Supporting More Investigators Sustainably and Efficiently

Prepared by the Office of Extramural Research (OER) and the Efficiency and Sustainability of Funding Policies Working Group of the EAWG (Jon Lorsch, Chair)

Presented by Michael Lauer and Jon Lorsch (EAWG Co-Chairs) with many thanks to OD/OER/OPAC/DPEA/Statistical Analysis and Reporting Branch, Luci Roberts, Katrina Pearson, Katie Patel, Deepshikha RoyChowdhury, and Rachael Walsh

113th Meeting of the NIH Advisory Committee to the Director
Thursday, December 8, 2016
Building 31C6, Room 6, NIH Main Campus, Bethesda, MD
“The erroneous assumption of never-ending rapid growth has created an **unsustainable hypercompetitive system** that is discouraging even the most outstanding prospective students from entering our profession—and making it difficult for seasoned investigators to produce their best work. This is a recipe for long-term decline.”

Alberts B, Kirschner MW, Tilghman S, Varmus H. PNAS 2014;111:5773-7
Core Problems Underlying an Unstable System

“We identified two core problems:
• Too many researchers vying for too few dollars.
• Too many postdocs competing for too few positions. Most other issues can be viewed as symptoms.”
Hypercompetition: Applicants and Awardees for NIH RPGs

Number (10,000s)

Fiscal Year

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We Also Know That …

Age Distribution of NIH Principal Investigators (PIs) and Medical School Faculty, 1980–2010.

Career Stage by Fiscal Year for RPGs and Other Select Activities

- Early (< 45)
- Mid (45 to 60)
- Late (> 60)

Fiscal Years:
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

Percent of Funded Investigators:
- Early (< 45)
- Mid (45 to 60)
- Late (> 60)

OER SARB
“In the United States, for example, funding success rates for all age brackets are less than half what they were in 1980, so researchers have to spend more time seeking funds. That burden falls most heavily on new faculty members. Extreme competition means that researchers have little time for anything not directly tied to getting ahead. That makes them conservative rather than ambitious.”
The “Fight for Funding” Is The Biggest Concern

**FIGHT FOR FUNDING**
The biggest challenge facing early-career scientists is the struggle to get grants, *Nature*’s readers say.

**Poll question:**
What do you think is the biggest challenge facing early-career scientists?

- The fight for funding
- Lack of work-life balance
- Progression judged too heavily on publication record
- Admin and bureaucracy
- Lack of clear targets
- Discrimination
- Other

11,882 responses
44%
19%
7%
5%
2%
4%
2%
“Agencies should be sensitive to the total numbers of dollars granted to individual laboratories…—although different research activities have different costs—at some point, returns per dollar diminish. We applaud the recent decision by the NIH to examine grant portfolios carefully before increasing direct research support for a laboratory beyond $1M per year.”

Alberts B et al. PNAS. 2014;111:5773-7
Sensitive to Dollars: Skewed Distribution

10% of PIs get over 40% of the funding
Signs of Inefficiency: Diminishing Returns

NIMH: Mol Psychiatry. 2015 Sep;20(9):1030-6
UK: PeerJ. 2015 Jun 9;3:e989
Alberts: Cell. 1985;41:337-8

• Input
  – Dollars, effort & grant count – problematic
  – New tool: “Research Commitment Index”

• Output
  – Relative Citation Ratio
  – Others: mentorship, patents, guidelines
  – “Cure Networks”
**Input: What About Number of Grants?**

- Couldn’t we simply count grants?
- Problems:
  - R01 ≠ R03 ≠ R21
  - R01 ≠ P01
  - R01 ≠ U10
  - Etc…
Tools to Measure Input and Output

• Input
  – Dollars, effort & grant count – problematic
  – **New tool: “Research Commitment Index”**

• Output
  – Relative Citation Ratio
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  – “Cure Networks”
Research Commitment Index (RCI)

• Measure of PI’s committed bandwidth
• Not simply measure of dollars
• Benchmarked to R01 (7 points)
  – R03, R21 less
  – P50, U54 (PI) more
• Effectively, a modified grant count
RCI Total Point Distribution in Fiscal Year 2015 for RPG and Select Other Activities

Most vulnerable investigators?

