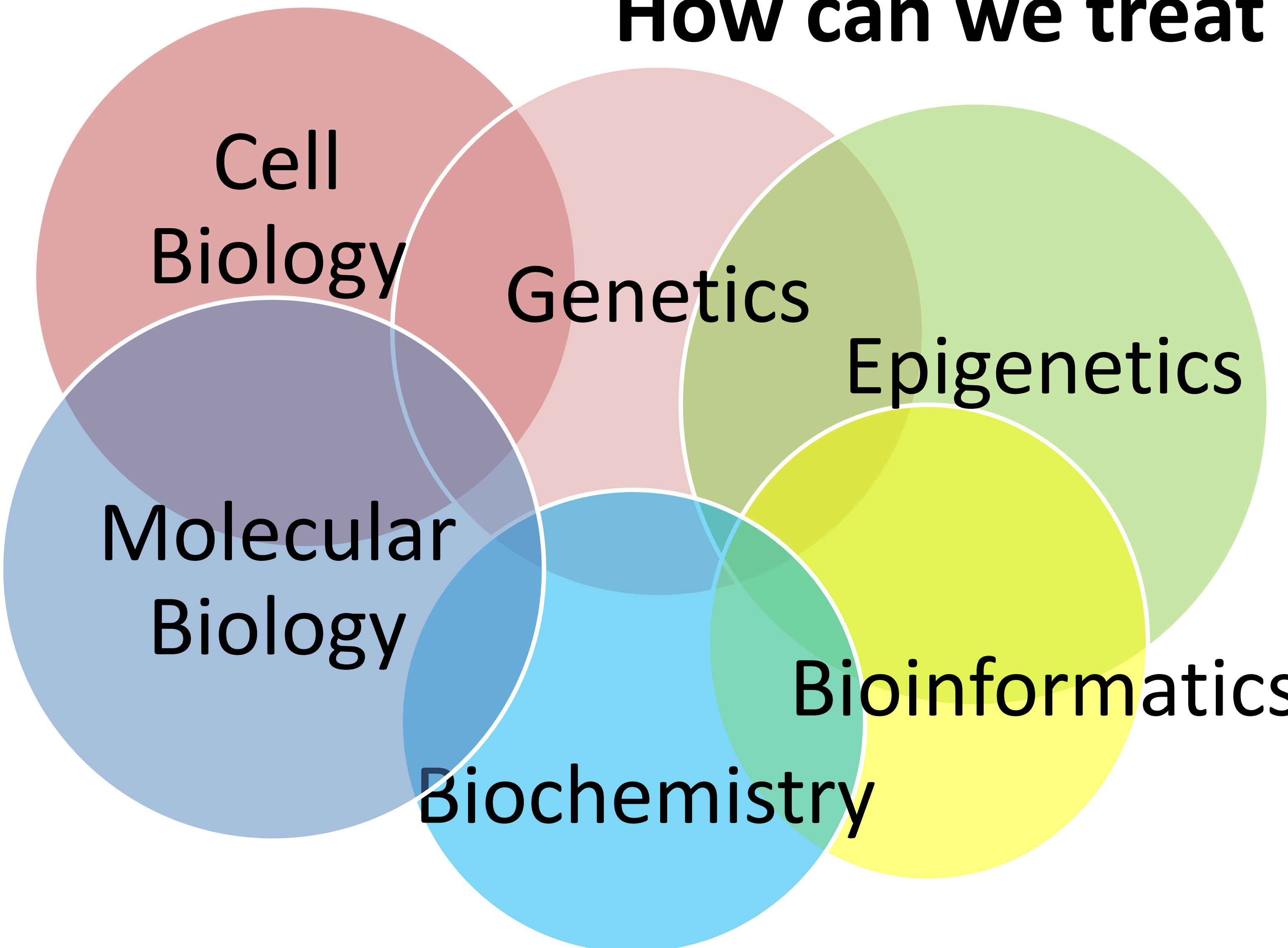
The science we do: basis of human disease



"What causes pancreatic cancer?"

How can we detect it?

How can we treat it?