Investigators

RCI Total Points
RCI Total Point Distribution in FY2015 for RPG and Select Other Activities
Tools to Measure Input and Output

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• Output
  – Relative Citation Ratio
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  – “Cure Networks”
Relative Citation Ratio

Co-citation network

- Article of interest
- Papers that cite the article of interest
- Papers that are co-cited with the article of interest
- Papers that are cited by the article of interest

0 = never cited  
1 = average  
2 = twice the average  
>20 = exceptionally highly cited
How Do We Know Whether It Means Anything?

2193 R01 papers  430 HHMI/NIH papers  290 R01 papers

NIH Office of Portfolio Analysis
PLoS Biology (September 6, 2016)
Diminishing Returns Across NIH
Strong Evidence of Diminishing Returns

N=71,493 Principal Investigators Funded 1996-2014
Median Annual RCI 7 (IQR 6-9)
Median Funding Years 5 (IQR 3-10)

Unrealized productivity?

OER SARB
• **Input**
  – Dollars, effort & grant count – problematic
  – New tool: “Research Commitment Index”

• **Output**
  – Relative Citation Ratio
  – **Others**: mentorship, patents, guidelines
  – “Cure Networks”
No relationship between funding level of mentors and the number of ESI awardees that they train

ESI RPG awardees per mentor versus the FY16 direct costs of their RPG-funded mentors

Thanks to George Santangelo and OPA
Tools to Measure Input and Output

• Input
  – Dollars, effort & grant count – problematic
  – New tool: “Research Commitment Index”

• Output
  – Relative Citation Ratio
  – Others: mentorship, patents, guidelines
  – “Cure Networks”
B

Sanders Williams R et al. Cell 2015;163:21-23

Ivacaftor

FDA trials

Scientists (N=2587)

Institutions (N=2516)

Documents / Publications
A Data-Based Outcome Story

Gleevec

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<thead>
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<th>Nodetype</th>
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Thanks Jim Onken, Brian Haugan, George Chacko, Shixin Jiang, Samet Keserci, Alex Pico, and Lindsay Wan
Putting It All Together

• Input
  – Focus on investigators as well as grants
    • New and mid-career investigators
  – Other tools: total budgets, RCI

• Output
  – Diminishing returns
    • Growing evidence within NIH system
    • Opportunities to fund more investigators
“New investigators are the innovators of the future - they bring fresh ideas and technologies to existing biomedical research problems, and they pioneer new areas of investigation. Entry of new investigators into the ranks of independent, NIH-funded researchers is essential to the health of our country's biomedical research enterprise.”

Sally Rockey, PhD

http://grants.nih.gov/policy/new_investigators/history.htm
Can we regain lost ground?
Career Stage by Fiscal Year for RPGs and Other Select Activities

Turn this curve?
• Unstable system with hyper-competition
• Hurting early- & mid-career faculty most
• Inefficient with diminishing returns
• Possible to fund more investigators
  – Especially early- and mid-career
• New tools to measure input, output
Appendix Material
SHOULD I QUIT?

Almost two-thirds of Nature’s readers say they have considered quitting research; 15% have actually quit.

Poll question:

Have the challenges of research ever meant that you have ... (8,820 responses)

- Considered quitting research
- Been judged solely on your publication count
- Published a paper you're not proud of
- Cut corners in your research
- Actually quit research
- Salami-sliced your results to get more papers
- None of the above
Changing our funding metric

“A question that at first glance may seem trivial but is, I believe, a significant one is whether our key metric for how we invest in … research should be the number of grants we award or the number of investigators we support.”

Lorsch JR. Mol Biol Cell 2015;26:1578-82
Dropout of Funded NIH Investigators

Year of First Award
- 1996-2000
- 2001-2005

PI Retention Rate vs. Years Since First Award
Difficulty Securing First Renewals, Especially for New Investigators

- Application
  - New
  - 1st Renewal
- Investigators
  - Experienced
  - New

Success Rate (%)


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Mean RCI Total Points by Fiscal Year for RPG and Select Other Activities

- NIH Doubling
- Payline Crash
- Post-ARRA Cliff and Sequestration

N=98,656 Unique Investigators
714,120 Person-Years
(ARRA Awards Excluded)

OER SARB
Distribution by Investigator Status

Total # PIs: 20,897
Total Number of Awardees: 32,159

Most vulnerable investigators?