Typical PhD curriculum – Year 1

- Biochemistry
- Cell Biology
- Genetics
- Statistics
- Molecular Biology
- Pathology
- Bioinformatics
- Epigenetics

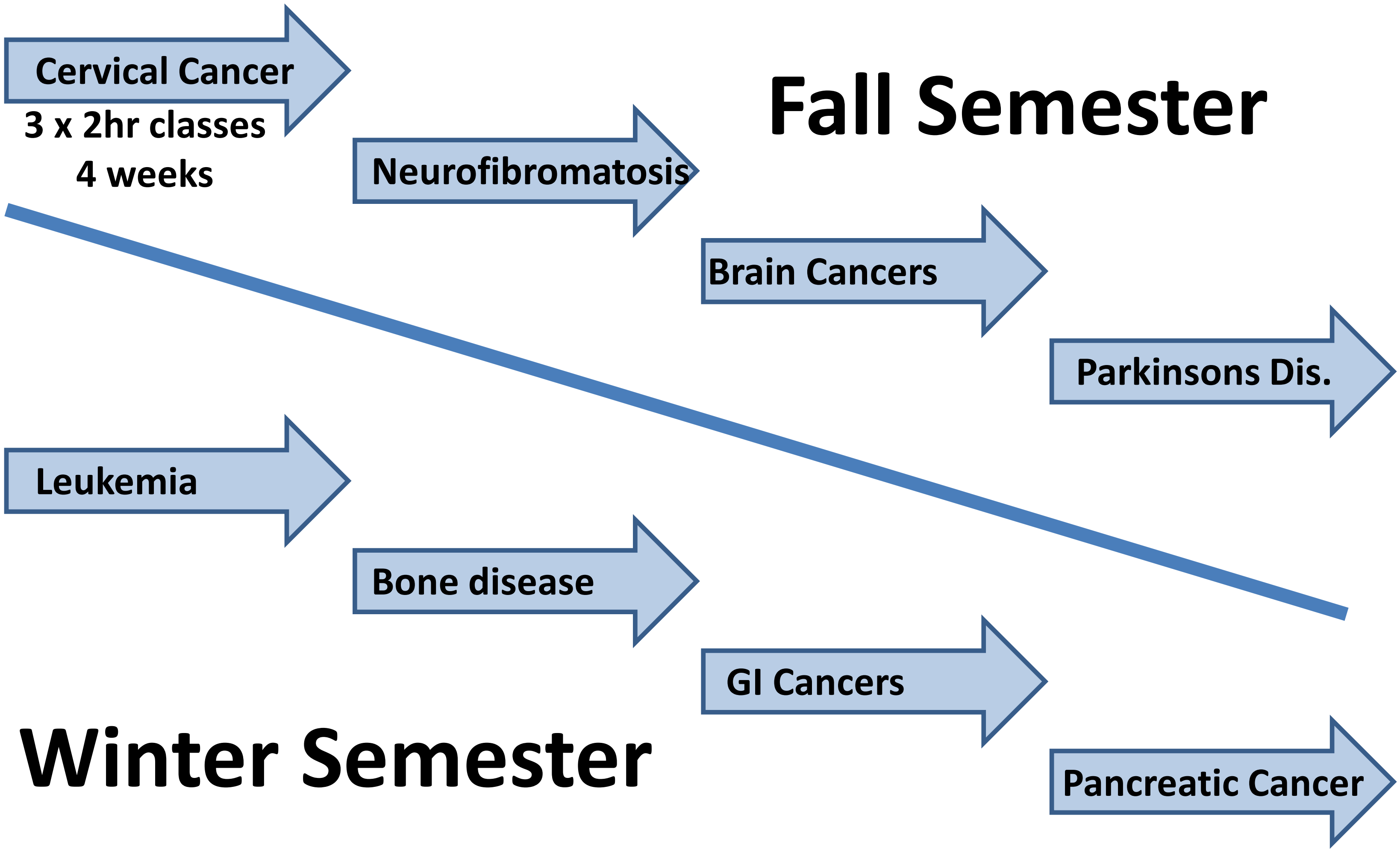
Problem-Based Learning

- **Integrate disciplines:** ***(content, methods)***
  cell and molecular biology, genetics, bioinformatics, pathology, immunology …

- **Authentic context for learning:**
  Research proposals (grant format)

- **Driven by "ill-structured" but well-planned problems in human diseases**

Our curriculum - overview



Our curriculum - overview

- **What happens in these modules?**
  - **Given: A problem relevant to this disease**
    (ill-structured … unsolved … well-planned)
  - **Task: Research Project Proposal (i.e., grant)**
    - ***"How will you attack that problem?"***
      = authentic context for learning!
  - **Process:** ***"Learn whatever you need to learn in order to create / write that proposal"***

Our curriculum – example Cervical Cancer

- **Context:**
  - **Cervical cancer is caused by human papillomavirus**
  - **Vaccines are available to block HPV infection**
  - **Not everyone gets vaccinated before infected**

  - **Problem: Could we design a <u>therapeutic</u> vaccine – to treat people who have cervical cancer, in contrast to inoculating all pre-adolescents?**

Our curriculum – example Cervical Cancer

- Problem: Could we design a therapeutic vaccine for cervical cancer?

- What would students need to learn?

(input from audience)

Our curriculum - example

Problem: Could we design a therapeutic vaccine?

- What would students need to learn?

- INSTRUCTOR has intended learning objectives

- Plan the “ill-structured” problem and the activities to lead students to achieve those objectives.

PBL at VAIGS

- **What happens in these modules?**
  - **Class meets 3x/week, 2 hours / session**

  - **What do the STUDENTS do?**
    - **"What do we need to learn NEXT?"**
    - **"What do we need to do to learn that?"**

      (then go away and do / learn)

    - **"What DID we learn since last time?"**

Our curriculum - overview

- **What happens in these modules?**
  - What do the STUDENTS do?
  - **What does the PROFESSOR do?**

Education is an admirable thing, but it is well to remember from time to time that nothing that is worth knowing can be taught.

- Oscar Wilde

Our curriculum - overview

- **What happens in these modules?**
  - **What do the STUDENTS do?**
  - **What does the PROFESSOR do?**
    - **Help students define new learning issues**
    - **Provide resources for learning**
    - **Clarify / correct their new understanding**
    - **Push for more depth / breadth**
    - ***Disclose the "intended" learning objectives***

How does PBL address our problem?

"How do we best help our doctoral students learn what they really need to learn for the work and career that they will come to?"

- **Too much knowledge to know it all**
- **Access to information is very rapid**
- **Growth of knowledge is too rapid to keep up**
- **They will need to learn (later) more than I know now: transfer is not the answer.**

What matters most –
the knowledge, or the learning?

“In preparing for battle I have always found that plans are useless, but planning is indispensible.”

- Dwight D. Eisenhower

Our curriculum - overview

- **What happens in these modules?**
  - **Students learn concepts / knowledge**
  - **Students develop / practice "thinking skills"**

How to:

- **<u>Define</u> what I need to learn**
- **<u>Find</u> information I need**
- **<u>Evaluate</u> the quality of that information**
- **<u>Find</u> the "gaps in knowledge"**
- **<u>Structure</u> the information to make sense**
- **<u>Communicate</u> in the style that scientists use**

Our curriculum - semester

What happens from one module to next?