- Awardees with 7 or fewer points
- Awardees with 8 to 14 points
- Awardees with 15 to 20 points
- Awardees with 21 points or more

OER SARB
Relative Citation Ratio

- Article of interest
- Cite the article of interest
- Co-cited with article of interest: the co-citation network
- Cited by the article of interest

NIH Office of Portfolio Analysis
PLoS Biology (September 6, 2016)
Strong Evidence of Diminishing Returns -- Nontransformed Axes

N=71,493 Principal Investigators Funded 1996-2014
Median Annual RCI 7 (IQR 6-9)
Median Funding Years 5 (IQR 3-10)
Funding and Mentorship: OPA Analyses

Early Stage Investigator (ESI) data

- Definitions
  - ESI applicant: PI submitting at least one competing RPG ESI application in FY2015-FY2016
  - ESI awardee: PI submitting at least one RPG ESI application that was funded in FY2015-FY2016

- All publications in each ESI biosketch were computationally extracted and matched to a PubMed ID
- For each successfully matched PubMed ID, disambiguation analysis and manual curation was used to confirm the link between each ESI name and author name

Linking ESI mentees to mentor PIs

- For each confirmed ESI PubMed ID, matches between the last author and an FY2016 RPG PI were identified
- A PI was considered a mentor of an ESI if both scientists were co-authors on at least two papers that had the mentor as last author; as above, disambiguation analysis and manual curation were used to confirm matches
- If an ESI had multiple applications, the corresponding ESI-mentor links were de-duplicated

Determining mentor funding

- A mentor’s total dollar amount is the sum of FY2016 direct costs for all RPGs linked to the mentor’s PI ID
- For projects with subprojects, dollar amounts are apportioned to each subproject PI
- For multi-PI grants, dollar amounts are split evenly between PIs

Thanks to George Santangelo and OPA
No linear relationship between funding level of mentors and the number of ESI applicants that they train

Number of ESI RPG applicants versus the FY16 direct costs of their RPG-funded mentors

ESI RPG applicants per mentor versus the FY16 direct costs of their RPG-funded mentors

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Stable Funding Associated with Higher Productivity

N=28,711 Principal Investigators Funded 1996-2014
All Funded at Least 7 Years
Martin Tingley was coming undone. It was late autumn 2014, just over a year into his assistant-professor job at Pennsylvania State University in State College, and he was on an eight-hour drive home after visiting his wife in Boston. He was stressed, exhausted and close to tears. As the traffic zoomed past in the dark hours of the early morning, the headlights gave him the surreal feeling that he was inside a video game.

Usually, Tingley thought of himself as a “pretty stoic guy” — and on paper, his career was already getting off the ground. He had been on the faculty there for two years, and he had been working on developing a new type of camera for monitoring heart rhythms. But he was feeling the pressure. Scientists starting labs say that they are under historically high pressure to publish, secure funding and

Young scientists and senior scientists alike feel an acute pressure to publish and are weighed down by a growing bureaucratic burden, with little administrative support. They are largely judged on their record of publishing and of winning grants — but without clear targets, they find themselves endlessly churning out paper after paper. The crucial question is whether this is harming science and scientists. Bruce Alberts, a prominent biochemist at the University of California, San Francisco, and former president of the US National Academy of Sciences, says that
## The RCI Point Schedule

<table>
<thead>
<tr>
<th>Activity Code</th>
<th>Single PI point assignment</th>
<th>Multiple PI point assignment</th>
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<tbody>
<tr>
<td>P50, P41, U54, UM1, UM2*</td>
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<td>10</td>
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<tr>
<td><strong>Subprojects</strong> under multi-component awards</td>
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<td>6</td>
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<td>R01, R33, R35, R37, R56, RC4, RF1, RL1, P01, P42, RM1, UC4, UF1, UH3, U01, U19, DP1, DP2, DP3, DP4</td>
<td>7</td>
<td>6</td>
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<tr>
<td>R00, R21, R34, R55, RC1, RC2, RL2, RL9, UG3, UH2, U34, DP5</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>R03, R24, P30, UC7</td>
<td>4</td>
<td>3</td>
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<td>R25, T32, T35, T15</td>
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Can we regain lost ground?

- Competing R01 Awardees -- New and Established In First Year of Award
- NIH Doubling
- New Investigator Policy
- Number
- Fiscal Year