Cervical Cancer

Neurofibromatosis

Bone disease

Parkinsons

– Progressive concept development

– Progressive skill development

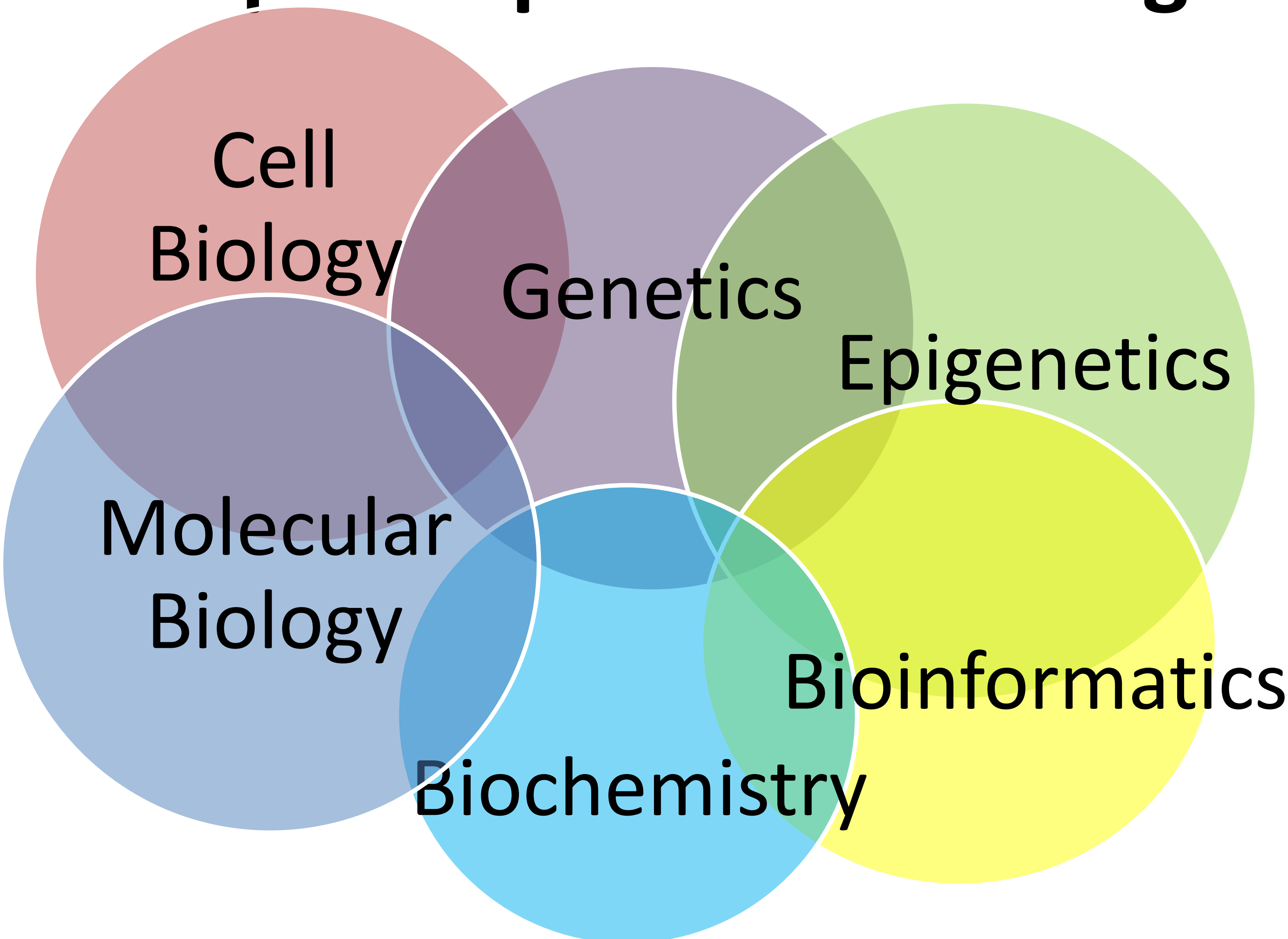
Our curriculum – whole year

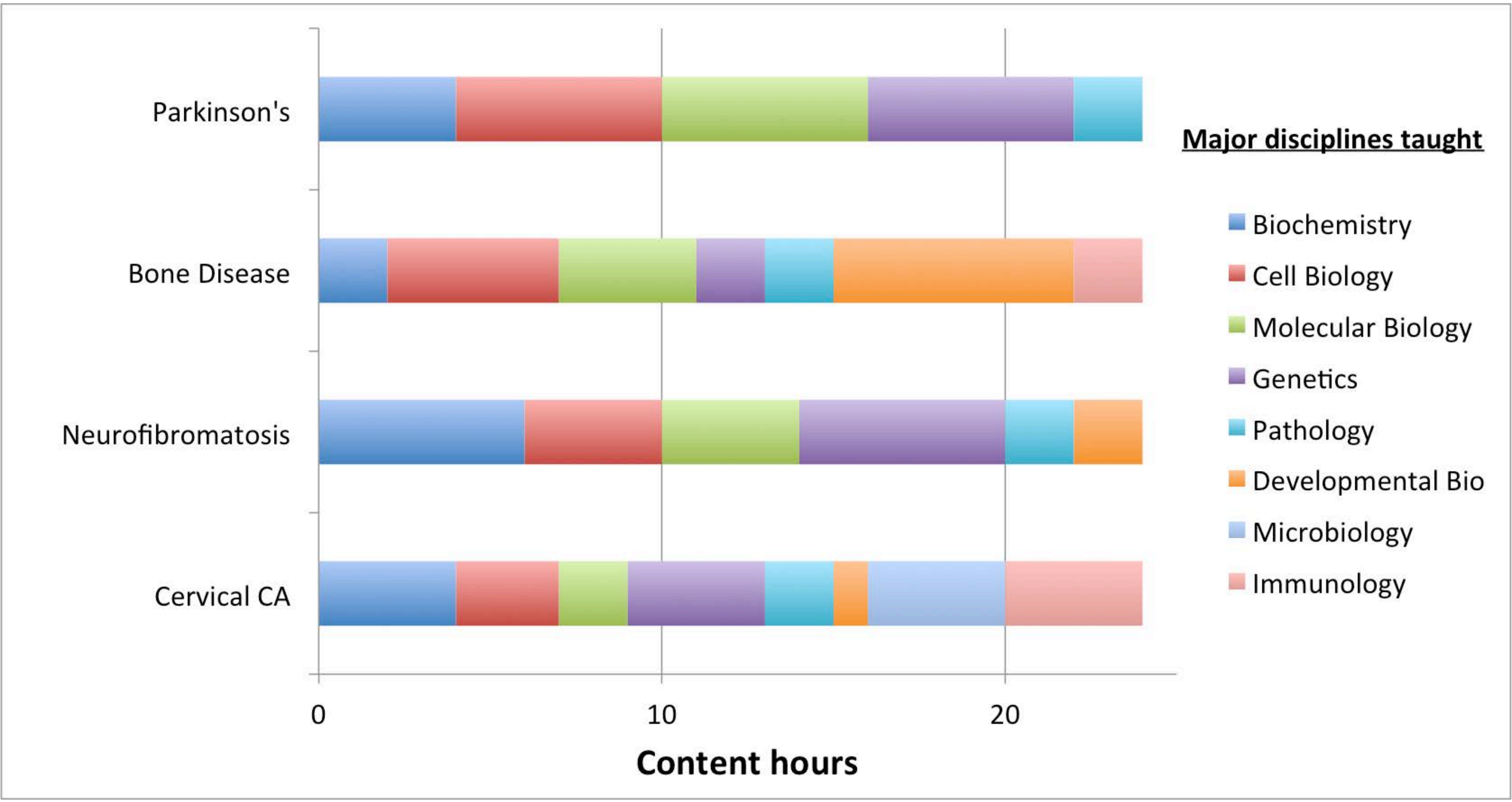
What happens from one module to next?

- Progressive concept development
  - Each module knows and depends on learning objectives in previous modules
  - Self-testing … spaced repetition … interleaving topics …
    "*Make It Stick*" (Brown, Roediger, McDaniel, 2014)

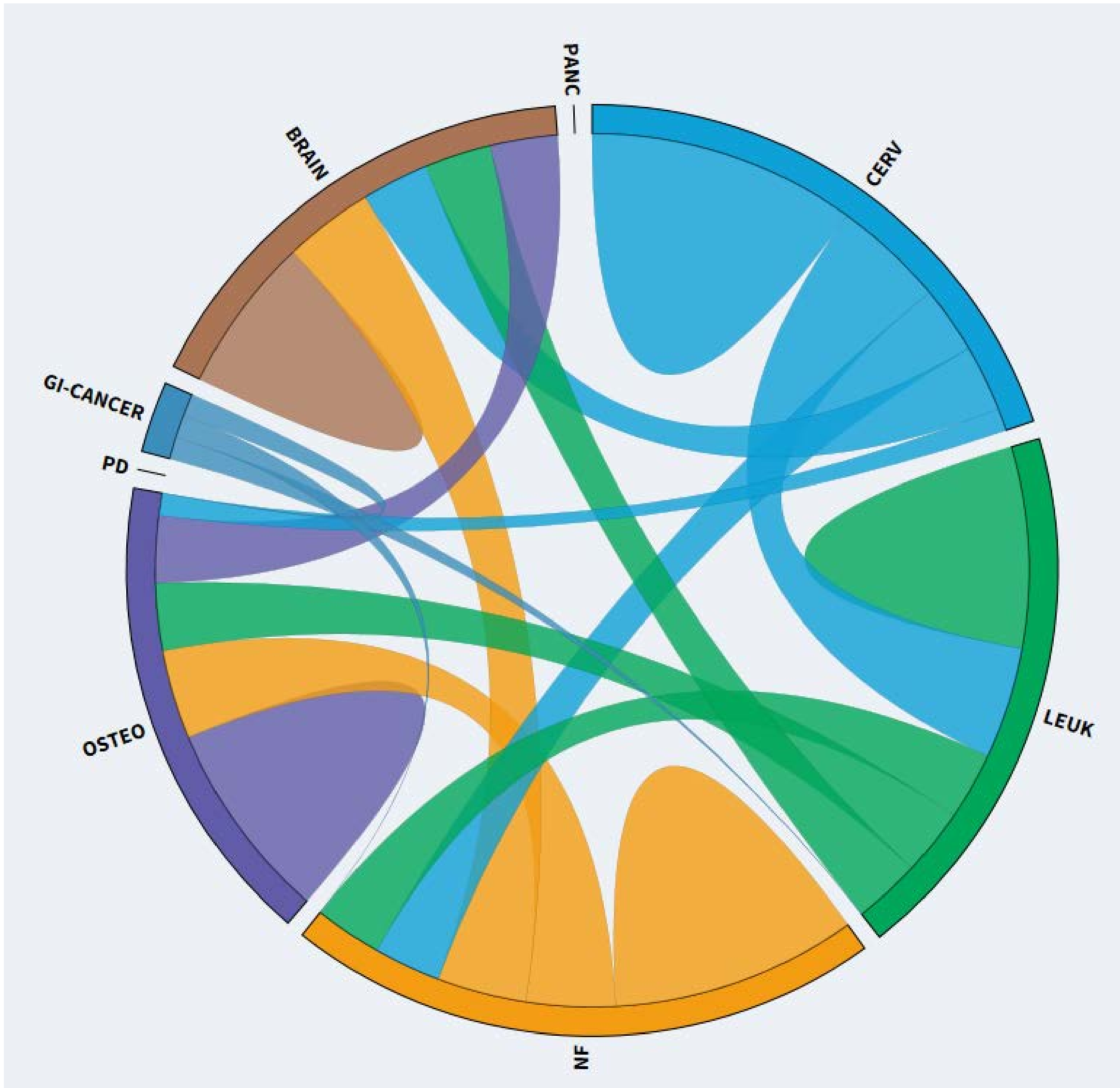
- Progressive skill development: practice / feedback how to:
  - Find information you need
  - Evaluate the quality of that information
  - Find the "gaps in knowledge"
  - Structure that information to make sense
  - Communicate in the style that scientists use

What happens to the discipline-specific knowledge?




Parkinson's
Bone Disease
Neurofibromatosis
Cervical CA
0
10
20
Content hours
Major disciplines taught
Biochemistry
Cell Biology
Molecular Biology
Genetics
Pathology
Developmental Bio
Microbiology
Immunology

Curriculum Organizer circos plot



Evidence-based highly effective learning strategies:

- Retrieval practice: recalling from memory
- Spaced repetition of key ideas
- Try to solve before being taught the answer
- Interleave different but related topics
- Testing to judge what was learned
- Build on prior knowledge
- Elaborate in your own words
- Extract ideas, build mental model

Brown, Roediger, McDaniel: *Make it Stick*, 2014 (Belknap Press)

How can you use this approach in YOUR setting?

What challenges / issues will you need to address in YOUR setting?

How can YOU use this model?

- **Pick a few concepts that students could learn**
- **Pick a few skills that students should gain**

- **What kind of "problem" in your discipline could drive students to learn those?**

- **How would you present that "problem"?**
  ("ill-structured but well-planned")

How can YOU use this model? *(alternative approach)*

- **Pick an interesting problem in your field**
- **What are key concepts connected to this problem?**
- **How could this "problem" be presented so that students learn concepts / gain skills?**

How can YOU use this model?

Then put together several such modules

- **each with their own problem**
- **each with their own product / outcome**

- **progressive development of knowledge**
- **progressive development of skills**

Questions, issues, concerns:

- How to get faculty to stop “teaching” and instead to let students learn

- Defining authentic exercises / activities based on the practice of your discipline

- How to get people “on board” – for a course, for a curriculum

Other questions, issues, concerns:

Resources:

- **Walker, Golde, Jones, Bueschel, Hutchings: *The Formation of Scholars,* 2008**
- **Brown, Roediger, McDaniel: *Make it Stick,* 2014**
- **Duch, Groh, Allen (eds): *The Power of Problem-Based Learning,* 2001**
- **Lovitts: *Making the Implicit Explicit*, 2007**

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More information at:

www.vai.org

Email: gradschool@vai.org

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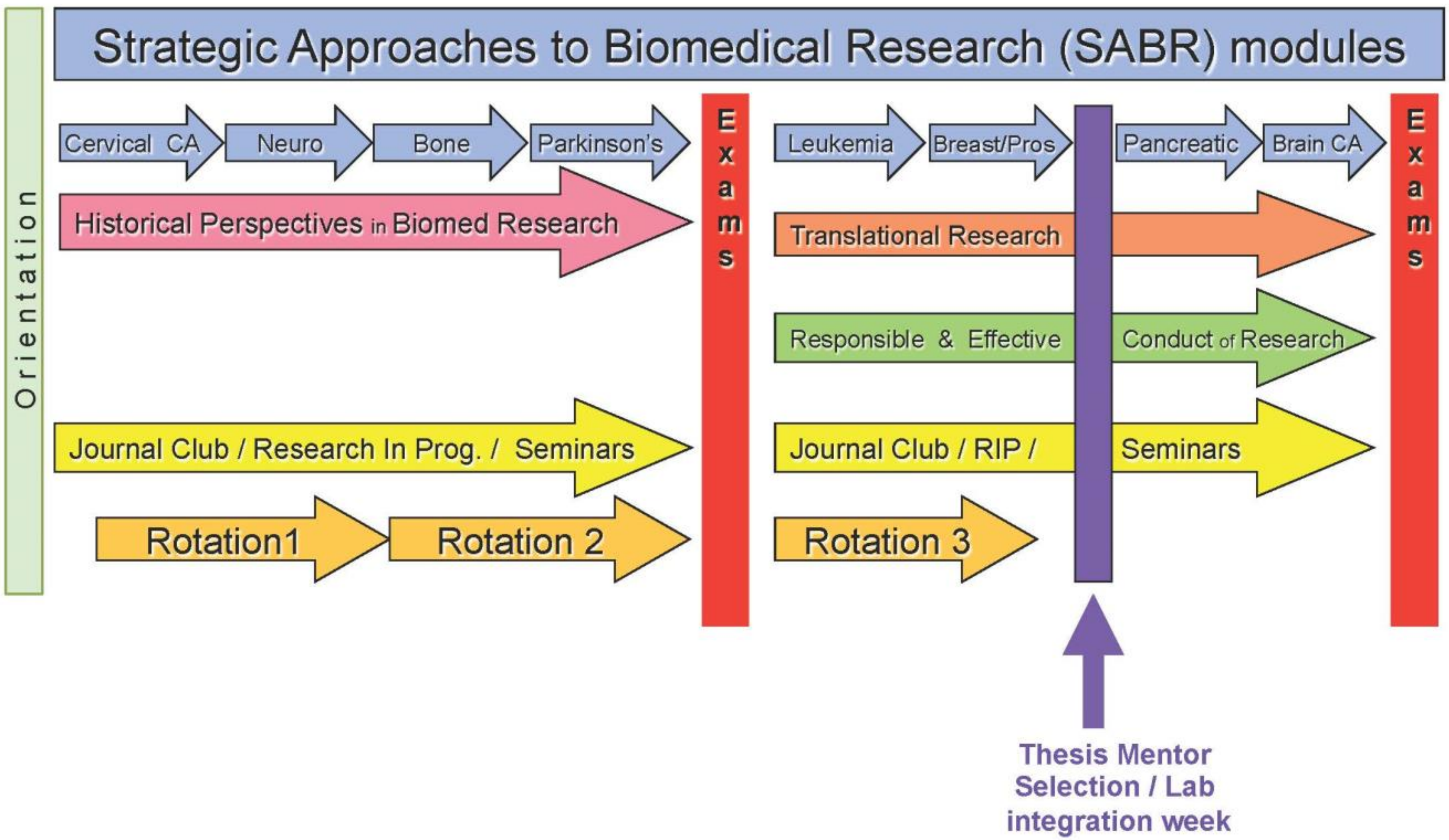
VAIGS Year 1 Curriculum Overview



VAIGS CORE COMPETENCIES v2

The student can and does:

KNOWLEDGE	Exceptional	Heightened	Advancing	Intermediate	Beginning
Describe key concepts in biomedical science	Evaluate new challenges or controversies relevant to concepts	Recognize and apply key concepts as they appear in new settings	Explain concepts with expanded historical and contextual detail	Describe general concepts correctly and clearly	Describe general concepts with gaps and errors
Place core concepts in the relevant clinical context	Use clinical information to elicit gaps in collective knowledge	Recognize and apply key concepts as they appear in new clinical settings	Connect clinical issues and molecular mechanisms accurately and broadly	Describe clinical context of molecular mechanisms as presented by others	Describe thesis research and disease association in general and limited terms
Know scientific literature relevant to the research area	Evaluate literature beyond the dissertation research area	Compare contradictory publications in the dissertation research area	Understand and evaluate a primary research article	Understand review article descriptions of emerging concepts	Understand biomedical textbook descriptions of key concepts
RESEARCH	**Exceptional**	**Heightened**	**Advancing**	**Intermediate**	**Beginning**
Define sound rationale / identify gap in knowledge	Effectively defend given rationale against objections or alternatives	Build expanded rationale for project and experiments	Use rationale to justify priorities for daily work	Understand rationale provided by others	Perform experiments as instructed without considering rationale
Frame appropriate hypothesis	Recognize alternative and testable hypotheses	Independently generate testable hypotheses coupled with specific aims	Generate independent but incomplete hypotheses	Contribute to formation of hypotheses	Accept hypothesis from others
Apply creative and appropriate experimental design	Invent and apply alternative strategies and troubleshoots potential outcomes	Critically evaluate and modify approaches	Seek expert advice & glean novel approaches from literature	Collect and employ appropriate approaches	Execute experiments designed by others
Use controls appropriately	Analyze unexpected results and allow new discoveries to emerge	Apply rigorous controls and use outcomes to redirect experimental path	Incorporate both positive and negative controls consistently	Use controls for most approaches	Perform controls as instructed by others
Execute experiments with technical skill	Generate high technical productivity, publication-quality figures; direct others in technique	Master technical understanding and troubleshoot experimental failures independently	Anticipate results and obtain reproducible results	Exhibit appropriate experimental technique and seek advice when experiments fail	Receive instruction and practice new skills with supervision
Demonstrate critical analysis and thinking	Defend position or hypothesis-driven experiments to expand the field of study	Compare contrary results, yielding multiple new hypotheses	Observe limits of current models; identify gaps in knowledge	Describe experiments that generated current model	Accept current models as accurate and sufficient
Integrate results into relevant models	Create new models that integrate experimental findings with external data; Critique data and analysis of others	Revise extant models based on new data from self or others.	Elucidate logical flaws in current models based on experimental data	Compare new data with prior results from self, same lab, other labs	Accept only those results consistent with hypothesis.

COMMUNICATION	Exceptional	Heightened	Advancing	Intermediate	Beginning
Speak effectively	Elegant communication in multiple settings (conferences, seminars, classroom, mass media, ad hoc).	Present effective poster or platform presentations at conferences; handle questions concisely and effectively; manage logistics and disruptions	Present clear, well-organized research and journal club talks or posters with effective use of schematic and data figures/conclusions	Plan and present journal club or research-in-progress talks for lab or center using simple or pre-set figures	Plan and present short oral summaries in lab meetings or mentor meetings
Write effectively	Present complex models or proposals using elegant language in multiple formats (essay, grant, research or review article)	Present complex models or rationale in cogent, convincing, and concise language	Build coherent and logical argument describing or proposing research studies	Employ standard structures of scientific communication (poster, manuscript, grant formats) with accurate attribution of citations	Write sentences, paragraphs, and essays using established structure and English language standards
Communicate to diverse audiences	Communicate science (one's own or other) effectively to varied audiences (scientists, clinicians, lay)	Communicate research effectively to larger and diverse audiences, wider age ranges	Describe research purpose and outcomes to small audience of lay adults	Convey goal, rationale, approach, and outcomes to scientists beyond lab group	Describe experimental purpose and outcomes to lab peers and supervisor
ETHICAL / PROFESSIONAL PRACTICE					
Manage data with scientific integrity	Demonstrate integrity in shared data; mentor others in appropriate data management	Rectify issues where data were not handled or recorded appropriately; revise record-keeping methods to prevent issues	Coordinate multiple formats for data collection and storage (notebook, electronic files, artifacts, sample identity)	Record data in prescribed format in timely, accurate, and complete manner	Record experimental results with flaws in timeliness, accuracy, and organization
Engage in best authorship practices	Lead collaborative writing team; serve as submitting author; conduct quality peer review of manuscripts or proposals; resolve authorship conflicts	Negotiate scope and structure of project or manuscript with multiple contributors; work out timeline/writing responsibilities	Develop or employ planning process for authoring projects; complete outline and initial draft; effectively edit drafts from others	Participate in design, writing, and editing of collaborative proposals or papers	Complete small assigned writing tasks on time for editing by others
Address ethical problems in scientific research	Counsel others effectively on ways to identify, work through, and resolve ethical problems	Apply effective approaches to address ethical problems; utilize support structures for best outcome	Identify the various stake holders in ethical dilemmas; identify key ethical principles relevant to given situation	Recognize ethical problems in case studies; describe processes to discuss, advise, or resolve ethical issues	Recognize that ethical problems can arise in science
Comply with safety and regulatory standards in laboratory activities	Serve on institutional safety or research review committees	Write protocols compliant with regulatory standards for animal, human, hazardous, or recombinant DNA research	Seek counsel from regulatory staff to improve studies and protocols	Complete training for animal, human, recombinant DNA, hazardous research	Complete minimal lab safety training as required and apply safe practices in laboratory setting
Display appropriate lab citizenship	Serve effectively in leadership role in lab operations and/ or institute initiatives	Serve as role model and mentor in lab skills and professional behavior	Seek guidance from peers and mentors with regard to interpersonal interactions and conflict resolution	Understand implications of one's behavior/attitude in lab and other settings; fulfill assigned lab duties	Treat others with respect; follow laboratory rules and standard practices
Work collegially and effectively as a team / collaborator	Design and lead collaborative projects to successful outcome	Present and accept honest and professional feedback in settings with multiple individuals; share primary project responsibility	Take individual initiative in obtaining input or collaboration from colleagues for specific projects	Work with lab members on shared project with defined individual responsibilities assigned by others	Work on individual project; accept direction and oversight from others